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FLEXIBILITY IN MANAGEMENT OF MODERNIZATION IN CONSTRUCTION - ELECTRICAL WORKS

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Abstract

The article presents the general principles of flexible approach, illustrated with case study regarding flexibility in modernization. Flexibility is understood in the present case as a skilful adaptation to changes in the dynamically changing environment. The essence of flexibility approach is being staged to make decisions based on environmental and process monitoring in progress. Presented case study of upgrading the electrical system in the multi-family housing in the common area is based on step by step procedure responding to damage state of this system. Simple analysis is based on cost comparison but there are other criteria (environmental, social etc.) and conflict solving situations taken into account in presented paper.

Keywords: flexible approach, light modernization, electrical contractor, energy savings modernization.

1. INTRODUCTION

The complicated situation of the construction industry compared to other sectors of the economy results from the specific characteristics, which manifests itself among others in:

- The high value of construction work
- Long life cycle
- Dependency on external conditions (also in the operation phase)

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- Large transport intensity
- Long chains of quality (the complexity of building processes).

Widely assumed knowledge of the scope of construction projects is not always the case. In the case of modernization works, due to only a general recognition of operating conditions, one should start the implementation being ready to change the originally planned scope of work. Meanwhile managing construction projects in the traditional way are subject to the risk of not meeting assumed deadlines or cost in the range of 30-50% [1]. These problems are observed not only in Poland but also in EU countries or the USA [9].

In light of these problems, one should see the possibility of introduction, apart from the typical elements of competitiveness, of construction companies (e. g.: deadline, cost or quality), the ability to adapt working methods to changing conditions. Such understood ability refers to the idea of flexible management, well-known and widely acclaimed in other sectors of the economy (the most common method of production in industry).

The purpose of this article is to indicate the possibility of applying the idea of flexible management in the modernization process and to show benefits of its introduction based on a case study on the modernization of the electrical system. Typical modernization activities involving the simultaneous exchange of elements of the existing system with the modern ones were replaced with strategy of flexibility (replacing elements of the existing system in case of its damage with the new ones).

2. FLEXIBILITY IN BUILDING

Discussing the issue of the introduction of flexibility in construction, based on adapting to the changing environment, one should emphasize new technological opportunities that create favourable conditions for this process. These are mainly: the development in the field of IT in the area of automated collection, transmission and management of data, the possibility of applying simulation (which may more accurately reflect reality), the use of mobile technologies for direct management of processes on the construction site (including remote), dynamic technological development in construction (e.g. the possibility of modifying materials, use of energy efficient technologies) and physical risk management at source (at the operational level). Mentioned new possibilities favour the change of approach from the reactive to proactive based on on-line monitoring of processes and the environment, the study from examples and simulations.

The immediate cause of the introduction of flexibility is the problem of proper forecasting of a changeable environment during the design, implementation and operation (and possible disposal) of a building. The variability is due to e. g .: changes in prices (e. g. fuel), economic or political conflicts, demographic changes, weather changes, changes in user requirements, system load changes (e. g. highway traffic load), changes in emission loading the environment (e. g. noise , exhaust fumes), predict the reliability of system components (e. g. the electrical installation).

The risk, resulting from these problems and uncertainties promote effectiveness and efficiency of the introduction of flexibility in the management of construction processes.

Flexibility is a common phenomenon in the business of engineering; however, its definition suitable for use in this approach requires clarification. First, it should be pointed out that the typical definitions in the literature relate to the economics and the strategic level.

The most classic definition is given by Upton [10]: "the ability to change or reaction associated with a slight deterioration of the efficiency of resources in terms of time, cost and outcomes".

Before giving definitions relating to this application flexibility, one should point out differences in the perception of flexibility in engineering practice. The first crucial problem is to look at the factor determining the justness of introducing flexibility. In a typical manufacturing process, the system function is directed to meet variable production range, whereas in the construction, the change relates to the operating conditions (changeable environment).

Another problem is the reference to various aspects of the production process: supplies (distortions of deliveries timeliness- logistic problems), or directly production execution (distortions of performance and production quality) [7, 8].

The third aspect is the analysis level of flexibility management:

- Strategic (relating to organization)
- Tactical (related to the implementation of the project)
- Operational (relating to processes).

It is proposed the following definition of flexibility relating to its application in management modernization process: the ability of the production system to apply different tactics of implementing, adequately to the changing environment based on a proactive approach, aimed at reducing the impact of hazards resulting from the risk and the use of emerging opportunities focused on achieving benefits in financial terms, (and also: environmental and social) in the implementation of the project.

It should be emphasized that flexibility can be implemented in different phases of the life cycle of a building (design, construction, operation, utilization). In each, these definitions may vary due to management level, period of operation, the role of decision maker, etc.

3. EVALUATION OF THE EFFECTIVENESS OF THE IMPLEMENTATION OF FLEXIBILITY

In the presented case, the mechanism of introducing flexibility is based on monitoring the environment and making decisions based on tactics to adapt to the current situation. This idea is a schematic representation of Fig. 1.

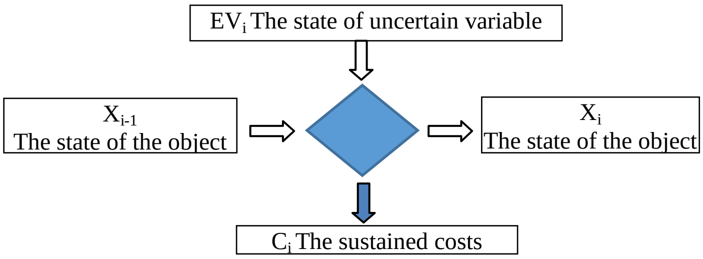

Fig. 1. The idea of a phased decision-making using a flexible approach.

Monitoring of the uncertain variable state is the basis for making decisions about appropriate changes in the present building (e. g. increasing the number of highway lanes to accommodate the increasing traffic load). The choice of method of action based on the tactics of flexibility determines escalating certain costs at a given stage. For the evaluation of the typical applications of flexibility one generally uses the NPV method based on the analysis of the cash flow in time.

Generally analyzing available formula of efficiency assessment, one should distinguished methods: static and dynamic. The advantages of static methods include the simple mechanism of action and communication, while the disadvantages include the lack to precision [3] resulting from the lack of analysis of the distribution of cash flows in time. Their application can be reduced to the initial analysis or evaluation of the activities carried out in short periods of time. A common method for estimating the efficiency of the use of the flexibility is the NPV method (especially in case of a long period of analysis of several tens of years):

$$NPV = \sum_{t=1}^{n} S_t (1+r)^{-t} - S_0 \qquad (1)$$

where: **NPV** – present net value, S_t – differences in incomes and expenses, S_0 – initial investment, r –discount rate, t– period of realisation (years).

To the disadvantages of the NPV method, one should include: a complicated process of the calculations, difficulty estimating model parameters (discount rate, residual value). The advantages are undoubtedly: the ability of taking into account the change of money value in time and to account for all cash flows associated with the investment.

4. CASE STUDY OF MODERNIZATION OF LIGHTING SYSTEM

For the purposes of article, one examined the modernization of electrical outlets, in the common parts of a building completed in 2009 in Poznań of usable housing area of 2 521 m^2 and garage hall area of 1205 m^2. The facility has 40 apartments and 7 commercial units. The property is fully used; i. e. premises have their owners and tenants. Modernization method of this facility, described in an article, can be successfully used in a wide range of other facilities, in which users or administrators would reduce the ongoing costs of maintenance with an emphasis on the objects that were built several years ago. In the case of these buildings, assumed reducing the electricity consumption during the design and construction stage, were not always a priority, and there were no appropriate technologies for energy-efficient solutions, so upgrading especially in these cases will be most effective. Method of carrying out the modernization process, in this case, was divided into several stages, which is illustrated in Fig.2.

Particular attention deserves the stage of verifying whether the proposed solution will meet the needs of users. It is known that the main aim is to reduce the cost of lighting of common areas, and thereby reduce the financial burdens of residents in this respect. One should keep in mind that opting for the modernization, residents comfort may decrease and one should, in the most compromise way, accept the desire for financial gain and to provide comfort for residents. The factors negatively affecting the comfort of the residents include, among others:

a) Reduction of power of lighting points which may result in insufficient illumination intensity in some parts of the object.
b) The colour change of light which is directly related to the change of the type of lighting for LED technology. Unfortunately, the current LED technology does not allow for warm hues lighting in reasonable price, hence the introduction of this type of lighting can be evaluated as less favourable.
c) Introduction of motion detectors, which causes that in many places the light is not non-stop on - one achieved reduction of electricity consumption at the expense of comfort in the absence of stimulus for the motion sensor.

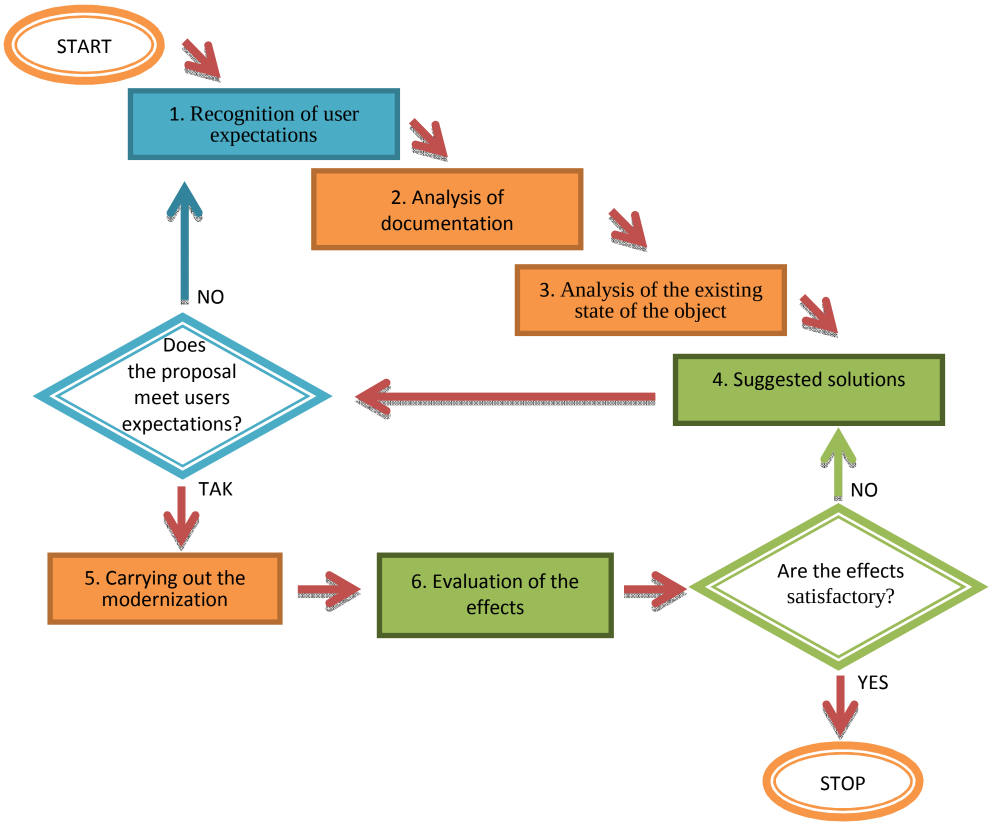

Fig. 2. Scheme of procedure for modernization

Before deciding to modernize residents must have in mind that the increase in electricity savings can mean reducing occupancy comfort on staircases, corridors and garage hall. As part of the modernization plan, it was presumed a flexible adjustment stage of the standard operation of the system (the inclusion period of light being switched on) to the requirements of tenants/ users.

A very important element of the plan is also to check whether after completing the work the results are satisfactory. The first criterion, a very easy to verify, will, of course, be electricity consumption. It should be noted, however, that the feelings of the residents are equally important in case when the customer will not be pleased, one would return to step 4 (Fig. 2) and propose a solution for emerging concerns/ problems.

It should also be clearly stated that the possibility of interference in the electrical installations of the building depends on its condition; hence the correct determination of installation parameters of the electrical system is crucial. One has to focus on the age and condition of installation [4] and depending on the assessment propose a suitable solution, i. e. partial renovation, replacement of defective parts or modernization of the overall installation in the facility [5]. In the analyzed example the state of electrical installation allowed for a partial upgrade of lighting points, which is an attractive financial option and requires a limited intervention only in areas where we need to make changes related to the replacement of defective components of the system.

It is worth noting that the type of originally used lamps and lampshades has been chosen by the designer in a manner allowing for the introduction of a flexible approach, as it has enabled the modernization reducing the additional costs through the use of relatively large lampshades, which made the replacement redundant.

4.1. Description of the performed works

In the described case, the subject of the modernization were 74 lighting points in staircases and corridors of the object, and the 13 lighting points in the garage hall. By modernizing of each point on the corridors and staircases one must understand:

a) Removal of the fluorescent lamps PL-Q 4 PIN power of 16W.
b) Application of luminaires of the basis e14.
c) The installation of LED bulbs on the basis of the e-14 and power of 3W.
d) The installation of motion sensors, in 10 places coordinated with the residents.

Additionally, one carried out a regulation of dusk sensors, managing lighting of staircases, in order to rationally use the daylight. The method of modernizing the point of lighting in the staircase is shown in Figure 3.

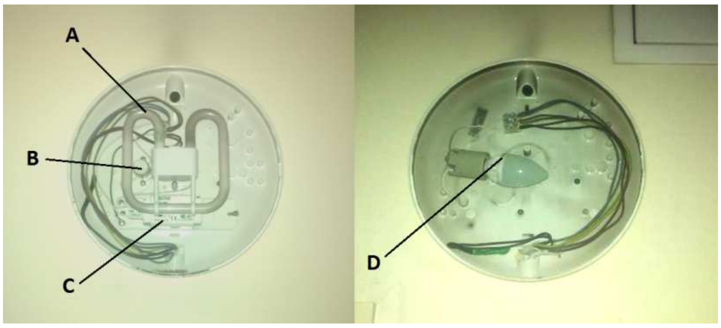

Fig. 3. View inside of lighting point before (left) and after (right side) modernization. A-fluorescent lamp PL-Q 16W, B-starter, C-ballast, D-3W LED bulb

Modernization of a point in the garage was about:

a) The removal of two 36W fluorescent lamps on the cap G13
b) Application of 2 luminaires on the thread e-14

c) Installation of 2 LED bulbs with the base e-14 and 3W each.

Here one additionally installed 2 motion sensors and time light switches, since before a modernization, the light in the whole garage hall was on non-stop.

All the works were carried out gradually over a period of 11 months in 2012. Due to the limited investment opportunities of residential community and a desire to maximize the use of existing and active fluorescent lamps, one proposed a flexible strategy for modernizing involving the "modernization with the removal of current faults" - called "step by step”. This mode was to change the type of lighting only those places, in which at a given time lighting point stopped functioning properly (fluorescent lamps blowing or failure of power supply / transformer).

The cost of materials to carry out modernization in the traditional way would be 3075,00 PLN. Thanks to a new approach, the whole modernization cost effectively 545,50 PLN, because without conducting changes, the cost of materials to the preserving works, maintaining the lighting in good working order in 2012 would be 2529,50 PLN per year, similar to 2011. This amount includes the costs of materials, i. e.: spare lamps, starters and ballasts for the whole object. Labour costs are not included, due to the fact that the works were carried out within ongoing technical maintenance of facility and at the proposed new approach, the time originally intended for the replacement of worn parts of the old installation was designed to carry out modernization activities.

For the purposes of the article was also prepared a simplified comparison of investment repayment period for both approaches at the time of completion of the investment [2].

$$PP=\left(\frac{NI_0}{St}\right) \tag{2}$$

where: PP – the period of repayment,
NI_0 – initial outlays,
S_t- the annual flow balance.

The repayment of investment for traditional methods would be 3, 86 of a month, while the carried out, according to the guidelines, was 0, 68 of a month, which is nearly 6 times more favourable.

The proposed flexible approach "modernization in the case of faults" helped saving additional funds by an investor compared to the typical model of modernization that is performed for a short period (1-2 weeks for the whole building). The main disadvantage of a typical modernization is the fact that at all times one should keep the old type of lighting in efficiency (incurring ongoing costs of purchase of materials for repair), and at the moment of a rapid transition to a new type arises a lot of waste in the form of used efficient materials (fluorescent lamps, ballasts, etc.). The proposed modernization approach eliminates this drawback, and additionally contributes to a better use of resources, because the only waste products are non-operational appliances and fluorescent lamps.

5. EFFICIENCY OF ELECTRO MODERNIZATION

Below is a chart illustrating the electricity consumption in common areas before and after carrying out all the work and expense of consumption and supplying electricity by the same supplier in 2011 and 2013, i.e. the year before and the year after modernization work.

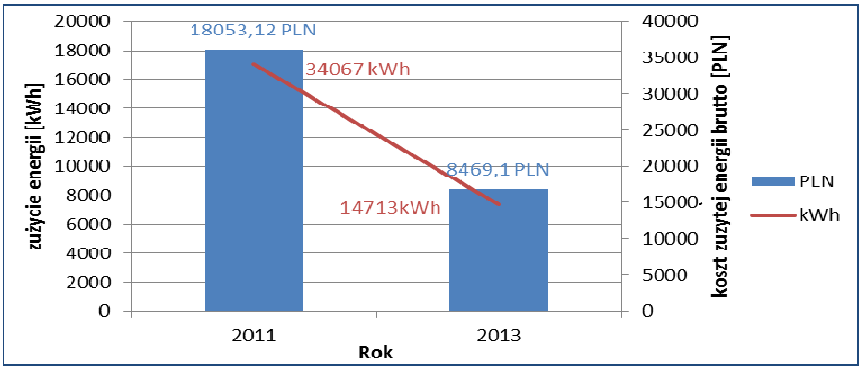

Chart 1. Summary of energy savings before and after modernization. [12]

As shown in the summary, one managed to achieve 57% reduction in electricity consumption, which translated into real savings for residential community in the amount of 9584,02 PLN in 2013. It should be noted that the cost of technical maintenance of common areas of the whole property, including work related to modernization of lighting points, without the cost of purchasing materials (which were mentioned in the previous paragraph) in 2012 amounted to 10,440 PLN and was no more than the cost of service in 2011.

In addition to high profitability due to a reduction in the cost of lighting of the object, which allowed the community to freeze rent increases caused by rising utility prices, including electricity, to the positive effects one should include reducing the current costs of electric service of the object. By using modern LED bulbs, which for at least 24 months operate without interference of the technician, compared to the PLQ fluorescent lamps, which were more failure-friendly and required repairs on average every 12 months, one was able to reduce the time required for the operation and maintenance of the lighting system in this facility. In addition, in the new lighting system in the lamp remains one device that may cause malfunction (LED bulb), whereas in the old system there were three such elements (fluorescent lamp, starter and magnetic ballast), hence the overall probability of failure declined several times compared with the initial variant of the system.

6. CONCLUSION

Presented theoretical basis together with an analysis of the case allow drawing the following conclusions:

1. Flexibility application in modernization of the electrical system made it possible to achieve significant financial benefits (undoubtedly, one also achieved environmental benefits that were not analyzed),
2. The essence of the proposed solution was to perform a replacement for LED elements at the time the lighting faults,
3. Element favouring the introduction of the proposed flexible approach was to design a lighting housings allowing relatively easy and economically beneficial form of modernization,
4. One managed to reach a compromise between the economic benefits of users and potential reduction in the usage comfort at the stage of implementation of the new lighting system.

It should be emphasized that flexibility enables the use of opportunities (possibilities of obtaining savings), which is offered by changing environment, which is the state of the installation and manner of conducting of the modernization itself, in which uncertainty factor is the moment of failure of individual lighting points.
The presented approach - according to the authors - can be used in analogous situations concerning, for example, multistage modernization. The authors plan further analysis of similar cases in order to determine the possibility to apply a flexible approach in building.

ADDITIONAL INFORMATION

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ELASTYCZNOŚĆ W ZARZĄDZANIU MODERNIZACJĄ OBIEKTÓW BUDOWLANYCH NA PRZYKŁADZIE ROBÓT ELEKTRYCZNYCH

S t r e s z c z e n i e

Artykuł prezentuje możliwość zastosowania elastyczności w modernizacjach istniejących obiektów budowlanych na przykładzie instalacji oświetleniowej. Elastyczność jest rozumiana w tym przypadku jako umiejętne dostosowanie się do zmian w dynamicznie zmieniającym się środowisku. Istotą podejścia elastycznego jest podejmowanie odpowiednich decyzji w odpowiednim czasie opartych na monitoringu środowiska i procesu w toku. Prezentowane studium przypadku modernizacji instalacji elektrycznej w budownictwie wielorodzinnym w częściach wspólnych obiektu (korytarze, klatki schodowe, hala garażowa) opiera się na wymianie i modernizacji tylko tych punktów, które w danym momencie ulegają awarii. Prosta analiza oby typów modernizacji opiera się na porównaniu kosztów, natomiast trzeba zaznaczyć, że możliwe są także inne kryteria (środowiskowe, konfliktu społecznego, itp.), które będą przedmiotem kolejnych publikacji. Zastąpienie tradycyjnych żarówek rozwiązaniami opartymi na technologii LED z zastosowaniem czujników ruchu może prowadzić do znacznych oszczędności, ale może też oznaczać obniżenie komfortu dla użytkowników (np. dla osób starszych, którym jeden cykl działania oświetlenia nie jest wystarczający do pokonania całej drogi na korytarzu). Osiągnięcie kompromisu w tego typu konfliktach interesów może być rozwiązane za pomocą podejścia elastycznego i zwinnego.

Słowa kluczowe elastyczne podejście, modernizacja oświetlenia, podwykonawca robot elektrycznych, oszczędności przy modernizacji.

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