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## METHODOLOGY OF LARGE PROJECT ACCOMPLISHMENT BASED ON NUCLEAR POWER PLANTS CONSTRUCTION

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### METODOLOGIA REALIZACJI DUŻYCH PROJEKTÓW NA PRZYKŁADZIE BUDOWY ELEKTROWNI JĄDROWYCH

#### Abstract

The paper looks at the systematic approach to management throughout the entire project life cycle. Some significant activities within particular phases of the overall process have been described in order to point out the fundamentals for a successful project. Planning assumptions, predicted risks and resources are always the basic parameters necessary for the optimal establishment of project objectives. Further stages of projects need to be driven through those objectives while all contemporary constraints in the execution of the project have to be overcome by project team. The monitoring of progress and costs will always be critical for each contractor, however it becomes a real challenge when project requires the demanding quality and safety arrangements, as is the case when constructing nuclear power plants. The highest standards and procedures recommended for project management have been established in the UK and the USA. The main conclusions concerning the most important stages of project have been supported by examples of construction processes experienced by author in those countries.

*Keywords: project lifecycle, project assumptions and risks, standards and procedures of project management*

#### Streszczenie

Artykuł jest próbą systematycznego podejścia do procesu zarządzania pełnym cyklem życia przedsięwzięcia. W celu wskazania podstaw do pomyślnego zakończenia projektu opisano kilka działań znaczących dla poszczególnych etapów całego procesu inwestycyjnego. Założenia planistyczne, przewidywane ryzyka i zasoby określają zawsze podstawowe parametry niezbędne do ustanowienia celów projektu. Dalsze etapy przedsięwzięcia winny być prowadzone w odniesieniu do tych celów, a wszystkie występujące w tym czasie ograniczenia wykonawcze muszą być pokonane przez zespół zarządzający. Monitoring postępu robót i kosztów będzie zawsze dla wykonawcy robót czynnością krytyczną, lecz w przypadku budowy elektrowni jądrowych wypełnienie wymagających ustaleń kontraktowych dotyczących jakości i bezpieczeństwa staje się prawdziwym wyzwaniem. W artykule wskazano najważniejsze normy i procedury dotyczące zarządzania projektami, które rekomendowane są w Wielkiej Brytanii i USA. Główne wnioski dla ważnych etapów przedsięwzięcia podparte zostały przykładami zaczerpniętymi z procesów budowlanych, których autor artykułu doświadczył w tych krajach.

*Słowa kluczowe: cykl życia projektu, założenia i ryzyka projektu, normy i procedury zarządzania projektem*

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### 1. Project lifecycle

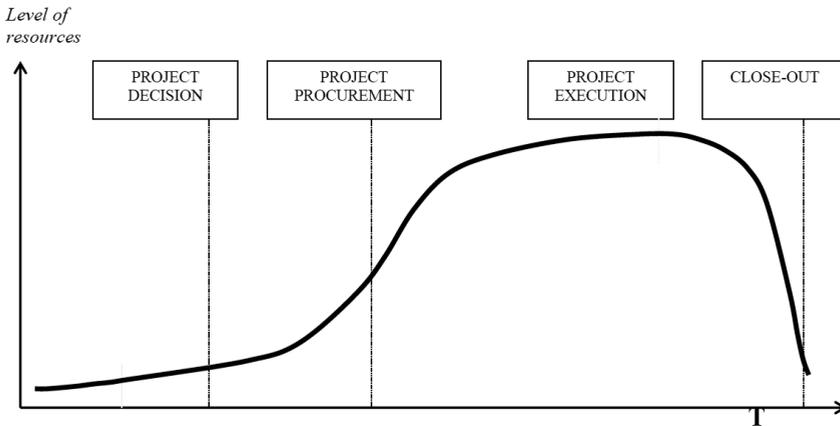
the performance of large projects has always been a challenge for all stakeholders throughout the life cycle of the project. Knowledge and experience in the execution of proper activities within the life cycle creates an obligatory base for effective results of all projects [1].

To date there has not been a standard guide for project life cycle published in Poland. Due to this, some flexibilities in the identification of necessary project activities are observed in general, particularly in the early stages of project. This also effects the efficiency of meeting project objectives.

British standard BS 6079–1:2010 provides guidance for managers in organizations which operate projects as well as for project sponsors. All project life cycles should include elements, which will be specifically identifiable for the project. Each project has its own phases, the decision points (“gates”) without which next phase cannot be started and milestones – delimiting the further progress of works [2]. According to the above mentioned standard the names and numbers of project phases are determined in general by control needs of contractors involved as well as by the milestones of overall project cycle.

Generally project life cycles comprise two to six phases – seldom more than ten. There are 5 phases in average: initiation and planning of project, feasibility study, execution, maintenance and close-out.

Meanwhile the British *Chartered Institute of Building* (CIOB) recognizes eight stages of a construction project [3] (Fig. 1). Commissioning and taking-over stages were clearly distinguished from the whole process in order to pay more attention to engineering services and their important role in the technical approval of project scope.



I INCEPTION	II FEASIBILITY	III STRATE GY	IV PRE- CONSTRUCTION	V CONSTRUCTION	VI COMMISS- SIONING	VII TAKING- OVER	VIII CLOSE- OUT
<i>Objectives</i>	<i>Project brief</i>	<i>BIM &amp; team</i>	<i>Designing &amp; optimization</i>	<i>Project team interaction</i>	<i>Engineer services</i>	<i>Completion Occupation</i>	<i>Project audit</i>
<i>Important resources</i>	<i>Project execution plan</i>	<i>Control system</i>	<i>Contractual arrangements</i>	<i>Environmental management system</i>	<i>Testing &amp; commission</i>	<i>Start-up</i>	<i>Close-out report</i>

Fig. 1. Stages in construction project according to CIOB (developed by author)

It should be pointed out that the construction process is a complete project just for the contractor but not necessarily most important for the employer. The distinct priorities of both parties result in different approaches to the common part of project. A building contractor is not usually involved in first three phases – inception, feasibility and the working-out of project strategy. This is probably the main reason project stakeholders underestimate these phases. However, the next “building” phases depend on them very much.

The overall scope of activities for building the **British nuclear power plant – Sizewell B** – had been broken down to seven stages of execution. The following milestones for these stages had significant meaning for overall life cycle of the project.

STAGE 1 – obtaining of public acceptance and optimization of power plant location,

STAGE 2 – confirmation of availability of technology licenses and designing,

STAGE 3 – contracting and execution of civil-mechanical-electrical design,

STAGE 4 – contractual procedures for civil – mechanical-electrical works,

STAGE 5 – performance of all construction works,

STAGE 6 – installation, testing and start-up of technology equipment – nuclear fuel load,

STAGE 7 – issue of safety and rating certificate.

## 2. Planning of larger projects

Due to a large scale of supplied materials and resources as well as due to the wide scope of branch works and technologies. the construction of a nuclear power plant has always been one of the most complex of projects. Therefore the investment process requires the implementation of management systems consistent with the effectiveness and quality of system requirements.

The construction of nuclear power plants has to be preceded by careful feasibility studies consisting a numerous sets of analysis. Impact on the environment and related activities are challenging when undertaking such a construction process. The environmental license as well as many technological, hydrological, geotechnical, seismic, geopolitical and legal parameters affect the optimal project location, therefore inspections leading to proper decision making usually accounts for 30% of the total time required for project completion.

British Nuclear Electric spent 5 years on initiation and design activities prior to a 7 year period of construction and the ultimate commissioning of Sizewell B nuclear power plant. The investment programme was derived from the project master programme which encompassed and iterated considerations covering design, licensing, manufacture, construction, testing and commissioning.

Iteration of all those processes underlies the basis for optimization of all major objectives. Satisfactory project objectives are always the most important condition for decision makers who have to consider external and internal assumptions, risks and the main resources necessary for project completion. To achieve the optimal balance between all of those parameters will always be challenging for project planners. Therefore the proper methodology has to be implemented in order to gain the project sustainability (Fig. 2).

Any default or mistake in this procedure will always result in various problems during the execution phase and projects are very often suspended or even canceled in such cases. The history of our Żarnowiec project shows how poor geopolitical assumptions could have led to wasting of time and money.

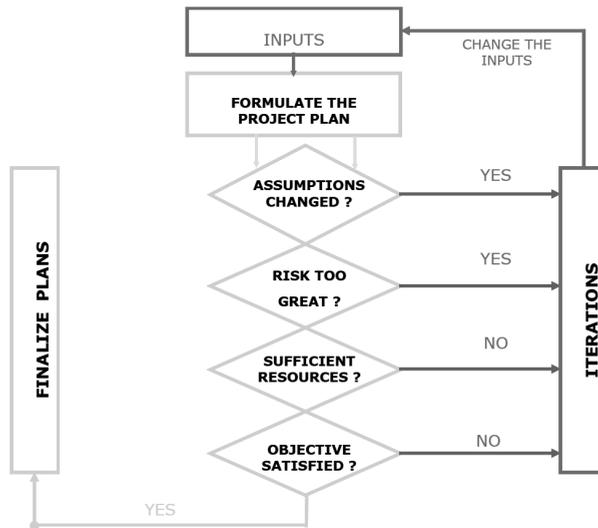


Fig. 2. Optimizing the project planning [4]

**At the Sizewell B project** many considerations were given environment issues. The Nature Reserve, the North Sea coastline and de-watering of the construction site without any draw down of the adjacent water level – were the main constraints to be overcome during the process of public inquiry and necessary licensing. Following the safety guidelines for the reactor structure the PWR (pressurized water reactor) system was approved, followed by the building of 1: 75 scale models. These models protected the work progress from many clashes and allowed for all of the key handover dates to be achieved and the whole project completed according to the master schedule.



Fig. 3. Execution of Reactor Bldg. in Sizewell B power plant (photo by K. Tracz)

Civil engineering design was managed under the cost reimbursable contract for most of the design period. When the remaining work could be more precisely defined, it was changed to a fixed price with progress related payments.

Rapid construction was pre-planned by plant being positioned in the lower floors of buildings in which the upper levels were still being constructed, thereby requiring the buildings to have temporary weather protection. To facilitate plant installation routes etc, access ways, construction openings, external ramps to ground level and concrete laydown areas were built into the design.

Meanwhile the current seven year-long construction of nuclear power plants in **Olkiluoto (Finland) and Flamanville (France)** had been planned for completion in year 2013/ 2014, however due to repeated time slides the real schedule date is expected to be around 2016.

To avoid common project management pitfalls the British CIOB paid particular attention to the following considerations [3]:

- Clear links between project and strategic priorities including agreed measures of success,
- Support, ownership and leadership,
- Effective stakeholder engagement,
- Effective project management and risk-management skills,
- Proper sequencing and scheduling of activities,
- Careful calculation of long-term value for money rather than overestimated initial price,
- Understanding of the supply chain,
- Integration between client, the project team and the supply chain.

The key to a successful project will always be well determined and analyzed Project Management Plan, often called a Project Execution Plan or Baseline Plan. It is a statement of policies and procedures defined by the project sponsor although it is usually developed by his project manager.

*\* According to British standard BS 6079-1:2010 the Project Management Plan shall be developed in order to set out the fundamental priorities and activities in respect to all management areas, of which a long list has been included in clause 7.1.4.2 of this standard.*

### 3. Project strategy

The main aims for the project decision-maker at the strategy stage include setting up the project organisation, establishing contributions required for the construction phase, delivery and commissioning issues through to identifying project targets, assessing and managing risks and working out a project plan. Therefore a typical strategy stage consists of the following elements : project brief, management structure, control system and procurement.

The procurement process should be considered to be most important as this formulates the basic inputs for other elements. It reflects the organisational and contractual arrangements which can be made to ensure that the interests of investor are safeguarded. The various procurement methods can be classified under the headings (Fig. 4):

- Traditional execution,
- Design-and-build,
- Build-Operate-Transfer (BOT),
- Construction management (Contract Engineer),
- Management contracting (Project Manager).

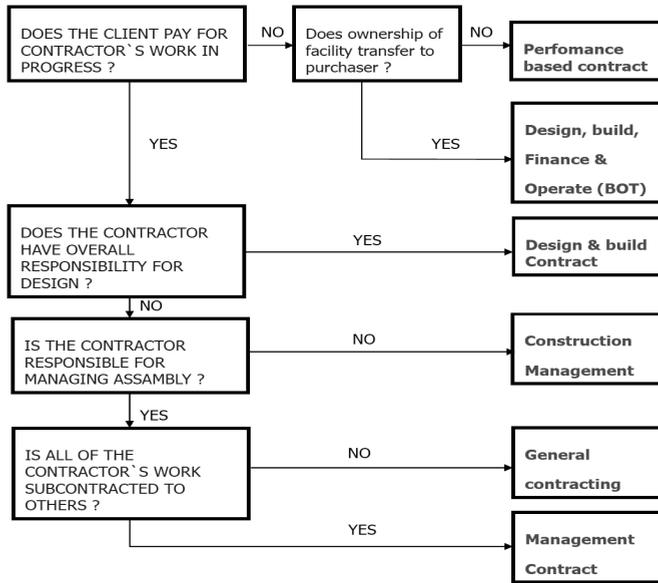


Fig. 4. Identifying procurement methods [6]

Careful considerations to be undertaken when preparing the scope of responsibilities and tender requirements for bidders. The consequences of not appropriate risks allocation as well as wrong formula of contract pricing are irreversible in most cases.

Public bids use lump sum pricing as an almost obligatory rule not taking into consideration all disadvantages related to such procedures. The mutual relation between scope changes, risks and incentives are usually underestimated by project sponsors and decision-makers (Fig. 5).

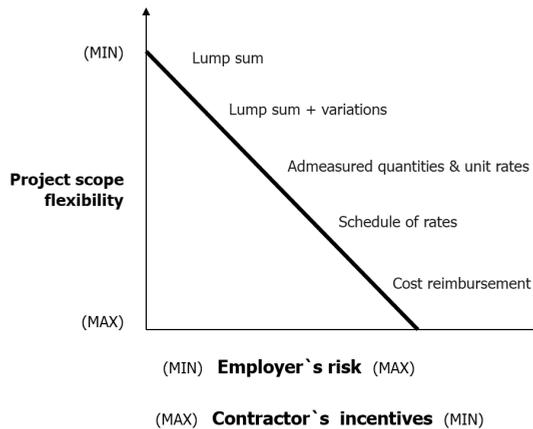


Fig. 5. Allocating risk through methods of payment [5]

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#### 4. Construction and commissioning stage of project

In order to meet required objectives in such areas as planning requirements, entire life cycles constraints, value engineering, procurement methods, health and safety, environmental issues, and so on, standardization of project execution needs to be implemented. All of these conditions have a direct influence on the methodology of works to be performed on site. Ideally, construction will be undertaken in accordance with a detailed schedule. However, this ideal situation is only possible with perfectly-developed designs, which means for large-scale project ... almost never. Most such projects, especially those using innovative technologies and designs, need proactive input from the project manager and all members of the project team. **The project manager has to steer the project to completion through continuous measurement of performance against time, quality and costs.** Therefore his broad skills are an obligatory condition for achieving success. Nowadays, various IT-based tools provide support for project management activities i.e. scheduling, earned value calculations, progress assessment etc. For the last few years the BIM (*Building Information Modelling*) methods have been dynamically developing and established models are considered to be a must for high-complexity projects.

**Any major changes** to defined fundamentals will usually affect time and financial aspects of project. However the negative influence of these changes could be limited and kept under control by using of proper procedure (Fig. 6).

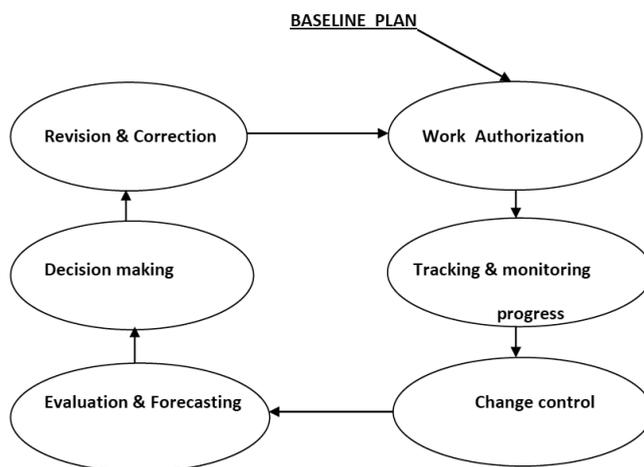


Fig. 6. The procedure of Project Plan control [5]

**Testing and commissioning** at Sizewell B was carried out under supervision of the independent quality assurance manager who reported directly to the project director. The quality department ensured the production of all the necessary QA procedures and documentation, including the quality system of suppliers and sub-contractors, and administered the site documentation centre. The QA department managed a team of independent inspectors who were closely involved in the inspection of all works on site, in additions to that carried out by site engineers. The regular review of non-conformism led to a significant reduction in rework and an improvement in overall costs.

Quality plans are the major references to the obligatory controls of all method statements, and the so called “hold points”, do not allow for continuation of building activities without the inspectors release. International standards ISO 10005 and 10006 to be used for better organization of QA system on site [9, 10].

Continuous control through specified technical, managerial and financial monitoring of the project seem to be the “golden mean” for final success of every project (Fig. 7).

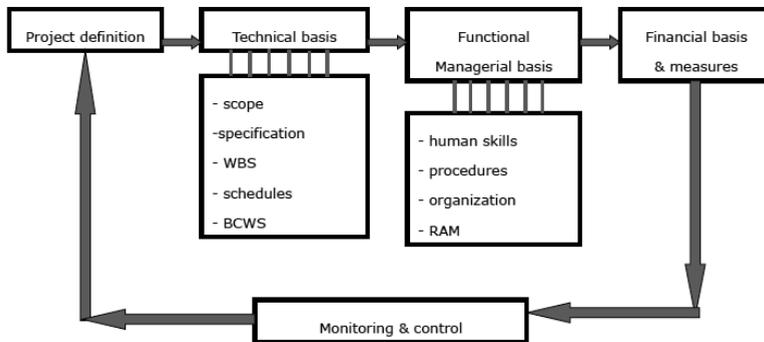


Fig. 7. Methodology of project execution according to Project Management Institute (PMI) [7]

## 5. Conclusions

there are many organizational, technical and methodological aspects described in this article with regards to large projects, such as power plant construction. Meeting project objectives as well as effective supervision should be based on proper risk allocation between the Employer and the Contractor, however all sponsors have to be aware that keeping full control of project life cycle leads to a greater risk acceptance. The introduced algorithms for project planning and procurement as well as methodology of their control might be a guide for key staff involved in projects in Poland, however some amendments resulted in polish legal acts yet to be implemented. One thing is for sure : the wider the scope of the contractors responsibility, the greater the risk of the employer losing control over the project. Therefore the proper supervision should be based rather on project management than on the contract engineering agreement. This conclusion is definitely to be considered by decision makers of the first nuclear power plant to be built in Poland.

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