The second life of industrial buildings and the process of their reuse

Executive summary of the dissertation submitted to the Budapest University of Technology and Economics in partial fulfilment of the requirements for the degree of

Doctor of Philosophy

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1. Introduction

The development of cities is determined by several geographical, social and economical aspects. The social, economical, industrial-technological changes caused a significant part of American and Western European plants and factories to close in the last third of the 20th century. The abandoned industrial areas were occupied by artists. (Keresztély, 2004) These initiations became accepted, even trendy after the late seventies, when market-based developments started up (Sóóki-Tóth, 2002). Reuse Projects became more and more popular and varied.

In Central and Eastern Europe, and thus in Hungary as well companies ceased or disintegrated with the political change. That is why there are a lot of abandoned or under-utilised industrial buildings, some of them very close to the city centre. Developments started in the former industrial areas, these utilisations usually meant the destruction of the buildings. (Barta–Kukely, 2004) The change of function in former factories and warehouses has become accepted by now – the rehabilitation of these areas and buildings is an interesting architectural-urban task in these days.

The reuse of industrial buildings, initiated either to preserve the industrial heritage or for real estate development, presents some serious technical issues and gives the building a chance to survive. Introducing reused industrial buildings and related projects, analysing the processes, developing related (technical-economical) examination, and evaluation methods can help to save valuable buildings from demolition. This makes it necessary to examine the reuse and the relevant areas, buildings, their structures, materials, and the technologies of refurbishment, strengthening structures and other interventions.

1.1. The scope of the dissertation

I used the following limitation of scope in certain sections of my research:

- The examination of the interactions between the city structure, the surrounding areas and the reutilisation was restricted to Budapest. The Hungarian capital has industrial areas in various locations, and this makes it possible to analyse the effects of different factors.
- I concentrated on the second half of the 19th century and the first half of the 20th century during the review of architecture and building structures. A relatively great number of industrial buildings has survived from that period, and the diversity of the applied materials and structures lends itself to scrutiny.
- To analyse and compare examples I collected and catalogued domestic and foreign realised projects, and a few projects being planned or under realisation.
- With regard to technical and economical issues, I used European, mostly Hungarian literature. Economy was examined in terms of technical interventions only.

Reuse means (unless stated otherwise) the reuse of the building, including partial demolition, structural alternation and extension.

The word *brownfield* means abandoned, under-utilised industrial, commercial and vehicular areas, where the probable contamination raises difficulties in the rehabilitation.

1.2. Summary of literature studied

The domestic and foreign literature studied presents a base for comparison and helps with methodology during the research.

The characteristics of the industry in Budapest are discussed in studies about the development of Budapest as well as in other sources concerning the history of the industry. Thus the emergence and changes of the industrial areas of the capital can be described. The size, location, usage of brownfields in Budapest were examined and presented, but the sources about brownfield renewal pay minimal attention to the factors that influence the future of buildings.

The recommendations of books about industrial architecture and building structures in the reviewed period help to form a comprehensive view of applied structures and considerations of forming space and substance. The literature in building diagnostics and reconstruction focuses on structures of residential buildings. After defining structures and materials typical of industrial architecture, the necessary examination methods and adaptable renewal technologies can be gathered. *The subject of reuse – the location, typical structures of buildings – and the feasible methods can be defined comparing source works, but there is no summarising study on this in the literature.*

The reutilisation of industrial buildings is rarely discussed in a theoretical view, mainly the realised outcome is reported from an architectural point of view (function, form, perhaps structure). The issues of real estate development or effects on city structure are hardly taken in consideration. Theoretical works on the reuse of industrial buildings deal with the problems and questions of preparation of implementation. *Different sources emphasise different aspects in introducing reuse projects. There is a lack of a uniform system of criteria and a conscious, unambiguous method for preparation and examination of reutilisation within the studies.* There is no synthesis of information, the data can not be compared, can not serve as a base for general conclusions and results.

A shortcoming of the literature on rentability is that the sources only allude to the extra costs of the reutilisation, but a detailed survey about the causes has not been performed. This lets us deduce that reuse is more expensive than a new building, but under particular circumstances costs can be spared. To come to a decision in the reuse process, not only rentaboility but also other aspects (such as ecology, considerations of men-environment studies etc.) should be taken into account.

2. The aims of the dissertation

In most cases of brownfield reutilisation, the decision is to demolish the buildings even if the condition would not necessitate it by all means. The foreign and (slowly thriving) domestic examples prove that the reuse of former industrial buildings can also be successful. Reuse promotes not only the aspects of preserving the built heritage but also the considerations of sustainable development. Reuse examples can be catalogued, analysed, compared in more, different respects with the help of an interdisciplinary, complex examination method.

The aim of the research is to reveal the conditions and the connections of the reuse by examining the reutilisation of industrial buildings:

1. Describing the reuse process;
2. Investigating the renewal of brownfields:
   a. Defining urban conditions;
   b. Examining the effects of contamination and the decontamination process;
3. Revealing the technical-architectural-urban factors that determine decisions about reuse;
4. Analysing the change of function in industrial buildings:
   a. Setting up a system of criteria for the inspection;
   b. Determining connections between the reuse, the new function, and the characteristics of the buildings;
5. Examination of the technical interventions related to reutilisation:
   a. Gathering and introducing the typical structures of buildings waiting for reuse;
   b. Introducing the available technologies of refurbishment and reinforcing;
   c. Evaluating the most important building materials used in the technical interventions;
6. Analysing the degree of necessary technical interventions:
   a. Developing a classification to describe the degree of interventions;
   b. Determining connections between the degree of the interventions and some characteristics of the building.

3. Research methodology

The renewal of industrial building and sites is a complex process, the plots and buildings have to be inspected from specific points of view, which determined the course of research. The method is principally based upon analysing publicised data and examining accomplished reuse projects.

3.1. Urban aspects of the renewal of industrial sites, decontamination

Besides studying factors determining the future of brownfields such as the City Structure Plan of Budapest, Conception of City Development of Budapest, zoning plans and building regulations of selected areas I chose two districts for further examination: the former plot of *Metallochemia* in *Nagytétény*, and the area along *Váci Street* in *Angyalföld*. The considerations of selection were the differences in the situation in the city structure, the conditions of renewal, the contamination, as well as issues of the investment. I examine among others the characteristics regarding the city structure (e.g. traffic, surrounding functions, etc.) and its influences on prospective functions, the development goals and tools of government and municipalities.

The process of decontamination and its consequence – starting from inspection of the effects of the former industrial technologies to the after-control – are described using foreign and domestic literature of the topic, publicised case studies as well as the inspection of operations in the field (Metallochemia).

3.2. Examinations of the building

The architectural characteristics are observed on European, publicised or visited examples (mostly from Budapest), and the Hungarian Austrian and German literature of industrial architecture of the period. I collect and systemise the examinations of the condition of the buildings aiming to determine the necessary interventions. The assessment of the historical, architectural value of the building is carried out with the help of the literature of protecting the industrial, built heritage and some protected industrial buildings.

3.3. Examination of the change of function in industrial buildings

The aspects of appointing the function during reuse and the influence of determined characteristics of the building on the prospective function can be analysed on real projects. Because of this foreign and domestic, publicised or visited, accomplished or ongoing projects are examined. Besides architectural aspects ones about the person of the investor are considered.

3.4. Analysis of typical materials and structures of industrial buildings, and the technical interventions of the reutilisation

The often applied materials and typical structural solutions are introduced using existing buildings, plans, books about industrial architecture and building structures and sample collections as source. The technical interventions related to reuse can be gathered and catalogued comparing the literature of technologies of renewal, reinforcing and maintenance and the practice.

The base of surveying the most important building materials available in refurbishment and reconstruction was an ecological assessment made by Független Ökológiai Központ (FÖK, Independent Ecology Centre). (FÖK, 2005) This was complemented with the technological characteristics and the costs of the materials. The weighted average of the results of these three assessments is the so called Quality Rating, which can be used to rank the building materials. In the course of the comparison the materials were evaluated in structures with nearly same technical characteristics and in the same units (m^2, m^3, pcs.).

In the assessment by the FÖK a Life Cycle Assessment materials was performed (through all stages of their life, "from cradle to grave"), that resulted the Ecological Rating (ÖJ) where materials get points from 0 (worst) to 3 (best).

The technological rating consists the aspects of choosing materials during the planning of implementation; these are Requirement of Machinery (G), Requirement of Labour (L), Requirement of Skilled Workers (SZ) and Time Investment (I). For analysis performance standards (or standard outputs) and material standards were used (Terc, 2005). The calculation of the Technological Rating (BJ) is:

$BJ = \alpha BG \times G + \alpha BL \times L + \alpha BSZ \times SZ + \alpha BI \times I$, (with a value of 0-3 points).

The costs of technical interventions depend principally on the building material, its usage and the building technology. The costs (including cost of material (A), cost of added materials (S), wages (M)) were assigned with Viking calculation software from Terc Ltd. (Terc, 2005) in characteristic structures. The value of the Cost-Rating (KJ) is:

$KJ = \alpha K1 \times A + \alpha K2 \times S + \alpha K3 \times M$ (with a value of 0-3 points).

Integrating these three parameters results the Quality Rating (MÉ), with a value of 0 (worst) to 3 (best) points:

$MÉ = \alpha Ö \times ÖJ + \alpha B \times BJ + \alpha K \times KJ.$

The weightings (α_{BG}, α_{BL}, α_{BSZ}, α_{BI}, α_{KA}, α_{KS}, α_{KM}, $\alpha_{Ö}$, α_{B}, α_{K}) in calculations can be determined considering different preferences of investors.

3.5. Checking rentability of planned functions and interventions

Analysing of typically applied technical interventions of the reuse can be performed with classification of the examples which were scrutinised during the investigation of change of function. With the extension of Nedderman's (2005) fault-rates of building structures to whole buildings the intervention-rates can be developed. The further aspects of the examination were: functional, location- and monumental categories.

4. New scientific results

1. *I proved with my examinations that the renewal process of brownfields in Budapest is principally determined by the two following factors:*

- *The situation of the areas in the city structure: the renewal of the brownfields depends primarily on the rate of approach from the city centre.*
- *The expenses of decontamination: the different technologies of decontamination can fulfil the technical conditions of the reutilisation, but in certain cases the high costs set back the renewal. (Lepel, 2006a)*

The future of brownfields is significantly influenced by the characteristics of the plot and the block of houses. An important factor of the renewal of the areas is their situation in the city structure, because the reutilisation has to accord with the existing city structure and its planned development. Ongerth (2003) draws connection between the speed of renewal of an area and its physical distance from the city centre. In the course of examining the selected areas (Dissertation chapter 4.1. and 5.1., Lepel 2006a) I observed that it is not the physical distance, but the rate of approach which is determinant. It is confirmed by the differences of renewal of the plots on the side of the main street and the ones on the side of the back-street in the same block of buildings. The renewal is finished on the plots next to the Váci Street, but the rehabilitation of the Madarász Street side has not even started yet in the block of Váci street 169-177. It can be observed that on the areas with the fastest renewal the utilisation of plots did not mean the utilisation of buildings.

The summary of technical interventions of decontamination reveals that a particular part of the interventions (e.g. all of the in situ solutions) can be carried out with the preservation of the buildings. (Dissertation chapter 4.2. and appendix 3.) The hypothetical or real contamination of the sites sets back the renewal and causes deterioration (Barta, 2002; Hornsby–Sawchuck, 1999). If the reason for that is not technological, then the costs of the decontamination must cause this negative effect. The decontamination of the Metallochemia with a so called sarcophagus could be realised with preserving some of the buildings. Beyond the contamination of the area the contamination of the building structures and the new functions explain the demolition.

2. *Based on my examinations I stated that after losing the function of an industrial site the future of the building is determined by*

- *the zoning plans, master plans of different level,*
- *the architectural and/or historical value of the building, protection of monuments,*
- *the contamination of the site, the according methods and costs of decontamination,*
- *the condition of building structures.*

The decision about reuse should be made considering technical, legal and economical aspects. Among technical aspects are the urban characteristics of the areas, the contamination of building structures, the soil and the subsoil water, the characteristics of the building such as the architectural and historical value, the size and form of available spaces, the building materials structures and their condition. Examinations of the areas are summarised in the Dissertation chapter 4.1. and 4.2., surveys of the building are summarised in chapter 4.3.. The question if the preservation is possible or worth it, is determined by the following technical-architectural-urban factors (Dissertation chapter 4.4.):

- The regarding zoning plans, master plans, layout plans and building regulations: when such function or building over is specified that can not be fulfilled with the preservation of the building, or when the preservation of some buildings is recommended or ordered to protect industrial heritage.
- The architectural or historical value of the building, which can result in monument protection.
- The contamination of structures can account for demolition of buildings.
- Among the building materials and structures primarily the condition of load bearing structures and the building envelope is that influences the decision about preservation, reuse. Load bearing structures can be classified as sufficient, passable or dangerous. In case of dangerous, life threatening structures danger must be removed – one way for that is to demolish the building.
- Other characteristics of the buildings such as location, size, layout structure.

It must be pondered in each case if there is a different way of solving the problems than demolition, especially when dealing with a valuable (architectural / historical value) building.

3. *In the course of my research I developed an examination method that enables the analysis, assessment of the change of function in industrial buildings from the aspects of architecture, urban studies and development. The building-function analysis matrix makes it possible to compare and statistically survey the collected examples. Using this matrix, I could observe relationships between*

- *the new function and the status in the city structure,*
- *the new function and the layout system,*
- *the new function and the monument protection. (*Lepel, 2006b és 2006c)

The building-function analysis matrix (Dissertation chapter 4.5.10. table 4., chapter 5.3. tables 26. and 27. and Lepel 2006b, és 2006c) contains the functional alignment

- Dwelling function;
- Offices;
- Commerce, services;
- Industry, warehousing;
- Cultural – exhibition, presentation, education;
- Leisure, sports;
- Miscellaneous;
- Other.

and some other characteristics of the building:

- the location of the building – three zones in the city structure; (Dissertation chapter 4.1.)
- the historical and architectural value of the building (Dissertation chapter 4.3.3.)
- the layout structure of the building (Dissertation chapter 4.3.1.)
- the person of investor (owner).

Building-function analysis matrix The relationship between building-characteristics and the new function, based on analysing examples	Dwelling function	Industry, warehousing	Offices	Commerce, services	Cultural - exhibition	Cultural - performance	Cultural - education	Leisure, sports	Miscellaneous	Other	Total
Location of the building											
Internal zone	7	0	5	2	3	3	3	4	1	0	28
Interim zone	6	5	2	8	7	4	4	5	11	1	53
External zone	4	6	2	2	2	1	1	4	5	0	27
Historical, architectural value of the building											
Monument (protected) – with hist. arch. value	5	5	2	5	5	3	3	2	11	0	41
Not monument – with hist., arch. value	6	2	5	5	6	3	0	6	2	0	35
No significant historical, architectural value	6	4	2	2	1	2	5	5	4	1	32
Layout system of the building											
Single-floor monoaxial (x)	0	2	1	1	2	4	0	4	0	0	14
Single-floor biaxial (x; y)	1	0	0	4	1	0	0	0	0	0	6
Multi-storey monoaxial (x; z)	10	5	4	4	3	1	2	3	6	0	38
Multi-storey biaxial (x; y; z)	4	1	2	1	3	2	3	1	2	0	19
Special	1	0	2	0	1	0	0	3	1	0	8
Composed	1	3	0	2	2	1	3	2	8	1	23
Investor, owner											
Private	4	3	7	10	2	0	0	2	4	0	32
Public (government, municipality)	2	0	1	0	4	2	6	3	1	0	19
PPP, state subsidised projects	11	8	1	2	6	6	2	8	12	1	57
Total	17	11	9	12	12	8	8	13	17	1	

1. table – The arrangement of the elaborated domestic and foreign examples in the matrix (The individual fields indicate the number of examples assigned to the proper category.)

Arranging domestic and foreign examples of reuse into the matrix led to the following results (Diss. chapter 5.3.)

- A great part of the reused industrial buildings (49% of the elaborated examples) is situated in the interim zone. This is explained by the original location of the buildings, but also lets us conclude a greater willingness of utilisation.
- The representation of multi-storey buildings is surpassingly high (52,3 % of the analysed projects). The reuse of multi-storey monoaxial buildings is the most typical. The reutilisation of multi-storey buildings can be explained with a specifically greater useful floor-space, and this design fits better to urban use of areas and buildings.

– The outstanding architectural, historical value (that results in protection) is not an advantage in the reuse: only 38% of the examined cases are protected. Buildings with no significant historical, architectural value make 29% of the analysed examples. The protection of the industrial heritage has longer traditions in Western Europe; the monuments have also higher prestige here. The rate of Hungarian examples is almost the same among protected buildings as in the whole set of elaborated examples.

4. *In the course of my research I developed an evaluation method, in which zhe existing economical assessment of the most important materials of technical interventions of reuse was extended to a quality rating that takes also the technological characteristics and costs into consideration. This enables to choose the most appropriate building material for each structural element.* (Lepel, 2004)

The choice of the building materials to be applied is made pondering several factors in the planning phase of reutilisation. Defining the Quality Rating:

Not only the technical aspects and costs are considered, but also the ecological characteristics of the building materials minding the sustainable development – according to the preferences of the decision-makers. The aspects and weightings of the evaluation of the building materials available for a structural element are listed in table 2. (Dissertation chapter 3.6. and 4.6. and Lepel, 2004). The characteristics of the materials of renewal of various structural elements are summarised in the Dissertation tables 9., 11., 15., 17., 19., 21., 23. and Appendix 5.

Sign.	Characteristics	Method of evaluation	S1	S2	S3	S4	S5
ÖJ	Economical Rating (FÖK, 2005)	Value of 0-3 points, where 0 is the worst, 3 is the best result *: values of 1-3 points	50	25	20	20	30
BJ	Technological Rating (Terc, 2005)		25	50	50	30	35
G	Requirement of Machinery		25	10	40	25	25
L	Requirement of Labour		20	10	10	20	20
SZ	Requirement of Skilled Workers		25	10	40	25	25
I	Time Investment		30	70	10	30	30
KJ	Cost Rating (Terc, 2005)		25	25	30	50	35
A	Cost of material *		35	35	35	35	35
S	Cost of added materials		30	30	30	30	30
M	Wages *		35	35	35	35	35

2. table – Aspects and weightings of evaluation of building materials

Here follow as example the evaluations of materials of foundations, building floors, roof structures and roof coverings (tables 3., 4. and 5.) with weighting S4: Nearly balanced, average approach of investors.

Materials - foundations	**Characteristic of the material***, lifespan, years	**ÖJ** Ecological rating*, points	**BJ** Technical rating**, points	**KJ** Cost rating**, points	**MÉ** Quality rating**, points
Local stone	100	1,58	2,15	2,00	1,96
Dismantled brick	50	2,00	2,46	1,30	1,79
Reinforced concrete	80	1,93	2,23	1,97	2,04
Concrete	80	1,92	2,30	2,54	2,34

*(FÖK 2005); **calculated data.

3. table – Evaluation of the materials of foundations

Materials – building floors	**Characteristic of the material** *, bulk density, kg/m^3	**ÖJ** Ecological rating*, points	**BJ** Technical rating**, points	**KJ** Cost rating**, points	**MÉ** Quality rating**, points
Wooden floor	600	2,53	2,23	2,70	2,53
Prefabricated floor	1300	2,03	2,50	2,38	2,35
Reinforced concrete floor	2400	1,93	2,23	1,97	2,04
Jack arches (brick)	1800	1,90	1,60	1,68	1,70
Steel strenghtening	u.c.	2,50***	2,33	1,84	2,12

*(FÖK 2005); ** calculated data; ***estimated data; u.c.: uncharacteristic data.

4. table – Evaluation of the materials of building floors

Materials	**Characteristic of the material** *, bulk density, kg/m^3	**ÖJ** Ecological rating*, points	**BJ** Technical rating**, points	**KJ** Cost rating**, points	**MÉ** Quality rating**, points
Roof structures					
Wood	600	2,40	2,35	2,94	2,66
Steel	7900	1,25	2,50	1,57	1,79
Steel-wood	7800	2,00	2,38	2,24	2,23
Reinforced concrete	2400	1,93	2,23	1,97	2,04
Roof coverings					
Ceramic roof tile	2500	2,40	2,35	2,91	2,64
Concrete roof tile	2400	2,23	2,35	2,84	2,57
Aluminium plate	2700	1,06	2,83	2,51	2,32
Steel plate	7500	1,25	2,83	2,51	2,35
Artificial slate	1800	1,70	2,35	2,68	2,39
Bitumen shingle	1000	1,63	2,18	2,34	2,15
Titan-zinc	7200	1,10***	2,35	1,00	1,43
Bituminous board	n.a.	1,58	2,20	2,00	1,98
EPDM sheet	n.a.	2,00	2,50	2,60	2,45
Plastic sheet	600	1,25	2,55	1,93	1,98

*(FÖK 2005); ** calculated data; *** estimated data; n.a.: not available.

5. table – Evaluation of the materials of roof structures and coverings

5. *In the course of my research I found it necessary to develop an examination method, which gives a quasi-statistical numerical data of the typical degree of interventions by using the classification of the technical interventions of the reuse. With this method relationships can be presented between:*

– *the degree of interventions and the new function,*
– *the degree of interventions and the layout structure of the building.*

The Intervention-classes describing the degree of interventions used in reutilisation and the selected technical-architectural-urban factors can be arranged into a matrix similar to the building-function analysis matrix (Dissertation chapter 4.7. and 5.5.) The table contains the intervention-classes:

- I. Intervention-class: cleaning and reparation – mostly the surfaces, claddings and coverings, roofing, doors and windows need restoration. There is no intervention in the loadbearing structure.
- II. Intervention-class: reparation, restoration, few new structures (change) among coverings, doors and windows, appliances, piping and networks of building engineering. Minimal reparation of the loadbearing structures may be needed.
- III. Intervention-class: major need of reparation, higher rate of replacement, change, applying new structures (e.g. new insulations, partition walls, etc.). Lesser strengthening of the loadbearing structures.
- IV Intervention-class: The rate of new structures (replacement, change) is higher than the rate of old structures (renewal, reparation). Significant intervention in the loadbearing structures (such as creating new sections of building floors) may also be needed.
- V Intervention-class: the amount of new structures is much higher than of old, restored structures – here belongs for example the change of the loadbearing structures.
- /A extension: besides the old building (part), new parts are erected. The costs of the new building can be estimated separately.
- /B extension: a part of the old building is demolished. The costs of repair, renewal, reconstruction are replaced partly by the costs of demolition.

and the following characteristics of the reuse:

– the location of the building; (Dissertation chapter 4.1.)
– the historical and architectural value of the building (Dissertation chapter 4.3.3.)
– the layout structure of the building (Dissertation chapter 4.3.1.)
– the new function of the building (Dissertation chapter 2.5.)

Arranging the domestic and foreign examples into the matrix presents these relationships:

– The interventions of the reuse of industrial buildings typically belong to the II. and III. Intervention-classes. Utilisation with minimal intervention (I. Intervention-class) was possible in 10 % of the cases, principally by functions industry, warehousing. Maximal (class V.) interventions were implemented only in cases of residential, office, commercial and mixed-used buildings.
– Reuses of I. Intervention-class were proceeded typically in monoaxial (single-floor and multi-storey) buildings. This is an other explanation of the high rate of reusing multi-storey monoaxial buildings.

Confines of costs can be assigned to the Intervention-classes based on existing statistical analysis and calculations.

Analysis matrix of the interventions of reused industrial buildings	I.	II.	III.	IV	V.	A	B	∑
Location of the building								
Internal zone	1	7	11	4	2	3	2	25
Interim zone	3	18	17	4	3	5	3	45
External zone	6	9	4	3	1	2	2	23
Historical, architectural value of the building								
Monument (protected) – with hist. arch. value	3	10	6	2	1	1	1	22
Not monument – with hist., arch. value	5	11	15	6	4	5	3	41
No significant historical, architectural value	2	13	12	7	3	3	3	37
Layout system of the building								
Single-floor monoaxial (x)	4	6	4	6	2	3	1	22
Single-floor biaxial (x; y)	0	2	1	0	0	2	1	3
Multi-storey monoaxial (x; z)	4	14	13	1	2	4	3	34
Multi-storey biaxial (x; y; z)	0	2	7	3	1	0	3	13
Special	2	0	3	4	1	1	0	10
Composed	0	11	6	0	1	1	1	18
Functions								
Dwelling function	0	3	7	2	1	2	5	13
Industry, warehousing	4	6	0	0	0	0	0	10
Offices	0	2	4	1	2	1	1	9
Commerce, services	2	4	1	2	1	0	0	10
Cultural - exhibition	1	6	2	0	0	2	0	9
Cultural - performance	1	6	3	3	0	1	0	13
Cultural - education	0	2	5	1	0	2	0	8
Leisure, sports	1	1	2	2	0	1	1	6
Miscellaneous	1	5	10	2	3	2	2	21
Other	0	0	0	1	0	0	0	1
Total	10	35	34	14	7	11	9	

6. table – The arrangement of the elaborated domestic and foreign examples in the matrix (The individual fields indicate the number of examples assigned to the proper category.)

5. Practical utilisation of the results

In the course of my research I intended on developing examination methods and results that are of theoretical and practical use. This dissertation makes up the shortage of recapitulative studies about the optimal reuse of industrial buildings in Hungarian language.

The methods and results introduced can be used by several participants of the reuse process (e.g. municipalities, owners, developers, designers, etc.) The examination of brownfields and the presentation of the decontamination can be used the most widely in the renewal process of brownfields, but the preparation of rehabilitation can be also supported by the value assessment of the buildings and the presented case studies. The prepared aspects of examinations and categories along with the datasheet help to develop a cadastre for value protection that can conduce to the optimal protection and reuse of industrial buildings, and the control of the processes.

The relevant chapters provide information for the participants (e.g. investors, designers, advisors, contractors, authorities etc.) in different phases of reuse process of industrial sites and individual buildings. In the phases of project preparation the presented examination methods for areas and buildings take part in the preparation of the decision about reuse.

In the course of planning the building-function analysis and its results can help in conceptual planning and finding a new function. These results should be taken into consideration in reuse projects and during planning a new building– minding the sustainable development one should think about the possibilities of the future reuse as well.

The collection of characteristic structures and the review of the needs and the available technologies of refurbishment-reconstruction can be directly used in the course of the renewal (building surveys, planning and implementation of technical interventions) and the maintenance of industrial buildings. The evaluation method of building materials and its results are useful during the preparation of decisions, planning of interventions and the implementation.

Introducing accomplished reuse projects can widen the approach of public and private participants; hence it can raise the chance of survival of former industrial buildings.

6. Possible tasks of further research

I analysed and evaluated several examples in the course of the research. As the number of reuse projects grows, the range of examples to inspect continuously flares. To broaden, refine and specify my results the *process of further examples* is necessary.

A practical extension of the examination of technical interventions in reuse projects could be the *numerical survey of the costs of interventions*, and the preparation of a database. It would need a great amount of cost-data of accomplished reutilisation projects to do it, but these are slightly accessible because of the characteristics of private investments.

The comparison and evaluation of renewal technologies could be similar to the evaluation of the materials. The technological characteristics and the costs as well as the ecological assessment of the materials and the technologies would be necessary for that. The ecological analysis of the materials contains the energy consumption and harmful emissions of the building process, but it is different in each technology even in each project. I did not find data on the ecological assessment of building technologies at the time of my research.

It had practical use to develop the detailed *system of building surveys* coming before reuse – also the methods of monument investigation and examinations of building diagnostics. Further research possibility is to reveal the special questions of implementation of the reutilisation.

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