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Eindhoven as an Example of Pragmatic Sustainable Design: Preparing the Period of the Post Carbon City

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Abstract

The contribution focuses on the city of Eindhoven in The Netherlands, especially the preparation of this city for the post carbon period. Morphologically the city can be typified as a growing together of several villages. Striking is the enormous post war enlargement according to the principles of modern urbanism in the north of the city, the Woensel area.

In preparing Eindhoven for the post carbon period, a sustainable strategy is necessary. Next to the usual policies of energy neutrality and carbon emissions, it is indispensable to intervene in the morphology of the city. The challenge is the adaptation of existing forms and structures as for a large extent they already represent the future sustainable city. The contribution takes the transition of Eindhoven from an industrial towards a post-industrial city as point of departure, focusing on the urban redesign of the post war district of Woensel. This performed is based on the vision of the city as a modular construct, proposed by Hildebrand Frey, as notion of a pragmatic design strategy to adjust form and rescaling an existing area, a method to implement new directions to work through challenges of sustainability.

In the presentation, assumptions of pragmatic sustainable urban design related with the method will be discussed, as also the concrete morphological analysis and redesign of Woensel as an example. The result shows the utility of the method in a new urban context, concluding that sustainability is a concept to transform the city, in which morphology is very important for the transition.

Keywords: Post carbon city, urban morphology, pragmatic sustainable design

Corresponding Author:

Introduction

During the last nineteen and twenty century, industrialization and global growth in urbanization, symbols of the modern period, brought a tendency characterized by the predominance of man over nature, marking the emergence of a new geological episode in our history caused by the human action in the cities: the Anthropocene (Hodson & Marvin, 2011; Zalasiewicz et al, 2011), addressing trends not only related to the rapid abandonment of the countryside to the city and the rise of fossil fuels consumption, but also with the rapid expansion of electronic communication, new technologies, economic connectivity, and the explosion of mobility.

For many, the beginning of industrial revolution around 1800s provides a logical start date for the Anthropocene (Steffen et al, 2011). The industrial revolution brought about a tendency characterized by the predominance of man over nature, which marked the end of agriculture as the most dominant human activity and starting with the carbon period, generating the rapid transformation of cities. In this period of early twenty-first century, the structuring of urban space still responds to the industrialization: cities in which their spatial processes are linked to highways and the automobile, reinforcing peripheral growth and promoting social inequality. If the city spreads out and loses its nice architectonic organization, it is not because of some regrettable decadence or sole negligence of urban planners, it is because all our relations with natural space and to the built environment are changing. The most important challenge of urban design practice in the twenty-first century is to prepare the city for the next post-carbon period following the path of sustainability.

Catastrophism and gradualism as staring point for sustainable redesign

The sustainability concept is complex and it has been openly discussed during the last decade, with many definitions and no fixed boundaries. The well-known Brundtland commission has defined the intentionality of the concept (United Nations 1987). Because of its openness sustainability sometimes becomes a misused or overused notion, used as a “master-signifier” for usual things (Davidson, 2010). In this case it does not easily lead to changes and sustainability becomes ornamental, in which the sense of urgency is denied. Openness also leads to a diversity of perspectives, in which in their implementation and operationalization only focus on one single issue, for instance energy or water. In the debate of sustainability different positions can be distinguished. On the basis of the typology approach, Szerszynski & Urry (2010) introduced the typology of skepticism, gradualism and catastrophism, characterized by different strategies ranging from mitigation to adaptation. Within this range different angles can be identified. In terms of design solutions, Middleton (2005) introduces a classification of techniques, values and designs, with emphasis on respectively engineering solutions, lifestyles approaches and creativity.

Catastrophism and gradualism take as a point of departure the imminent end of our civilization and focuses on notions as climate change, the end of fossil fuels, the peak of oil, and the end of Anthropocene. In this approach, sustainability as an intentional notion means: we have to prepare for the post carbon period. In urbanism this means we have to prepare for the post carbon city. Besides, catastrophism forces us to creativity. In that way, it is an obvious strategy for the architect or urban designer because it requires a thorough design of the city –as a gradual transformation, especially the city of the post carbon period.

However, this contribution chooses a pragmatic design strategy. Such a pragmatic design strategy does not deny the intentional notion, even catastrophic dimension inherent to sustainability, but also gives the opportunity to take the existing city as a point of departure. Sustainable urban design so implies the transformation of the current city urban design by a process of redesign, especially the redesign of urban form and structure.

Pragmatic as a way of thinking

The assumption to achieve sustainability in the city is to shape a resilient city, flexible structures of the city: future city is the existing city transformed into the direction of sustainability by the shaping of a flexible structure, able to create a solid community in the core of a healthy and pollution-free environment (Zumelzu, 2011). Therefore, are there certain urban forms that contribute more than others to sustainability?

During the last few years, human impact on the environment has begun to appear in debates on sustainability and the shaping of a post carbon future (Popper & Popper, 2010). From the perspective of urban morphology, discussions have been focused on seeking ideal urban models that contribute towards better sustainability (Ehlers, 2011; Jabareen, 2006); in which many suggest that sustainable urban form should be compact from core to edge (Breheny et al, 1996), while others suggest that the city may consist of different compact settlements which are decentralized but linked by public transport (Neuman, 2005). However, these discussions have been both, in discourse and practice, confused and sometimes inconclusive, and researchers focus on a limited number of aspects and they have not generated reliable answers to the question. In addition, cities are always openly developing, and do not necessarily following consequently a certain model. Models have proved to be abstract, theoretical and in the practice quit far away from realities. In this sense, the message is clear: to achieve sustainability requires not only new development to be guided by appropriate urban models but also the review of forms, structure, land use patterns and socio-economic conditions of existing urban areas. The challenge is to redesign existing cities, towns and settlements to make them more sustainable (Barton, 2000; Frey, 1999). This involves a pragmatic way of thinking: pragmatic method will be an effective tool in bringing sustainable considerations to achieve these objectives.

The aim of this paper is to introduce a pragmatic vision to make our cities sustainable taking the city of Eindhoven as example. The paper shows a review of a qualitative research, based on the assumption that "the sustainable city of the future for a great part coincides with the current city and that sustainability means the sustainable transformation of the existing city". The approach relies on the recognition of this assumption in the vision of the city as a modular construct, a pragmatic method for redesign existing city to achieve the challenges of sustainability.

Research Method

This study argues that the city can be seen as a modular system of construct, and that this modularity is the basic assumption of the methodology elaborated by Hildebrand Frey, as part of the project *Urbanising suburbia* in the research on the City-Form consortium (Frey et al, 2010). This method is chosen because it clearly takes as staring point that the future sustainable city, for a large extent is the already existing city, analyzing the city by different parts and by a multidisciplinary approach.

The vision of the city as a modular construct advocate to the identification of urban components with high level of aggregation, and within whose contours one can identify intensities of interaction that are several magnitudes higher than the influence of exterior effects, and therefore justify the level of an urban quarter. Urban quarters are modular units that meet certain criteria to achieve sustainability in the city (Frey, 1999). An urban quarter is a physical unit of the city –neighborhood unit, district unit- that does not grow on its own, but is built by people. Thus, all this in turn necessitates the conception of the city as a modular construct: a city composed of different urban quarters. The concept of module is referred to as something that has its own structural and functional integrity while being part of a larger system (Buchanan, 2002; Kropf, 2009), in which an urban quarter is a modular entity of the city, being neighborhoods and districts formed types of modular units of the city (Frey, 1999; Frey and Yaneske, 2007).

The main objective of Frey´s method is to link these modular dimensions to key sustainable indicators or criteria, in order to construct boundaries of sustainable entities and thus to identify the units of the city that are well equipped and correctly scaled to begin to address the complex agenda of sustainable urban development. These key criteria are classified as environment, social, economic and built form, and they lay down important guidelines for neighborhoods borders and centers. Table 1 shows a summarized classification of the key sustainability criteria for urban quarters, establishing different characteristics to each component of sustainability in the city.

Table 1. *Key sustainable criteria for urban quarters of the city. Source: Frey, 1999; Frey et al, 2010*

Built form criteria	Environmental criteria	Social criteria	Economic criteria
Inclusion of open land	Energy conservation	Social inclusion	Affordable housing: a balanced range of property prices and rent levels in the neighborhood
The size, area and development density of urban neighborhood	Water conservation and local management	A balanced population age profile	Keeping profit in the area/neighborhood
Threshold population required to support local amenities	Waste recycling	A balanced mixture of dwelling and tenure types	A balance between economically active and inactive people in working age
The maximum walking distance from edge to centre of the neighborhood	Establish or re-establish biodiversity	Participation of community in local decisions	
The required local services and facilities including public transport			

From carbon to post carbon: Eindhoven as an example of Anthropocene city

Industrial societies have demonstrated a high dependence on fossil fuels consumption. Even though until the 1950s coal was the main source of energy in Europe, the major changes came between 1950s and 1960s in which auto-mobilization took off and with it substitution in home and industry of oil for coal. In this sense, modernity is clearly associated with the sustained throughput of large amounts of fossil fuel consumption.

Atkinson (2007, 2008) stands that collapsed societies involve geographic fragmentation into much more locally independent entities with simpler economies and consumption patterns and less sophisticated and less monumental cultural self-expression, less flow of information and less complex structuring of what people do and how they relate to one another. Two key aspects are driving it over the edge: suburban living and the obsession with the automobile. Suburban lifestyle and living with cars is the core of modern life representing the nemesis of modern civilization, in the way that our society insistently follow out their lifestyle desires and specifically how the car becomes a dimension of their personality that reflects their responsibility away from a sustainable future. The impact of the collapse on the urban settlements has been reflected on the phenomenon of spread city or urban sprawl around the world, in which extensive landscapes will continue to be occupied by the remains of modernity with periphery urban areas, called suburbia (Frey, 1999). It is expect that much of the urban structure of today all around the world being abandoned or with greatly reduced populations clustering on urban edges or in new peri-urban towns. In Western Europe, many cities and districts in the industrial period grew at least as rapidly as their present day, being especially industrial settlements part and the main contributors of the Anthropocene

period (Zumelzu, 2012). As example of Anthropocene city, it is possible to mention the case of the city of Eindhoven.

Eindhoven is a city located in the south of the Netherlands, which emerged because Philips Company established its business in the city. During the 20th century, Eindhoven expanded to fifth city of the Netherlands, with at present around 216,000 inhabitants. Eindhoven is a typical city of the industrial development, a process that was ending by the late of twentieth century and largely dependent on the availability of fossil fuels, where the car played a key factor. However, by the end of twentieth century the "*de-philipsing*" effect occurred: a post-industrial development phenomenon highlighting the importance of the creative and knowledge economy (Doevendans, 2009). Next to this, the ideas of the modern or functional city were very influential in the design, structuring and realization of the city (Figures 1A and 1B).

The expansion of the city becomes around 1920, when the municipality of Eindhoven annexes a number of surrounding villages and grows from 8,000 to 45,000 inhabitants. In the period 1926-1929 Philips expansions peaked, with Eindhoven growing to 100,000 inhabitants in 1930. The *Uitbreidingsplan* Eindhoven (General Extension plan of Eindhoven) of 1930 was, together with Philips´ factory architectures, the first attempt to represent and realize the *ingenium* of modernity as the modern city of Eindhoven (Schippers et al, 2007).

Figure 1. (A) *The great industrial explosión in Eindhoven around 1930*

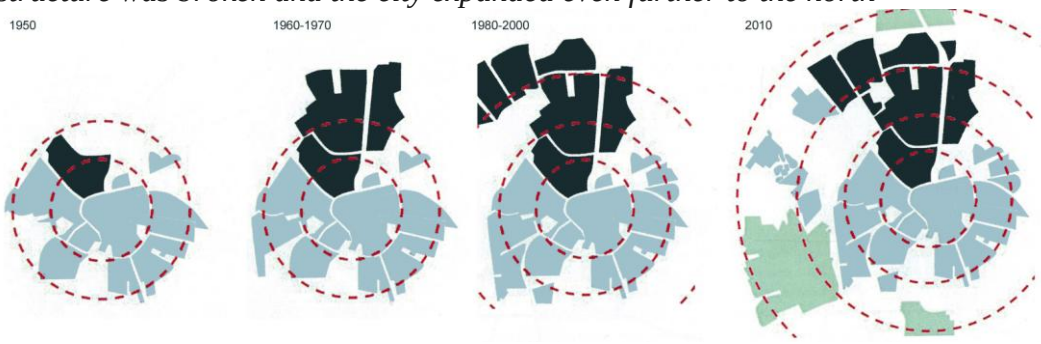
Source: Schippers et al, 2007

Figure 1. (B) *The city of Eindhoven today, as a post-industrial development*

Source: Author´s photo

However, as the most industrial cities, after that explosion Eindhoven has an inappropriate scale and image problems, starting with the development of 1970s as a gradual transformation process. Morphologically the city can be typified as an altogether growth of five villages, in which is striking the enormous postwar expansion of the north of the city according to the principles of modern urbanism, the Woensel district. The striking postwar expansion of Woensel started as consequence of housing shortage in Eindhoven around 1950, in which major space was needed for expansion. In twenty years (1955-1975), over 25,000 housings were built and this made possible the significant increase of Eindhoven. This gradual growth was mainly caused by increased prosperity, the strong rise of the car, and the dominant residential pattern, due to increasing demand for more space in which the automobile infrastructure was rising in importance. Consequently, an increasing of the scale of the urban environment was developed and boundaries of urban system virtually disappeared: the district developed exponentially to the north in which the concentric model of the city no longer exist; there are not clear boundaries as a district, and Woensel in Eindhoven occupies a separate place (Figure 2).

Figure 2. *The concentric structure of Eindhoven is clearly recognizable in 1950. With the implementation of Woensel (black) in 1960, the concentric structure was broken and the city expanded even further to the north*

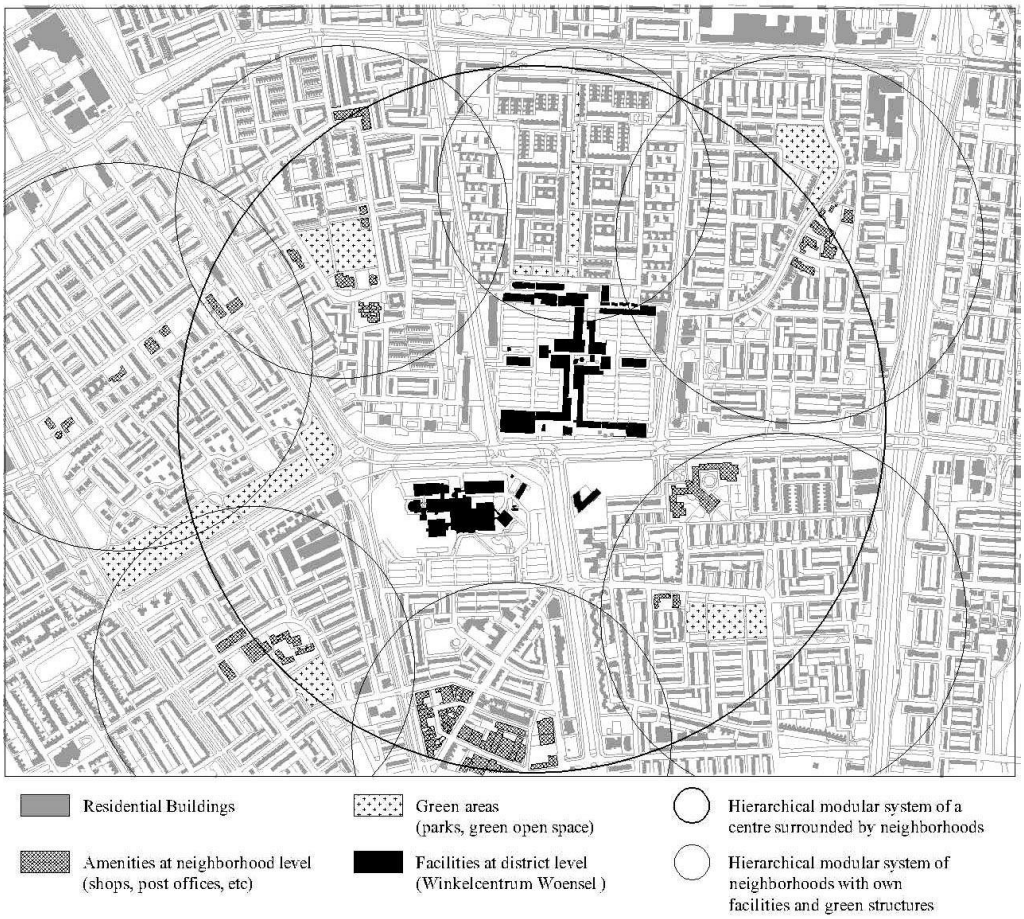


The example of Eindhoven, specifically the Woensel district, is part of the debate of the Anthropocene and the post carbon period: how to make the city survive as a post-industrial city? Eindhoven is a city in Western Europe with a clear transformation phenomenon by dispersion, which has followed a car-dominant model of urban and suburban development, planned according to the principles of modern urbanism. This model of urban and suburban development is not sustainable. Recognizing the limitations of this "outmoded" model is the first step in planning for our future of economic, social, and environmental uncertainty. Therefore, in preparing Eindhoven to the next post carbon period, a sustainable strategy is necessary. Following the vision of the city as a modular construct established by Frey, we argue that this period of the city can be seen as an opportunity to adjust form and rescaling of Woensel to create a new structure and modularity. The aim of this first analysis is to demonstrate the existence of urban quarters -or modular structures- in the study area.

Morphological analysis of Woensel

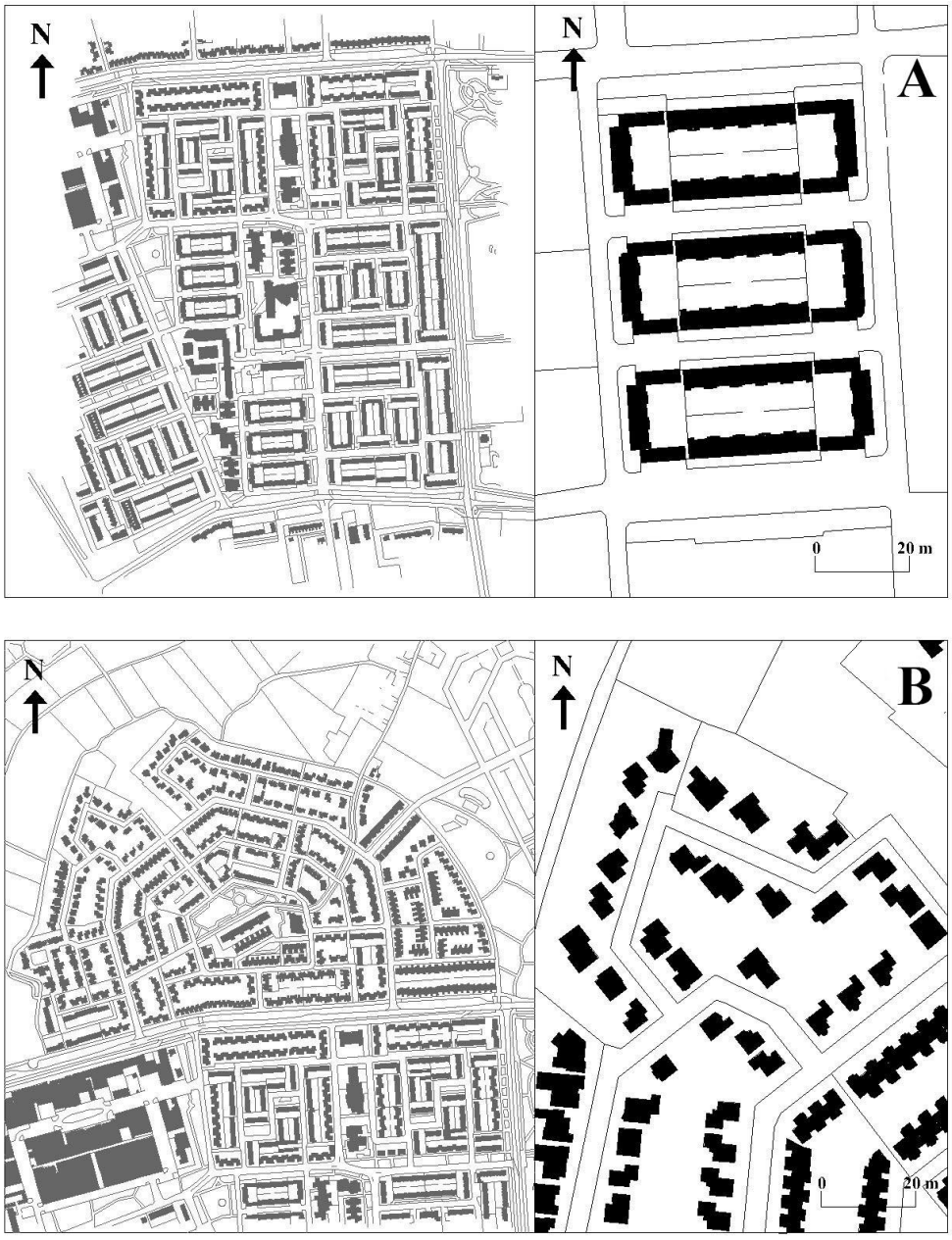
As a rigid product of modern urban design Woensel has a clear modular structure, particularly identifiable in the south side of the district. The background design of this district consists of a model based on distribution planning, together with the concept of dwelling units (Doevendans & Schram, 2005). The dwelling unit is defined at several levels of scale. At the district level, neighborhoods are identified as the dwelling units. These neighborhoods are self-supporting in regard to facilities –shops, green areas, catering, etc. A number of such dwelling units configure the district; at present the facilities do not meet the actual demands and need to be improved. This neighborhood concept can be defined as modular system with a strong hierarchy (Figure 3).

Figure 3. *The clear modular structure of Woensel. A hierarchical modular system consisting of a district center surrounded by neighborhoods*



At another scale we recognize dwelling units as clustering of allotments. Dwellings grouped together in a model that can easily be repeated. In Dutch urbanism this group of dwelling units is called the “stamp” (Figure 4A and 4B).

Figure 4. *(A) Example of a model of stamp identifiable in Woensel, like a tissue repeated in neighborhoods developed in the 60's and 70's; (B) second stamp example, developed during the 90's, being part of the urban transformation process of Eindhoven*



Because Woensel is such an extensive area, it is clear that in different parts different ideas of urban design are recognizable. Woensel is a sample of emerging visions of modern urban design. This also indicates that modern modularity of neighborhoods and stamps was gradually released. In short, the rescaling of the city of Eindhoven has been considered as a general guidance, where Woensel is a more independent part consisting of units that have lost their main character of neighborhoods as systems, especially in the north in

which this modularity has been lost. We need "larger units" to meet the criteria of sustainability as formulated in Frey methodology.

In this approach, our focus is in the north of Woensel, in which major transformation and fragmented planning process occur. The aim in the next level of the investigation is related with the analytical analysis of how existing urban quarters of the district meet the criteria of sustainability established in Frey method, which could help transform currently unsustainable urban areas in Woensel into sustainable urban quarters.

Redesign of Woensel district

The comprehensive investigation of the application of Frey method in Woensel neighborhoods allow to determinate which levels of sustainability of these urban areas can be assessed on the basis of threshold, average, and target values of sustainable urban form. Target values of urban development are deemed to be values, while threshold values are regarded as minimum acceptable values in achieving sustainability in the city (Frey et, 2010). A detailed investigation of Woensel areas generates a primary data by using Census statistics, fieldwork analysis, ArcGIS, and information provided by the city council. The data are collected in maps as well as built form, environment, social and economic characteristics sheets. It is not possible to include all this material here, but a brief outline of the key characteristics of Woensel areas is outlined below to enable an understanding of the location, its socio-economic context, and built form environment characteristics.

For the applicability of the criteria on the study area it was necessary to make an evaluation of each unit identified. The evaluation consisted of making an analysis of the place, focused on environment, economic, social and built form characteristics of north areas in Woensel. The results of the analysis were placed on the evaluation Table 2, describing comparative data of existing neighborhoods analysis, illustrating two selected examples of qualitative relationships. This process allows establishing what areas meet and do not meet the criteria, obtaining estimated percentages of every neighborhood evaluated under each criteria applied, establishing a total average for each area. According to this, nine neighborhoods are potential sustainable areas in Woensel, in which five of them are located in the north. Those areas meet mostly of the key sustainable criteria (Figure 5).

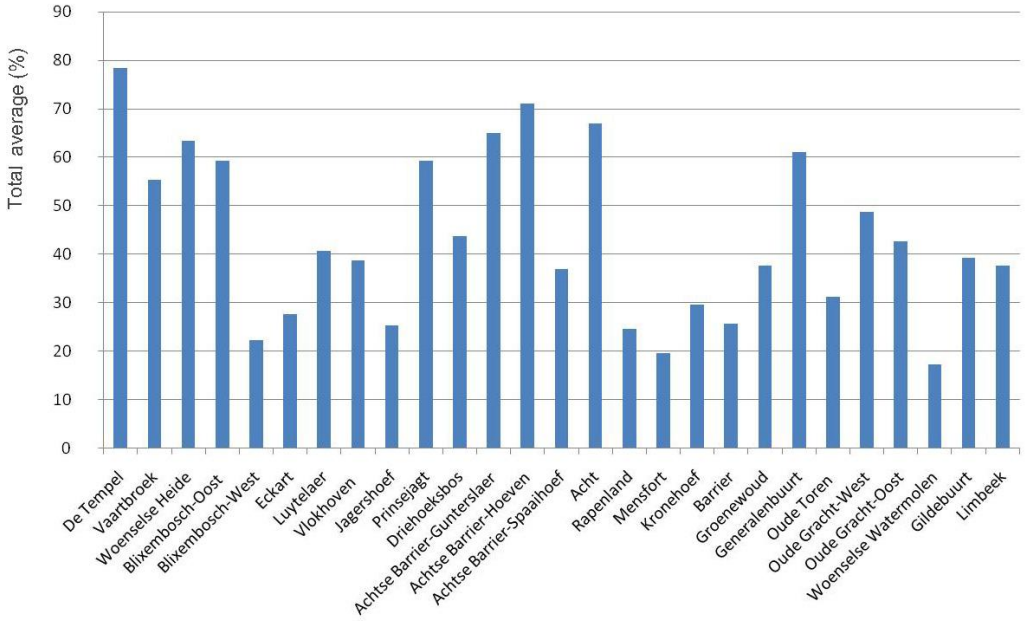
Of all areas, Woenselse Heide, Tempel, Blixembosch east, Prinsejagt, and Achtse Barrier are potential areas according to the key criteria of sustainability. These areas have a size range for total population over 4,000 inhabitants to support the development of local services and facilities. Woenselse Heide and Tempel have a reasonably good access on foot to most services and facilities and open spaces, with all required local amenities especially located in a core/central area. Also, they have a consistency with the optimal target value in terms of mixed use of land, having a good balance between housing and no-housing land. One of the most important aspects is the green condition of Woensel north, with many open spaces such as sport fields and parks for recreation and leisure, mainly located at Achtse Barrier area. In terms of

density, the most of the areas are under target value, with graded density development from edge to center, and similar development forms with reduced variety of dwelling types, such as the neighborhoods Blixembosch west and Acht in Woensel north, that are required to achieve a socially mixed population.

Table 2. *Comparative data analysis of existing values of built form characteristics with target and threshold values according to Frey method. Source: based on Frey et al, 2010*

Indicators		Existing values neighborhoods Woensel				Target values (for 1 urban quarter)	Comments
		De Tempel		Vlokhoven			
Total population (inhabitants)		5.028		3.533		Between 4,000 - 10,000, in average 7,500	De Tempel meets the size range for total population.
Gross population density (gppha)		42		63		Target 85 Average 66 Threshold 54	The existing gross population density in Vlokhoven is over the threshold.
Total area (ha)		119		56		Target 88 Average 113 Threshold 140	De Tempel has a good size, close to average and threshold target values; However Vlokhoven existing area is too small for 1 urban quarter.
Net dwelling density on estimated housing land (ndpha)		36,4		47		*Target 67 Average 50 Threshold 43 *dwelling density of neighborhoods needs to reflect local conditions(Eindhoven 2010)	Vlokhoven presents continuous density from edge to centre, tending to favour similar development forms and therefore having reduced variety of dwelling types that are required to achieve a socially mixed population.
Net population density on estimated housing land (nppha)		70,8		99,2		Target 141 Average 110 Threshold 89	Vlokhoven is over the threshold. Therefore. The suggestion is to increase number of inhabitants.
Land use (ha)	Housing land	71	59,7%	35,6	64%	60%	. De Tempel has consistency with the optimal target value, having a good balance between housing and mixed-use of land
	Mixed-use land	48	40,3%	20,4	36%	40%	
Average household size (pphh)		2,1		2,0		1,8 – 2.0 (Eindhoven average)	In both neighborhoods, household size is close to Eindhoven average
Walking access to local amenities (min.)	amenities	Value (min.)	score	Value (min.)	score	Target distances (m.)	In De Tempel there are all required local services and facilities, specially located in a core/central area at Belgium square.
	Primary school	8,5	good	6,75	good	150 - 250 m walk	
	Local shops	6,75	good	13,1	poor	300 - 400 m walk	
	Public transport	5-6	good	8,37	poor	300 - 400 m walk	
	Community Park	8,25	good	9,1	good	400 - 600 m walk	
	Post office	7,50	good	12	poor	400 - 600 m walk	
Environm. quality	Quality of local amenities	good		poor		Open space development is rather poor designed and maintained, except park Henry Dunant in De Tempel, which is shared with other neighborhoods in Woensel. Vlokhoven has a monotonous development from post-war period, with dwellings partially built in 60's and 70's, with generally poor quality.	
	Quality of parks and open space	good		poor			
	Quality of housings	Poor to good		Very poor			

Figure 5. *The graphic shows a summary of the total average evaluation of neighborhoods in Woensel under the criteria of sustainability*



In sum, neighborhoods in Woensel have predominantly residential functions and hardly mixed use in terms of spatial and built environment, with only eleven urban quarters within the range of total population and presence of suitable amenities centers. In general, non-potential areas in Woensel north - Acht, Blixembosch west- are mostly represented by great land for residential patterns, with imbalanced mixed use of land for other uses. For the northern areas access on foot is difficult, as the same time with absence of social-economic mix profiles, and lower total population to be one urban quarter to support the development of local services and facilities.

The fragmented planning process of Woensel, especially the northern parts, has created a messy and characterless district, being too large and too diverse to be identified as a whole (Figure 6). Following the criteria for sustainable urban quarters as a framework (Frey, 1999; Frey et, 2010), this work proposes two scenarios to restructure and redesign Woensel, mainly by making non-potential sustainable areas part of potential ones and thus to create large urban units of sustainable urban quarters (Figure 7).

Figure 6. *Current development pattern with potential neighborhoods highlated. The map shows a depilated spatial structure especially in the north and west in Woensel*

Figure 7. *The illustration shows the clustering of Woensel north in two districts, and the creation of large urban units by making non-potential sustainable areas part of potential ones*

Figure 8. *(A) Existing condition and redesigning of the new district center of Woensel north; (B) Existing and new remodeling spatial structure condition of Blixembosch west and east. (autor`s drawing)*

First, following Frey`s criteria, the interaction between urban quarters, say four or five of them, allows the formation of a district with a core that might become the focus for a much larger population of 25,000-35,000 inhabitants. The district center ought to be linked to neighborhoods centers by public transport. The north of Woensel has a large size and the presence of facilities is striking. The stores provide assistance for all types of the numerous housings in this area as a result of the lack of facilities. In the north of Woensel reside about 70,000 inhabitants. This population size could be organized into two districts with potentially sustainable units and its own centers, with a total population size of 35,000 inhabitants each. This approach would create enough support for the district facilities in the area. The new district proposed is defined as recreational center, located in the northwest and current area for recreational activities. This is upgraded with trade and cultural facilities. The second district is the existing Woensel center.

Accordingly, the second scenario aims to join non-potential with potential areas for the creation of large urban units –integrated sustainable neighborhoods. The development of patterns in Woensel varies considerable: in north-west parts, the neighborhoods Achste-barrier, Acht and Blixembosch west have irregular grid mostly dominated by detached housing pattern, in which stamps gradually released. In these areas, densities are under the target. In Blixembosch west, the grid structure is inconclusive. The scale of its area is close to that required by the criteria, but especially Acht-barrier and Acht are over a radius –from center to edge- of 600 meters; increasing distances to main amenities especially by foot. However, major green spaces for leisure are very close proximity. So from the perspective of the method, the large open spaces can be provided at the edge of rather than inside the district, and this will help to achieve the required population density.

The redesigned Woensel is described in the figures 8A and 8B. The layout considers two districts for Woensel, proposing one new center for Woensel north created by large urban units set up by the interaction between non-potential and potential sustainable areas. Large urban units provide local services and facilities, located at core central area with strong mixed use spatial, connected by public transport and easy access by foot from the edge. Regarding the borders of Woensel, they have been developed to improve the borders with the countryside. Boundaries are restructured and enhanced as conservation green areas, in which the districts are limited by natural boundaries that serve as open spaces for recreation. Design concept for Woensel is intended to generate clear district centers, assigned for mixed use developments, linked between each other by new central routes. These routes will accommodate the major public transport lines, connecting the new centers with the city center as well as with the suburban municipalities of the region. Therefore, the new-redeveloped structure of Woensel shows a clear density development with peaks at district centers and large units centers, which accommodate mixed uses, to give each new area an identity and sense of centrality.

Results & Discussion

The elaboration of results indicates that Woensel can become part of sustainable areas through the redesign of existing city. The case study of Woensel in Eindhoven clearly demonstrate that it is possible to restructure currently unsustainable urban areas into a series of integrated sustainable neighborhoods, all with their own amenities in walking distance from peoples´ front doors and all with their local centers directly linked by public transport.

Concerning to the operational value, the application of the method in a new urban context such in Woensel, demonstrate the validity, advantages and weakness of the methodology of Frey and its criteria for sustainability. Accordingly, the main advantage is that highlight the importance of the sustainability concept as a tool, where the underlying strength of the

sustainability concept consists of the integration of issues –such as economic, social, local activities, environment, mobility- to address urban problems. Besides, testing the method in a different urban context has shown benefits from a morphological point of view, but it has also disadvantages especially focused on consulting local communities and stakeholders. The upgrading of urban areas to achieve sustainable development focus not only on achieving sustainable urban forms and structures, but also on improving existing people´s prosperity and quality of life, making individuals part of the process.

Regarding the discussion of a modular unit of the city, the module as part of a structure is not necessarily the most important element of that structure; much more important are the links between these modular units that generate a complex overlapping network in the city. The city, as many natural phenomena has hidden structure that develops unconsciously not driven by design or intellect, but an inbuilt logic and growth process, and the modular structure makes the city more functional and more adaptable to continuous shifts and changes, and also more repairable without switching off the entire city. This given, this contribution suggests that the city structured around neighborhoods and districts, and with a predominantly radial road structure –industrial city model, is not anymore the appropriate model; most important is to upgrade existing urban units of the city by an integrated process of redesign.

Therefore the recommendation is that, in preparing for the next episode of the city in the history –the post carbon period, discussion of sustainable urban development of the future need to follow a more heuristic trajectory, addressing towards methods and tools rather than producing one-rule model or optimal solutions such the "compact city" for instance. New challenges require new approaches, new methods and tools, and new strategies for urban design. The sustainable urban design for the future can no longer be based on the certainty of models and rule-conditions. Instead the designer is confronted with changing conditions and shifting programs and practices. The vision of the city as a modular construct represents an important method, as a point of departure, to follow this trajectory.

Bibliography

Atkinson, A. (2007). 'Cities after oil-2'. *City* 11(3): 293-312.

Atkinson, A. (2008). 'Cities after oil-3'. *City* 12(1): 79-106.

Barton, H. (2003). *Shaping neighborhoods –A guide for health, sustainability and vitality*. London & New York: Spon Press.

Buchanan, M. (2002). *Small world: uncovering nature´s hidden networks*. London: Phoenix, new ED edition.

Breheny, M., K. Williams, M. Jenks & E. Burton (1996). *The compact city: a sustainable urban form?* E&FN Spon, London.

Davidson, M. (2010). 'Sustainability as ideological praxis: the acting out of planning's master-signifier'. City 14(4): 390-405.

Doevendans, K. & Schram, A. (2005). 'Creation/Accumulation city'. *Theory, Culture and Society* 22(2): 29-43.

Doevendans, K. (2009). *The ontphilipste city, opportunities for architectural policy in Eindhoven*. Eindhoven: Eindhoven university of Technology. [In Dutch].

Ehlers, E. (2011). 'City models in theory and practice: a cross-cultural perspective'. *Urban Morphology* 15: 97-119.

Frey, H. (1999). *Designing the city: towards a more sustainable urban form*. London: Spon Press.

Frey H., S. Bagaeen, C. Gianchis & P. Faria (2010). *Urbanising suburbia: the handbook. Establishing threshold, average and target values of sustainable quarters*. Report in city-fom.org.uk. Available at http://www.city-form.org/uk/pdfs/CityForm_US_Handbook.pdf.

Frey, H. & P. Yaneske (2007). *Visions of sustainability, cities and regions*. 1st ed. Taylor & Francis group.

Hodson M. & S. Marvin (2010). 'Urbanism in the Anthropocene: ecological urbanismo or Premium ecological enclaves? ' *City* 14(3): 298-313.

Kropf, K. (2009). 'Aspects of urban form'. *Urban Morphology* 13: 105-120.

Jabareen, Y. (2006). 'Sustainable urban forms: their typologies, models, and concepts'. *Journal of Planning Education and Research* 26(1): 38-52.

Middleton, H. (2005). 'Creative thinking, values and design and technology education'. *International Journal of Technology and Design Education* 15(61): 61-71.

Neuman, M. (2005). 'The compact city fallacy'. *Journal of Planning Education and Research* 25(1): 11-26.

Popper, D. & F. Popper (2010). 'Smart decline in post-carbon cities, the Buffalo commons meets Buffalo, New York'. In: R. Heinberg & D. Lerch (ed.), *The post carbon reader: managing the 21st century's sustainable crises*, 314-322. Watershed Media: University of California Press.

Schippers, H., J. Bosman & K. Doevendans (2007). *City-plan Eindhoven (1967-1970): the last modern design for the city*. Eindhoven: Walburg Pers. [In Dutch].

Steffen, W., J. Grinevald, P. Crutzen & J. McNeill (2011). 'The Anthropocene: conceptual and historical perspectives.' *Philosophical Transactions, The Royal Society* A 369: 842-867.

Szerszynski, B. & J. Urry (2010). 'Changing climates: introduction'. *Theory, Culture and Society* 27(1): 1-8.

United Nations (1987). *Report of the World Commission on Environment and Development, General Assembly Resolution 42/187, 17 December 1987*. Available at http://www.un-documents.net/a42rl87.htm

Zalasiewicz, J., M. Williams, A. Haywood & M. Ellis (2011). 'The Anthropocene: a new epoch of ecological time? ' *Philosophical Transactions, The Royal Society* A 369: 835-841.

Zumelzu, A. (2011). 'Sustainable transformations of cities: the case of Eindhoven, the Netherlands.' Proceedings of the International Conference of Management and Innovation for Sustainable Built Environment, June 19-23, in Amsterdam, the Netherlands.

Zumelzu, A. (2012). 'Sustainability as a global problema in the carbon era: Eindhoven as an example of Anthropocene city. ' Revista AUS 10: 4-7.