Implementing an ecosystem approach to the adaptive reuse of industrial sites

L. Kirovová & A. Sigmundová
Faculty of Architecture, Czech Technical University, Czech Republic

Abstract

Global changes and processes associated with the transition to post-industrialism that are interconnected with the downturn of heavy industry and the rapid growth of the service sector have greatly influenced everyday life and the structure of towns and cities. The majority of cities changed through industrialisation must now deal with vast brownfields and the associated problems. Consequently, issues connected with the adaptive reuse and regeneration of industrial cities have thus emerged as an established discipline, although whether contemporary regeneration is sustainable remains an open question. Since it is thus important to understand the potential of former industrial areas for resolving and mitigating environmental and social problems which have occurred in the past, it is necessary to identity sustainability principles for adaptive reuse that will lead to the reintegration of former industrial sites into the local socio-economic and urban structure. This will also assist us in attaining sustainability in respect to new functions for former industrial sites, spur regeneration, and increase habitability. Viewing such sites in terms of ecosystems makes it possible to perceive them as complex and dynamic systems formed by a pattern of diverse interacting subsystems with characteristic metabolic cycles. Because the majority of industrial complexes have operated according to a model of rational metabolic cycles representing technological flows, the ecosystem approach is both relevant and useful for understanding the complexity of the issue and identifying sustainable ways in which to readapt discarded industrial sites.
Keywords: industrial sites, adaptive reuse, ecosystem approach, habitability, sustainability, material reuse, economic factors, vegetation, water management, social factors.

WIT Transactions on Ecology on The Built Environment, Vol 142,
www.witpress.com, ISSN 1743-3509 (on-line)
doi:10.2495/ARC140371

1 Introduction

The transition from industrialism to post-industrialism and beyond has led to a wide range of new understandings of structural matter in the built environment. Changes in the scale, form, and location of industrial activity, together with changes in the central economic forces in society, have generated many new issues and problems within the socio-environmental sphere. This has produced a significant number of new challenges for current and future politicians, urban planners, investors, and researchers.

In addition to the economic and socio-cultural changes connected with post-industrialism, many industrial areas and complexes have fallen into disuse. The presence of vacant and obsolete industrial buildings provides symbolic material testimony to this transition.

It is also the case that large-scale urbanization, which was initially associated with the shift from an agricultural-based economy to a society characterized by mass industry, technology, and services, has continued in the post-industrial and post-information age.

Changes in city functions and the evolution of city structures have long had an effect upon former urban industrial areas. As industry has steadily disappeared from inner cities, unemployment, empty buildings, and unsightly and often dangerous waste have been left in its wake. However, former industrial sites within city centres and previously industrial neighbourhoods have begun to adopt new residential and commercial uses. In addition, vacant suburban industrial sites have become parts of the city structure because of continued urban growth and expansion.

It is of essential importance to reconnect empty industrial shells and the blank areas on city maps with city structures. And it is obvious that this needs to be done in the most sustainable way possible.

2 Characteristics of vacant urban industrial sites

2.1 Urban characteristics

Small industrial areas – Closed complexes, possibly within the city block structure and often located in former industrial neighbourhoods, where residential functions have been mixed with industrial production. In general, former light industrial sites that are interconnected with their surroundings.

Large urban and suburban areas on the perimeter of the centre – Isolated complexes with their own built infrastructure that typically lack functional interconnections with the urban environment and form.

Technical infrastructure of the city itself – Water towers, transformer stations, purification plants.

Transport infrastructure – Former railway stations and underutilized roads and rails that now serve more as barriers within the urban public space.

New designs can take advantage of these areas and objects in a program of sustainable reuse, which also lowers costs and enhances local identity through the utilization of existing material.

2.2 Socio-economical characteristics

Former industrial areas are often decayed or underutilized. This has a negative influence upon the quality of life in the surrounding neighbourhoods because it reduces safety, has a deleterious impact on criminality, etc. There is also often a high rate of unemployment in cities with a large number of vacant industrial sites that is connected both with the downturn in heavy industry and with the lack of financial resources needed to regenerate the affected areas.

Environmental problems, such as pollution associated with degradation as well as residual pollution from former operations, threaten public health and cause discontent among nearby residents.

However, industrial buildings and complexes may have historical significance within the city structure in connection with cultural heritage and local character. Industrial heritage sites exemplify socio-cultural and historical objects within the context of the given place, and their fate exerts a psychological influence upon residents and affects their thinking. This can also affect residents' confidence in local authorities insofar as the manner in which the latter deal with degraded industrial facilities can be taken as reflecting their qualifications and ability to govern.

The adaptive reuse and rehabilitation of former industrial areas upon the basis of sustainability can also become an important strategy for intelligent growth and the prevention of urban sprawl.

3 Adaptive reuse and principles of sustainability

Adaptive reuse is a process of finding a new purpose for an existing site or building that implements new functions within existing structures with an eye towards their economical, social, and environmental viability after conversion. However, creative reuse is more than simply converting or rehabilitating a property. As Lantham [1] observes, it is a process that harnesses the original energy and quality of a building and combines it with the new energy and activities that a new use brings. The successful adaptive reuse of a built structure is inherently sustainable since it reuses existing energy and material rather than discard it. It is also a way in which to ensure continuity in the history of craftsmanship, which requires handling the products of human knowledge and skills as elements of a sustainable approach. But this does not mean that adaptive reuse projects are sustainable without exception. Even when an appropriate function has been identified and the potential of the existing structures is well understood, much careful thought and planning is necessary in order to attain sustainability after conversion. As in all other construction activities, a good project, respectful planning, and skilful execution are essential, but the particular issues associated with sustainability must also be taken into account. The approach required to resolve the environmental, social, and economic problems involved while also identifying sustainable development strategies is inevitably complex.

One of the first questions to be asked concerning sustainability is: when is adaptive reuse warranted? While such words as reuse and recycle have recently become fashionable among environmentalists, they are often removed from their wider context. We must keep in mind that reusing existing constructions while adjusting them to current standards may not always be a sustainable practice. This is a complex question inherent in the very notion of sustainable and adaptive reuse that can only be answered through comprehensive case-by-case evaluation.

Even if it appears likely that a particular adaptive reuse project possesses a viable program and future use along with the needed scale and funding, reusing material and energy is but one aspect of sustainable design. It is also necessary to take into consideration a variety of economic and social factors as well as the need to reduce energy demands, reduce waste production, make appropriate use of vegetation, and manage water usage, all of which have an important impact on the micro-climate. Consequently, the rehabilitation of an industrial site can be sustainable only when all aspects of sustainable design are taken into consideration during the design process – a holistic approach and an awareness of the numerous issues involved are crucial to attaining sustainable goals.

The ecosystem approach can help us perceive the complexity of such issues while learning from ecosystems in nature, which represent one of the most complex and efficient systems of interconnectedness.

4 Industrial sites viewed as ecosystems

Natural ecosystems are open, dynamic, and complex systems with characteristic metabolic cycles of energy, material, and waste flows. They are composed of diverse subsystems interconnected by various relations and feedback loops. Newman and Jennings [2] note that the most characteristic feature of natural ecosystems is that they are autotrophic, that is, they are able to capture sufficient energy to meets their needs and deal with the wastes they produce within the areas they occupy.

Urban ecosystems, in contrast, are highly heterotrophic since they supply a very large amount of the resources and energy they need from locations beyond their boundaries and are not able to deal with the waste they produce within the areas they occupy. Rogers [3] argues that the circular metabolism model, which is based on the autotrophic properties of natural ecosystems, would be more appropriate for our cities in terms of their stability and sustainability.

Large industrial complexes, which are designed to optimize energy and material flows during production and consist of efficiently interconnected buildings and infrastructure, are artificial systems of build environment that depend on both natural resources and physical laws. In addition, their inner structure corresponds to the technological flows of particular production processes. Such complexes may thus be regarded as analogous to natural

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ecosystems insofar as they are composed of diverse natural, built, socioeconomic, cultural, and technological layers and subsystems that interact with each other.

The successful reuse of such industrial sites requires that we understand how the various layers and subsystems of the readapted design will be interconnected with and influence each other, as is the case with the various elements of natural ecosystems. While most such projects focus only on refurbishment and give little or no consideration to sustainability, they are typically regarded as implementing a sustainable design insofar as they involve the reuse of existing materials and structures. However, only a complex holistic approach will enable us to design and implement a well-performing sustainable project that will have a positive impact on its urban and social surroundings. For example, the design of functions in public space can draw people into the adapted site and thereby forge a stronger link between the latter and its surroundings. This may, in turn, attract a larger number of customers to the commercial elements of the project and help generate financial support for the further operations of the project. Another example of this approach concerns the appropriate use and integration of vegetation into the architecture. This can both make public spaces more attractive, and also have an important influence on the local climate and on energy demand.

Underutilized industrial complexes often represent a waste of materials and energy that could otherwise be reused and adapted to the needs of cities and society today. It is important to reconnect abandoned urban industrial sites with their environment and make them once again parts of our cities. We must be mindful of the importance of such locations as elements within the socio-cultural and historical context that are analogous to the various elements of natural ecosystems, which are never isolated from each other. All elements of a city structure should interact with and influence each other in a beneficial way.

5 Principles of sustainable adaptive reuse

5.1 Functional adaptation

The proper choice of functions for sites to be reused is crucial for a viable, sustainable, and efficient project. These new functions must correspond to certain basic features of a given site.

5.1.1 The nature of the existing building or complex

The scale, interconnections, and typological characteristics of the new proposed functions must be appropriate to the technical state, form, etc., of the existing building fibre.

5.1.2 The local and wider conditions

The character of the proposed functions must be connected with the position and role of the existing building or complex in the life and structure of the city. Within a broader perspective, they must also be connected with any historical and cultural value the building or complex may possess, various socioeconomic factors, and other issues.

Important buildings should be treated with great care, and it is most suitable for them to be open to the public. Their adaptive reuse should become part of the city's image, and new public spaces should be included in the reuse project so that interconnections within the city's structure are enriched. The focus at the local level should be on the creation of a habitable public space that can attract the public, entice current residents to stay in the location, and help interlink the site with its immediate surroundings.

In a problematic location, the creation of inexpensive rental spaces can help improve the local economy.

However, a new purpose must not ignore the structure of both the built and natural environment and of the readapted building's future role within it. This becomes even more important in larger cities, where the density of built matter and correspondences with existing functions and interactions are of major significance. The proposed new function must also take into consideration the overall city plan. The aim is not only to retain the durability of a newly renovated industrial site, but also to have a positive effect on city life, commercial activities, the quality of adjacent public spaces, etc.

5.1.3 The needs of contemporary society

It is not possible today to ignore demands for living comfort and for a high technical level of equipment in a building. Nevertheless, every technical improvement should be carried out with the utmost care, particularly in respect to important cultural heritage objects.

5.2 Material reuse

Material reuse is the most characteristic feature of adaptive reuse. Reusing and recycling materials greatly reduces the total energy used in construction in comparison to that needed for building new objects. Particularly significant is the reduction of energy consumed in transporting materials, producing new materials, etc. Analysing the condition of existing material structures may both reveal new opportunities for reusing materials and also help determine the level of cost effectiveness.

In general, it is desirable to reuse the supportive structure whenever possible. In many cases, the supportive structure of industrial buildings was designed for such large loads that it has a sufficient capacity for new non-industrial uses provided that it remains in a sufficiently good technical state. Various other industrial materials and elements can be reused to provide added value to the project by preserving a unique industrial atmosphere.

It may also be possible to reuse certain technically insufficient elements even if this is not initially evident. For instance, old windows that do not meet modern thermal performance standards do not always need to be removed. It may instead be possible for them to remain in place and be doubled by new windows with modern thermal insulation qualities, which may result in even better thermal efficiency than through the use of new windows alone. One example of this approach is the Lokremise project in St. Gallen, which reuses the largest surviving locomotive ring depot in Switzerland in a way that preserves its industrial heritage while making the building usable for contemporary culture. A new and unexpected architectural quality can also be brought to a project by reusing common materials in an innovative way. This is the case with the Matadero project in Madrid, in which roof tiles were used to form partitions.

5.3 Energy efficient design

5.3.1 Passive design strategies

Passive design strategies based on the optimal organization of interior functions in respect to heating needs are essential for achieving good energy performance in buildings. In addition, the careful selection and use of materials in respect to their heat absorption, permeability, etc., can influence energy demands and the microclimate.

A significant issue in passive design strategy concerns the use of natural ventilation (fig. 1), which can reduce the amount of technologies that need to be implemented in the adapted object. The high spaces of industrial halls, for example, can form part of the ventilation strategy by serving as naturally ventilated atriums. Such strategies can also produce better aesthetic values in interior spaces.

Figure 1: Centro Cultural Daoíz y Velarde in Madrid by Rafael De La-Hoz. Natural lightning and ventilation is combined with the use of geothermal energy for heating and cooling.

The use of natural interior lighting is also very important because it not only conserves energy, but also promotes a sense of well-being and health among people. Achieving a good level of natural lighting can be difficult in certain industrial buildings with a large amount of interior space, which makes it necessary to rethink interior function and spatial organization in respect to the possibilities for natural lighting. Such constructive solutions as atriums or roof windows can be used in such cases. The Gemini Residence in Copenhagen provides for adequate natural lighting in an interesting way that also reduces the need to intervene in the existing building fabric. It reuses two former grain silos as the core of the structure in order to distribute light throughout an interior lobby that is as tall as the building and to provide support for apartments with fully-glazed facades that are hung on the exterior walls.

Many of the demands for additional thermal insulation can be resolved through the use of built-in forms, that is, various spaces which can be heated without having to alter the original facade. One example is the above mentioned doubling of such elements as windows and doors in order to preserve the originals while also meeting contemporary standards.

5.3.2 Alternative sources of energy

It is possible in some cases to use alternative sources of energy, such as photovoltaic panels, solar collectors, and geothermal energy, in order to make the readapted complex more self-sufficient in respect to energy supply. In the case of industrial buildings, the placement of such systems must be thoughtfully considered in order to not destroy the historical heritage values of the architecture. While this may be difficult at times, it is not impossible. These systems can be placed, for example, on the roof (fig. 2), within new structures in public space, or on newly built objects within the complex.

Figure 2: Halle Pajol, Paris. Jourda architects. Photovoltaic panels on the roof structure.

5.4 Storm and waste water management

Water pollution represents one of the most serious global environmental problems, and today it has become necessary to take into consideration on site water treatment and water management in even small scale projects. For instance, on site storm water management can reduce the dimensions of sewage piping and thus save both money and water, which can then be returned to its natural cycle. While the use of permeable surfaces in public spaces is the most important element in on site water management, swales and wetlands can also be constructed both to purify storm water and grey water, and to collect water for maintaining the vegetation or for use in toilets. Water consumption can in fact be reduced by up to 70% through the recycling and reuse of grey water. Because such water elements as fountains, constructed wetlands, etc., have a significant climate impact on their surroundings, they can be used to make public space more attractive and habitable.

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5.5 Vegetation as an integrated element of design

Many architects and urban planners underestimate the importance of vegetation and its climate performance as a component of urban architecture even though vegetated surfaces have, as Jabareen remarks [4], a substantial effect upon on the climate, air quality, and water runoff properties of the site, and on the stability of the local hydrological system. The most important properties of vegetation are photosynthesis and evapotranspiration. CO_2 consumption during photosynthesis has a direct impact on air quality, while the return of water to its natural cycle through evapotranspiration lowers the local temperature and improves humidity. In addition, the tree canopy reflects a significant part of solar radiation, which mitigates its absorption by building structures and other surfaces [5]. These properties make vegetation one of the most effective means available for reducing the urban heat island. The appropriate location and integration of vegetation in order to utilize its beneficial climate properties and reduce energy demands for cooling and heating can thus be an important element of passive design strategy. Alberti [6] discusses how vegetation, in addition to its climate impact, also has a fundamental influence upon the creation of aesthetic values, providing attractive public spaces of high quality and making a community liveable. It is also important to note that certain species of plants possess phytoremediation properties that can be utilized to clean contaminated soils during brownfield regeneration [7]. This is of significant relevance for former industrial sites. The appropriate integration of vegetation in building structures and public areas can thus improve the sustainable performance of a readapted complex in a very natural way.

5.6 Economic factors

As mentioned above, the future viability of adaptive reuse projects requires professional evaluation in all cases. Well prepared analyses of whether it is possible to successfully adapt a given building or site is an extraordinarily complex task that must always conducted in cooperation with qualified experts. As James Douglas [8] remarks, “the adaptability of a building is its ability to undergo a change of state.”

The condition of the structure and the materials is one of the major factors that must be taken into consideration at the very beginning of a reuse project since the cost of reusing and reforming existing structures may be immeasurably greater in certain cases than the cost of demolition and new construction. When there is no demonstrable cultural-historical value in a given structure, and when no social impact is foreseen in connection with its reuse, costs factors can push a given project beyond the limits of sustainability. It is always necessary to evaluate the qualities of a specific building with great care.

The way in which a particular adaptive reuse project is budgeted is also important in determining its sustainability. Expenses must be addressed responsibly and conceptually. Neither should the quality and possible positive social effects of an adaptive reuse project be sacrificed for the sake of commercial success, nor should a project be implemented solely for the social

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effect it will have. The higher the funding for a project, particularly when public finances are involved, the greater is the social responsibility associated with its implementation. The new Hamburg Philharmonic Hall, which is now being constructed on a former warehouse site in Hamburg harbour, provides an unfortunate illustration of what can go wrong with a publicly funded adaptive reuse project. Due to technical problems and poor initial cost estimates, the current total project cost of approximately €800 million is more than 400% over the initial 2006 budget of €186 million. In addition, the building is now expected to be completed seven years behind schedule in 2017 [9].

Low-cost reuse strategies – which may at times be the only possible way in which to proceed – are both valuable and logical. They involve beginning renovation as a long term ongoing process that initially focuses on reusing those parts of the site that are needed in the early stages of a given project. Low-cost initial use may also attract a degree of public or private attention support that will facilitate proceeding to subsequent stages of the project. Phased implementation is in fact almost always necessary in the renovation of a large industrial object. A good example of the phased low-cost adapted reuse of a very large former industrial area is Matadero in Madrid. The adaptation of this former slaughterhouse complex into a cultural centre consisting of a library, non-fiction cinema, theatre and music hall, gallery, etc., was divided into several phases in accordance with how particular areas of the site were to be reused. The readapted areas that have already been opened to the public are expected to help attract the additional financial resources needed to complete the project.

5.7 The circular metabolism model

All of the issues mentioned above need to be interrelated during the design process in order to form a well-functioning whole. This is necessary in order to adapt and improve the original technological flows of a former industrial ecosystem so that it can be transformed into an adaptive reuse ecosystem. This will ensure the durability and efficiency of the new uses of the object, reduce its ecological footprint, and provide environmental and social benefits for the surrounding area.

A successful example of a city district design strategy based on the circular metabolism model is Hammarby – Sjöstad in Stockholm. This urban district is built adjacent to a power station equipped with modern clean technology that burns waste. All water, waste, material, and other cycles are closed loops that minimize energy demand, maximize waste and water recycling, and provide a habitable public space with a high aesthetic value. The city of Stockholm is currently working on several other projects for new sustainable neighbourhoods in former port facilities, urban industrial areas, etc. The areas to be developed through these projects, which involve the entire range of sustainability principles, will be well connected to the city structure. It should be noted that Stockholm is one of the most progressive cities in respect to sustainable urban development.

6 Conclusions

The Fifth Assessment Report of the IPCC released in 2014 confirmed once again the inevitability of environmental and social problems associated with global climate change. This has furthered discussion among politicians, researchers, and architects who are focused on transforming our cities into more sustainable systems. There are many theories current in urban planning, including dense cities, eco-villages, new urbanism, smart growth, etc. [2–4], that seek to identify how it may be possible to attain sustainable goals. One common topic concerns the adaptive reuse and recycling of materials, waste, and energy. Adaptive reuse is a strategy with a high potential for sustainability that should be supported by local representatives. Focusing on abandoned urban sites and on methods for their sustainable adaptive reuse can help the city as a whole achieve the goal of sustainability and initiate the transformation of a linear urban metabolism into one that is circular.

Our research concerning adaptive reuse projects has revealed that a holistic approach encompassing such features of sustainable design as the use of alternative energy sources, water management, passive design strategy, etc., has as yet rarely been an element of adaptive reuse strategies. The ecosystem approach can enrich adaptive reuse projects with many valuable features and properties capable of having a positive impact on local climate, energy demand, and social sustainability. Projects based on this complex approach could become flagships of sustainable urban transformation and development. Although there now are a number of methods based on long research concerning how to design self-sufficient and sustainable buildings, the transformation of former industrial sites into liveable and sustainable green oases continues to constitute a significant challenge. Further exploration of this issue is required so that adaptive reuse can be integrated into contemporary urban strategy.

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