Energizing industrial landscape: Transformation of underutilized space to landscape integrating renewable energy in Duisburg

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Graduation studio
Flowscapes: infrastructure as landscape, landscape as infrastructure

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1.1 Introduction

The landscape architecture graduation laboratory explores spatial, societal and environmental issues by design research and research-by-design approaches. It addresses landscape architecture themes and projects from different perspectives and in various contexts.

The studio explores infrastructure as a type of landscape and landscape as a type of infrastructure (cf. Strang, 1996). The hybridization of the two concepts seeks to redefine infrastructure beyond its strictly utilitarian definition, while allowing landscape design to gain operative force in territorial transformation processes. Through focusing on landscape architectonic design of transportation-, green- and water infrastructures the studio aims to develop innovative spatial armatures that guide urban and rural development and represent their civic and cultural significance. With movement and flows at the core, landscape infrastructures facilitate aesthetic, functional, social and ecological relationships between natural and human systems. Through design-based case studies at different scale levels the studio seeks for a better understanding of the dynamic between landscape processes and typo-morphological aspects; here interpreted as flowscapes.

The studio is concerned with the design of new topographies by integrating new programs into the ‘genius of place’ and time, and with regard to landscape processes, the continuation of spatial quality and cultural identity of the landscape. It does this through the development of landscape architectural concepts, methods and techniques for design research and research-by-design. Our landscape architectonic design explorations require a multilayered understanding of landscape: its spatial structure or visual landscape, history, context, or relational system and involve the underlying the ecological, economic and social processes. In this process visual thinking and communication are considered to be crucial.
1.2 Fascination

Open space in contemporary urban landscapes like the Ruhr area are taking on a multifunctional character where functions like leisure and tourism, conservation of nature and landscape, and cultural heritage start to predominate. It is becoming a public space. This transformation calls for development-based approaches and requires management to, on the one hand, continue to meet present-day requirements and, on the other, to safeguard the spatial quality of the surroundings. At the same time, a robust spatial structure has to be developed where ecological and other landscape-related values are protected and maintained. Regional project envelopes as exemplified by the Emscher Landscape Park or Rhein-Main Regional Park serve as a practical, goal-oriented incentive for urban landscape development and protection with key roles for landscape architects and urban planners. Their involvement in spatial design-driven research on the regional scale ensures that metropolitan areas are developed in a responsible fashion.

We have a variety of possibility to transform industrial landscape which can be seen in the Emscher Landscape Park projects. The industrial landscape transformation makes the place peaceful and natural. I am impressed by the power in the industrial image from the historical picture and energy is the spirit of industry in my point of view. I see the potential in industrial landscape that can be energized by integrating new programs into the ‘genius of place’ besides natural space. The effect of industrialization shows the giant leap in human society, it would be challenging to reappear the spirit of industry in the landscape transformation.

Therefore, I am thinking of the possibility of combining the industrial landscape with a new practical functional program which can be developed in metropolitan areas. With this type of landscape infrastructure, beneficial effects in ecological, economic and social aspects can be brought to the surrounding environment and the quality of human life with regard to landscape processes, the continuation of spatial quality and cultural identity of the landscape.

“*The beauty that arises from function, which we still believe is basically co-determining for beauty as function, can probably be best observed where the function comes to light in its purest form without sentimental props …*”

Max Bill
1.3 Site Selection

The studio is framed around the Rhine-Danube corridor, integrating and defining Europe between the North Sea and the Black Sea.

Duisburg is a typical industrial city with more than 150 years of industrial history in the western part of the Ruhr Area (Ruhrgebiet) in North Rhine-Westphalia. It is located in the Lowland Rhine area at the confluence of the Rhine and Ruhr and near the outskirts of the Bergisches Land. The city spreads along both sides of these rivers. With the world’s biggest inland harbor, Duisburg has become an important venue for commerce and steel production.

Comparing to other cities in North Rhine Westphalia, Duisburg is still in the process of transformation from industrialization. Steel industry is still supporting products for the country after the industrial depression. But a number of industrial companies have moved away from the city and amounts of underutilized space are left for lack of investment.

Thanks to its history as a harbor city and a trade industrial center Duisburg offers a variety of architectural places of interest, such as the Landschaftspark Duisburg-Nord.

Emscher Landscape Park

The International Building Exhibition (Internationale Bauausstellung) Emscher Landscape Park exists to assist in this development. It is a program of the North Rhine-Westphalia for the future of the Northern Ruhr - the Emscher region. In 1989, the IBA Emscher Park was created for a term of ten years to give an Impulse for new ideas and projects. During the past ten years about 120 projects in six central working areas have been developed and realised.
The city of Duisburg is the product of the merger of formerly independent towns and municipalities. The city spreads along both sides of the Rhine and Ruhr rivers.

The Structural Characteristic of Duisburg
- The structure of the city is decisively influenced by the location on the Rhine and the Ruhr.
- The Rhine divides the city into areas on the left bank and on the right bank of the Rhine.
- The Ruhr divides the city into a Northern part and a Southern part.
- The Ruhrort intensifies the barrier effect between northern Duisburg, city centre and southern Duisburg.
Industrial Area: 40 km²
Residential Area: 70 km²
Green Area: 47 km²
Water Area: 21 km²
Open Area: 56 km²
The industrial area in Duisburg spreads along both sides of the Rhine and Ruhr rivers. In the 19th century it grew because of its strategic location along the Rhine and close to the coal deposits in the Ruhr area, based on the iron and steel producing industry into a major industrial center. The harbor with its center in the district of Ruhort is considered the largest inland port in the world. Duisburg characterizes the image of the city as well as the iron and steel industry.
Residential Area

The residential area developed around the industrial area in order for the workers to live close to their work. Since the industrial area in Duisburg spreads along both sides of the Rhine and Ruhr rivers, the residential area are blocked by the factories from the Rhine and it is inaccessible to the river even though the landscape along Rhine is good enough for citizens.
Population of Duisburg

With 591,635 inhabitants the highest level reached in 1975, the population of Duisburg is declining continuously. Duisburg has 487,839 inhabitants reported in December 31, 2014. The reasons for the decline are less at birth but decline primarily to the massive emigration of many of the population.

Compared to the six percent of foreign citizens in the early 1970s, today the proportion of people with a foreign passport is at about 15 percent. In the last decade, about 45,000 people have with immigrant background. Overall, the report of the Federal Statistical Office from the year 2010 show 32.7% people of Duisburg have an immigrant background.

In “Guide Demographic Change 2020” published in 2006, it predicted a decline in population from 2003 to 2020 by 9.8 percent (49,449 people) for Duisburg. According to the forecast Duisburg, it is assumed that a decline in population by 33,140 during 2010-2030.

Financial Crisis

Since the 1970s, Duisburg is suffering structural change (steel crisis) due to the decline in labor demand, especially in the mining industry for decades under one of the highest unemployment rates in Germany. Similar to many other large cities, especially the Ruhr area, Duisburg is facing a financial crisis in decades. The decline of the coal and steel industry and the related decline of trade tax revenues and rising spending on social purposes bring about the financial crisis in Duisburg.

Duisburg belongs furthermore to the cities with the highest unemployment rates in West Germany. It amounted to 12.4% in November 30, 2014.
A number of industrial companies have moved away from the city due to the industrial depression and amounts of underutilized space are left for lack of investment. Besides brownfield and factories, large space along the river bank which were used and separated by the industry are seldom in use.
Duisburg is always brought in connection with heavy industry. Mines, steel industry and smelting used to dominate the cityscape. Since the steel crisis of the 1970s, the significant loss of purchasing power was particularly threatening to the city, which is consequence of high unemployment were and rapid population decline. Many industrial companies are removed and large amounts of underutilized space are left in Duisburg for lack of investment in a long time.

Due to the historical development, the industrial area are located on both sides of the Rhine and Ruhr rivers. Yet, having settled at the waterfront for easy access to transport and water, industry had severed the link between the Rhine and the population. In many places in the city people still cannot enjoy a walk along the river banks. The proximity of industrial and residential area lead to poor quality of life in Duisburg.
Renewable Energy in Germany

After the Fukushima nuclear accidents in Japan, Merkel’s government announced that it would close all of its nuclear power plants by 2022. Chancellor Angela Merkel said the nuclear power phaseout would give Germany a competitive advantage in the renewable energy era. Germany’s goal of demonstrating that a thriving industrial economy can switch from nuclear and fossil energy to renewables and efficiency. The share of renewable electricity in Germany rose from 6% to nearly 25% in only ten years. Recent estimates suggest that Germany will once again surpass its renewable electricity target and have more than 40% of its power from renewables by 2020. With the energy transition, Germany aims to not only keep its industrial base, but make it fit for a greener future.

The economic benefits of the transition already today outweigh the additional cost over “business as usual”. The switch to a highly efficient renewable energy economy will require large-scale investments of up to 200 billion euros. Renewables only seem to cost more than conventional energy, but they are getting cheaper, while conventional energy is getting more expensive; furthermore, fossil fuel remains highly subsidized, and the price of fossil fuel does not include environmental impacts. By replacing energy imports with renewables, Germany’s trade balance will improve and its energy security will strengthen. Already, roughly 380,000 Germans work in the renewables sector – far more than in the conventional energy sector. Unemployment has reached an all-time low since reunification in 1990. While some of these are manufacturing jobs, many others are in installing and maintenance. These jobs for technicians, installers, and architects have been created locally and can’t be outsourced. They already have helped Germany to come through the economic and financial crisis much better than other countries.

Renewables create more jobs than conventional energy does

Employment in Germany in renewable and conventional energy sectors, 2005-2011

(source: http://energytransition.de/2012/10/key-findings/)
Renewable Energy landscape in Duisburg

With the renewables potential, landscape architecture starts to integrate renewable energy into research. Designing with renewable energy resources, including sunlight, water, wind, energy crops, can create different possibilities to the environment. In Duisburg, amounts of underutilized space can be reserved for windturbines, biomass and other renewables material as the source of renewable energy. After processed by the existing industrial infrastructure or abandoned facilities, the industrial area can supply the electricity and heat, the production from renewable energy, for the industrial and residential use. Therefore, the underutilized riverbank and other urban green infrastructure have the potential to develop renewable energy landscape in Duisburg.
Based on the context and analysis above, the main research question is:

**What is an effective landscape strategy to use renewable energy integrating with urban green infrastructure to improve the quality of life in Duisburg?**

To better understand the main research question, the following subquestions have to be considered:

1. **What are the potential types of renewable energy can be effectively developed in Duisburg? Which types of renewable energy can practically integrate in landscape design?**

   Among many types of renewable energy, we have to find out the appropriate and abundant ones in Duisburg in order to develop them efficiently at low cost. Besides this, we should also think of the forms of renewable energy whether they are suitable to integrate in a visible landscape design without much extra facilities and whether such technological landscapes will bring negative effects for human and the environment.

2. **How can the landscape design with renewable energy be applied in the urban green infrastructure?**

   In order to apply new element ‘renewable energy’ to urban green infrastructure, we have to know what is the existing urban green infrastructure in Duisburg. Through analysis, the problems can be found in the system and related solving approaches will be proposed for the system in difference aspects. After that, we can try to add renewable energy layer to the approaches and see whether it has more value to improve the system and what its potential can contribute to the living environment in other aspects, such as ecological, recreational, social, and economic, etc.

3. **What are potential contributions of the energy landscape production to solve urban problems in Duisburg? How can the landscape strategy work effectively to improve the quality of life in Duisburg?**

   Duisburg is a industrial city with long history. And what are the severe and obvious urban problem and risk in Duisburg? How renewable energy landscapes can deal with these problems in order to improve the quality of life for the citizens? And what’s the meaning of such industrial landscape transformation for the city?

   With these questions, the project will propose an appropriate landscape strategy according to the Duisburg condition and elaborate the physical forms of renewable energy landscape in the urban green infrastructure through detailed site design. By proposing an effective strategy and design of renewable energy landscape, the research goal is that the energy landscapes can be regarded as urban infrastructure and cultural identity to develop the spatial quality and to improve the current quality of life in Duisburg.
2.1 Theoretical Framework

With the research question, the project will do the research in two aspects: renewable energy landscape and urban green infrastructure. In this chapter, theories and related approaches in these two topics can help to frame the project and direct to the following strategy and design.

For the renewable energy part, ‘Three dimensions of meaning’ (Robert Thayer, 1994) is the basic theory to explore the perceptual, functional and symbolic meaning of energy landscape. Based on the characteristics of different types of renewable energy, a tool box of energy landscape will be summarized as typology for the following design. As landscape architecture is a visible and perceptual design, visualizing the energy landscape will be the main approach to the design by mapping and rendering. Meanwhile, the ‘Five-step approach to the design of sustainable energy landscapes’ (Sven Stremke) can be reference method for the research.

For the urban green infrastructure part, the principles of green infrastructure planning: multifunctionality, connectivity, integration, communicative and social inclusive process, long-term strategy will be the theory to diagnose the existing green infrastructure and also the goal for the proposing strategy and design. Through the typology green infrastructure, we can understand better what green infrastructure’s definition is. A system of ‘hub’ and ‘links’ is the approach to achieve the goal.
Since the industrial depression, many industrial companies are removed and large amounts of underutilized space are left in Duisburg for lack of investment in a long time. The isolate green system and the proximity of industrial and residential area lead to poor quality of life in Duisburg.

What is an effective landscape strategy to use renewable energy integrating with urban green infrastructure to improve the quality of life in Duisburg?
THEORY

THEROY IN LANDSCAPE ARCHITECTURE (Robert Thayer, 1994)

THREE DIMENSIONS OF MEANING
- Perceptual
- Functional
- Symbolic

ATTITUDES TOWARD TECHNOLOGICAL LANDSCAPE
- Topophilia
- Technophilia
- Technophobia

URBAN ECOLOGY (Jari Niemelä, 2012)

PRINCIPLES OF GREEN INFRASTRUCTURE PLANNING
- Multifunctionality
- Connectivity
- Integration
- Communicative and social-inclusive process
- Long-term strategy

TYPOLOGY

TOOL BOX OF ENERGY LANDSCAPES
- Wind energy
- Water energy
- Solar energy
- Biomass
- Geothermal Energy
- Biogas (power plant)
- Heat pumps

PARKS AND GARDENS - urban parks, country and regional parks, formal gardens

AMENITY GREENSPACE - informal recreation spaces, housing green spaces, domestic gardens, village greens, urban commons, other incidental space, green roofs

NATURAL AND SEMI-URBAN GREENSPACES - woodland and scrub, grassland, heath or moor, wetland, open and running water, wasteland and disturbed ground, bare rock habitat

GREEN CORRIDORS - rivers and canals including banks, road and rail corridors, cycling routes, pedestrian paths, and rights of way

OTHER - allotments, community gardens, city farms, cemeteries and churchyards

SUSTAINABLE ENERGY LANDSCAPES

FIVE-STEP APPROACH TO THE DESIGN OF SUSTAINABLE ENERGY LANDSCAPES
- Analyzing Present Conditions
- Mapping Near-Future Developments
- Illustrating Possible Far-Futures
- Composing Integrated Visions
- Identifying Spatial Interventions

ENERGY LANDSCAPE VISUALIZATION
- Mapping
- Rendering

GREEN INFRASTRUCURE SYSTEMS

HUBS
- Reserves
- Managed native landscapes
- Working lands
- Regional parks and preserves
- Community parks and natural areas

LINKS
- Landscape linkages
- Conservation corridors
- Greenways
- Greenbelts
- Ecobelts
2.2 Renewable energy

"Meaning" Dimensions of Technological Landscapes

<table>
<thead>
<tr>
<th>Perceptual</th>
<th>Functional</th>
<th>Symbolic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human/Landscape Interaction</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Emotions/Attitudes toward a Specific Landscape

Three Dimensions of Meaning
(Robert Thayer, 1994)

2.2.1 Theory

'It is possible to construct a three-dimensional framework for examining the meanings of landscape - particularly that which has been influenced by technology and utilitarian necessity - and its impact on human affect or emotional response.' (Robert Thayer, 1994) In the 'Three dimensions' theory, Thayer categorized the technological landscape in perceptual, functional and symbolic meaning. The strategy and design of renewable energy, as a typical technological landscape, will follow the theory as principles.

The purpose in developing each type of renewable energy in landscape design can be evaluated according to intrinsic “positive-negative” scales or operative procedures. In short, the significance level of each energy landscape depends on the overall perceptive or emotional response which is positive or negative.

According to the relationship between landscape and human interaction, Robert Thayer put forward a theory about emotion toward energy landscape: "Most landscapes, examined at any scale, embody elements of all three social attitudes of topophilia, technophilia, and technophobia." (Thayer, 2002) Characterizing the proportion of three attitudes for energy landscape can be facilitated by triangle framework. (Fig. 1) Each type of landscape production integrating with renewable energy can be positioned in this theory based on the proportion of the three attitudes. Through this framework, comparisons between energy landscapes can facilitate the appropriate selection of energy landscape for the site in the design. (Fig.2)
2.2.2 Typology

Before integrating renewable energy with landscape design, we have to investigate the potential types in specific site. Furthermore, each type has its own advantages and disadvantages, such as efficiency, resources supply, process infrastructure, etc. According to the report Analysis of Potential Renewable Energy Sources in Duisburg (Potentialanalyse regenerative Energiequellen in Duisburg), these types of renewable energy can be used potentially: geothermal energy, biogas, wind energy, water energy, biogas wastewater treatment plants, energy recovery from power plants, solar energy, heat pump, waste heat from sewers, biomass, and mine gas. (Table 1)

The following table summarizes the renewable energy potentials together. The theoretical potential is the energy supplied by nature as light, water drainage or heating value of biomass respectively. Unless meaningful quantification was possible, the theoretical potential is labeled "very high".

<table>
<thead>
<tr>
<th>Theoretical Potential</th>
<th>Theoretical Potential</th>
<th>Theoretical Potential</th>
<th>Economic Potential</th>
<th>Economic Potential</th>
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<tr>
<td>GWh/a</td>
<td>GWh/a</td>
<td>GWh/a</td>
<td>GWh/a</td>
<td>GWh/a</td>
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<tr>
<td>1 geothermal energy</td>
<td>Very high</td>
<td>16</td>
<td>204</td>
<td>-</td>
</tr>
<tr>
<td>2 biogas</td>
<td>22</td>
<td>7</td>
<td>12</td>
<td>-</td>
</tr>
<tr>
<td>3 Wind</td>
<td>Very high</td>
<td>26</td>
<td>-</td>
<td>5</td>
</tr>
<tr>
<td>4 water</td>
<td>20</td>
<td>10</td>
<td>-</td>
<td>10</td>
</tr>
<tr>
<td>5 Biogas from sewage treatment plants</td>
<td>128</td>
<td>32</td>
<td>44</td>
<td>32</td>
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<tr>
<td>6 natural gas expansion</td>
<td>12</td>
<td>8</td>
<td>-</td>
<td>8</td>
</tr>
<tr>
<td>drinking water turbine</td>
<td>2</td>
<td>1</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Power plant cooling water outlet</td>
<td>4</td>
<td>2</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>7 passive solar energy use</td>
<td>11</td>
<td>-</td>
<td>6</td>
<td>- 6</td>
</tr>
<tr>
<td>Solar thermal</td>
<td>5.298</td>
<td>-</td>
<td>350</td>
<td>-</td>
</tr>
<tr>
<td>photovoltaic</td>
<td>11.857</td>
<td>1.304</td>
<td>-</td>
<td>435</td>
</tr>
<tr>
<td>8 surface geothermal</td>
<td>Very high</td>
<td>-</td>
<td>101</td>
<td>-</td>
</tr>
<tr>
<td>9 Waste heat from wastewater</td>
<td>63</td>
<td>-</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>10 mine water</td>
<td>102</td>
<td>-</td>
<td>4</td>
<td>-</td>
</tr>
<tr>
<td>11 forest wood</td>
<td>48</td>
<td>-</td>
<td>8</td>
<td>-</td>
</tr>
<tr>
<td>waste wood</td>
<td>40</td>
<td>7</td>
<td>15</td>
<td>7</td>
</tr>
<tr>
<td>biowaste</td>
<td>6</td>
<td>0</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Energy crops, biofuels</td>
<td>34</td>
<td>*9</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>12 marsh gas</td>
<td>164</td>
<td>54</td>
<td>87</td>
<td>54</td>
</tr>
</tbody>
</table>

Sum 12,490 1,469 832 554 49
Proportion 68% 19% 26% 1% 1%
Total consumption in Duisburg 2,150 4,300 2,150 4,300

Table 1: Theoretical, technical and economic potential (GERTEC GmbH, 2008)

Data source: Potentialanalyse regenerative Energiequellen in Duisburg
1. solar energy
2. biomass
3. wind energy
4. water energy
5. geothermal energy
6. biogas (power plant)
7. heat pumps

Spatial aspect

Ecological aspect

Recreational aspect
2.2.3 Approach

Visualizing Energy Landscapes
Renewable energy involves diverse professions: ecology, economy, chemistry, geothermics, environics, etc. By comparison, Landscape architecture as the exclusive field particularly considers spatial design with its related recreational function. Spatial design includes aesthetics, morphology, and perception while renewable energy is an abstract concept whose form and process is invisible in general. As Landscape architect, we aim to transform the energy supply and transition into a perceptible spatial design. Sören Schöbel deems that visualizations in landscape architecture research and practice should be situated in-or applicable to-a concrete space instead of staying abstract. (Schöbel et al., 2012) Visualization of energy landscapes should contribute to depiction of landscape diversity, perception and relationship between environmental quality and design objectives. With understandable landscape, we can critically assess the potentials and limits of each tool, which will be demonstrated by means of discussing two types of visualization: rendering and mapping. (Schöbel et al., 2012) Renderings are effective in communication with public whereas mappings open up experimental fields in research and practice. Visualizations as renderings or mappings are made landscape design legible and comprehensible by adhering to the methodical phases and worked out with planning steps for research by design.

2.2.3.1 Wind Energy

Wind energy is the energy extracted from wind using wind turbines to produce electrical power, wind mills for mechanical power, wind pumps for water pumping. A wind turbine that converts kinetic energy from the wind into electrical power has been considered as a special element of contemporary landscape design. The diameter of the rotors on many modern wind turbines is 100m or more. The hub height can reach up to 135m, and the tip height up to 200m. Due to the monolithic volume, wind turbine or wind mill has a strong identity for the design site. A wind farm or wind park is a group of wind mills or wind turbines used to produce energy. A large wind farm may consist of several hundred individual wind turbines distributed over an extended area, but the land between the turbines may be used for agricultural or other purposes. The siting forms of windturbines will relate to the character of landscape.

![Priority areas for wind farm](image)

Data source: Potentialanalyse regenerative Energiequellen in Duisburg

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**Landscape design with windfarm**

Source: guidelines on the Environmental impacts of Windfarms
Size of turbines indiscernible in open landscape

Scale difference obvious in relation to building

Size and Scale

Sensitive

Dominating

Sculptural

Utilitarian

Image and form

Simple

Confusing

Agricultural pattern

Undulating moorland

Landscape Character

Neighbouring settlement

Open space

Appropriate windfarm siting and design

Where key landscape features are not obvious, it may be most appropriate for a windfarm to form a distinct feature of its own

A wind farm sited in relation to local undulations appears irrational within the key views of the distant development where the broad scale landform is emphasized
Visibility in enclosed space but dominant in character of local area

Development appears as focus within linear space

Development obstructs linear space

Water energy potential map
Data source: Potentialanalyse regenerative Energiequellen in Duisburg
2.2.3.2 Water Energy

Water energy or hydropower is derived from the energy of falling water and running water with the aid of water wheels or turbines. The energy contained in the water is first converted to the turbine into mechanical work, and then through a generator into electricity. Therefore, downhill dam must be built above the river. The accumulated water passes through the intake structure to the turbine house on the lower basin and supplies to the turbine. The optimum operating range depends primarily on water quantity and drop height.

In this study, only the location Ruhr weir is drawn to the use of water power into consideration. There may be other small streams in Duisburg, which would still be useful for very small systems. In relation to the potential energy of the Ruhr these are insignificant and are not investigated.

The Duisburg weir is located near the district Kaßlerfeld. The weir is located between the waterways Ruhr, Rhine-Herne Canal and the Rhine. The map provides an overview of the waterways in Duisburg. This is where the Ruhr, Rhine-Herne Canal and along the Rhine. The situation can be described as follows: The water of the Rhine-Herne Canal has the lock Meiderich a connection to the Rhine and Ruhr entrance gate, branch to the Ruhr side. The Ruhr water flows directly to the weir Duisburg and is partly fed by the Rhine-Herne Canal. The water level which is maintained by the interaction of the Rhine-Herne Canal is about 25 m. The level of the Rhine is on average at about 20 m. These two different intermediate levels are at the weir Duisburg on average, a drop height of 5 m for a hydropower use.
Examples of roof surface components in different types of settlements

2.2.3.3 Solar Energy

Solar energy is radiant light and heat from the sun harnessed using a range of ever-evolving technologies such as solar heating, solar photovoltaics, solar thermal energy, solar architecture and artificial photosynthesis. (International Energy Agency, 2011) Nowadays solar energy is widely used in architecture, urban planning, agriculture and horticulture. Two types of utilization of solar energy are necessary to distinguish: the passive use of solar energy and the active solar energy utilization. The passive solar energy use refers to the solar energy gains that can be achieved by appropriately aligned windows, shadow-free and building structures. The active use of solar energy can be done in two ways:

- Solar thermal energy to produce heat
- PV to generate electricity

Photovoltaics (PV) is a method of converting solar energy into direct current electricity whose system employs solar panels composed of a number of solar cells to supply usable solar power. Solar energy can be obtained by solar panel integrating with building façade and roofs.

The potential refers to the built up areas of the city and on the open spaces that serve the agriculture, forestry and recreation. It is important to distinguish the types of settlements. A comprehensive evaluation of the whole city area is too complicated in the context of this potential study. It is based on various types of settlement and buildings with roof ratio. Theoretically available slanted roof adds up over all functional areas of the city of Duisburg on approximately 12 million square meters.

Solar energy potential map
Solar Panel

1. Roof on the building
2. In the landscape
3. Lighting facilities
4. Art installation
2.2.3.4 Biomass Energy

Duisburg has a forest area of 1,863 ha, 201 ha are protected nature reserve. The forest inventory is composed of 91% deciduous and thus to 9% of coniferous forest. On the basis of average growth rates of different tree species in NRW is assumed that takes place every year, an increase of 9.1 fm/ha. (GERTEC GmbH, 2008) For energy use due to the unique primacy of the material use the massive logs is not available, but only the small timber. The competition of material and energy use role in the field of wood is already noticeable.

The agricultural area in Duisburg is about 2100 ha. On this surface energy crops could be grown that might be for biofuels, vegetable oil, or ethanol available after appropriate processing. The cultivation of energy crops is almost always compete with the cultivation of food products or plants for the material use, etc. The acreage would be the current theoretical potential, if the total area could be used for the cultivation of energy crops.

Biomass includes a broad variety of raw material such as wood, agricultural crops, byproducts of wood processing, agricultural and forestry industry products, manure and the organic fraction of waste streams.

**Planting Strategy**
derived from the study of short rotation coppice and the characteristic of the species.
Energy crops

Maize
Rape
Wheat
Miscanthus

Poplar
Hemp
Willow

Straw
Manure

Byproducts

Agriculture can provide dedicated energy crops as well as byproducts in the form of animal manure and straw. Land can be used for growing conventional crops such as rape, wheat, maize etc. for energy purposes, or for cultivating new types of crops such as poplar, willow, miscanthus and others, which maximize the yield of dry matter per unit area. Energy crops including reed canary grass, willow, hemp, poplar can not only contribute to agriculture but also apply to the renewable energy producing. These diverse shapes of plants provide numerous permutation and combination to form new landscape spaces. Therefore biomass has more potential value in landscape design than other types of sustainable energy landscape.

<table>
<thead>
<tr>
<th>Species</th>
<th>Willow</th>
<th>Poplar</th>
<th>Black locust</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crop density stools/ha</td>
<td>18-25,000</td>
<td>10-15,000</td>
<td>8-12,000</td>
</tr>
<tr>
<td>Rotation years</td>
<td>3-4</td>
<td>1-3</td>
<td>2-4</td>
</tr>
<tr>
<td>Av. butt diameter at harvest (mm)</td>
<td>15-30</td>
<td>20-50</td>
<td>20-40</td>
</tr>
<tr>
<td>Av height at harvest (m)</td>
<td>3.5-5.0</td>
<td>2.5-7.5</td>
<td>2.0-5.0</td>
</tr>
</tbody>
</table>

**Short Rotation Coppice** is coppice grown and a plantation characterized by a very short rotation as an energy crop. This woody solid biomass can be used in applications such as district heating, electric power generating stations, alone or in combination. They will be planted in a short rotation and cut parts of them for energy in short years. During this period, they can form different space in the landscape. Because of the diverse species, it has many possible combinations of different plants to design spatial forms.
2.3 Urban Green Infrastructure

2.3.1 Theory

URBAN ECOLOGY  (Jari Niemelä, 2012)

<table>
<thead>
<tr>
<th>Principles</th>
<th>Planning and management of urban green infrastructure (green infrastructure) needs to:</th>
</tr>
</thead>
</table>
| Multifunctionality | • Consider a broad suite of ecosystem services: abiotic, biotic, and cultural.  
• Consider combining different functions/uses whenever possible: multiple-functions of single greenspace, interconnected green structure, and integrated structures.  
• Prioritize among functions/uses and set up clear goals through comprehensive analysis and stakeholder involvement.  
• Conduct monitoring to learn which functions are operating as expected, in a learn-by-doing adaptive manner.  
• Improve awareness of the multifunctions of green infrastructure through communication and public participation/education. |
| Connectivity | • Consider physical and functional connections between green spaces at different scales and from different perspectives: e.g. recreation, biodiversity, urban climate, stormwater management, etc.  
• Base green infrastructure planning on thorough analysis of the urban green space resource and its functions. |
| Integration | • Consider integrating and coordinating urban green infrastructure with other urban (infra) structures in terms of physical and functional relations (e.g. built-up structure, infrastructure, water system).  
• Create beneficial relationships through communication and negotiation between different professions, administrations, and other actors. |
| Communicative and social-inclusive process | • Attempt to meet the needs and interests of all stakeholders.  
• Involve stakeholders in decision-making through coordination, cooperation between different professions, sectors at different levels, between public sector and private sector, and public participation. |
| Long-term strategy | • Adopt the sustainable development concept, considering long-term benefits instead of short-term economic gains.  
• Consider multiple uses, interactive structures, and balance between different stakeholders’ interests, which will help achieve a long-term goal.  
• Allow adaptation through ongoing learning and discussion between different actors. |

Main principles of green infrastructure planning (Li 2008, modified)

2.3.2 Typology

PARKS AND GARDENS: urban parks, country and regional parks, formal gardens

AMENITY GREENSPACE: informal recreation spaces, housing green spaces, domestic gardens, village greens, urban commons, other incidental space, green roofs

NATURAL AND SEMI- URBAN GREENSPACES: woodland and scrub, grassland, heath or moor, wetland, open and running water, wasteland and disturbed ground, bare rock habitat

GREEN CORRIDORS: rivers and canals including banks, road and rail corridors, cycling routes, pedestrian paths, and rights of way

OTHER: allotments, community gardens, city farms, cemeteries and churchyards
2.3.3 Approach

"Green infrastructure encompasses a wide variety of natural and restored native ecosystems and landscape features that make up a system of 'hub' and 'links'."
Case Study

Renewable energy landscape

Urban green infrastructure

Vauban, Freiburg, Germany
Sustainable neighbourhood

Guthrie Green Park, Tulsa, USA
Urban park including a geo-exchange system

Jühnde, Germany
Bioenergy village

Dycker Feld, Schloss Dyck, Germany
Landscape garden using Miscanthus
Renewable energy landscape + Urban Green Infrastructure
3.1 Introduction

Based on the methodology, this chapter will propose regional strategy for the selected area South Duisburg. Before the strategy part, the analysis of the urban green infrastructure in the whole city will diagnose the problems in a larger scale. By using the Rhinepark as a case study in the city, the concept for the strategy based on the ‘Hub-Link’ approach mentioned above will be specified according to the urban condition.

In the selected location, the strategy will complete in five approaches in accordance to the site analysis to show how the greenlinks look like and how they connect.

3.2 Regional Analysis

Following the typology, the green infrastructure will be separate in maps to analyze their characteristics. The main problem can be seen in the maps: not connective. Besides isolated, the parks are located fragmentally in the city and the riverbanks are meadow less used. But we can see an exception along the Rhine in Duisburg, the Rhinepark.

Urban Green Infrastructure

- parks and gardens
- amenity greenspace
- natural and semi-urban greenspaces
- green corridors
- other
REGIONAL STRATEGY

- forest
- meadow (river landscape)
- park
- outskirts
- one-side along the river
- scattered
Rhinepark

Water was also decisive in the establishment and the rapid economic rise of the city, based on coal-mining and steel manufacturing. For, at the time of industrialisation, the Rhine and the Ruhr were already important trade routes. Still today, Duisburg is Europe’s largest steel manufacturing city. Yet, having settled at the waterfront for easy access to transport and water, industry had severed the link between the Rhine and the population. In many places in the city people still cannot enjoy a walk along the river banks. Consequently, water has become the key to enhancing quality of life. The recent conversion of a derelict industrial site at Duisburg-Hochfeld into the spacious Rhine Park re-introduces the Rhine to the people, which opens up the city centre to the waterfront of Rhine. It combines high-quality residential and leisure functions with beautiful riverlandscape. Through new park areas and the use of old industrial buildings as cultural centers as well as innovation centers the standard of living has improved immensely.
3 REGIONAL STRATEGY

Duisburg HBF
Central Station

Rhinepark

Industrial railway
The Rhine Park in Duisburg Hochfeld - opening the city to the waterfront.

As an example park siting along the Rhine, the Rhine Park in Duisburg Hochfeld opens the city to the waterfront and attracts residents and tourists to gather and have social activities. Therefore, we can see the potential of underutilized space on the riverbank to develop into the new green infrastructure which can provide citizens beautiful river landscape to improve the quality of life.
"A connected system of parks and parkways is manifestly far more complete and useful than a series of isolated parks."

- John Olmsted and Frederick Law Olmsted Jr. 1903
Social / Cultural aspect
Recreational aspect

Conceptual Strategy in city scale
### 3.3 Regional Strategy

With the concept, the selected district Angerhausen will specify the strategy in the following. The calculation of renewable energy for this area can satisfy the basic energy consumption of the surrounding neighborhood based on data from the power per unit land (MacKay, 2009)

#### Power per Unit Land

<table>
<thead>
<tr>
<th>Power Type</th>
<th>Power Density</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind</td>
<td>2 W/m²</td>
</tr>
<tr>
<td>Offshore wind</td>
<td>3 W/m²</td>
</tr>
<tr>
<td>Tidal pools</td>
<td>3 W/m²</td>
</tr>
<tr>
<td>Tidal stream</td>
<td>6 W/m²</td>
</tr>
<tr>
<td>Solar PV panels</td>
<td>5-20 W/m²</td>
</tr>
<tr>
<td>Plants</td>
<td>0.3 W/m²</td>
</tr>
<tr>
<td>Rain-water (highlands)</td>
<td>0.24 W/m²</td>
</tr>
<tr>
<td>Hydroelectric facility</td>
<td>41 W/m²</td>
</tr>
<tr>
<td>Geothermal</td>
<td>0.017 W/m²</td>
</tr>
</tbody>
</table>

*Source: Sustainable Energy - without the hot air, David MacKay (2009)*

#### District Energy Consumption

\[
125 \text{ kWh/day} \times 22,117 = 2,764,625 \text{ kWh/day}
\]

#### Estimated Renewable Energy

<table>
<thead>
<tr>
<th>Source of Energy</th>
<th>Power Density</th>
<th>Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind</td>
<td>2 W/m²</td>
<td>6.4 km²</td>
</tr>
<tr>
<td>Solar energy</td>
<td>0.3 W/m²</td>
<td>4.5 km²</td>
</tr>
<tr>
<td>Water energy</td>
<td>0.3 W/m²</td>
<td>6.2 km²</td>
</tr>
<tr>
<td>Biomass</td>
<td>0.24 W/m²</td>
<td>14.9 km²</td>
</tr>
</tbody>
</table>

*Source: Sustainable Energy - without the hot air, David MacKay (2009)*

\[
125 \text{ kWh/day} \times 22,117 = 2,764,625 \text{ kWh/day} = 3,217,352 \text{ kWh/day}
\]
Walking and cycling distance

To analyse the green infrastructure and characterise the study area, the walking and cycling distances can best estimate that residents may be prepared to travel to access green space. There are three possible travel distances (zones). The first is 400 metres, which represents the maximum distance that an adult who was physically unfit, older or not able bodied would be likely to cover in a 10 minute walk. The second zone is 800 metres and represents the maximum average distance that a fit or able-bodied adult could be expected to cover in a 10 minute walk. The final zone is 2.5 kilometres and represents the maximum average distance that a physically fit adult could be expected to cycle over the same time period. (Jason Byrne, 2010)

According to the distance analysis, green infrastructure in 400m and 800m can almost satisfy the surrounding neighborhoods. But 2500m zone is not connective and sufficient. The incoherence of green infrastructure will affect the residents’ cycling activities.
Zoning Analysis

HKM, the biggest steel company in Duisburg is located among the densely populated area and the green infrastructure are divided into western and eastern parts by the large industrial area. Based on the strategy, the new green infrastructure should link this two parts by green links. Therefore the new green links should detour the industrial area.
**Green Link Strategy**

**Linkage of green space**
Several parks and green space are located in this area, the strategy is to use the green link to connect the existing green infrastructure.

**Accessibility to the river**
To open up the waterfront of Rhine to the residents, green link will help direct residents to the river by connecting paths and cycle route.

**Circulation**
The circulation of green links will better the cycle route. Currently, residents can only ride to the river bank and return back in the same way.
5 Approaches to Green Links

1. High Voltage Powerline
2. Wind Turbine
3. Connectivity
4. Industrial Isolation
5. Cycle Route
High Voltage Powerline

The high voltage powerline in Duisburg-Rheinhausen was built in 1926. The height range of pylons is from 80m to 120m. With this long history, the powerline has been the landmark for this area, which can be regarded as a heritage for the industrial area.
The linear space underneath the powerline has the potential to form a coherent ecological network to maintain and improve biodiversity as well as a valuable recreational structure.

The triangle space near the neighborhood which is lack of green infrastructure in 400m zone can build a biomass park to provide a new green park for residents to walk and gather.

Reference: Ecological Energy Network, Lola Landscape Architects
Source: https://www.lolaweb.nl/projecten.php?id=70
Selection of Wind Turbine

As the most important technological landscape elements with renewable energy, wind turbines will be added to the new greenlinks. Since its large form and noise, it is suggested to build the turbines 500m away from the residential area even though Germany has no policy to restrict the distances for wind turbine.

Due to the strong image from the high pylons, the project will select 50m rotor diameter, 75m height wind turbines for this district. The wind energy amount is 10500 kW which is close to 12800 kW the wind energy data estimated above.
The row of wind turbines is the coherent symbol in the greenway.

Wind Turbines Siting
Comparing to the pylons' image, wind turbines are exposed in the landscape but not expressive otherwise they will compete with the pylons. The forms of wind turbine siting will be linear following the agricultural patterns in the area. The arrangement of wind turbines will give the characteristic for this greenlink and create a directive landscape with different scene in the circulation for cyclists.
Rows of turbines appear logical in an agricultural landscape with formal field boundaries.

Radius of residential area

- 100 m
- 300 m
- 500 m

Greenlink of Windturbine
Reference: POSAD Veenet impression cycling routes
Source: http://posad.nl/projects/veennet/
3. CONNECTIVITY

With the new green infrastructure of powerlines and wind turbines, another type of green links can connect them in order to form a circulation.
4. INDUSTRIAL ISOLATION

Among the industrial area, some boundaries of residential area is adjacent to the factories or railways. The new green links will be built between them in order to retard the noise and gas emission from the industry.
Last but not least, the cycle route will play an important role in the new green links. To make a circulation of cycle system in this area, the cycling paths will detour the industrial area where has beautiful river landscape but inaccessible currently. Meanwhile the new cycle route will lead the residents to the Rhine with the hint of lighting system combining with the solar energy panel.

“Greenspaces that are connected with other green or open spaces through walking and cycling trails or greenways promote higher levels of physical activity and encourage more visits and longer stays.”

------“Green and open space planning for urban consolidation”
Cycling and Solar Energy
1. Solar cycle path, NL
2. Van Gogh Path, NL
3. Westmill Solar Park, UK
Regional Strategy

- New green infrastructure
- Existing green infrastructure
- New cycle route
- Existing cycle route
Biomass plan proposal

- *Phalaris arundinacea*
- *Panicum virgatum*
- *Sorghum*
- *Zea mays subsp. mays*
- *Brassica napus*
- *Miscanthus*
- *Linum usitatissimum*
3.4 Energy Network Proposal

With the regional strategy, the energy network proposal in this area can be seen in this diagram. The wind turbines will generate energy for the residential area. The agricultural area can be used to plant energy crops and other biomass processed by the industrial area. In a small scale, the cycling path will combine with the solar panel and the solar energy will be supplied to its lighting system.
REGIONAL STRATEGY

- Residential Area
- Industrial Area
- Agricultural Area
- Wind turbine
- High Voltage Powerline
- Substation
- Generator
- Transportation
4.1 Introduction

Based on the regional strategies mentioned above, the detailed design of green link and green hub will be elaborated as example for the region in this chapter. The physical forms can show how to apply renewable energy to the landscape and how to transfer the abstract energy strategy into spatial design.

The project chooses the beginning part of Angerbach as the greenlink design and the three pieces of brownfields surrounding as the green hub design location in South Duisburg. According to the site situation and condition, site analysis can help to diagnose the environmental problems and then use related design approach to solve them.

Due to the project topic, the design direction will focus on applying renewable energy to the landscape to better the environment and improve quality of life in the surrounding neighborhood. The type of energy landscape can be selected from the design tool box and added in the design as an important design element. Due to the densely populated area, wind and water energy which need to build large wind turbines and dams are not appropriate to develop in this area. So the solar energy and biomass will be the main renewable energy type in the following landscape design.
4.2 Site Context

The site is a typical industrial area with one of the biggest steel company in Duisburg HKM (Hüttenwerke Krupp Mannesmann) and other companies with large industrial facilities and railways which impresses as an intensive industrial image. The new land art Tiger & Turtle, a walking roller coaster, was built in 2011 and attracts numbers of tourists as a new local landmark but the surroundings are not in a good condition because of the brownfields and industrial areas. With the comparison of the new and old industrial facilities, this site become interesting and complicated. Due to the close distance, the invisible danger and contamination cannot be observed easily by the residents and tourists under the risk of the Duisburg Plant GNS. With these complicated conditions, the three main brownfields and some other underutilized space has potential to develop renewable energy landscape to improve the living environment and the quality of life in this area.
4.3 Green Link - Angerbach

Angerbach, a tributary of Rhine, is a typical green link in the site. The dike was created in 1930 after it had the worst floods of the past 150 years. To continue to provide protection against floods, the old dike must be rehabilitated. The Angersbach is over-green for the dike. Trees tear large holes in the dike that grow on its flanks. They grow their roots into the soil; overthrow their roots and leaves voids. 40 trees must therefore be removed if the dike is being renovated. The creek itself backflow from the Rhine will sometimes flood. Water enters the dike and flushes out the smallest particles which remains small holes.

Due to the over-dense plants and lack of cycling system, the linear space along the creek is seldom used but the greenery landscape space has the potential to attract residents by adding connectivity of green infrastructure, connection to the residential area and surrounding recreational programs.
New bridge to Haus Angerort

Remove the tree and open the view

Upgrade cycle path along the Angerbach

Add one level on the dike and access to the park

Lessen over-dense plants and facilitate activities
4.4 Green Hub - Energy Park
Duisburg Plant GNS

Since 1985, Duisburg Plant GNS treats nuclear waste from operation and shut down of German nuclear power plants. Due to the decreasing amount of operational waste during the nuclear phase out in Germany, GNS will close its Duisburg Plant by 2019.

GNS operates a central conditioning plant for the nationwide processing of medium-level radioactive nuclear waste. Dr. Birgit Beisheim deems that a zero-emission with such a system does not exist and it will be charged the surrounding environment. The accessibility of nuclear waste is carried out in 20-foot standard containers on normal trucks. The direct road access to the GNS was indeed transferred to an industrial wasteland through densely populated residential areas.

Aerial photograph shows its close distance to residential areas or public roads. By comparison, a minimum distance of 500 meters between a wind turbine and residential area has less effects. It is incomprehensible to us that such a nuclear plant could be located in this densely populated area, especially the conditioned radioactive waste in Duisburg accumulating throughout the Republic.

In particular, the ungated crossings Street Heiligenbaum and Atroper represent a major hazard potential. The route leads to the residential area. In addition to the railroad crossing Street Heiligenbaum there is a tram stop on the other side of the entrance to a supermarket. So many people come into direct contact with the nuclear waste trains.

Nuclear Power in Germany

German nuclear power began with research reactors in the 1950s and 1960s with the first commercial plant coming online in 1969. The anti-nuclear movement in Germany has a long history dating back to the early 1970s. In 1986, large parts of Germany were covered with radioactive contamination from the Chernobyl disaster and Germans went to great lengths to deal with the contamination.

Nuclear power has been a topical political issue in recent decades, with continuing debates about when the technology should be phased out. The topic received renewed attention in 2011 after the Fukushima nuclear accidents in Japan. Within days of the March 2011 Fukushima Daiichi nuclear disaster, large anti-nuclear protests occurred in Germany. Merkel's government announced that it would close all of its nuclear power plants by 2022. Chancellor Angela Merkel said the nuclear power phaseout would give Germany a competitive advantage in the renewable energy era, stating, “As the first big industrialized nation, we can achieve such a transformation toward efficient and renewable energies.

Renewable energy not only indicates sustainable environment but also takes the place of nuclear power which represents a profound meaning of energy transition in Germany. Therefore, the green hub design can be seen as a memorial park which would tell the energy development story to the citizens and the landscape can decontaminate the nuclear waste to some extent.
Anti-nuclear protest near nuclear waste disposal centre at Gorleben in northern Germany, on 8 November 2008.
Mutations result from damage to DNA. Once a mutation occurs in a gene sequence it then has normal DNA structure and cannot be repaired.

Mutants included malformed antennae, dented eyes, bent wings, and abnormal color patterns. Photo courtesy of Joji M. Otaki

4.4.1 Design Concept

Since the Fukushima disaster, some research shows that mutant insects keep increasing and reproduce. Genetic mutation is under the risk of nuclear power but people seldom realize the danger around their living environment.

The energy park can be seen as a memorial of energy transition in Germany. Therefore, the design applies ‘Mutation’ as concept to landscape in order to indicate the benefits from nuclear power to renewable energy as metaphor. The design concept will show beneficial mutations in landscape in two ways: Function reform, time dynamic.

A mutation has caused garden moss rose to produce flowers of different colors.
4.4.1.1 Function Reform

Since the GNS plant will be closed by 2019, the place and facilities will be probably left as the other abandoned factories. With the three brownfields, a biomass process system can be applied to refunctio the facilities and develope into this site: Containers can be reused as storage for biomass material; the plant can be converted into biomass factory to process raw material and the existing railway can deliver them to the factory.

With the greenhouse as a new program for the site, the new system can reduce the cost of greenhouse by using the wasting heat and CO₂ and the emission of greenhouse gas. Meanwhile the producing biomass energy can provide heat and electricity to neighborhoods.
With the biomass system in the site, the brownfield will be rebuilt into a residential park with ‘industrial image’ by reforming the existing industrial elements, for example containers, cranes, railways, etc. In accord to the theme of the project, these elements will be redesigned with the renewables, solar panel and biomass plants.

Besides the energy layer, the park is the production of energy transition from nuclear power to renewable energy in Duisburg. It has the educational meaning for citizens. So an educational layer will be added to the park and visitors can have a tour to experience the biomass energy process when they are walking in the park. The Angerort, the historical castle will be reused as a museum to exhibit the historical development of the energy in Germany which can provide more information.

For the residents, they can enjoy some other recreational programs in the park, for example urban farming, fishing, cycling, swimming, etc.

Since the site is polluted by the zinc and nuclear waste, the energy park will be deemed as decontamination for the area by growing plants for purification.
Greenhouse Container

Housed on the roof of a container, the greenhouse combining with aquaponics can be the urban farming area for the park. Vegetables and fishes can be obtained environmentally friendly for organic production and energy efficiency. Using a container allows for the equipments to remain secure and hidden. In addition, this can be a good way for reform containers to find a new career.

The water circulates in a closed circuit in the system: the excrement of the fishes is degraded by bacteria in the sewage tank serve as fertilizer for the plants.
Hygenisation

Raw fertilizer for agricultural use

Energy crops

Livestock farming

Raw fertilizer for agricultural use

Digestion residue storage

Biogas

Gasometer

Digester

Combined heat and power station (CHP)

Hygenisation

Exhaust gas

Heat exchanger

Greenhouse

Electrical energy

CO₂

Biomass Process Scheme
Transportation

Tram and industrial railway are across the three brownfields. Therefore, the energy park needs to build bridge system to connect them together in order to avoid the transportation. Meanwhile, the bridge will connect the park route to the mound Heinrich-Hildebrand-Höhe where the landmark Tiger & Turtle located.
Container Bridge

When the plant GNS is close, numbers of old steel containers are no longer being used. These containers can be transformed and be shaped into the bridge to connect the three pieces of brownfields. The bridge is based entirely on the frame of containers with truss.

The bridge allows for movement of cyclists and pedestrians. Towers with stairs and elevator will be set for going up and down in the park.

The roofs are the original roofs of the containers. In addition to this, there will be solar panel setting on the roof at suitable angles which will provide electricity from solar energy to illuminate the bridge and its surroundings.
4.4.1.2 Time Dynamic

Nearly a century of industrial zinc production in Duisburg ended in 2005 when the MHD Sudamin zinc smelter became insolvent and was decommissioned. The company left behind a legacy of extreme environmental pollution. The City of Duisburg decided to initiate a large-scale landscaping project and now the Angerpark was officially opened up to the citizens of Duisburg. Heinrich-Hildebrand-Höhe, named after a local historian who died in 2004, is part of the Angerpark. A greened artificial mound, it encloses the grounds of the former MHD Sudamin’s disposal site. Heinrich-Hildebrand-Höhe contains soil and rubble from the premises of the former zinc smelter.

This formation can be read as landscape mutation because it is changed from harmful zinc-polluted heap to greenery mound. Time is a key to landscape mutation since the green need time to take the place of zinc. Inspired by the mound, the project will present the concept mutation in another way by using the time dynamic in the landscape.
Phase 1
The area is heavily polluted with zinc smelter. The heavily polluted soil will be purified by Pennisetum Alopecuroides and Vetiveria Zizanioides which are used to clean zinc-polluted soil. A specially selected combination of other plants is used to stabilize, break off and take up pollutants. On the foot site of Heinrich-Hildebrand-Höhe this organic way of cleaning the soil will result in a working landscape, cleaning the soil while creating habitat and producing biomass since Vetiveria Zizanioides can be used as biomass as well. The biomass from the area will be used as raw material to develop products and energy in the park biomass system.

Phase 2
After purification, the place will become wetland by channeling from the Angerbach to retain water. Years later, the place would probably turn into a pond then recreational programs would be added to the site, such as fishing, swimming and boating. The floating platform with information center and fitting room will facilitate the recreational activities.

We see it as part of the park educational knowledge by means of letting the system of nature are part of the design. So we want to give new meaning to the brownfield in the city and its public space.
1. Wetland
2. Swimming pool and information spot
3. Tiger & Turtle
4. Biomass trees
5. Biomass storage warehouse
6. Tree exhibition greenhouse
7. Park Information & Culture Center
8. Urban Farming Greenhouse
9. Cafe & Restaurant
10. Bugeejumping & Fishing
11. Biomass Process Factory
12. Parking lots
13. Main entrance Plaza
Phase 1
The project is starting to rebuild the three pieces of brownfield before the plant GNS closed.

Phase 2
After the plant close, the surrounding area can used as purification first before the biomass factory reform.

Phase 3
When the transformation of the factory completed, the biomass system is in working process and the park is done.
Biomass Process Program
Biomass Plant Proposal
5.1 Reflection

Aspect 1  The relationship between research and design

The Ruhr area is an industrial region in the process of transformation. Under the circumstances Duisburg is facing the environmental, economic, social problems after the industrial depression. The research focus on integrating renewable energy into landscape design in this industrial city. As natural life sustaining system, urban green infrastructure is the ecological framework needed for environmental, social and economic sustainability. Through the study of energy landscapes and green infrastructure, the landscape design applies renewable energy landscape to urban green infrastructure to improve the quality of life. Based on the research, the disconnection in the existing urban green infrastructure can be solved by the energy landscape design and landscape transformation can help to call for participation and more social possibilities in the future.

Aspect 2  The relationship between the theme of the graduation lab and the subject chosen by the student within this framework

The Flowscape graduation lab explores infrastructure as a type of landscape and landscape as a type of infrastructure, allowing landscape design to gain operative force in territorial transformation processes. Through focusing on landscape architectonic design of green infrastructure the subject ‘renewable energy’ regards as new program and approach to the landscape. The energy landscapes can concern with the urban infrastructure to develop the spatial quality and cultural identity in Duisburg.

Aspect 3  The relationship between the methodical line of approach of the graduation lab and the method chosen by the student in this framework

The graduation lab explores spatial, societal and environmental issues by design research and research-by-design approaches. With the fascination of industrial landscape, the methodological framework of the project contains two aspects of research: renewable energy landscapes and urban green infrastructure. Through the research, appropriate design principles and approaches to energy landscapes can be applied to the landscape design under the local condition. For South Duisburg biomass, wind and solar energy are the selected types of renewable energy which can be integrated into the landscape design. The results of research act as a clue for the landscape design in the region. Meanwhile, design is a complementary approach to the research. In the design location Duisburg plant GNS needs to be reformed, which is treating nuclear wastes and will be closed in 2019. The historical development and cultural identity can be translated in the landscape design. Through the landscape design, the relationship and transition of nuclear power and renewable energy can be introduced and explored in the necessity and meaning of the subject ‘energy landscapes’.
Aspect 4 The relationship between the project and the wider social context

Through the research and design, the potential role of the renewable energy landscape can be seen in the social context. On one hand, the industrial culture and identity in Duisburg can be translated into the energy landscape design. Energy can be regarded as a spirit in the industrial development and renewable energy is an ideal substitution for traditional fossil fuels. The regional strategy in the project provides the possibilities to supply renewable energy from the landscape to the residential and recreational use. On the other hand, the meaning of renewable energy is prominent since the nuclear phase out in Germany. The energy park design aims to elaborate the historical story about the energy development in Germany and to help people to realize the latent nuclear risk in their surroundings with different recreational programs.

Since the Fukushima Daiichi nuclear disaster, Germany announced that all the nuclear power plants would be closed by 2022. But the nuclear waste disposal still brings about contamination problem to the human and environment. Germany has developed advanced non-conventional renewable energy for electricity generation to offset the phase-out of nuclear energy. Renewable energy landscape has the potential to reduce the contamination and improve the quality of life by providing the most basic elements for life: clean air and water.

The role of green infrastructure in the ecosystems is absolutely critical. Forests renew our air supply by absorbing carbon dioxide and producing oxygen. Trees also clean our atmosphere by intercepting airborne particles, and by absorbing ground-level ozone, carbon monoxide, sulfur dioxide, and other greenhouse gases. A single tree can absorb 10 pounds of air pollutants a year, and produce nearly 260 pounds of oxygen - enough to support two people. Urban trees can do even more for clean air. Depending on location, species, size, and condition, shade from trees can reduce utility bills for air conditioning in residential and commercial buildings by 15 to 50%. Through shade and the evaporation of water from their leaves, trees also provide natural, low-tech cooling that reduces energy use and the need to build power plants.

From nuclear waste to renewable energy landscape, the new green infrastructure system improve the quality of life in Duisburg, enhance the health of the natural environment and its ability to provide a wealth of ‘ecosystem services’.