

Selected issues on the role of electric lighting in the regeneration programs of urban spaces in Poland

Abstract. This paper reflects on the basic research done in the area of outdoor public lighting in regard to regeneration processes. The general purpose of this scientific paper is to investigate the role that lighting design plays within regeneration frameworks. Referring to a wide spectrum of academic publications, the paper provides an overview of regeneration and outdoor public lighting objectives. Emphasize is put on the obstacles for lighting design implementations in the regeneration processes in Poland.

Streszczenie. Referat obejmuje wybrane zagadnienia dotyczące projektowania zewnętrznego oświetlenia elektrycznego w procesach rewitalizacji terenów miejskich. Celem tego opracowania jest zbadanie roli projektu oświetleniowego w programach i procesach rewitalizacyjnych. W referacie zestawione są zadania rewitalizacji z zadaniami projektów oświetlenia miejskiego. Przedstawione są też powody, dla których problematyka projektowania zewnętrznego oświetlenia elektrycznego w tkance miejskiej nie jest szeroko popularyzowana w kontekście procesów rewitalizacji. (Wybrane zagadnienia dotyczące roli zewnętrznego oświetlenia elektrycznego w programach rewitalizacyjnych przestrzeni miejskich w Polsce.

Keywords: architectural lighting, regeneration frameworks, lighting design

Słowa kluczowe: oświetlenie miejskie, rewitalizacja, projektowanie oświetlenia

Introduction

The purpose of this paper is to reflect on the role of outdoor electric lighting design for public spaces in urban regeneration (1). There seems to be a widespread absence of public lighting within urban regeneration considerations and studies in Poland. The role of electric lighting design in revealing a night image of the city [1,2], creating safety [3,4,2,5], stimulating human circadian system [6], and creating social experiences for its users [7,8], are widely discussed, as well as energy saving potentials in public lighting [9]. The extensive usage of light and light pollution issues are also commented on [10,11,12]. However the subject of outdoor electric lighting is not investigated properly in respect to the revitalised urban areas [13].

Background: urban regeneration definition, approaches and objectives

Regeneration frameworks and projects are very complex, multidimensional processes, whose vast issues include the social, spatial and economic aspects of changes, introduced to declining urban areas, to transform their negative image. Such processes are based on the cooperation of partners and professionals from different sectors: public, business, industry, government, but also depend on the residents' involvement. The understanding of the urban regeneration and revitalization processes differs as well as the character and scale of the transformations. [14,15] (2). The regeneration processes may include actions to find solutions for particular social problems, e.g. to improve housing and living conditions or safety (prevention of social pathologies). The chosen intervention should enable economic growth by ensuring good conditions for local business development (new jobs). It may also transform spatial planning and infrastructure by culture and heritage renovation, modernization and maintenance of historic architecture and spaces [14]. Furthermore, regeneration processes should ensure sustainable development in the community and an improvement of the environment (see Fig. 1), [16].

The systematically implemented regeneration plan should be evaluated for improvements and changes in a context of the local environment but also regarding political and institutional arrangements to guarantee the legislative and organizational adequacy of adopted strategies [16]. In the *Revitalization Act*, regeneration is understood as a

planned set of activities involving an integrated restoration of degraded area, aimed at recovery and improving the functionality of the area or the quality of life in the area [17]. For the purpose of this paper, urban regeneration is understood as a chain of activities performed to bring about an economical, environmental, spatial and social revival within the declining urban locations (see Fig. 1) [16,18].

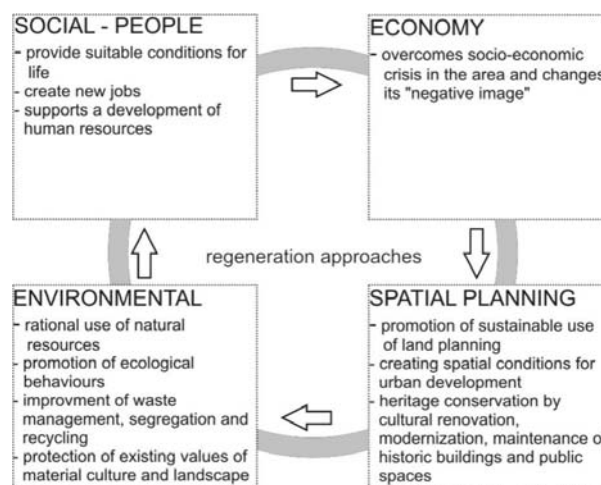


Fig. 1. Approaches towards urban regeneration

The urban regeneration can include actions like repairs, modernizations, restorations and other operations, which improve the situation of the local communities [19], and emphasize the city dwellers' feeling of local identity. A regeneration of city centres and a renewal of historic parts of the urban landscape are regarded as elements of effective urban regeneration [20]. Studying urban regeneration projects and methods, each case brings a slightly different set of perspectives and solutions. The regeneration solutions are case-sensitive. However the objectives often have a universal character. The objectives of urban regeneration may include:

- I. Socio-economic recovery through improving the quality of public space, according to the rules of spatial order and aesthetics as well as promoting entrepreneurship.
- II. Development of tourism and culture on the basis of national heritage resources.

III. Increasing the safety of inhabitants and improving the communicational possibilities inside the housing estates.

IV. Integration of inhabitants, preventing and combating social exclusion [21].

Revitalization goals are seen as actions aimed towards creating favourable conditions for the development of a labour market, the implementation of ecological and efficient development of the housing stock, transport, environment, recreation, culture and the protection of a city's assets [22].

Urban regeneration and planning in Polish context

Urban regeneration processes were introduced in the late 1950s in many of the EU-15 countries. In Poland, the urban regeneration processes were launched after the socio-political transformations of the late 1990s. The acceleration of urban rehabilitation processes could be observed after Poland accession to the EU. With the second tranche of 2015-2020 of the EU funds, urban regeneration plans in Poland are still developed and implemented.

Urban regeneration aspects are widely described in Polish architectural scientific discourse (14, 16, 23, 24, 25, 26). The main issues of urban regeneration in Poland focus on reviving deserted city centres, which have lost their role as the focal points of cities; improving the quality of life; redeveloping the brownfield sites or post-military sites; and restoring social interactions in the areas of large residential dwellings (blocks of flats) [16, 23, 24, 25].

On the 3rd of November 2015 the new *Revitalization Act* was published in the *Polish Journal of Laws* [17]. Therefore, the importance of regeneration processes within urban planning and spatial management in Poland was reinforced by legal documents. It must be mentioned that the scales of revitalization processes may be vast, starting from one urban area and ending with projects at a national or worldwide scale. It is estimated that at least 22% of all developed lands in Polish towns and cities, which occupied around 120,000ha of urban areas, required urban regeneration (26).

Urban planning is a part of spatial planning. The stages of urban planning may include:

- analysis and understanding of the current state and dynamics of the chosen space
- identification of the urban vision and urban composition
- determination of planning regulations
- implementation of the urban vision – spatial economy

In the current practice, planning documents prepared at the local level (by local authorities) are divided to: *the mandatory documents* and *other studies on spatial development*. The urban regeneration plans belong to the latter group. Both groups of documents can affect the whole municipality structure or its chosen fragment. In addition, the plans are divided into those that present city functional structure, those that govern the possibilities of legal conditions and those that describe courses of action.

The urban regeneration processes in Poland are mostly based on the *local revitalization plan*. The plan created according to requirements delivered by *The National Regional Development Strategy (Narodowa Strategia Rozwoju Regionalnego)* and by the *Regional Operational Programme* for different voivodeships (*Regionalnego Programu Operacyjnego*) adopted by city councils. Those documents describe the main agendas for development of declined areas; urban rehabilitations objectives as well as regeneration plans (see Tab.1).

The urban regeneration programs should combine the operations of several areas, including the physical structure economy and rehabilitation plans. Unfortunately, in some cases these programmes are narrowed down only to an

adaptation of a single dwelling or a renovation of a few dwellings, missing the wider aspects of the urban regeneration and social revitalization [27]. Thus, despite some critical voices over the nature of regeneration processes in Poland, the belief is that spatial management level in is the right place to introduce lighting planning. The scale and character of urban regeneration processes require inclusion of lighting master planning especially in a case of selected areas of the city [13] (see Tab. 2).

Table 1. Typology of the planning documents in Poland

Area	City Structural Plans	Regulatory Documents	Action Plans
The whole municipality	Conditions and Directions of Spatial Development Study <i>Studium Uwarunkowań i Kierunków Zagospodarowania Przestrzennego</i> Community Development Strategy <i>Strategia Rozwoju Gminy</i>	---	Strategy policies
The chosen part of the municipality	Other urban studies and strategies <i>Strategie Obszarów Urbanistycznych</i>	Local Spatial (Management) Plan <i>Miejskowy Plan Zagospodarowania Przestrzennego</i>	Division strategies relating to the development of particular areas- including Urban Regeneration Programs Implementation Strategies

Table 2. Typology of the planning documents vs. lighting planning

Area	Action Plans
The whole municipality	Strategy policies
The chosen part of the municipality (city)	Division strategies relating to the development of particular areas- including Urban Regeneration Programs INCLUDING LIGHTING PLANNING Implementation Strategies

An incorporation of lighting scenarios within urban regeneration programmes creates a chance that public lighting would become integral part of the functional and spatial urban planning.

Lighting in the urban environment

The role of exterior electric lighting in the urban environment alters along with the rapid social and spatial changes taking place within a contemporary city. Until the early twentieth century, the public lighting was one of the elements of urban planning. However, the innovations in the light technology in twenty century along with urban design metamorphosis led to an accumulation of different layers of city lighting: lighting for public spaces, road lighting, lighting for pedestrians and cycling routes, floodlighting or architectural lighting, signage lighting, marketing and retail lighting. The design of public lighting got more complex and became an independent field, a domain of lighting specialists rather than urban planners.

The presence of electric light within cities is being taken for granted by inhabitants of well-developed urban areas, where life expands 24/7, and sought by people from the developing areas. On the other hand, a constant presence of electric light affects the local eco-systems, can be harmful for animals and interferes with the human circadian

system [6]. Extensive exposition to outdoor electric lighting during night hours disrupts circadian rhythm, misleads nocturnal animals. Excessive, misdirected, and obtrusive artificial light can generate an increase of light pollution. It may be concluded that perception of public light is subjective, while some demand more light, others ask for less light to keep the sky at night dark.

Quantitative approaches to public lighting

The approaches adapted by city authorities are traditionally based on quantitative data: lighting technical performance, value of light (in road lighting) and economical savings. This position is well represented in different lighting regulations, which define quantitative levels of illuminance and luminance and methods to achieve them [28]. A lot of work has been done in describing lighting applications in terms of: choice of the most efficient sources and luminaires [29, 30], and choice of the proper lighting design solutions [1, 31]. The traditional approach towards outdoor public lighting and road lighting focuses on using new technologies to ensure economical savings and technical performances according to the existing recommendation levels. This method focuses on provision of good visibility conditions to the users of outdoor public spaces during the hours of darkness to support traffic safety, traffic flow and public security [32] but also on energy efficiency. Drivers' visibility comfort and pedestrians reassurance has been investigated [4, 5]. The emphasis is put on elimination of obtrusive lighting, sky glow, trespass lighting, glare and flicker lighting but the major accent is put on ensuring safety conditions for road users. A result of this approach, are national lighting regulations and guidance documents which focus on illuminance levels, uniformity more than on aesthetic issues [28].

Qualitative approaches

The aesthetic contribution to city night image, enhancing urban amenity, feeling of safety, visual ambience, enriching night-time experience of the city are also objectives cited by city authorities but more often by lighting designers and practitioners. 'Quality-based' approach to lighting design is also mentioned in lighting codes and guides of good practice [31, 33]. Architectural lighting of historic buildings (3) and master planning seems to be areas, where a strong accentuation is put on aesthetic quality and visual appearance of the space. The other approach emphasizes social aspects of lighting design since lighting is intended to affect the perception and experience of people. The need for human oriented design, social design and a reevaluation of the light levels and methods described in statutory documents are supported by many [7, 1, 2, 8]. Some lighting professionals suggest that urban lighting is the next layer of the constantly changing city experience [34]. The changes in the urban environment and social relations should be followed by change in the lighting design. The interaction of social perception of public spaces and the constant drive towards virtual reality has an effect on lighting design within the urban environment. Therefore, the lighting design approach should be more quality and experience driven [35]. So far, many researches in the area of public lighting have been conducted with regard to pedestrians' sense of security [3, 4, 36 (4), 37, 2, 5, 38] and social and economic activity. Those researches repeatedly raise the question of how to improve lighting and whether improved lighting could have an impact on people's reassurance, feeling of safety or visual performance and light perception [39]. A study done by researchers at the University College London suggests that white lighting is twice as good as yellowish light from the high-pressure sodium lamps in respect to facial recognition. Moreover,

standard high-pressure sodium lamps do not provide the necessary level of lighting to alleviate fear [37]. Having in mind, that previous recommendation on pedestrian lighting required set lighting levels irrespective of the colours, the UCL scientists' discovery triggered some changes in a perception of conventional sodium lighting.

City image and the marketing approach

The next approach is driven by new possibilities brought by the developing technology of solid-state lighting (SSL) and the changing character of a modern city. In this approach exterior public lighting is seen as a tool in a creation of positive city image, which, can contribute to city beautification and safety (coordinated road lighting).

The night appearance of in the city is dominated by road lighting in the sense of lighting fixtures physical forms and illuminance levels. Apart from light for driving, cities are full of lit way-finding signs, illuminated commercial displays, illuminated retail and office buildings and lighting decorations. Therefore, the functional layer of city lighting is followed by a layer of aesthetic lighting and then by the layer of lighting for marketing. Those layers interact with each other, creating a multifunctional luminous lighting environment.

There are endless possibilities brought by the lighting emitted diodes (LEDs), tiny sources of light, which can transform from small points to luminous walls or media facades. Reflecting upon Kevin Lynch's term of imageability [40] which refers to those characteristic of urban space that leave lasting impressions and assist people in deriving personally meaningful connections with a place [41], Susanne Seitinger expanded this term naming the layers of night city lighting *infrastructures of imageability* [41]. Those infrastructures add additional meaning to the city fabric. Lighting image of the city is incorporated into the overall image of the city and this notion is very often used by city authorities using a marketing approach towards lighting schemes (see Fig. 2). City night landscape is regarded as a product to sell, when electric lighting is a tool of product beautification [42].

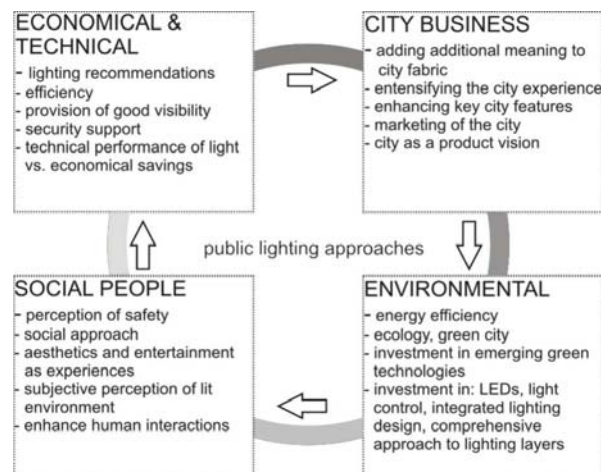


Fig. 2. Graph illustrating approaches towards public lighting

State of research: Public lighting and revitalization objectives

Public lighting

The main objective of outdoor lighting is to illuminate an urban environment in a way which is safe and visually pleasing for its users. The objectives of the city lighting can be studied from different sets of perspectives: the human factors perspective [36, 37], a city image perspective [1, 43] and a performance perspective [44] or marketing

perspective [45, 42]. City lighting should provide basic needs of city dwellers that include provision of: safe movement, visual orientation, visual comfort, facial recognition and a general feeling of safety [46]. The comprehensive public lighting design can help to transform its image by increasing the city's attractiveness and enhancing key features of the architecture. The holistic approach towards urban lighting based on human-oriented design, and an implementation of layered lighting and an installation of energy efficient sources can reduce the city's energy use [37].

Lighting master planning

Lighting of public spaces requires a holistic perspective, in a form of general lighting plans – the Lighting Master Plan. Such plans have been introduced by many cities in the world. The city of Lyon (France) introduced the first lighting plan 25 years ago and the plan has been subsequently reviewed and extended through time [47]. The City of Melbourne (Australia), in *City Plan 1999* called for a comprehensive and integrated urban lighting strategy for all streets, [48] adopted such strategy in 2002, and reviewed it in *The City of Melbourne Public Lighting Strategy 2013* (Melbourne 2013). In 2002 the LUCI (Lighting Urban Community International), a network and a platform for city cooperation, was appointed. The association brings together 63 cities, which have introduced or are working on lighting master planning [49]. Guidance and recommendations on the comprehensive planning of urban lighting are under preparation by the CIE (International Commission on Illumination) Technical Committee TC5 21 as: *A Guide to Urban Lighting Master Planning* [50].

Lighting objectives within revitalization plans

While looking through revitalization plans of urban areas that include a theme of lighting, the objective “improvement of public lighting” is frequently mentioned. It is repeatedly seen as a reduction of the city's electricity consumption, a replacement of the old pedestrian lighting infrastructure and an introduction of new control systems. It is also added that lighting can be used as a tool to enhance city amenity and beautification. And that public lighting should be integrated with road lighting. The lighting objectives may be understood as:

LIGHTING OBJECTIVE: To develop a programme for improved lighting in the neighbourhood.

- Conduct a light study
- Increase lighting for public/private properties
- Continue tree-trimming programme
- Explore creating a private property lighting compliance programme
- (...form the Public Safety Objectives)
- Install lighted bus shelters [51]

Lighting shall be an integral part of any new or existing development. Lighting shall contribute to the individuality, security and safety of the site design without having overpowering effects on the adjacent areas. Lighting is viewed as an important feature for functional and security purposes, as well as enhancement of the streetscape and public spaces. The design of light fixtures and their structural support should be integrated with the architectural theme and style of the main structures on the site [52] (5).

The objectives of public lighting design can fit within the aim of revitalization processes to revive declining areas (see Tab. 3). Despite the differences in scales and profoundness of urban regeneration and lighting considerations, electric lighting might be seen as a part of regeneration planning. Although, the first objective of lighting is provision of visibility, good lighting design may also lead to spatial recovery.

Table 3. Revitalization and public lighting primary objectives described in relevant literature

Set of chosen basic objectives:	Regeneration	Public lighting
revival of the declining areas	✓	
socio-economic recovery	✓	
restoration of social interactions	✓	
improvement of the quality of life	✓	
redevelopment of post-industrial and post military sites	✓	
spatial recovery	✓	
promotion of economic development by supporting 24 hour leisure economy, services and access to public facilities (ILE 2006)	✓	✓
facilitation of social inclusion by providing the freedom to walk along and use our streets after dark (ILE 2006)	✓	✓
promotion of sustainable transport, promoting public transport, cycling and walking (ILE 2006)	✓	✓
increase in general feeling of safety	✓	✓
provision of safe movement	✓	✓
provision of visual orientation		✓
provision of visual comfort	✓	✓
facial recognition		✓
city amenity	✓	✓
comprehensive planning	✓	✓
enhancement of aesthetics	✓	✓
enhancement of key features of the area	✓	✓
quality energy performance	✓	✓
marketing		✓

Lighting objectives within different urban areas

The sets of objectives for outdoor electric lighting relating to urban regeneration of various city areas may slightly differ. In other words, the accentuation may be put on different objectives. Targets for lighting of residential areas focus on factors like safe movement, facial recognition and an improvement of visual orientation and comfort. Town centre lighting objectives usually refer to increasing attractiveness of the city, highlighting particular features of the urban landscape, and increasing comfort for people within an urban space [44, 45]. Lighting objectives for post-industrial areas rather focus on attracting people to the area, creating unforgettable lighting aesthetic, and lighting events or installations that captivate visitors and promote the new character of the space.

Electricity consumption and lighting infrastructure organization

As described above public lighting is undergoing a major change. There are a few factors driving this change. One of them is the search for the most energy efficient and sustainable solutions. Globally, electricity consumption used for lighting in 2005 was 2,650TWh, which accounted for 19% of total global electricity consumption. More than 50% of the electricity consumed by lighting is attributed to International Energy Agency (IEA) member countries [53]. Yet the growth rate of electricity consumption used for lighting in non-IEA countries is increasing. 48% of electricity for lighting is consumed by the service sector, 28% is consumed by the residential sector, 16% by the industrial sector. Street and other lighting consume 8% of global electricity. Generally, electrical lighting consumption varies from 5% to 15% of the total electricity consumption. While

these data may differ in developing countries, it is said that over the next decade global electricity consumption for lighting will rise to over 4250TWh, at an average rate of 19% per annum [53]. Therefore, changes are welcome to assure the best possible savings.

Polish public lighting in numbers

There are different estimations on the street lighting energy consumption in Poland. These data depend on the number of street luminaires included and their average power per point consumption and other additional factors. According to the Górczewska and Ślęk [54] study of 2008 that was published on the web pages of The Ministry of Economic Security, Department of Energy (*Ministerstwo Gospodarki Departament Energetyki*): the number of lighting points¹ is estimated at 3,200,000, the average power of light point is 175W, the total power of installed luminaires is approximately 560MW and the potential electricity consumption (assuming 4000 hours of light and 100% efficiency luminaires) is 2,2TWh (data form 2006). The cost of electricity is appraised at 750 - 800 million PLN per year, with 300 - 400 million PLN as the annual cost of maintenance [54].

According to NFOŚiGW, street lighting in 2011 had consumed 1,558TWh of electricity per year [54]. There are more modern data available in regard to the annual cost of street lighting in Poland but due to the lack of proper scientific publications they are not mentioned here (7).

The results of surveys carried out in October of 2013 by the MillwardBrown opinion research institute on behalf of the NFOŚiGW, indicated that there are about 3.3 million street lights in Poland, the majority of which are sodium lamps (approximately 60-65%), followed in number by mercury lamps, incandescent and neon lamps [55]. For example in Poznań there are 45,606 lighting points and the annual burn time is calculated at 4045.35 hours [56]. Gdańsk authorities state that the cost of erecting one light pole is 8,500 PLN and the monthly cost of illuminating 100 meters of a road is calculated at 154 PLN. However, the Gdańsk authorities do not provide any link to scientific research or calculation which supports these data [57].

Half of Polish municipalities plan to modernize street lighting over the next five years. The main reasons for the planned modernization are to reduce the high cost of maintaining the current lighting systems, to improve lighting quality and to invest in more energy efficient technologies like LEDs. Short periods (a few years) for reimbursement characterize investments in energy-efficient lighting with expected saving figures at around 80% [58].

There are programmes to reduce energy consumption in public lighting designed by local municipalities to save public funds. In order to meet energy saving needs, the NFOŚiGW has approved the national financial programme SOWA² 2013-2015 - energy efficient street lighting. The programme, which is implemented within the framework of Green Investment Scheme (GIS), aims to reduce carbon dioxide emissions from the energy sector by 50 thousand tonnes per year by improving the energy efficiency of street lighting systems [59].

Structure of public lighting in Poland

The lighting infrastructure in Polish municipalities is owned by power companies or their subsidiaries in 70% - 75% of cases [59]. According to the *Energy Law* (Art. 18. Ust. 1- *Ustawa Prawo Energetyczne*) the financing of road lighting and public lighting belongs to the tasks of local government. The municipalities do not invest in lighting infrastructure because they do not own it. On the other hand, energy companies are not interested in modernizing the lighting infrastructure, because the expenditure on

investment is on their side, while the benefits of reducing electricity consumption would be only on the side of municipalities. This legal situation means that the municipality gradually takes over the lighting infrastructure of power plants; and this process is slow mainly due to the lack of necessary funds. In Poland there are three basic models for the organization of city lighting and many mixed systems [61, 62]. The most common model is "passive municipality", in which the power company owns the lighting infrastructure and has responsibility for its maintenance, while the municipality pays the power company for the consumption, usage and maintenance of lighting. The other model is "active municipality" in which the municipality assumes the acquisition of the lighting assets by the local municipality unit and the electric company debits the municipality the cost of electricity consumed by street lighting. The maintenance of light can be performed by any entity, selected in accordance with the public law. The third model occurs when another unrelated company created by the municipality and the utility company party takes over the lighting assets form and handles the lighting infrastructure [61, 62].

Still, there are voices stating that the structure of financing for public lighting needs to be clarified by new laws [63, 64].

Selected characteristic of city lighting in Poland

The main observations for discussion on public lighting in Poland reveal: a lack of coherent concepts in lighting practices and policies, a small number of comprehensive lighting master plans and many examples of poor aesthetic solutions mixed with well-executed installations. Additional problems include: dissimilar colour temperature given by different sources and low standards in maintenance of existing systems, which gives the impression of further deprivation of outdoor lighting. The apparent lack of holistic and comprehensive lighting approaches is frequently caused by the separation of lighting design from urban and architectural planning, as well as from revitalization planning. New installations of high-grade road lighting based on PN-EN 13201-(1-4): 2007P [28], which reduce the requirements of light levels on roads (where low speed vehicles are also in put in service) are often perceived as dimmer in comparison with the older installations on roads of low-grade lighting [65]. In addition, architectural lighting or signage lighting seems, in many cases, to be designed without coordination with existing exterior lighting schemes. This situation often gives an impression of lighting chaos. On the other hand, the demand for good public lighting design is increasing steadily which may be observed in a rising number of applications.

Urban regeneration and public lighting: objectives, scale and scenarios in Poland

In the context of urban development in Poland, urban regeneration objectives are related to socio-economic, environmental and spatial issues. Thus infrastructure operations, architectural and urban planning are subordinate objectives. Characteristic of regeneration processes are their complexity and synergistic character of actions. Revitalization planning not only enforces the cooperation of public services, local municipalities, business, and industry, but encourages residents' involvement as well.

On the sketched background, public lighting strategies complement the subordinate objectives of complex urban planning. Despite a lack of proper practises in Poland, the belief that public lighting should be planned in a comprehensive way and coherent concepts of lighting for entire cities should be implemented, are voiced often [58, 64, 65]. The concept of comprehensive lighting master

planning may be the way to follow by many municipalities to ensure uniform and planned lighting design for streets and urban areas [1, 47].

The basic objectives for lighting master planning in Poland [65] are:

- to determine the current state of lighting (surface luminance and luminance site measurements);
- to determine lighting requirements, based on the lighting recommendations and standards for all roads in the city;
- to research the communication functions of the roads, and different urban sites,
- to identify the main routes, transit roads, places of public interest pointed out by district and local authorities;
- to determine the final requirements in the light function of each of the streets as part of the street lighting system;
- to determine maintenance factors.

These objectives may overlap with many targets of initial urban planning during regeneration processes. The introduction of coherent master lighting planning recommendations and good practice procedures could help to establish a ground for public lighting design within regeneration strategies.

The urban revitalization scenarios may differ depending on their scale, character, time frame, main objectives and the physical and functional characteristics of the area included and many other mentioned factors. The schedule presented in table 4 is the simplified version of revitalization scenarios found in Polish literary sources reviewed for the purpose of this paper [16, 19, 66, 67]. The lighting schedules also vary depending on the scale and functions, technical solution, sources and application processes employed for different public areas schemes [47, 48, 50], (please see Table 4 in Appendix 1).

Having in mind that lighting design should be coordinated with other urban planning decisions it seems that regarding revitalization processes, lighting design should be considered during the strategy phase of regeneration strategy.

Summary

This paper aims to reflect on the research done in regard to lighting within urban regeneration processes. The important role of public lighting in the creation of the contemporary city experience and image is unquestionable. The city inhabitant's sense of well-being results from a complex mix of factors, which are present in the urban environment. Lighting certainly enhances people's experience of the urban forms after dark. Urban regeneration processes are vastly complex. Despite complexity of these processes, lighting strategies should be a part of regeneration considerations. Well-designed lighting forces comprehensive thinking and planning, ensures responsible energy use, promotes improvement to safety and amenity, and it should be implemented as a part of urban regeneration planning. The experience of lighting master planning constitutes a range of complementary improvements in relation to urban spaces, architecture and associated infrastructure, with the intention of achieving social, economic and environmental benefits. It seems that there is a lack of regulation in regard to comprehensive city lighting design in Poland. There is also a lack of clear public recommendations on an inclusion of lighting within urban planning and regeneration. The role of electric lighting design within urban rehabilitation, especially among heritage sites, needs further case-related studies.

List of public and road lighting subjects under a current revision by CIE

D5/ TC 5-21: A Guide to Urban Lighting Masterplanning

D5/ TC 5-28: Guide on the Limitation of the Effects of Obtrusive Light

D4/ TC 4-15: Road Lighting Calculations

D4/ TC 4-33: Discomfort Glare in Road Lighting

D4/ TC 4-47: Application of LEDs in Transport Signalling and Lighting

D4/ TC 4-50: Road Surface Characterization for Lighting Applications

D4/ TC 4-51: Optimizing of Road Lighting

D4/ TC 4-52: Lighting for pedestrians: new empirical data

(1) For the purpose of this paper and to avoid a discussion about the differences in translations between expressions: urban regeneration and urban revitalization the authors decided to use both terms in a meaning of the "rewitalizacja w kontekście urbanistycznym".

(2) There are many definitions of revitalization, revitalizing, urban revitalization, urban renewal and urban regeneration. The author of this paper is under the impression that in the case of revitalization the working and developing definition should be considered. The professionals from different fields often understand the term revitalization differently. The authors notice that many American and British cities along with some European urban organizations provide short papers to explain revitalization or regeneration terms. The purpose seems to be making sure that different professionals working together have a similar understanding of revitalization issues.

(3) Illumination of buildings (iluminacja) is often used as synonym of architectural lighting design in Poland. In other countries, including Germany, the UK, the USA or Scandinavian countries lighting design definition is usually broader and includes aspects of interior and exterior lighting design, master planning, daylight design, or even luminaire design.

(4) Light and Crime chapter in *Human Factors in Lighting* by Boyce, P., gives a historic overview on the major research done in the area of lighting, security and crime since 1958.

(5) Mercer Island Municipal Code, A Codification Of The General Ordinances of The City Of Mercer Island, Washington, Code Publishing Company, Seattle, Washington

(6) Development and Design Standards.

1. Pedestrian-Scale Light Fixtures. Pedestrian-scale light fixtures should be incorporated into the site design to give visual variety from one building to the next and should blend with the architectural style.

2. Light Type. Lighting should use minimum wattage metal halide or colour corrected sodium light sources, which give more "natural" light. Non-colour corrected low-pressure sodium and mercury vapour light sources are prohibited.

3. Building Entrances. All building entrances should be well lit to provide inviting access and safety.

4. Building-Mounted and Display Window Lights. Building-mounted lights and display window lights should contribute to lighting of walkways in pedestrian areas.

5. Parking Areas. Parking area light fixtures should be designed to confine emitted light to the parking area. The height of the light fixtures should not exceed 16 feet.

6. Neon Lighting. Neon lighting may be used as a lighting element; provided, that the tubes are concealed and are an integral part of the building design. Neon tubes used to outline the building are prohibited.

7. Shielding. All lighting fixtures should be shielded or located to confine light spread within the site boundaries, to the extent possible, especially when adjacent to residential uses. The Mercer Island Municipal Code is current through Ordinance 14C-04, passed May 5, 2014.

³There is a discussion about a definition of the lighting point, since it is not clearly defined by the regulations.

(7) The annual cost of street lighting is estimated at 1 billion 390 million 126 thousand, where 354 million 240 thousand PLN is the cost of operation for the installation of lighting; the rest is the cost of electricity. These numbers published by Eco.Wat Kancelaria Doradztwa Energetycznego are very difficult to verify due to a lack of research studies available on similar published public records. In order to get street lighting costs data these simplifying assumptions had been adopted: one (the most common) group tariff; the current price of energy and the rate of distribution of one (of the six main) operator, averaged a flat rate for the operation of one luminaire.

(8) SOWA (*eng. owl*), the chosen symbol of this programme is also an acronym that can be developed as: lighting systems in cities- in Polish: *systemy oświetlenia w aglomeracjach*. Among the examples of projects that will be covered by the funding of SOWA, there are devices for intelligent lighting control systems and controllable power reduction and stabilization of the supply voltage, the replacement starters, power cables and poles. However, to raise funds for the implementation of such projects, the requirement should be met to reduce CO2 emissions by approx. 40% (not less than 250 tons / year). The condition is also, among others, a five-year warranty on the lighting made infrastructure and meeting the standard PN-EN 13.

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Appendix

Tab. 4. Simplified lighting design and urban regeneration possible scenarios.

LIGHTING DESIGN: PUBLIC LIGHTING			URBAN REGENERATION		
			Analysis	Social consultations	Strategy documents
			Appointment of coordinating bodies	People appointments	
			Vision and strategy	Social consultations	
Analysis and strategy documents	Initial analysis of needs	Site measurements of existing lighting conditions	Local development plans (local consultations)		
		Residents consultations + city municipality consultations			
		Review of statutory lighting documents			
		Local Development Plans, Road Plans			
		urban planning consultations			
Design Documents	Analysis of lighting design options Luminaires Light sources Control Systems Integration with Daylight solutions	Environmental impact assessment	Analysis of urban regeneration options	Environmental impact assessment	Reports of results
		Financial options	Economic evaluation of chosen options	Financial options	
		Budget		Socio-economic analysis	
			Budget		
	1 Statement of needs and objectives, Operational Statement 2 Site Survey, establishing critical viewpoints 3 Heritage building lighting assessment 4 Evaluation of Lighting Conditions 5 Desirable Baseline Conditions+ SAFETY conditions 6 Essential Lighting Task Analysis 7 Analysis of Environmental Setting 8 Lighting Design Objectives 9 Lighting Design Methodology 10 Calculated Predictions 11 Obtrusive Light Calculation 12 Comparing Design with Baseline Values 13 Designer's Critique 14 Viewpoint Visualisation 15 Virtual Walkthrough 16 Surface Colour Schedule 17 Luminaire Schedule 18 Energy Usage 19 Schedule of Luminaire Profiles 20 Essential Layout Plan		'Revitalization Plan'		
Financing Documents	Financing within revitalization plan		Financial options	Financial Plan	Financial structure
				Business Plan	
			Public sources EU funds Private investments Public-Private Partnership ¹		
	Implementation financial sources				
Final Design & Implementation Documents	Implementation		Implementation		Progress reports
Evaluation Doc.	Evaluation of light		Evaluation of implementation + evaluation of effects		Monitoring reports
	Evaluation of social experience				Research studies

REFERENCES

- [1] Brandi, U., Geissmar-Brandi C., *Light for Cities: Lighting Design for Urban Spaces*. Birkhauser, Switzerland, (2007)
- [2] Raynham, P., Public Lighting in Cities. *International Conference ILLUMINAT 2007 & BALKANLICHT* (2007)
- [3] Pease, K., A Review of Street Lighting Evaluations: Crime Reduction Effects. *Crime Prevention Studies*, volume 10, Criminal Justice Press, (1999), pp. 47-76
- [4] Van Bommel, W., Caminada, E., Considerations for the Lighting of Residential Areas for Non-motorised Traffic. *Proceedings of CIBSE National Lighting Conference*. London: CIBSE, (1982), pp. 158–67
- [5] Unwin, J., Fotios, S., Does Lighting Contribute to the Reassurance of Pedestrians at Night-time in Residential Roads? *Ingenieria Iuminatului* (2011), 13, 2, pp. 29-44
- [6] Rea, M., Smith, A., Birman, A., Figueiro, M., The Potential of Outdoor Lighting for Stimulation of the Human Circadian System. *ASSIST; Alliance for Solid-Stat Illumination System and Technologies*, Lighting Research Center, Rensselaer Polytechnic Institute, system , New York, <http://www.lrc.rip.edu> (viewed online 08.06.2014)
- [7] Tillett, L., A Social Activity Approach to Design, *Practical Issues* (2003), pp. 22-29
- [8] Casciani, D., Rossi M., ELSE, Experience of Lighting Sustainability in the Environment. *Proceedings of Cumulus*, Helsinki, (2012)
- [9] *Light's Labour's Lost. Policies for Energy-efficient Lighting*, In support of the G8 Plan of Action. International Energy Agency, (2006)
- [10] Brons, J. A., Bullough, J.D., Rea, M.S., Outdoor Site-lighting Performance: A Comprehensive and Quantitative Framework for Assessing Light Pollution, *Lighting Research and Technology* 40 (2008), p. 201
- [11] Longcore T., Rich C., *Ecological Light Pollution. Frontiers in Ecology and the Environment* 2 (2004), pp. 191–198
- [12] Rabaza, O., F Aznar-Dols, F., Mercado-Vargas, M. J., Espín-Estrella, A., A New Method of Measuring and Monitoring Light Pollution in the Night Sky, *Lighting Research and Technology*, 46 (2014), p.5
- [13] Graczyk, R., Nawrowski, A., Kołata, J., Oświetlenie elektryczne jako element rewitalizacji na przykładzie aglomeracji poznańskiej, *Deklinacja odnowy miast. Z dyskusji nad rewitalizacją w Polsce*. Wydawnictwo Naukowe Wydziału Nauk Społecznych UAM, (2012), pp. 269-278
- [14] Contemporary Understanding of Revitalization in Poland, edited by Noworól, A., Skalski, K., *Monographs and Studies of Jagiellonian University Institute of Public Affairs*, Kraków (2010).
- [15] *Revitalizing Broadway East - What does "revitalizing" mean?* The document includes definitions from various sources and is compiled by the Project Facilitator, Sylvia Holland, for Weaving Policy, People and Place Together, a Mount Pleasant, Neighbourhood House initiative to collaboratively support Community Plan implementation in Mount Pleasant. Source: <http://www.mpnh.org/~ASSETS/DOCUMENT/WPPPT/REVITALIZATION--%20Working%20Definition1.pdf> (viewed 08.08.14)
- [16] Strzelecka, E., Rewitalizacja miast w kontekście zrównoważonego rozwoju, *Civil and Environmental Engineering*, 2 (2011)
- [17] Revitalization Act, pp 1-12. Source: [http://orka.sejm.gov.pl/opinie7.nsf/nazwa/3594_u/\\$file/3594_u.pdf](http://orka.sejm.gov.pl/opinie7.nsf/nazwa/3594_u/$file/3594_u.pdf) (2015), (viewed: 08.12.2015)
- [18] Milczyńska-Hajda, D., Analiza działań prowadzących do ustawowej regulacji wsparcia programów rewitalizacji miast dla potrzeb Miejskiego Programu Rewitalizacji dla Poznania, Urząd Miasta Poznania, (Retrieved 08.2014: <http://www.poznan.pl/>), (2011)
- [19] Lorens, P., Pojęcia Podstawowe, in *Wybrane zagadnienia rewitalizacji miast*, ed. by Lorens, P.; Martyniuk-Pęczek, J., Wydawnictwo Urbanista, Gdańsk (2009), pp. 7-9
- [20] Zieliński, M., Regeneracja, odnowa, czy rewitalizacja miejskiej przestrzeni publicznej? *Przestrzeń i Forma*, nr 15, (2011) Wydawnictwo SFERA, Szczecin, pp. 163-179
- [21] *Local Revitalization Programme for the City of Warsaw for 2005-2013*. The Local Revitalization Programme (LRP) describes a revitalization strategy for the City of Warsaw, which covers activities of a spatial, social, and economic character. The mission of the LRP is coordinating the chosen policies of the City of Warsaw in the areas covered by revitalization and supporting the districts directed at bringing back to life as well as balanced development of given areas, which lost social and economic functions. Source: <http://rewitalizacja.um.warszawa.pl/en/the-local-revitalization-programme-for-the-city-of-warsaw> (viewed 10.03.14)
- [22] Billert, A., Problemy rewitalizacji w Polsce na tle doświadczeń niemieckich. Międzynarodowa Konferencja w Lubaniu Śląskim – Rewitalizacja Miast, (2006)
- [23] *Wybrane Zagadnienia Rewitalizacji Miast*, edited by Lorens, P.; Martyniuk-Pęczek, J., Wydawnictwo Urbanista, Gdańsk (2009)
- [24] Noworól, A., Rewitalizacja jako wyzwanie polityki rozwoju. W: *O budowie metod rewitalizacji Monografie i Studia Instytutu Spraw Publicznych* by Skalski, K., Instytut Spraw Publicznych Uniwersytetu Jagiellońskiego w Krakowie, Kraków (2010)
- [25] Skalski, K., Rewitalizacja w Polsce po roku 2009 a rozwój dydaktyki dla zarządzania tym procesem, W: *O budowie metod rewitalizacji Monografie i Studia Instytutu Spraw Publicznych* by Skalski, K., Instytut Spraw Publicznych Uniwersytetu Jagiellońskiego w Krakowie , Kraków (2010)
- [26] Założenia polityki rewitalizacji w Polsce. 2010. ed. Ziobrowski, Z. In: *Rewitalizacja Miat Polskich*, Kraków: Instytut Rozwoju Miast, Tom 9, p 278.
- [27] Olejko, W., Transformation of Industrial Facilities – Revitalisation or Adaptation? *Civil and Environmental Engineering Reports*, No. 9 (2012), Silesian University of Technology
- [28] Polish Lighting Norms:
- PN-EN 12665:2011E Światło i oświetlenie -- Podstawowe terminy oraz kryteria określania wymagań dotyczących oświetlenia;
 - PN-EN 40-2:2005P Słupy oświetleniowe -- Część 2: Wymagania ogólne i wymiary;
 - PN-EN 50172:2005P Systemy awaryjnego oświetlenia ewakuacyjnego;
 - PN-EN 12464-2:2014-05 Światło i oświetlenie -- Oświetlenie miejsc pracy -- Część 2: Miejsca pracy na zewnątrz;
 - PN-EN 13201-(1-4):2007P Oświetlenie dróg -- Część 1: Wybór klas oświetlenia; Oświetlenie dróg -- Część 2: Wymagania oświetleniowe; Oświetlenie dróg -- Część 3: Obliczenia parametrów oświetleniowych; Oświetlenie dróg -- Część 4: Metody pomiarów parametrów oświetlenia.
- [29] Rombauts, P., Vandewyngaerde, H., Maggetto, G., 1989. Minimum Semi-cylindrical Illuminance and Modelling in Residential Area, *Lighting Research and Technology* 21 (1989) 2, pp. 49-55
- [30] Kuhn, L., Johansson, M., Laike, T., and Govén, T., Residents' Perceptions Following Retrofitting of Residential Area Outdoor Lighting with LEDs, *Lighting Research and Technology*, 45 (2013), pp. 568–584
- [31] *SLL Code for Lighting*, edited by Raynham, P., Society of Light and Lighting, CIBSE, (2012)
- [32] *Final Report Lot 9: Public street lighting* edited by Van Tichelen, P., Geerken, T., Jansen, B., Vanden Bosch M., Van Hoof, V., Vanhooydonck, L., Vercaesteren, A. Study for the European Commission DGTREN unit D3, 2007 p 99. Source: <http://www.eup4light.net/assets/pdf/FILES/Final/VITOEuPStreetLightingFinal.pdf> (viewed: 20.03.2014)
- [33] *IES Lighting Handbook* 10th Edition, Illuminating Engineering Society, editors: Dilaura, D., Houser, K., Mistrick, R., Steffy, G., (2011)
- [34] Discussions after Nona Schulte-Romer's lecture: *Light for remaking cities. Trend and reflections on urban design*. PLDC Convention Proceedings, 19-22 October 2011 in Madrid, Spain (2011)
- [35] Tillett, L., Gardner K., A Social Activity Approach to Design, *Professional Lighting Design*, Jan/Feb (2003)
- [36] Boyce, P. R., *Human Factors in Lighting*, London, Taylor & Francis, Lighting Research Center, (2003)
- [37] Oreszczyn, T., Urban Lights: Sustainable Urban Lighting for Town Centre Regeneration: *ESRC Full Research Report*, L487254007. Swindon: ESRC (2005)
- [38] Fotios, S., Cheal, C., Using Obstacle Detection to Identify Appropriate Illuminances for Lighting in Residential Roads. *Lighting Research and Technology*, 45 (2013), pp. 362–376
- [39] Johansson, M., Rosen, M., Kuller, R./ Individual Factors Influencing the Assessment of the Outdoor Lighting of an

Urban Footpath, *Lighting Research and Technology*, 43 (2011), pp. 31–43

- [40] Lynch, K., *The Image of the City*. The MIT Press, (1960)
- [41] Seitinger, S. *Liberated Pixels. Alternative Narratives for Lighting Future Cities*. PhD Thesis, MIT, 2010 (viewed online 02.04.2014)
- [42] Martyniuk-Pęczek, J., *Światła miasta*. Wydawnictwo Marina, Wrocław, (2014)
- [43] Czora, G., Świetlna akupunktura- nowy wizerunek publicznych przestrzeni miast, *Czasopismo Techniczne. Architektura*, Kraków, 106 (2009), p. 1-A.
- [44] Raynham P., Gardner, C., 2001. *Urban Lights: Sustainable Urban Lighting for Town Centre Regeneration*, Reykjavik: Lux Europa (2001)
- [45] Mansfield, K., Raynham P., *Urban Lights: Sustainable Urban Lighting for Town Centre Regeneration*, Berlin: Lux Europa, (2005)
- [46] Raynham, P., *Public Lighting, How and Why? Bled: Lighting Engineering 2006 Proceedings*, (2006)
- [47] Mansfield, K., Diana Del-Negro, D., *Urban Lighting Master Plans: Environmental and Sustainable Guidelines, The International Journal of Environmental Sustainability*, Vol. 9, Issue 4, (Dec. 2014), pp.49-59
- [48] *The City of Melbourne Public Lighting Strategy 2013*. <http://www.melbourne.vic.gov.au> (retrieved 15.08.2014)
- [49] Lighting Urban Community International, main source: <http://www.luciassociation.org>
- [50] CIE, Commission Internationale de l'Eclairage, International Commission on Illumination Technical Committee TC5 21 as: A Guide to Urban Lighting Master source: <http://www.cie.co.at/div5/info/tclist.html> (retrieved 14.08.2014)
- [51] *Greek Row Area Revitalization Plan City of DeKalb*. Implementation Review, Community Development Department City of DeKalb, 2007, source: <http://www.cityofdekalb.com/PW/PlanDev/PlanDev%20Docs/Greek%20Row%20Implementation%20Review.pdf> (viewed 20.03.14)
- [52] Mercer Island Municipal Code, A Codification Of The General Ordinances of The City Of Mercer Island, Washington, Code Publishing Company, Seattle, Washington, source: <http://www.codepublishing.com/wa/mercerisland/html/MercerIslAnd19/MercerIsland1911.html#19.11.090> (viewed 20.06.2014)
- [53] *Anex 45, Guidebook on Energy Efficient Electric Lighting for Buildings. Summary report*. Edited by Halonen, L., Eino Tetri, E., Bhusal, P., Aalto University, School of Science and Technology, Department of Electronics Lighting Unit, Espoo (2010)
- [54] Górczewska, M., Ślęk, B. *Analizy i ekspertyzy dotyczące źródeł światła. Źródła światła w gospodarstwach domowych. Oświetlenie dróg, ulic i miejsc publicznych*. Ministerstwo Gospodarki Departament Energetyki, 2008 source: <https://www.mg.gov.pl/NR/rdonlyres/AADB6664-50BD-4B03-9F65-21344D9C77C2/56655/Analizacalosc.pdf> (viewed: 11.08.2014)
- [55] Narodowy Fundusz Ochrony Środowiska i Gospodarki Wodnej source: www.nfosigw.gov.pl, (viewed 08.08.2014)
- [56] Zarząd Dróg Miejskich w Poznaniu source: <http://www.zdm.poznan.pl> (viewed 08.08.2014)
- [57] data from: www.nfosigw.gov.pl and <http://www.wfosigw.gda.pl/> and <http://www.gdansk.pl/cennik> (viewed 08.08.2014)
- [58] Zwierchanowski, R, Czy światło jest ważnym czynnikiem dla otoczenia? Krajowa Agencja Poszanowania Energii S.A. (KAPE S.A.), *Konferencja Naukowo – Techniczna Sztuka Oświetlania. Systemy oświetlania. Elektroenergetyczne urządzenia rozdzielcze*. Kołobrzeg 17-19 May (2007)
- [59] Zajkowski, M., Program "SOWA" modernizacji oświetlenia w gminie, *Technika Świetlna 2014, XXIII Krajowa Konferencja Oświetleniowa*, Warszawa 20-21 listopada 2014, pp.166-173
- [60] SOWA, Ministerstwo Środowiska, source: http://www.mos.gov.pl/g2/big/2012_12/c0cae5c00e3f6d7484174d1b1232811d.pdf, (viewed: 12.08.2014)
- [61] Jankowski, A., *Oświetlenie ulic — tak czy inaczej... ?*, *Wokół Energetyki* nr 1 (2003)
- [62] Rechul, H., Jewuła, T., Rechul, M., *Modernizacja oświetlenia ulic na przykładzie gminy Jaworzno*, *Wokół Energetyki*, czerwiec (2007)
- [63] Szpringer, Z., *Opinia dotycząca kosztów finansowania oświetlenia autostrad i dróg ekspresowych przez gminy. Zeszyty Prawnicze Biura Analiz Sejmowych Kancelarii Sejmu*, nr 3(31) (2011), pp. 220–232 also <http://www.eko-wat.eu/problemy-zwazane-z-oswietleniem-drog-publicznych-opinia/> (viewed 08.08.2014)
- [64] Gorzonkowski, J., *Inwestycje oświetleniowe w gminach - problemy prawne*, *Technika Świetlna 2014, XXIII Krajowa Konferencja Oświetleniowa*, Warszawa 20-21 listopada 2014, pp.50-54
- [65] Zagan, W., Czyżewski D., *Kompleksowe ujęcie problematyki oświetlenia miast*, II Konferencja Naukowo-Techniczna z cyklu „Energooszczędność w oświetleniu” DIODY LED Poznań, 24 + 25 May (2011)
- [66] *Podręcznik rewitalizacji. Zasady, procedury i metody działania współczesnych procesów rewitalizacji*. Urząd Mieszkalnictwa i Rozwoju Miast, 2003, source: file:///D:/Documents%20and%20Settings/ten/Pulpit/podrecznik_rewitalizacji.pdf, (viewed: 12.08.2014)
- [67] Mastalerz M., Koźmińska M., Sarnacka A., *Projekty rewitalizacyjne – zawartość i przygotowanie*, *Urbanista 7* (2006), p. 28

[68] Additional Guidance

- [1] Chartered Institution of Building Services Engineers *CIBSE Lighting Guide 6: The outdoor environment*, London: CIBSE
- [2] Chartered Institution of Building Services Engineers *CIBSE Factfile 2: Car park lighting – dilemma solved*, London: CIBSE
- [3] Commission Internationale de l'Eclairage CIE Publication 150: 2003: *Guide on the limitation of the effects of obtrusive light from outdoor lighting installations*, Vienna: CIE
- [4] Commission Internationale de l'Eclairage CIE Publication 154: 2003: *Maintenance of outdoor lighting systems*, Vienna: CIE
- [5] Commission Internationale de l'Eclairage CIE Publication 115: 2010: *Lighting of Roads for motor and pedestrian traffic*, Vienna: CIE
- [6] Commission Internationale de l'Eclairage CIE Publication 136: 2000: *Guide to the Lighting of Urban Area*, Vienna: CIE
- [7] Commission Internationale de l'Eclairage CIE Publication 140: 2000: *Road Lighting Calculations*, Vienna: CIE
- [8] Commission Internationale de l'Eclairage CIE Publication 088: 2004: *Guide for the Lighting of Road Tunnels and Underpasses*, Vienna: CIE
- [9] Commission Internationale de l'Eclairage CIE Publication 094: 1993: *Guide for Floodlighting*, Vienna: CIE
- [10] Institution of Lighting Engineers, *Guidance notes for the reduction of obtrusive light*, ILE, Rugby
- [11] Institution of Lighting Engineers Technical Report 28, *Measurement of road lighting performance on site*, ILE, Rugby
- [12] Society of Light and Lighting SLL Factfile 7: *Environmental considerations for exterior lighting*, London: CIBSE