



UNIVERSITY OF NIŠ  
The scientific journal FACTA UNIVERSITATIS  
Series: **Economics and Organization**, Vol.1, No 5, 1997 pp. 93 - 100  
Editor of Series: *Dragiša Grozdanović*  
Address: Univerzitetski trg 2, 18000 Niš, YU  
Tel: +381 18 547-095, Fax: +381 18-547-950

## SELECTION AND OPTIMAL DISPOSITION OF EQUIPMENT IN A INVESTMENT PROCESS

UDC: 669.3:338.45

**Drago Soldat**

"Beogradska Banka, a.d." – Bank - Institute for Investment Economics  
Knez Mihailova 2, Belgrade, Yugoslavia

**Abstract.** *In this paper, we will analyze the selection of equipment which is necessary for investments in production facilities and also the disposition of this equipment in new investment projects. The selection and optimal disposition of equipment in production facilities was achieved by studying the adequate technology, which is one of the significant aspects in the process of making efficient investments. The analytical approach to this problem represents a generalized model, which can be applied in any other type of job.*

### 1. INTRODUCTION

The selection and optimal disposition of equipment is important in any kind of work, especially in production jobs. They have most important influence on the setup of a project when investment costs, which also include production costs, are calculated. The right selection and disposition of equipment demands detailed study on the technology of the production process.

Such an investment is a complex task and has to include methods of planning, project development and evaluation, which provide accurate information about the effectiveness and exploitation effects of the future investment.

A specific methodology of investment project development and evaluation is based on empirical methods, i.e. a method of individual expert evaluation. The process of planning depends on the research instrument this methodology provides us with.

The selection and disposition of equipment in production facilities depends on the type of production, the kind of job and its complexity. It directly correlates with the job task and the space where the equipment should be located.

The process of selection and optimal disposition of equipment in production facilities, has to include interdisciplinary approach, modern quantitative instruments for evaluating the goals and effects we want to achieve.

It should also be mentioned, that the study of equipment selection is in correlation to other aspects of investing, which are not the subject of this paper.

The main objective of this paper is to present a method of analytical approach to the problem of selection and optimal disposition of equipment in production facilities. The intention also is to modify this method according to the demand of a particular investment, in order to rationalize the planned investment activities.

## 2. BASIC PROPERTIES OF TECHNOLOGY

Technology is defined as a set of production activities, which include the use of raw material, equipment, energy, human resources and should result in the realization of planned job tasks.

The efficiency of a production type, depends on its technology. That means, that selection and optimal disposition of production equipment also depends on the technology of production.

Knowing the technological characteristics of the production process and all corresponding conditions, is essential for the accurate control and management of the equipment, regardless of the type of project<sup>1</sup>. Evaluating the alternatives should do the selection, optimal disposition and control of production equipment. For that purpose, it is necessary to study the specific characteristics of technical services and engineering, which could significantly affect the selection of particular production techniques, and also the whole equipment. The level of automation of a technology could also be very important. This is directly connected with the engagement of adequate expert personnel, i.e. the cost of human engagement [1].

When choosing between alternatives in technology, special attention has to be paid to the evaluation of the function of the corresponding equipment in the given conditions of a production facility. Besides that, the possibility for optimal usage of equipment, which is the subject of a specific investment, and improvement of production during the lifetime of equipment, has to be analyzed. This possibility is in close relation to the level of obsolescence of the equipment.

It is very important to test the technology in the production process. Old, outdated technologies as well as the ones that have not been tested in exploitation should be avoided, in other terms, one should choose those alternatives which make possible using more modern equipment and working methods.

In choosing between technology alternatives, raw material and materials play a very important role. One should choose technology alternatives which do not depend on imported components. It should be taken care that these components should be provided in sufficient amount and quality during the projected lifetime of the production process.

---

<sup>1</sup> In a investment project, we have two project types. One concerns investing in the reconstruction, modernization or expansion of existing facilities, the other concerns investing in new facilities.

The analysis of technology alternatives, is generally also very important, considering the engaged number of experts and the needed working personnel. In some countries, the cost of the personnel is much lower than in Western Europe. This fact should also be considered when choosing between technology alternatives. Special attention should be paid to the question whether it is optimal to choose a technology with a higher or lower level of automation. It is often the case that some technology can't be used because there is no qualified personnel or it is simply not possible to conduct an adequate training of the personnel [1], [2].

The application of a particular technology demands the analysis of the supplied energy that should be used. This analysis should be based on the criteria of economic consumption and the conditions under which the supplied energy can be obtained.

The alternatives should also be analyzed from the aspect of maintenance of the equipment, which are an essential part of this technology alternative and the aspect of the training of expert personnel. If the technology directly depends on the production equipment,<sup>2</sup> it is necessary to make special analysis and the decision which alternative to apply and which equipment trademark to choose for production. The references of the producer of the equipment, the price, the delivery and payment terms can be very important in the selection of a particular technology alternative [3].

When technology is being used according to engineering principles, the type and subject of engineering services have to be analyzed in detail from the start of the project to the test operation after its implementation.

In case of a licensed technology it is important to master all critical elements, which could possibly emerge, from the license contract. It is necessary to clear out all problems concerning the legal aspects of the use of this technology.

If a patent technology, i.e. a technology with a registered trademark is selected, the main objective is to clear out the legal aspects of use, as well as the right concerning the sale of products which were produced according to this technology [1].

When buying technology from others, the type of technology transfer is important as well as to respect all legal aspects.

The selected technology directly affects the selection of necessary equipment and has also influence on organizational and technical problems in the process of production.

### 3. SELECTION OF ADEQUATE EQUIPMENT

Equipment is a set of machines, devices and tools necessary for the realization of products.

The production includes not only machines and devices, which are components of the production process, it, but also other tools and equipment, which are necessary in this type of production.

Technology and equipment are closely related. The basic condition for the selection

---

<sup>2</sup> In some projects, production and operating technology are directly dependent of the production equipment, which is not the case with other projects, where technology is obtained independent from the production equipment, i.e. the selection of equipment is being adjusted to the technology.

of adequate equipment is how much it is adjusted to specific demands of the investment project, which means that the selection of equipment has to be the result of a detailed analysis of every component.

In general, the selection of equipment is a much more delicate problem in machine and food industry than in chemical industry. The reason lies in the fact that there is a great number of possible production operations equipment has to accomplish in machine and food industry, while this is not the case in chemical industry where the production process is continuous.

Basic information about the equipment needed in the technological process of production can be obtained from technical and commercial documentation. Commercial documentation includes preliminary and final offers made by the suppliers of equipment [2].

Attention should be paid to the analysis of purchase of equipment on the domestic or foreign market. Purchasing equipment from the foreign market asks for special expert arguments. This arguments should primarily include technical advantages of the foreign equipment. When selecting equipment, it is necessary to classify it. This classification depends on the type of production and its complexity. The classification of equipment should be adjusted to the specific terms of the investment project.

The application of a particular type of production is directly dependent on the selection of adequate equipment, including adequate tools - Table 1 [4].

Table 1. Technology, equipment and tools as a function of the production type

No	Type of production	Technological process	Equipment	Tools and accessories
1.	Single	Small number of operations	Universal	Universal and specialized
2.	Serial	Operations by type	Universal and specialized	Universal and specialized
3.	Large-scale	Elements and operations	Specialized Automated Aggregates	Specialized Universal

The summary of the necessary equipment is given in Table 2.

Table 2. Summary of the necessary equipment

No	Name of equipment	Name of operation	Technical capacity of equipment	Amount of equipment	Number of personnel			Total
					1shift.	2shift.	1shift.	
1.	Production equip.							
2.	Transportation equips.							
3.	Storage equips.							
4.	Quality control equips.							
5.	Maintenance equips.							
6.	Energy supply equips.							
7.	Equipment for environmental protection and protection at work							
8.	Infrastructure equips.							

Considered what has previously been said, it is good say the following:

In production technologies, besides the selection of equipment also important is the capacity of equipment. Capacity (lat. *capex, capere*), basically defines a volume of space, but generally also defines the production ability of an equipment. The capacity of the production as a total, depends on various segments (departments, workshops, etc.). The realization of the planned amount of production and an adequate capacity of the production equipment depend, among other items, on a general level of organization of the labor process and on the efficient use of the capacity of the production equipment and the efficient use of the production facility.

An important item in the selection of equipment is the conditions under which the production plan is fulfilled and the number of working shifts. These conditions are important for the protection of workers who work with the equipment and the protection of the equipment, in order to avoid any damage. This is achieved by applying regulations concerning the protection of workers and production equipment, fire protection, mechanical protection, etc.

Equipment maintenance is of great importance, considering that the owners of equipment want to keep it working throughout the whole exploitation period. This matter is often neglected even while the equipment is being exploited, and particularly not when the decision about the selection of equipment is made.

#### 4. OPTIMAL DISPOSITION OF EQUIPMENT

To make an optimal disposition of equipment in production facilities, it is necessary to make a detailed analysis of the technological process, with a defined capacity and amount of production, an analysis of the applied organizational schemes, which will be applied in the production process.

Optimal disposition of production equipment is possible only with an investment where a production plan with a palette of products is implemented in exploitation for the first time. In investment projects, which include reconstruction, modernization or expansion of existing facilities, we can't accomplish an optimal disposition, because a disposition of equipment already exists. The new implemented equipment can't be disposed in a way that would provide an optimal solution for the whole production facility. The new equipment, in most cases, replaces some existing equipment, so an optimal arrangement can't be achieved.

To make an optimal disposition of the selected equipment it is necessary to have a precisely defined production program with a defined assortment of products, in order to make an analysis of the technological process.

A technological process, generally speaking, is a complex set of planned operations which are, in most cases, coordinated, and which define the boundaries of the process and also the optimal disposition of the necessary equipment in the production facilities.

A detailed description and full knowledge about the technological process is necessary, because it is the basis for the purchase and optimal disposition of equipment. Without detailed study of the process it is not possible to organize the production of any item on the basic principles and scientific methods of labor organization. A detailed analysis gives us also information about all other production parameters which are not a

subject of investment, but which are necessary for the production process.

This information is processed according to the principles that the experts from various fields have to follow .

The analysis of the technological process is done by processing information concerning [2],[5].

The analysis of this information's is necessary, but not sufficient in creating an optimal disposition of equipment. Besides that it is necessary to obtain information about the type and complexity of the production, which we discussed in previous parts of this paper.

It is necessary, for a production to be more rational, that the period that an item, which is the subject of the production process, spends under treatment (from the store of raw material to the store of final products) is as short as possible. The ideal case would be if the equipment were disposed in such a way that the production item travels on a straight line. Practically, such a disposition of equipment is not possible for the following reasons [6]:

- amount and assortment of some products,
- evenly distributed production,
- organization of technological process and technical control,
- available machines,
- work protection and environmental protection regulations, etc.

To make an optimal disposition of the selected equipment, there should be rational movement of the production item from one machine to the other, because the path on which the production item moves is an important criterion for evaluation of general organization quality of the production. An optimal disposition of equipment can be achieved (respecting the information about the production technology) by applying the triangle method or a combined disposition method, which is practically the case. The project managers must have in mind the criteria of modern production organization, which states that the movement of workers in the production process has to be adjusted to the movement of the production items, and not vice versa.

Optimal disposition of equipment defines the physical space of a project, therefore it is the basis for evaluating the production and investment costs. The general functional disposition, shows the relation between production equipment, objects which are subject of the investment, and the construction work. It is necessary to take the possibility of a future production expansion, into consideration. For this it is necessary to know about the conditions under which the product will exist on the market [1].

The total capacity, as well as the capacity of components also affects the optimal disposition of equipment. A general rule in optimal equipment disposition is to respect the principles of functionality and rationality, as well as the safety of workers at their jobs, regardless of the installed capacity.

The organization of the whole production process, is based on the disposition of the chosen production equipment and the workers which work on it. This should be considered at the start of the project and not after the disposition is finished.

The need for protection at work, should not be especially emphasized, because it is an obvious condition, very important for the concept of workers safety and the safety of the production process in general.

Optimal disposition of equipment should be studied in detail, in a way that provides the necessary technical arguments and solution which correspond with the scientific based organization of production. Other investment aspects should also be studied (objects and their accessories, infrastructure, location, etc.). They are closely related to the matter, but are not a subject of analysis in this paper [3].

It is, of course, very important to make the necessary analysis concerning the organization of space and its functionality. This includes data about the dimension of all the facilities, room's etc.

The disposition of all accessories and the type of infrastructure also affect the problem we are discussing here, where the following should be analyzed:

- sufficiency (by contents, capacity and technical properties)
- adjustment to the equipment in the surrounding
- possibility to make necessary interventions and maintenance
- possibility of a future expansion
- adjustment of external connections to the public infrastructure [2],[5].

## 5. CONCLUSION

The selection of equipment needed for the realization of an intended investment and its optimal disposition involves studying the technology of the given production process.

The selection and the optimal disposition of adequate equipment are the basic condition for a successful project. Knowing that, a methodological and skillful approach to this problem includes necessary analysis, in order to get those solutions, which will implement a rational production, which on the other hand, will affect the total cost of equipment and exploitation during the economic lifetime of an investment.

The final solution to selection and optimal disposition of equipment in production facilities includes detailed study made on basis of technology, which is one of the most important aspects in the process of efficient investing. We must also have in mind that we can get a valid solution only if we also analyze the other investment aspects, which were not discussed in this paper. These problems are analyzed in various ways, among which we should choose the one that shows the most advantages.

The properties of the basic concept of equipment selection and its optimal disposition, which are matters that were discussed in this paper, are the correspondent nature of the analytical instruments for the multiple criteria evaluation of the way in which problems of this kind can be approached generally, in order to achieve a satisfying level of rationality, in the investment process, as well as the production process itself.

The analytical approach to the problem of selection and disposition of equipment in production facilities, presented in this paper is a model that can be applied in any kind of industry. It is a good solution for investment projects, which include only new equipment, in fact, only in that case it can be applied - from the start, when only an idea exists to the final realization.

## REFERENCES

1. *Priručnik za primenu industrijskih studija izvodljivosti*, UNIDO - Organizacija Ujedinjenih nacija za

- industrijski razvoj, Beograd, 1984.
2. Soldat, D., Plavšić, R., *Tehnološko-tehnički aspekti provere ocene investicionog programa*, Privredna izgradnja, 1995, 38, 1-2, 71-84.
  3. *Priručnik za primenu zajedničke metodologije za ocenjivanje društvene i ekonomske opravdanosti investicija i efikasnosti investiranja u SFRJ*, - Operativno uputstvo za izradu investicione studije - programa, Udružene banaka Jugoslavije, Beograd, 1989.
  4. Bajić, M., *Projektovanje fabrika (Projektovanje proizvodnih sistema)*, Mašinski fakultet Univerziteta u Sarajevu, Sarajevo, 1984.
  5. Soldat, D., Plavšić, R., *Pristup projektovanju investicionih objekata i opreme u proizvodnim delatnostima*, Prvi međunarodni simpozijum "Industrijsko inženjerstvo '96" - Zbornik radova, Mašinski fakultet, Beograd, 1996.
  6. Dašić, V., *Metode naučne organizacije rada - Organizacija i ekonomika preduzeća*, Naučna knjiga, Beograd, 1964.

## **IZBOR I OPTIMALNI RASPORED OPREME U PROCESU INVESTIRANJA**

**Drago Soldat**

*U radu se analizira problematika izbora opreme neophodne u procesu investiranja proizvodne delatnosti kao i njen optimalni raspored kod projekata tipa nove investicije. Izbor opreme i njen optimalni raspored u pogonima proizvodne delatnosti izvršen je proučavanjem odgovarajuće tehnologije kao jednog od bitnih aspekata u procesu efikasnog investiranja. Analitički pristup ovom problemu predstavlja uopšten model primenljiv u bilo kojoj grani delatnosti.*