Urban Harvesting as planning approach towards productive urban regions

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1: Introduction

In recent times cities became almost disconnected, focusing on location of functions, from the sources that make an urban life style possible. Food, energy, and materials are just coming in and waste is going out. Steel (2008) illustrates the concept of a "hungry city" and links it to what might be called a fossil fuel focused energy system. To solve this, we propose that a more sustainable energy system is required, and that thermodynamic principles as exergy are of use to understand such a system (Dincer & Rosen, 2005).

Urban regions might become also productive next to consumptive, if a shift towards a sustainable future is taken seriously. Urban regions can produce the resources they need to fulfill their demands. Therefore production requires a place within the urban fabric, which becomes a mixture of several urban functions that work together: housing, industry, leisure, shopping, etc.

Bringing industry back to the city, or keeping it, creates opportunities for re-using waste products, like material recycling or using residual heat within various industries and also housing areas. Moreover job creation and lower transport demand might give new positively judged identities to urban regions. Therefore, in these regions, industries are not only seen as producers of materials, but also as energy suppliers, identity creators, or providers of leisure activities.

With help of a case-study, Kerkrade-West, a neighborhood of the Dutch city of Kerkrade in the south of The Netherlands, it is possible to illustrate this way of reasoning in which spatial functions become mixed-up, using both connectivity and proximity as relevant spatial principles. Moreover the case helps to understand how the concept of urban harvesting – emphasizing that cities are reservoirs of un-used resources and focusing on use and re-use of these resources – can be used as a planning approach in regional planning. Planners should face multi-functionality within urban regions as a chance, not a threat. If distances among the different functions within the city are shorter, it is easier to recycle materials and re-use, e.g., residual heat flows within the urban fabric. Shorter distances might also lead to what is referred to as "the sustainable mobility paradigm" (Banister, 2008).

The authors developed a method for an urban metabolism conscious spatial planning, emphasizing on energy, towards productive urban regions, which consists of seven steps. This paper describes the theoretical background of this method, explains the method by using the case-study Kerkrade-West, shows some results and discusses that the proposed method can be broadly applied to reach productive urban regions.

2: Theoretical framework

The authors propose a method to develop a sustainable urban design in which smart productive landscapes are integrated. At the one hand we address sustainability and sustainable development in general, and at the other hand more specifically urban regions that need to be designed sustainably.

2.1: Sustainable development and Urban Metabolism

The most known, and most frequently used, definition of sustainable development is the definition of the WCED, Brundtland Commission (1987): "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". Important is that sustainability is a multi-dimensional concept: in order to reach a sustainable urban region it is not enough to focus only on ecological and environmental aspects. The proposed measures should also focus on economical, social and governmental aspects. The measures should, e.g., create value and money, raise jobs, offer opportunities for innovation, create healthy, safe and attractive cities, and raise awareness and ask input of governments and local stakeholders, and guarantee the urban region's functioning over time.

To illustrate how the different aspects work and come together, we use an example of creating green areas and surfaces, e.g. green roofs, in an urban region. This is a possible measure to minimize negative impacts of the Urban Heat Island effect, like heating up of urban regions and by that increasing demand for cooling (Arnfield, 2003). In tackling this problem, the measure also contributes to improve social sustainability of the urban region – more green improves health of people (Tyrväinen et al., 2005; Currie & Bass, 2008). The measure further contributes to lower negative environmental impacts – green areas and trees mitigate air pollution (Currie & Bass, 2008), reduce peak flows during storm events due to retention capacity (Bliss et al., 2009), and can contribute to lower energy costs (Akbari & Konopacki, 2004). Another potential use of the extra created green urban surface, green roofs, can be local food production (Bertram & Peck, 2007).

In order to develop a sustainable urban design, we have to focus on the way the urban region functions energetically wise and how resource flows are used within the built environment. At the moment cities have a linear metabolism: non-renewable resources are imported, are used inefficiently, and after use waste is exported and valuable resources are thrown away, e.g. emissions of CO_2 to the air (fig. 1, left side). To reach a more sustainable urban region, cities have to evolve to a circular metabolism – a closed cycle resource management (Rovers, 2008). Circular metabolism means that incoming, renewable, resources are captured and transformed for efficient use in the urban region, and waste creation is minimized by applying recycling and re-using (fig. 1, right side). If we use this concept, we can look at an urban region as one system with an urban metabolism. This provides a holistic framework for analyzing an urban region's input–output relationships with its surrounding biophysical environment. It uses the metaphor of biological metabolism and treats urban regions as an organism, i.e. the chemical process within an organism involving intake of resources, their transformation into more or less complex forms, and the subsequent excretion of wastes (McDonald & Patterson, 2007). In the last decades, "urban metabolism has been used as a useful framework for providing valuable information about energy efficiency, material cycling, waste management and infrastructure in urban systems" (Kennedy et al., 2007).
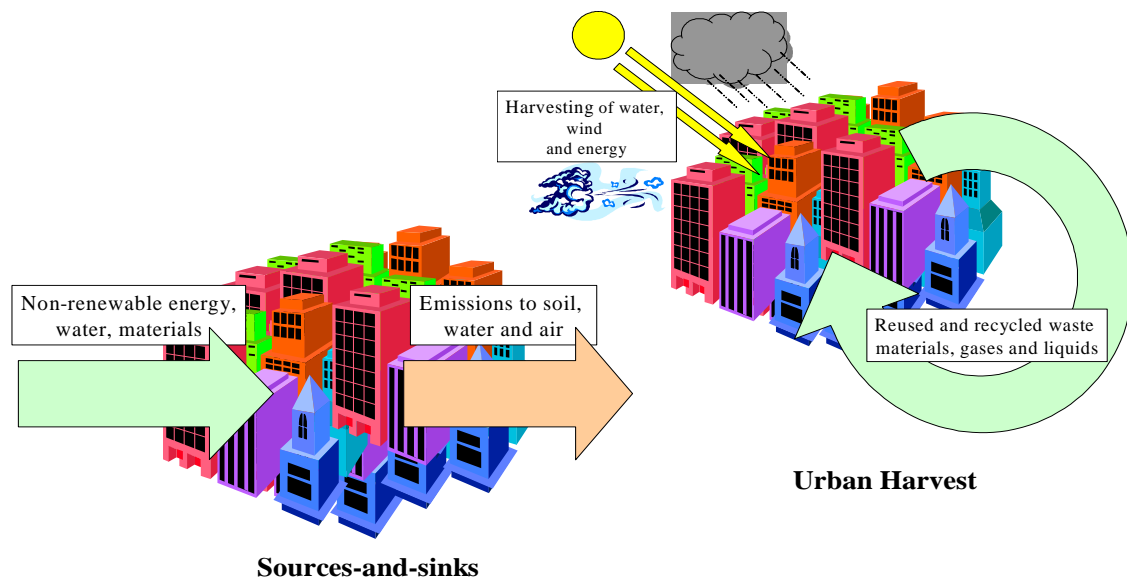
Fig. 1: Linear vs. circular urban metabolism

2.2: Industrial Ecology

To reach productive urban regions, we need to look at interactions that can be feasible between various urban functions with different patterns of using energy, water, materials and even space. An urban region is built up of several functions which are classically categorized as residential area, commercial area, area for leisure activities, transport area, and also business/industrial sites. Moreover, several non built-up functions, located within municipal/district borders, can be indicated such as agricultural area, forest area and water surface. Nonetheless, we could also categorize various spatial functions within the urban fabric according to, for instance, their energy demand or supply of useful products and waste. Where the first categorization helps to identify, for instance, sustainable mobility issues (like distance reduction, modal shift, see: Banister, 2008), the last categories might help to identify sustainable energy systems. Literature (Brabec & Lewis, 2002) indicates that urban regions can become more sustainable and productive if both built-up and non built-up functions work together as one system.

 Thus, it is important to look for the synergies that the combination of these functions brings, and use these synergies to reach productive urban regions. For example, industrial areas are historically grown separated from the rest of urban functions because of possible harmful effects and other environmental issues. In that sense, the 'Industrial Ecology' concept was developed to reach more sustainability on the scale of an industrial area. In this concept, an industrial system is seen as an industrial ecosystem in which consumption of energy and materials is optimized, waste generation minimized, and effluents of one process serve as raw material for another process (Frosch & Gallopoulos, 1989; Gibbs & Deutz, 2007). For this industrial ecosystem, the ecosystem principles apply (Korhonen, 2001):

- Roundput: recycling of matter and cascading of energy (see also Van Kann & Leduc, 2008);

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- Diversity: diversity in actors, in interdependency and co-operation, diversity in industrial in/output;
- Locality: use local resources and wastes, respect local natural limiting factors, co-operation between local actors;
- Gradual change: undergo evolution, a transition towards a sustainable system, and no sudden change or chock.

As stated above, it is important that we see industrial areas as part of the urban metabolism. The industrial area is the place where productivity can take place, and where residual flows emerge. Industrial processes are not isolated from their surroundings, but are part of a more integrated whole, and influence and are influenced by their surroundings (Coelho & Ruth, 2006; Frosch & Gallopoulos, 1989). If industrial ecosystems are not part of the larger urban metabolism, we see four main problems to reach productive urban regions. Firstly, proposed solutions focus on industrial symbiosis and forget possible, maybe more efficient, solutions when connecting to other urban functions. Secondly, companies want to get rid of their waste and look for symbiosis with other companies that can use that waste as raw material, but in this reasoning it can be economical profitable to create as much waste as possible which is non-sustainable in the long run. Thirdly, it resembles a linear way of thinking: something comes in and what goes out may be useful for another company, but the process or system as a whole is not taken into account. Finally, diversity that is given by multi-functionality is missing. Multi-functionality is important because different users or functions have different demand requirements and that allows cascading of flows.

2.3: Urban Harvest and Low-exergy Planning

In order to tackle the mentioned problems and to reach productive urban regions, the authors propose to use the Urban Harvest approach. Urban Harvesting is a method to use input and output of an urban metabolism more effective and in a sustainable way. The Urban Harvest approach is developed as a strategy to investigate all possible options for harvesting local resources and (re)using emissions and wastes within the urban area. Urban Harvest is seen as a positive contribution to the needs of cities, complementary to reducing negative impacts of consumption, and limiting inflow (Rovers, 2007). Urban Harvest addresses the capture of any renewable primary resource and any secondary resource within an urban system, aims for the (re)use within that same urban system, and thus for a closed cycle resource management (Rovers, 2007, 2008). The focus in Urban Harvest is not on energy itself, but on the quality of energy, called exergy (second law of thermodynamics: 'energy can never be lost'; see, e.g., Wall, 1977, 2009; Dincer & Rosen, 2005). According to the exergy principle, an outgoing flow is not waste, but a flow with a lower quality. Therefore, the remaining quality of these residual flows can be useful for another activity within the urban metabolism.

Within the concept of urban metabolism, and to use urban harvest as a planning approach towards productive urban regions, it is important that urban regions are built up of a mixture of urban functions – multi-functionality – that are connected to each other, and are also in close proximity so the residual and renewable flows can be used in an optimal way as suggested by Van Kann and de Roo (2009) in to what they refer to as low-exergy planning (see also Van Kann & Leduc, 2008). Nevertheless, the focus of urban harvesting is broader than only energy, it also

focuses on other urban flows, as materials, water and space. As already mentioned it is necessary not only to consider urban areas as a multi-functional mix of various land-uses but also to develop existing areas more and more into multifunctional structures. Crucial to ideas for exchanging residual flows of materials, water, and energy are variables like distances, densities, and system sizes (Van Kann & de Roo, 2009). This has to deal with the necessity to make use of infrastructure as it is obvious that especially in existing urban areas demand for and supply of residual flows are usually not on the same place, or on the same time. In order to make use of infrastructures in an efficient and cost-effective way we need to find synergies between clusters of spatial functions (size and densities) on appropriate distances. Therefore we do not only elaborate on a method to identify the urban metabolism, but we argue for an approach to explore possible infrastructure patterns and networks.

The proposal of the authors to reach productive urban regions is an integrated design in which the urban harvest approach is applied to harvest, capture, re-use and recycle the renewable and residual flows within an urban metabolism, based upon concepts as exergy, multi-functionality, connectivity and proximity. The next paragraph will describe the proposed method.

3: Method: 'Urban Harvest as planning approach towards productive urban regions'

The method we have developed for an urban metabolism conscious spatial planning, emphasizing on energy, towards productive urban regions, consists of seven steps:

1. Make an inventory of spatial functions: built-up area, non built-up area, and sub-functions like water, agricultural area, forest/green area, residential area, business area, recreational area, etc.; illustrated by an urban tissue, which gives a quick and easy to grasp overview of urban land-use distribution;

2. Identify large consumers of energy (and/or materials, water) within various categories of land-uses that might influence or determine the 'centre of gravity' of the energy use in a specific energy related spatial cluster;

3. Make an inventory of existing energy demand (and water and materials if you want to get a broad overview of all flows in the study region), and categorize energy demand according to type of energy demand – quality of energy – and according to amount of energy demand – quantity of a certain quality. For example electricity demand (differentiated for voltages), heat demand (differentiated for temperatures), and transport demand (differentiated for distances, size, modal shift). Furthermore, study and identify local renewable energy potential and residual potential;

4. Identify and localize clusters of spatial functions according to categorization of energy demand;

5. Identify energetic linkages between localized clusters of spatial functions, both within clusters (closing cycles / park-management), as between clusters (source-sink concept / cascading), and identify missing links;

6. Connect clusters and explore possible network patterns: minimize volumes; link by cascading sources and sinks; try to reach high densities along line-infrastructure; make use of existing spatial structures, like main roads and central points; and consider planned developments ready for implementation;

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7. Develop smart spatial policies with clear rules to improve and strengthen energy conscious spatial interventions: policy to attract/develop new urban functions that fit within gaps that become evident in park-management or cascading, to minimize size of network, to allow growth of existing urban system if it fills in a missing link in a locally developed cascade or if growth is energy/material neutral or even positive.

4: Results: Application of method – case-study Kerkrade-West

This section will describe the seven steps of the method applied to a real case: the district of Kerkrade-West, including the direct surrounding. It should be stated in front, that an approach towards productive urban regions in planning practice means a not to strict focus on administrative boundaries, as synergies might emerge just across traditional boundaries. Kerkrade-West is a district of the municipality of Kerkrade in the province of Limburg, in the south of The Netherlands close to Germany and Belgium (see also: map 1). The municipality of Kerkrade again is part of an area that is now called Parkstad (Park-City) Limburg (agglomeration of Heerlen-Brunssum-Landgraaf-Kerkrade-Simpelveld-Voerendaal-Onderbanken), previously known as the "Mijnstreek", where coal mining has taken place for centuries.

**Map 1: Kerkrade-West as part of an urban area close to Maastricht and Aachen**

If we try to describe the urban area of Kerkrade-West in more detail, we better refer to the former coal mining region Parkstad Limburg as it is one region in which municipalities have common interests in economic and spatial developments. Therefore Parkstad Limburg is an official regional authority dealing with regional planning. In the regional plan the area is described as a fragmented one. This fragmentation does not only refer to the institutional aspect, the seven municipalities, but also to the physical aspect of small villages existing within (approximately) one

large rurban, rural and urban, area. This so called amorphous urbanization is a consequence of the regions history, which is heavily characterized by coal mining. Fragmentation was and still is a result of it. Therefore it actually is an example of an energy landscape in which land-use and settlements are based on energy, fossil energy (Gordijn et al., 2003). Nowadays it is a region with 238,000 citizens and with both an urban and rural appearance. The region also became a significant player in tourism next to the fact that large industrial sites have been developed. Analyzing the spatial structure of Parkstad Limburg we should state:

- urban area with sometimes very high building densities, but also green areas;
- rural area with a natural landscape and agriculture and with also a high level of services nearby;
- a mix of spatial functions;
- historically it was an energy supplier and currently it is an energy demander.

Zooming in to Kerkrade-West we finally should mention that it is a kind of fragment of Parkstad Limburg, but than on a smaller scale. In Kerkrade-West almost 16.000 people live in an area of around 1000 hectares. Like in Parkstad Limburg we also find various building densities, next to urban functions also agricultural areas, and a mix of spatial functions in the urban fabric. Historically Kerkrade-West was also an energy supplier as it is now an energy demander. To get this urban area more productive again we test our urban harvesting approach here.

The first step is to take an inventory of spatial functions. Map 2, figure 2 and tables 1-3 give an overview for Kerkrade-West. Map 2 indicates the spatial functions of Kerkrade-West including in red the administrative borders of the area. Figure 2 shows more abstract a quick-scan of urban land-use distribution downscaled to one hectare, instead of 1000 hectares in reality. Table 1 shows the real surfaces for land-use distribution. Tables 2 and 3 give further specification for several urban functions.
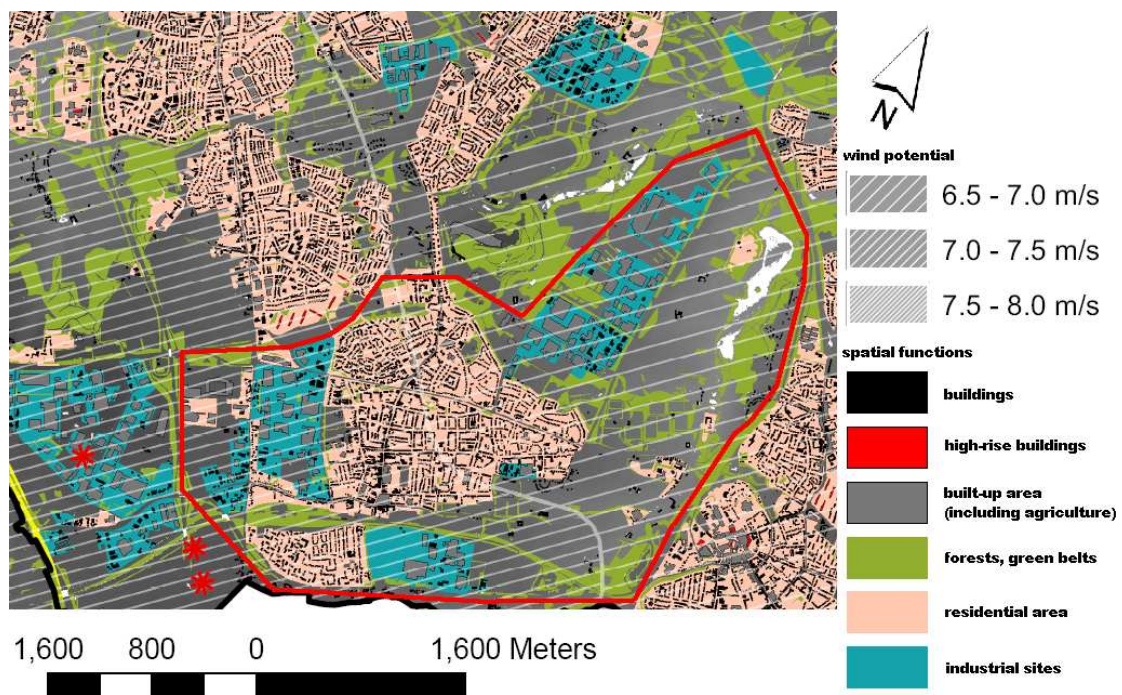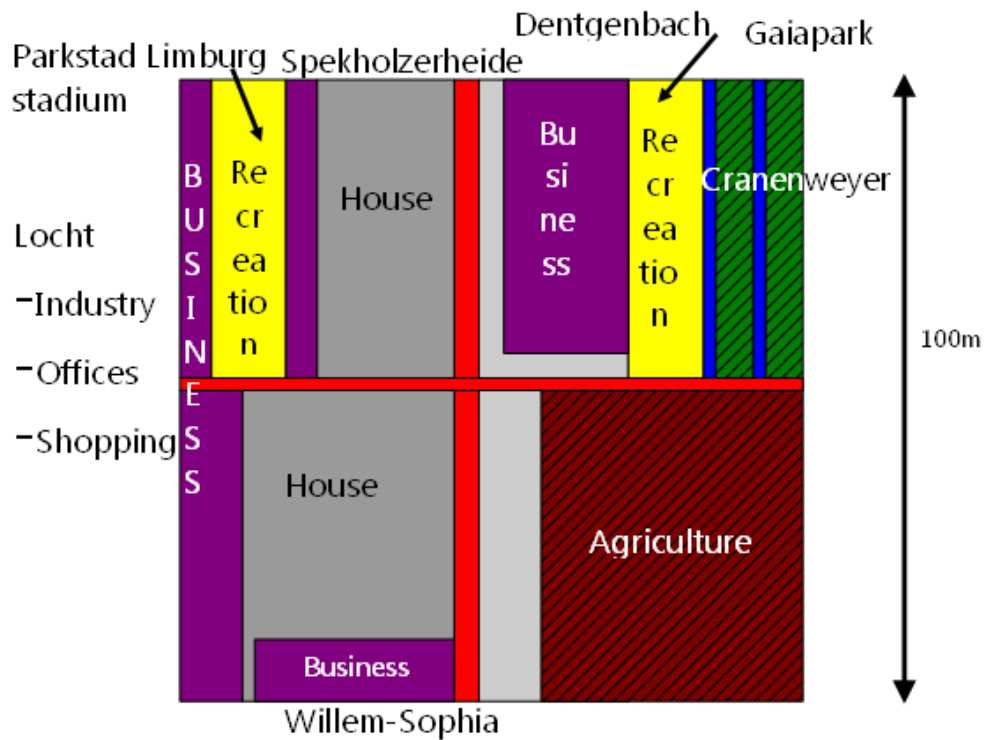

Map 2: Spatial functions in Kerkrade-West indicated

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Fig. 2: Urban Tissue (land-use distribution) of Kerkrade-West, on 1 ha (100 m by 100 m)

Table 1: Urban land-use distribution, statistical data, ha

Total	Land						Water
1006		Urban				Non-urban	
	987	Built-up	Semi built-up	Recreation	traffic	(agri & forest)	19
		426	100	120	61	279	

Table 2: Number of houses, total and specified, and surfaces other urban functions

Houses, total number	Detached	Semi-detached	Row	Apartments
7215	866	1443	3968	938

	Surfaces, ha
Schools	3.2
Care	14.0
Hotel & catering industry	3.0
Retail	13.0
Offices	4.0

Table 3: Business area specification, ha

Business area	Offices	Large-scale Shopping	Hotel & catering industry	Warehouses	Industry
De Locht		11.3		11.3	
Rodaboulevard*	1.1	1.9	0.6		
Spekholzerheide+				25.4	8.2
Willem-Sophia**				23.2	
Dentgenbach				85.3	25.1

*: the soccer stadium is in this area, total area (stadium + parking) is 9 ha

+: also waste collection point and storage, 8.5 ha

**: also quarry, 9.9 ha

In the second step, we identify large energy consumers related to spatial functions. It can be large quantities of a certain function that together have a large energy demand or it can be only one entity that has a large demand by itself (see table 4).

Two of the business areas include heavy industry. In Spekholzerheide, we find a machinery industry, Medtronic Cardiac Surgery (medical appliances production), Tredegar (chemical film production), and a brick producing industry. In Dentgenbach, we find E-max (aluminum melting), a large bakery, 4 chemical industries (production of synthetic fibers and pharmaceutical products), 2 paper/card board industries, 2 synthetic material processing industries, and a rubber processing industry.

The third step is to take an inventory of existing energy demand and to categorize that demand according to type of energy demand – quality of energy – and according to amount of energy demand – quantity of a certain quality. Table 4 shows the results. From this table, we can identify larger consumers: e.g., all business areas together represent the largest demand for the different specified energy qualities. The heavy industry within the business areas of Spekholzerheide and Dentgenbach account for the largest contribution. We can further see that all houses together represent a substantial energy demand, and also the retail within the district. Another large consumer, of a fourth energy quality, is traffic.

Table 4: Energy demand quantities of several qualities for studied urban functions

Function	Elec, MWh	Heat/gas, GJ	Other, GJ
Houses	24,300	481,000	
Schools	880	11,250	
Care	760	6800	
Hotel & Catering industry	3700	26,500	
Retail	15,000	54,000	
Offices	520	1100	
Public lighting	670		
Business area	435,000	2,072,000	3300
Traffic, liter	17,000,000		

Furthermore, we study and identify local renewable energy potentials and residual potentials as last part of the third step of our approach. We indicate the potential of PV-cells on roofs of houses and other buildings, e.g. in business areas, to show local

renewable energy potential. We assume that the PV-cell has an efficiency of 15 %, which results in 150 kWh/m^2 per year for The Netherlands. In the business areas, we assume around 416,000 m^2 of roof area available, and for the houses around 170,000 m^2. This results in a renewable electricity production of about 88,0000 MWh (88,000,000 kWh).

The heavy industry has a large heat demand: we find in the area an aluminum smelter which needs about 660º C; a brickworks industry which needs about 1200º C; and some synthetic material production and processing industry which needs 95-240º C. After processing, a large amount of heat, that is now wasted, remains. Cooling-water from industry has a temperature of about 40-100º C, steam from industry about 100-300º C, and burning of biogas – which can be produced locally – can deliver high temperatures, 600-1800º C. If we apply our theory, this would be residual potentials, that can be used as a source to fulfill parts of the energy demand of urban regions.

In the fourth step, we identify clusters of demand and clusters of energy users: e.g. all the houses together form a cluster with the same energy quality demand (electricity and heat). We subsequently make a distinction between various residential areas on the basis of both building densities and age of buildings. Moreover we identify various utilities, like we do with industrial sites with a high-quality energy demand and business sites with a lower quality energy demand. See also figure 3 for an overview of energy demand clusters in Kerkrade-West.
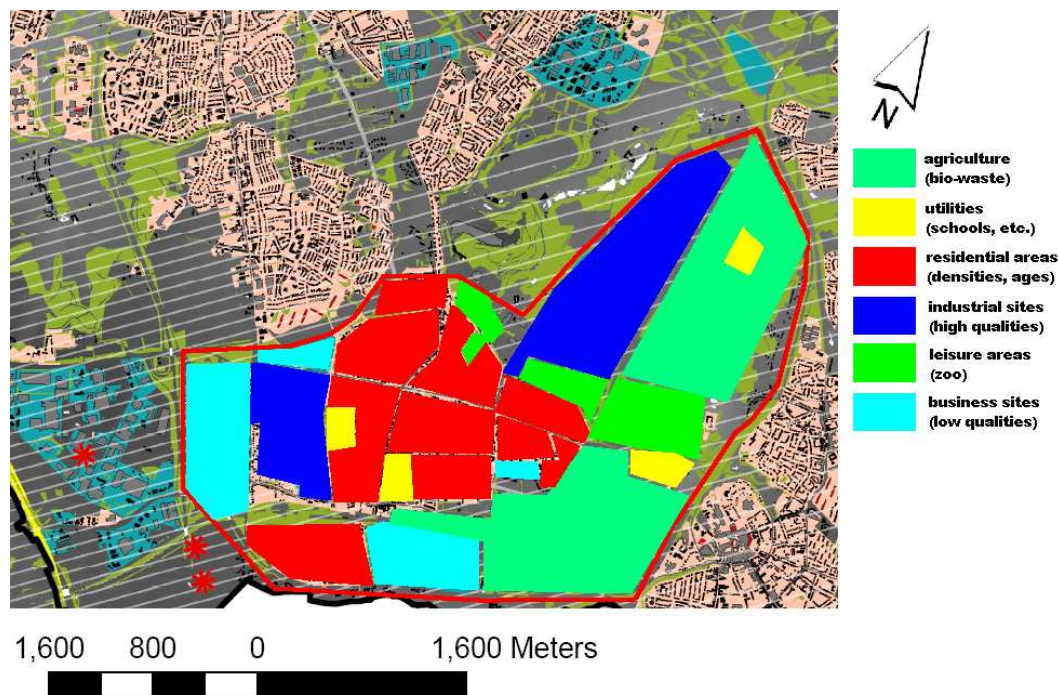

Fig. 3: Demand clusters

The fifth step is to link/connect clusters and close cycles. Therefore, we have to identify sources and sinks, and missing links. We suggest to install park-management in industrial areas, to study methods to decrease distances, and to encourage multi-functionality. In our case, we think it is feasible to locate for instance a brewery in the urban region, because it can fill a gap in the park management of

industrial site Dentgenbach (orange box 1, fig. 4). The brewery makes use of local resources and it might contribute to increasing local identity. Another option is to look beyond the administrative borders and for instance see the yellow boxes in figure 4 as an interesting option to combine in a closed cycle scheme. The yellow boxes represent a large indoor ski resort and also a touristic feature called World Gardens, where you actually can see tropical gardens and animals in greenhouses. An additional possibility here is to build a 'waterworld' (see, e.g., Houben, 2010), a large swimming/bathing facility (orange box 2), that fills also a gap both in a heat cascade and in a water cascade. Moreover such new functions (Brewery and Waterworld) might not only create energetic synergies but can also increase multi-functionality, and therefore robustness, and they can create new jobs.
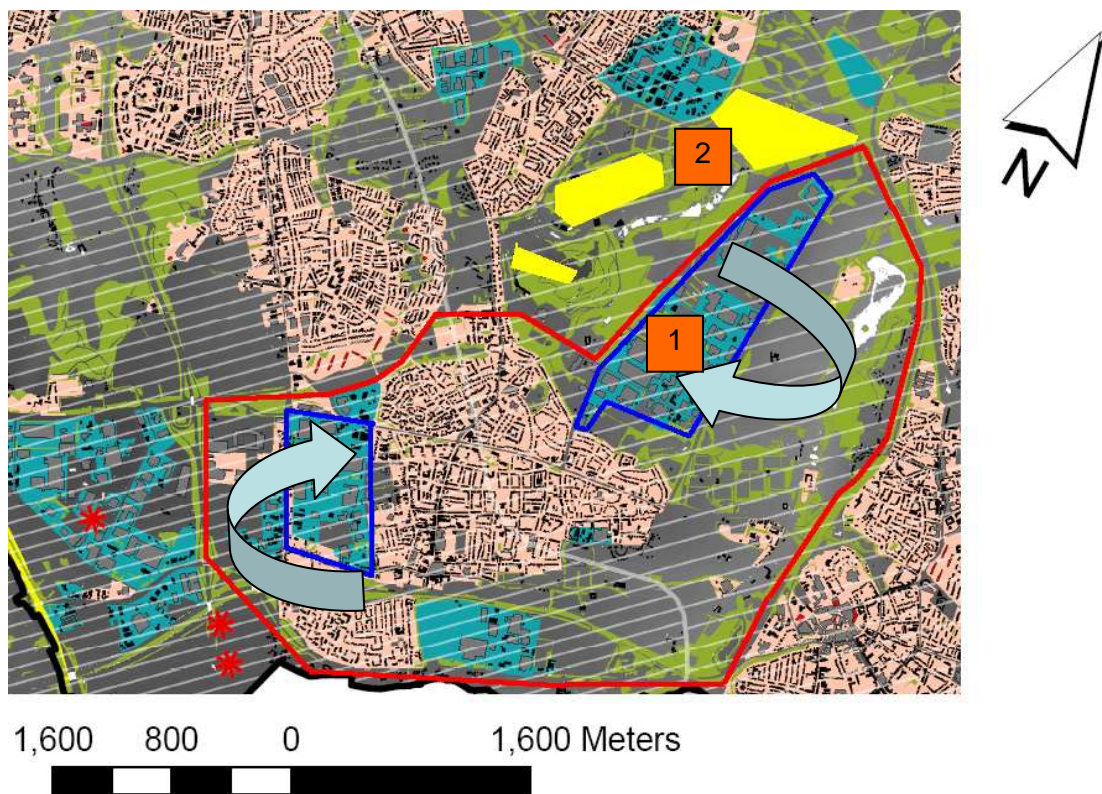

Fig. 4: Expansion of study region with extra land-use

The sixth step is to join clusters and study possibilities of networking: minimize volumes – lower the total energy demand by re-using or using remaining qualities; couple sources and sinks and cascade, therefore, decrease distances between urban functions, and try to reach high densities. In figure 5 we show a possible route for an urban heat network. The basic idea is to connect the residential areas to both central points of the industrial sites. On the one hand we assume that at those central points residual heat flows are existing on relatively low-temperatures (< 90° C) as these are still valuable for heating purposes in residential areas. On the other hand we argue for connecting the residential clusters to both industrial sites on the basis of robustness. Two areas that deliver residual heat are more reliable then only one. For defining the route, we use building densities, shortest paths, existing road patterns, and redevelopment plans to argue for the route as indicated in figure 5.

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Fig. 5: Heat networks, main structure (fundamentals)
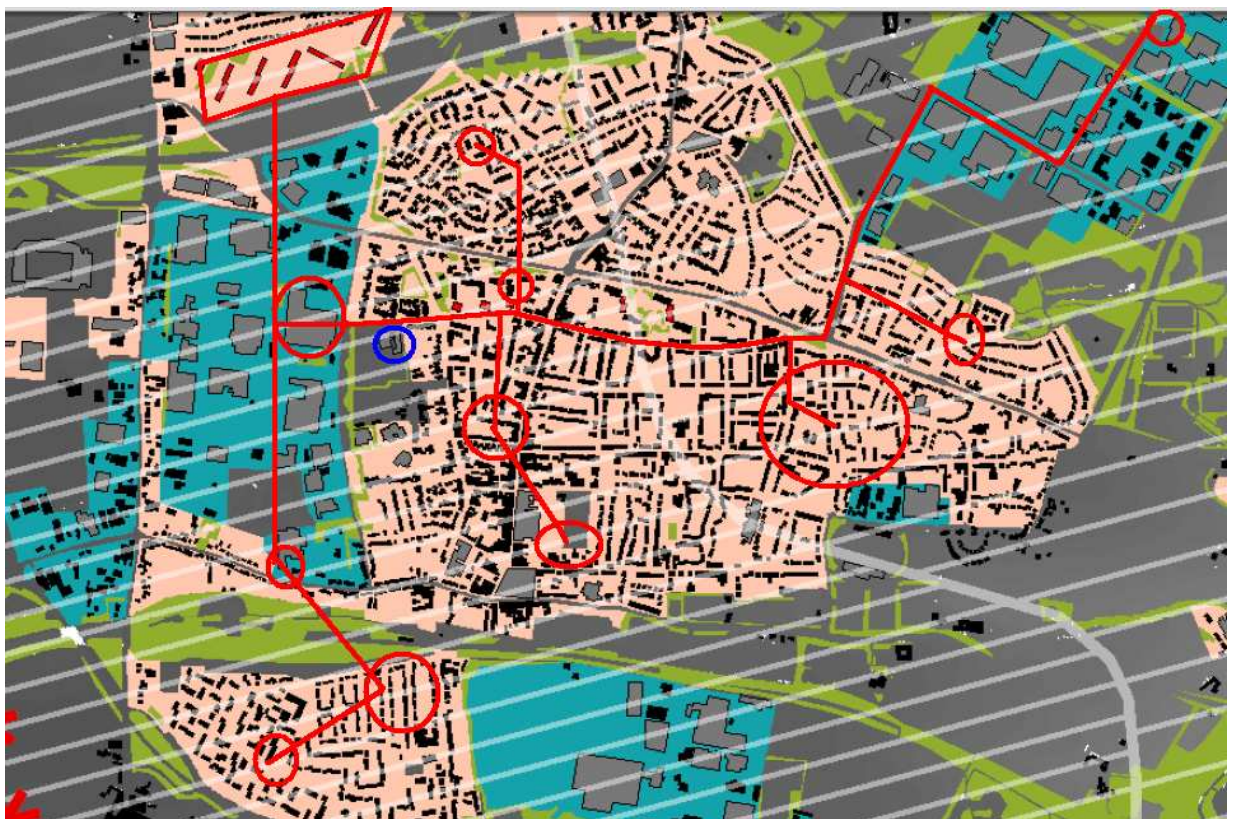

Fig. 6: Heat networks, cascading and making use of existing structures (additional)

Subsequently, on the basis of the main structure we identify possibilities for heat cascading between residential areas in Kerkrade-West. This illustrates figure 6. Two main variables are used to draw the urban heat network extensions. First, we look for housing clusters that can be heated with help of lower water temperatures, think of relatively new buildings, well insulated, or recently renovated buildings. Then we can actually add an extra (lower) heat cascade step to the main structure, that carries higher temperatures determined by the residual flows of the industrial sites. Secondly, we look for 'centers of gravity' in specific energy related spatial clusters, that are indicated with help of red circles. Red circles are now for instance indicating schools, district scale shopping centers and nursing homes, but also a district where there are already solar collectors installed for tap water, which implies that we can use very low temperatures for just space heating. Finally we have indicated an additional link to the main grid towards some high-rise buildings just across the boundaries of Kerkrade-West. These high-rise buildings, as an external 'center of gravity', might help to strengthen the main grid, add critical mass to a project plan, and create a more robust system, as locally installed combined-heat-power generators can function as back-up system. This results in an infrastructure plan as shown in figure 6.

Step 7 is to develop smart spatial policy to improve energy conscious spatial planning, like smart policies to attract missing urban functions. Examples are to install a park-management facility at the local industrial sites that supports the exchange of waste flows between various companies. At the same time this facility can make an inventory of remaining qualities, in energetic, material, or water quality terms, that is not used within the industrial park. It would be smart to, on the one hand start acquisition policies for missing industries, like a brewery, or waterworld, by showing possible synergies, and on the other hand to look beyond the industrial park.

Another option is to look for regionally embedded energy infrastructures, like heat and cold grids, that help to distribute residual flows within an urban region from sources to sinks. Then it becomes possible for a local, or even international, energy distribution company to sell heat and cold to customers, that themselves do not longer need fossil fuels to gain heat. It really helps to save energy use, if residual heat flows are used more efficiently and more effective (appropriate temperatures). In that perspective we also see opportunities for additional spatial functions that can produce food, materials, or attract, for instance, tourists on the basis of residual low-temperature heat. Examples we propose in the Kerkrade-West case are algae ponds for bio-oil, greenhouses for local food production, and additional tropic shelters, heated, for a more attractive zoo. Finally, we suggest to implement policies that strongly support energy neutral buildings on those locations where no efficient use of residual energy flows is possible. Or maybe it is the other way around: policies do not allow new construction sites on remote locations, which are not connected to residual flows, if they are not energy neutral themselves, or even assimilate energy for the urban region.

All together it means that urban harvesting as a planning approach towards productive urban regions can result in a spatial strategy like in figure 7 and 8. The existing spatial structure of various clusters is linked into one multifunctional urban fabric that exchanges residual flows. It starts with introducing park-management and industrial ecology, closing cycles, and goes on with cascading to other functions. Moreover it helps to identify missing links, or in other words opportunities for specific policies to attract new companies and extending existing ones without using more

energy, water or materials. That is how urban harvesting can provide a spatial strategy to gain more productive urban regions, like Kerkrade-West.
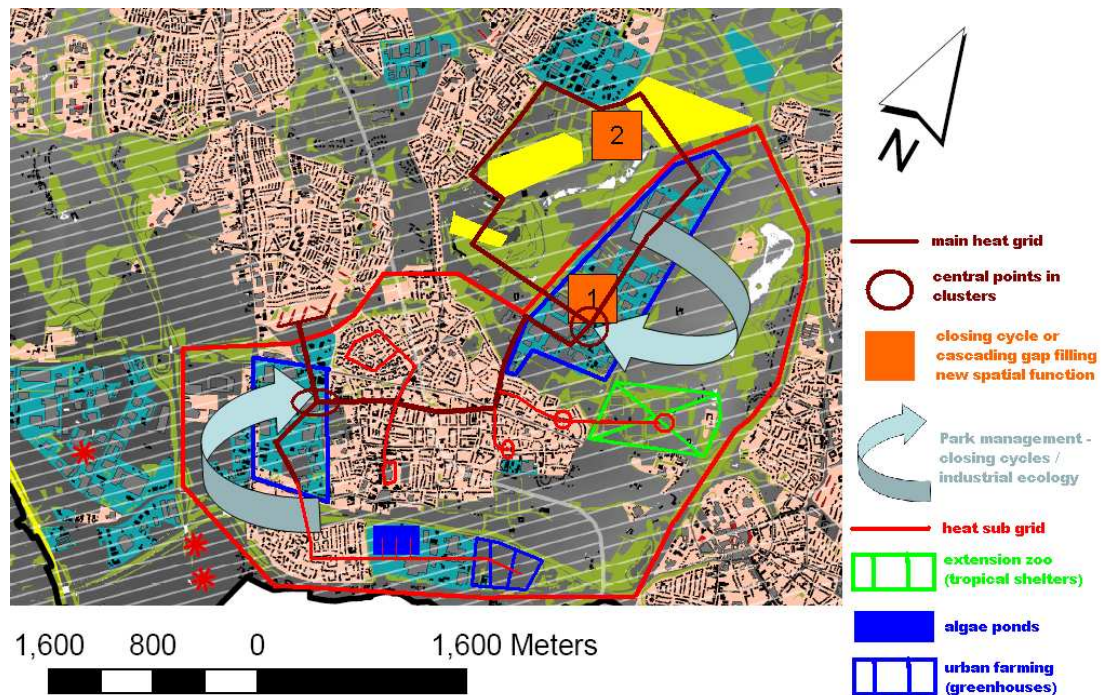

Fig. 7: Spatial strategy based on urban harvesting as a planning approach towards productive urban regions (planning practice)
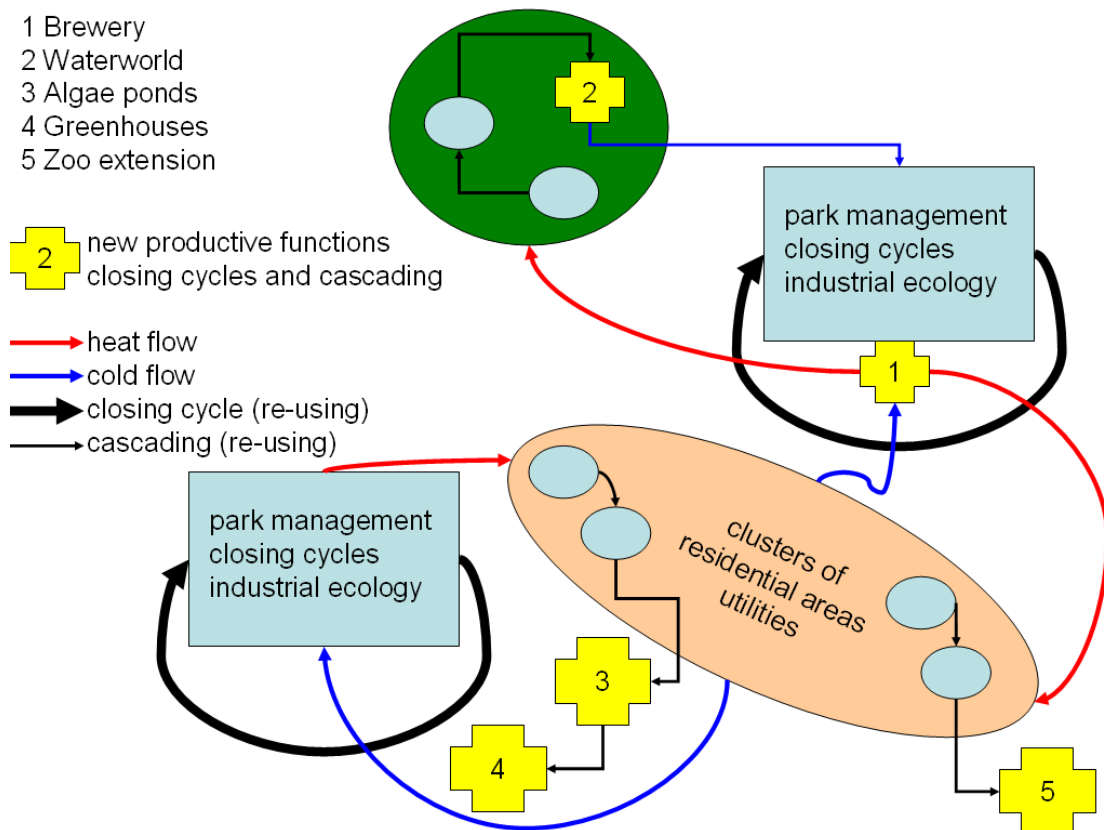

Fig. 8: Spatial strategy based on urban harvesting as a planning approach towards productive urban regions (in abstraction)

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5: Discussion and conclusions

We describe four ecosystem principles that also apply for the concept of industrial ecology: roundput, diversity, locality, and gradual change. We also identify some drawbacks of the industrial ecology concept: proposed solutions focus on industrial symbiosis and forget possible solutions when connecting to other urban functions; it can be economical profitable to create as much waste as possible; it resembles a linear way of thinking; and diversity that is given by multi-functionality is missing.

In order to tackle the mentioned problems and to reach productive urban regions, the authors propose to use the Urban Harvest approach, based on a circular urban metabolism. It is a method to use input and output of an urban metabolism more effective and in a sustainable way, and to aim for a closed cycle resource management. The focus in Urban Harvest is on the quality of energy: an outgoing flow is not waste, but a flow with a lower quality. And the quality of this residual flow can be useful for another activity within the urban metabolism.

The coupling with spatial aspects is a next important part of our research. We not only need an inventory of the local demand and potential supply of various spatial functions, but in order to do that, urban functions need to be coupled and connected. Therefore we identify spatial concepts as connectivity and proximity, that need to go together, and multi-functionality.

Our seven-step method towards energy-conscious spatial planning, uses urban harvesting, based on the urban metabolism concept, as a planning approach towards productive urban regions. We tested it on Kerkrade-West, a small urban region in The Netherlands, but we are convinced that the method is broadly applicable to other urban regions. If Urban Harvest and the described planning aspects come together in an urban system, we talk about an urban metabolism. Such a metabolism opens possibilities for use of local potentials as it makes them clear. Moreover it helps to identify niches to fill in gaps towards a more robust urban metabolism. Furthermore, it enhances sustainability by, e.g., creating value, money and identity; raising jobs; seeing 'waste' as valuable asset; making use of local knowledge; lowering CO_2-emission; using renewable technologies; creating green spaces and decrease distances; encouraging slow transport and public transport; raising awareness and asking input of governments and local stakeholders. So there is a lot to gain by spatial strategies or visions that emerge for urban regions if urban harvesting is used as planning approach to get those regions more productive again.

It is important, like we have explained in the developed method, to first define energy demand based on an inventory of existing urban functions, steps 1 to 4 of our method. If that is done, the next steps can be applied: identify new concepts, look for possibilities of clustering and joining, try to apply them in the urban area – develop smart spatial policies – steps 5 to 7 of our method.

In order to reach productive urban regions, we propose an integrated urban design were urban functions and demands are identified and coupled, using the urban harvest approach, based on concepts as exergy, multi-functionality, and connectivity and proximity.

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