City Space Recycling: The Example of Brownfield Redevelopment

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Abstract. In many parts of the world the manufacturing and mining industries have left a huge mark on the spatial structure of entire regions, as well as individual cities. Urban tissue has been growing for years around the dynamically developing industrial plants and mines during the period of intensive industrialization. As a result of industrial restructuring, abandoned and degraded post-industrial areas created problematic places in the structure of cities. Moreover, many of them are located in the direct neighbourhood of the centers of these cities, in the strict urban fabric. Nowadays, in the era of balancing urban development, creating compact, smart and eco cities, one of the important problems faced by city authorities, architects and urban planners is solving the issue of optimal shaping of city structure, including revitalization of post-industrial areas. The article deals with the subject of transforming brownfield areas into modern urban tissue, related to the surrounding areas, and at the same time referring to its industrial heritage. For this purpose, a number of studies were carried out, including comparative analyzes. Therefore, five examples of projects from Europe related to the transformation of brownfield sites for the purposes of industrial and technology parks were selected. This list includes two examples of Polish parks located in Upper Silesia and three examples of areas located in Germany in the Metropolis of the Ruhr Area. Selected areas were analyzed and evaluated in terms of a number of parameters in order to identify the most important factors positively influencing transformations and problem areas requiring the most attention. Based on the results of the case study, a model concept for post-industrial area development was prepared for the purposes of developing an industrial and technological park and recreational areas, complementing the leisure offer for the surrounding residential areas. The location in former Baildon ironworks in Katowice in Upper Silesia was chosen as the place of the conceptual design. Upper Silesia is known as one of the most urbanized and industrialized regions of Poland, which is still struggling with the negative effects of industrial restructuring. Research results indicate that the areas of former mines and production plants, thanks to their strengths, can be attractively transformed into other functions to become again a showcase of the entire city, providing an incentive to learn about the industrial history of the region. The introduction of a diversified program and giving a new character to areas with huge investor potential, helps to return the city to areas of great social, economic and spatial importance.
1. Introduction

The dynamic development of heavy industry related to coal mining and processing had a huge impact on the development of new urban centers located around industrial areas. The cities of Upper Silesia are one of many examples of such areas. It is one of the most strongly urbanized and industrialized regions of Poland with a very characteristic, still industrial panorama. The cities of today's Silesian agglomeration thrived during the Industrial Revolution at the turn of the 19th and 20th centuries. This development was drastically stopped as a result of political and economic changes at the end of the 20th century. They resulted in deep restructuring of the entire industrial region. Over the past few decades, this process has had a huge impact on the functioning of Silesian cities. Deindustrialisation is associated with many economic, social or economic problems, and is largely responsible for the degradation of industrial spaces. Extensive undeveloped areas in the central areas of Silesian cities are undoubtedly a big and still current problem. Especially in the era of development of Upper Silesian Metropolis they are a difficult and complex topic that requires research.

The aim of the article is to analyze the possibilities of transforming post-industrial areas, both on examples of completed case studies and own proprietary concept. The main task of the developed concept is to create a master plan enabling the introduction of a diversified program and to give a new character to areas characterized by huge investor potential, which would to some extent offset the excessive urban sprawl of Silesian cities. In addition, the study aims to propose mechanisms to develop entrepreneurship at the local level and restore these areas to urban residents.

The subject of the concept is the revitalization of the former industrial area of the former Baildon steelworks located in Dąb, one of the districts of Katowice. Location of the area in the near of the city center and areas with a residential and service function requires a special approach to the development of regeneration activities. A model solution for the development of an industrial and technological park presents activities that support the development of local entrepreneurship, the creation of public urban spaces and the adaptation of post-industrial buildings with high aesthetic and historical values reminding of the industrial heritage of the area.

2. Method of research

The research work carried out by the Authors, on the subject of which they defined as "city space recycling" can be generally divided into three main parts: research, analysis and design. Due to the limited amount of space, the article presents selected issues from the analytical and design part. Postindustrial area is an important concept used in the article. It is understood here as a degraded area, left over or unused in its full potential, which originally had an industrial function. The concept of post-industrial area is associated with the concept of degraded area, however, the latter is broader because it also includes landfills and contamination of waters and soils as the closest surrounding to industrial plants. [1], [2].

Brownfield is another key concept. The use of this type of area is a specific type of investment implemented through the reuse of buildings, facilities and areas related to post-industrial infrastructure, often degraded, which it seeks to give new functions [3].

Several research methods were used in the research work. The first is the historical and interpretative method, consisting of: gathering facts and available historical documents, analyzing literature on the subject while looking for correlations of historical, spatial, social and economic factors. The next used method was the method of logical argumentation - made in the form of analysis and subsequent synthesis of available materials such as planning documents, urban projects, archival architectural competitions and literature sources. The last research method used was case study. For the needs of this method, five examples of projects best reflecting the problems and opportunities associated with investments involving the transformation of post-industrial urban areas into industrial and technology parks were collected, described and analyzed. The list includes two examples of implemented projects from Poland from the Upper Silesian Metropolis and three examples from Germany from the Metropolis of the Ruhr Area. [4]
3. Analysis of examples of brownfield transformation

3.1. Case I - "Nowe Gliwice", education and business center

The first example of brownfield site transformation is Nowe Gliwice, the education and business center. The center is located in the area of the former Coal Mine in Gliwice in the Upper Silesian Metropolis. The history of coal mining at this place began in 1910. The mine and workers' colony were designed by Emil and Georg Zillman. The plant operated without interruption until 1999, when the long-term mine liquidation process was completed.

The area remained undeveloped until 2005, when the authorities of the Silesian Voivodeship handed it over to the city of Gliwice, which began revitalization works. An undoubted advantage of the post-mining area was the excellent location near the junction of the A1 and A4 motorways. The investment area covered 15 ha of the mine area along with the historic buildings of the directorate, stamp house and director's villa. The area was divided into two main sub-areas: the education zone and the business zone, creating the basis for the development of numerous business incubators. [5]

3.2. Case II - Silesian industrial and technological park

The second analyzed transformation of the brownfield area is an industrial and technology park located on the border of two Silesian cities: Świętochłowice and Ruda Śląska. The park includes areas of the former "Poland" and "Walenty-Wawel" coal mines. In total, they cover an area of over 1090 ha. It is the largest industrial and technology park in this ranking. This area was subject of degradation over a period of 6 years (from 1997 to 2003). The transformations began with the revitalization of the former mine canteen facility and its adaptation to the activities of the "Rudzki Inkubator Przedsiębiorczości". Then, at the initiative of the local authorities of both cities, a Silesian industrial and technology park was created. The land was redeveloped for the needs of future investors to encourage them to invest in this place. [6]

3.3. Case III - Zollverein, a cultural center and craft park

Another example of the transformation of brownfields for technology parks is Zollverein - the most famous project in Germany. It is located in the northern district of the city of Essen in the metropolis of the Ruhr Area. The complex of the former mine and coking plant in its glory period (1851-1986) was the largest area of this type in Germany and one of the largest in Europe. In 1993 the complex was finally closed and a slow process of revitalization of the area and adaptation of post-mining facilities began. Zollverein has had conservation protection and included on the list of the European Industrial Heritage Trail. It is now one of the major attractions of this trail. In 2003, the then authorities of the Land of North Rhine-Westphalia approved a transformation plan to include cultural center and craft park. Many well-known architects took part in the revitalization process. Sir Norman Foster designed the adaptation of the coking plant building for the workshop of the North Rhine-Westphalia Design Center. Another well-known architect was Rem Koolhaas, who developed a comprehensive urban design for a cultural center with the separation of areas for future investments. [7]

3.4. Case IV - Phoenix West, technology park

Another example located in the very center of the Metropolis of the Ruhr Area is the Phoenix West technology park in Dortmund. The investment in recent years has been the most important transformation project of post-industrial areas in Germany. The blast furnace plant for Ironworks Phoenix operated in this area continuously for 159 years from 1840. In 1999, the object's blanking process was completed.

After two years, it was decided to transform the wasteland into a modern industrial and technological park with a total area of 170 ha. The SPAP architectural office was responsible for developing the masterplan. The urban assumptions show a desire to maintain a transparent communication system. Thanks to it, it is possible to develop the area over many years, with many stages, while maintaining numerous urban green areas (60 ha in total). In the central point of the
assumption, architects referred to the identity of the place - a fragment of the blast furnace was preserved, creating a cultural zone and a monument of bygone times. [8]

3.5. Case V - Rheinelbe, science park
The last example of an industrial and technology park located in post-industrial areas is the Rheinelbe science park in the city of Gelsenkirchen in the Ruhr region. This area is unique because of its location in the very center of the city, 800 meters from the main station. Due to its location, the park is characterized by a small area, about 30 ha, and interesting design solutions related to the adaptation of post-industrial areas in downtown areas. From the 1840s, the area was intensively exploited for over 100 years until the "Rheinelbe" mine closed. In subsequent years, the area and buildings fell into ruin. It was until 1995 that the area was recovered by a revitalization project as a part of IBA Emscher Park. Kiessler architectural studio decided to "return" the area to the city. They allocated a significant part of the area to a city park with a pond, creating a space for meetings and recreation. At the same time, they closed all required functions of the science park in one building. [9]

3.6. Case study results
The above examples have been described and analyzed. The results were compiled and compared with the division into four main sections: general data (table 1), environment analysis, analysis of the study area (table 2). Selected information on individual case studies is presented below.

Table 1. General information about collected examples

|                           | Nowe Gliwice | Śląski Park P-T | Zollverein | Phonix West | Rheinelbe |
|---------------------------|--------------|-----------------|------------|-------------|-----------|
| 1 Country                 | Poland       | Poland          | Germany    | Germany     | Germany   |
| 2 Town                    | Gliwice      | Ruda Śląska/Świętochłowice | Essen     | Dortmund    | Gelsenkirchen |
| 3 Foundation year         | 1910 yr      | 1846 yr         | 1847 yr    | 1840 yr     | 1845 yr   |
| 4 Primary function        | Hard coal mine | Hard coal mine | Hard coal mine & coking plant | Blast furnace plant | Hard coal mine & foundry |
| 5 Closing year            | 2000 yr      | 1997 yr         | 1993 yr    | 1999 yr     | 1931 yr   |
| 6 Year of adaptation      | 2005 yr      | 2003 yr         | 2003 yr    | 2001 yr     | 1995 yr   |
| 7 Current function        | Education & business center | Industrial and technological park | Culture zone and craft park | Technological park & leisure center | Science Park |
| 8 Acreage                 | 25,2 ha      | 1089 ha         | 100 ha     | 170 ha      | 30 ha     |
| 9 Architects              | -            | -               | Rem Koolhaas OMA | SPAP | Kiessler architekten |

A summary of the brownfield transformation case study analysis is presented in Table 3. It contains a subjective assessment. The following were assessed: the attractiveness of the location of the park, the surroundings and the area itself, as well as safety, pedestrian and wheeled accessibility, aesthetics, transparency of the obtained urban layout, the size of arranged green areas and the occurrence of recreation places.
Table 2. Site analysis

|   | Nowe Gliwice | Śląski Park P-T | Zollverein | Phonix West | Rheinelbe |
|---|--------------|----------------|------------|-------------|-----------|
| 1 | Plot shape   | average        | bad        | average     | good      | good      |
| 2 | Building area| 2,75 ha        | 1,078 ha   | 10 ha       | 45,5 ha   | 0,925 ha  |
| 3 | Parking places (above-ground) | 600 | 59 | 868 | 207 | 135 |
| 4 | Greenery     | 1,3 ha         | X          | 80 ha       | 72 ha     | 29,753 ha |
| 5 | Functions located in the area | + development - electrotechnics - energetics - telecommunications - aviation - service | + development - entrepreneurship - laboratories | + development - industrial - micro & nano technology - service - aviation | + development - IT - energetics - service | + development - energetics | + development - social care - recreation |
| 6 | Expandability (free space) | 17,50% | 0,11% | 13,2 % | 68 % | X |

Table 3. Attractiveness assessment of areas

|   | Nowe Gliwice | Śląski Park P-T | Zollverein | Phonix West | Rheinelbe |
|---|--------------|----------------|------------|-------------|-----------|
| 1 | Location attractiveness | 5 | 4 | 3 | 5 | 4 |
| 2 | Surroundings attractiveness | 3 | 2 | 4 | 5 | 5 |
| 3 | Security | 4 | 3 | 5 | 4 | 5 |
| 4 | Accessibility | 5 | 4 | 3 | 5 | 4 |
| 5 | Area aesthetics | 4 | 3 | 5 | 5 | 5 |
| 6 | Totality | 21 | 16 | 20 | 24 | 23 |
| 7 | Comments | Lack of greenery | No visible urban layout. Lack of parking places. Large undeveloped areas. | X | Large undeveloped areas. Still in development | X |

As can be seen from the table above, the attractiveness of the location coincides with the accessibility of the brownfield area. In terms of both criteria, Nowe Gliwice and Phonix West scored the highest number of points. In turn, the most favorable surrounding areas have: Phonix West and Rheinelbe. They, together with Zollverein, were considered the most interesting in terms of architecture and urban planning. In the summary of the case study analysis, the Silesian Industry and Technology Park was ranked at the lowest position.
On this basis, it can be thought that the city space recycling can be stimulatingly affected by: relatively small diversity of functions, too much space difficult to develop and manage, and thus the lack of a clear overall functional and spatial program, low aesthetics of architectural objects and their surroundings, a small amount of arranged greenery, poor transport accessibility, not very favorable location in the city structure, unattractive neighborhood. These conclusions became the basis for formulating design guidelines for the author's proposal to transform the brownfield area into an attractive urban space.

4. Masterplan of brownfield redevelopment - “Baidon Steelworks”
To develop the proposal of masterplan in the brownfield area, selected the area in Katowice - the most important city of the Upper Silesian Metropolis.

The post-industrial area of 56 hectares after the former "Baidon Steelworks" due to the short distance from the city center and good transport links can be included in the group of areas with great opportunity for both city residents and potential investors.

The area is located in downtown buildings. around its borders are quite varied functions:
- housing - low, typically Silesian housing development as well as high-rise housing estate with tower blocks called "Kukurydze" (eng. “Corns”),
- housing and service - buildings in the city center,
- service and commercial - on the other side of the road is a large shopping center,
- recreation and leisure – Silesian Park with an area of 620 ha - one of the largest city parks in Europe.

In the immediate vicinity of the proposed masterplan are also many facilities with the functions of culture, health care, education and all kinds of services.

An undoubted advantage is the proximity of one of the two main thoroughfares connecting the main Silesian cities.

The developed case study and a series of analyzes, which included analyzing local planning documents, urban inventory, and preparing analyzes of the area and its immediate surroundings enabled the development of design guidelines (Figure 1) necessary to start work on the masterplan.

![Figure 1. Scheme of the concept of revitalization](image-url)
According to the main assumption of the concept, it was necessary to design an area that meets the requirements of industrial and technology parks, and at the same time make the area available to nearby residents. The area was divided into six main sub-areas, each with a different dominant function. In addition, it was proposed to transform the existing urban layout based on the results of wheeled and pedestrian access analyzes.

An important element of the masterplan was the creation of the largest amount of park greenery merging into a recreation area that runs through the entire complex (Figure 2). The main task of the green zone was to connect together all historic buildings and the possibility of free movement between them.

The concept identifies four main areas:
- boulevards on the Rawa River,
- composite axis leading to the rest area located around the water tower,
- main park - connecting the old railway bridge and the former heavy machining hall
- a composite axis leading to the building of the steelworks management.

The most important park greenery zone is the area around the heavy processing hall that deals with heavy machining. It was designed as a place of recreation and outdoor events. It is intended that the layout of pedestrian paths is to reflect the location of former railway tracks leading from the old railway bridge to the heavy processing hall itself. Moreover, it was decided to introduce so-called pocket parks in places with limited availability of free space.

Circular communication has been designed taking into account the guidelines of urban planning documents and maintaining the assumptions of plans for the expansion of surrounding areas (Figure 3). The urban layout of the streets has been maximally simplified, while allowing optimal access to investment areas. This solution, together with the introduction of one-way access roads to industrial facilities, will enable traffic unloading during peak hours.

Another important design assumption was to reduce the primacy of pedestrian traffic over pedestrians. This was achieved by simplifying the wheeled communication system mentioned above, as well as introducing a significant number of pedestrian and bicycle paths (Figure 4).
The shaping of new buildings based on communication system solutions and recreation areas was associated with program segregation of services (Figure 5). This action was aimed at achieving the most optimal functional and spatial solution, enabling sustainable development and proper prosperity of the park in the future.

The areas of preserved industrial services have been enriched with new industrial facilities with smaller cubature. Around them grouped, buildings supporting services for the development of business incubators, such as higher and vocational education services, and research and development services. Buildings which supports services for the development of business incubators, such as higher and vocational education services, and research and development services.

A large part of the area around the main paths was intended for the development of office services. Culture and recreation services were also located in the study area. To a large part, they were designed in adapted historic buildings. To maintain consistency with the surrounding urban tissue, the height of the designed objects has been adapted to the surrounding areas, taking into account the spatial dominants leading to key design assumptions.

In order to solve the problem of insufficient parking spaces, underground parking places have been designed under each new designed quarter of buildings, maintaining above-ground parking lots only in places that require it.

5. Results and discussions

The main spatial solutions proposed in the project are best illustrated by the diagram of the percentage share of different areas in the total area of the study (figure 6). Noteworthy is the fact that development areas occupy a slightly smaller area than biologically active areas, which were the most important goal during creation the concept. It is worth paying attention that the percentage share of wheeled communications is over two times smaller. The diagram also illustrates the area occupied by surface parking lots. As it was described in the concept, it was decided to reduce parking lots to a minimum. This area is now less than 2%. In the southern part of the development area, where the building density is higher, routes both for pedestrian and wheeled communication were designed. These areas occupy up to 0.14% of the whole area.
Figure 4. Percentage share of land

Figure 5.: Visualization of the steelworks revitalization concept

Figure 6. Visualization of the main park
6. Conclusions
The purpose of the article was to attempt to define, based on case studies, guidelines for future design transformations of brownfield areas in the urban structure, and then to propose those implementations in the author's concept. The authors were guided by the idea of designing a modern industrial and technology park, which would also be a valuable urban area serving as attractive public areas - new jobs and rest places keeping the identity of the place. The proposed functional and spatial solutions are intended on the one hand to provide maximum comfort to employees of the industrial and technology park, and on the other hand to make these areas available to city residents. The creation of new investments has a chance to significantly affect spatial order, filling a large gap in the urban fabric and social activation of residents. The concept of brownfield land development is a modern response to the need to revive degraded areas. Space, in particular urban space, should be treated as a difficult renewable resource, which should also be recycled. At the same time, the actions should take into account guidelines for sustainable development and adaptation to climate change, ensuring the right proportions of built-up, transport and biologically active areas.

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