Optimal Design of Energy Systems (M2794.003400)

Chapter 1. Engineering Design

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Course Introduction

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1.1 Introduction

Type (a)

Type (b)

- It is hard to adjust flow rate of the water in case of type (a)
- Type (b) is more convenient to adjust flow rate of the water

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1.1 Introduction

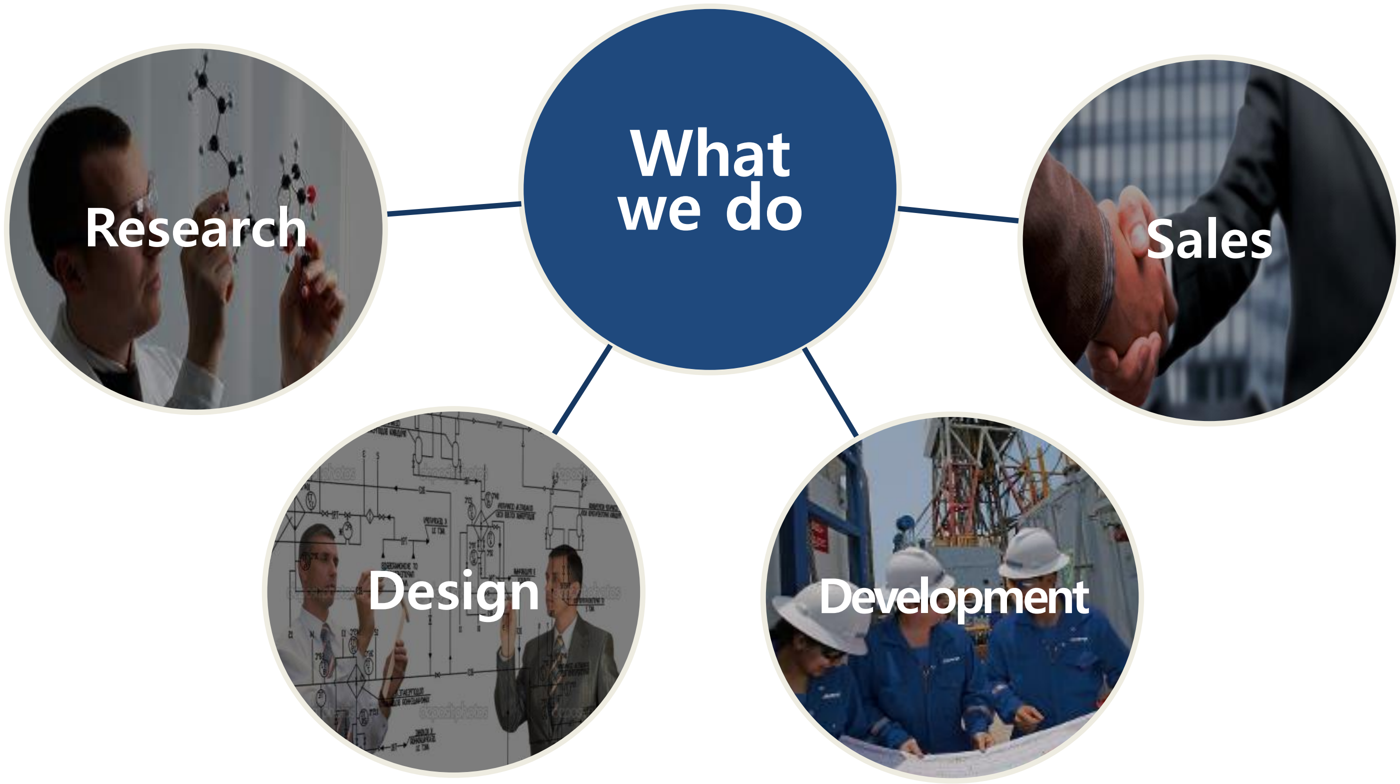

Fig. Activities of Engineers

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1.1 Introduction

- Major concern of this lecture is **system design**. Especially for **thermal system**.
- System is defined as a collection of components with interrelated performance.

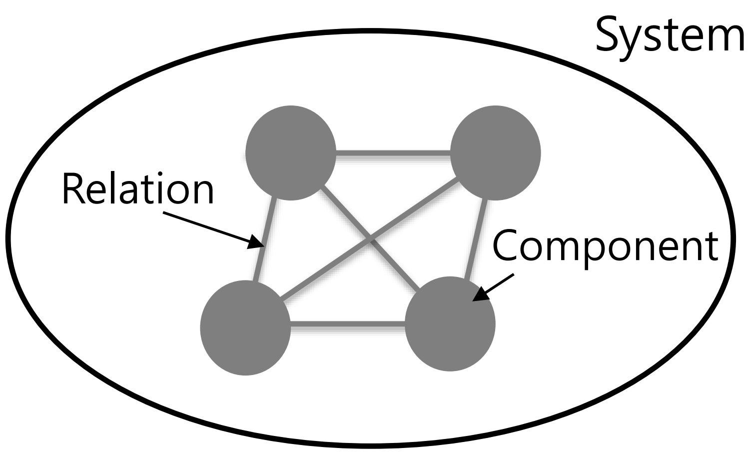

Fig. How the system is organized

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1.2 Decision in an Engineering Undertaking

- Analyzing the decision process leads to the more logical coordination of the individual efforts.
- The flow diagram shows typical steps followed in the **conception**, **evaluation**, and **execution** of the plan

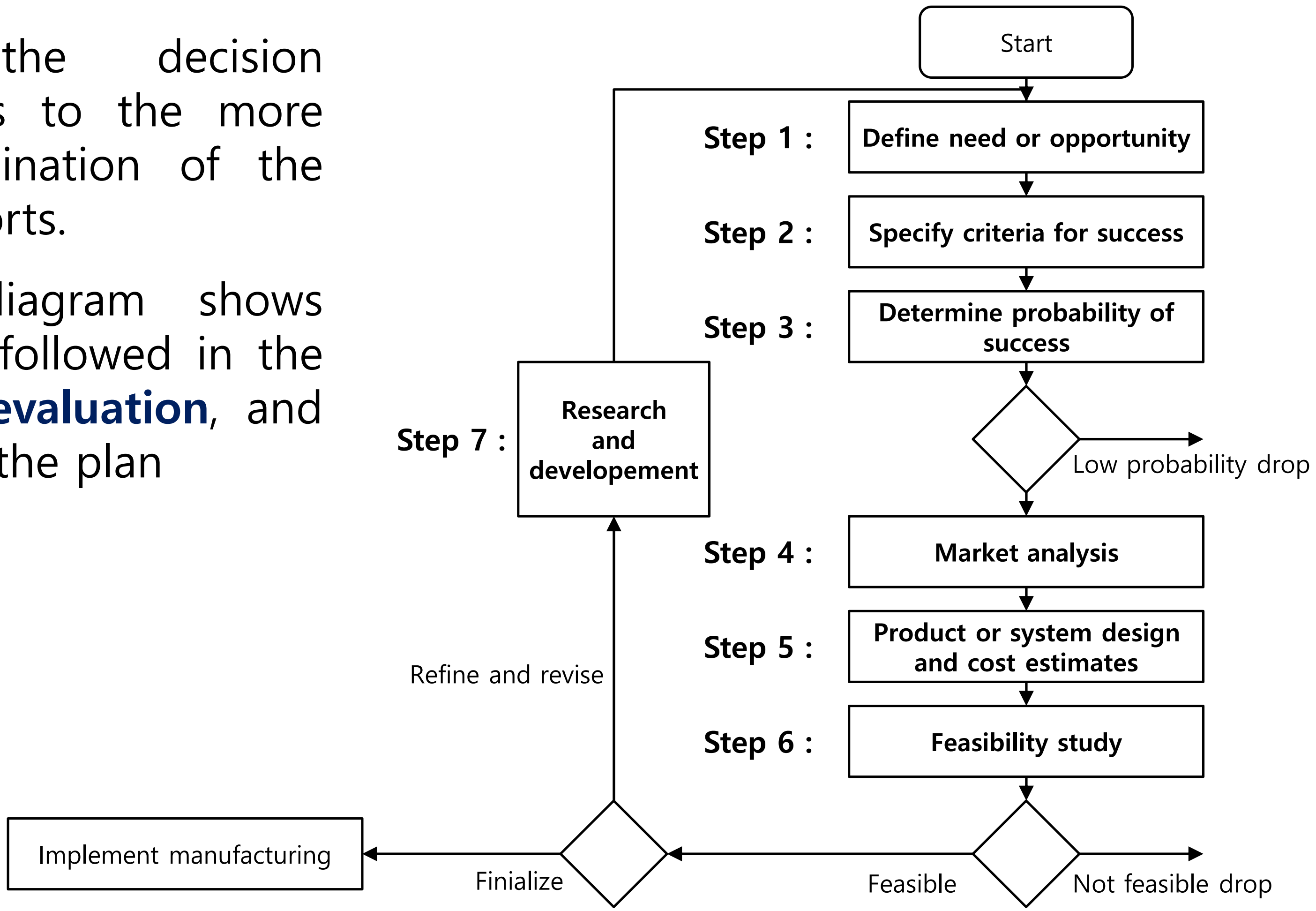

Fig. Flow chart for decision process

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1.3 Need or Opportunity (Step 1)

- The word ‘**opportunity**’ has positive connotations, whereas ‘**need**’ suggests a defensive action.
- But, sometimes the two words cannot be distinguished.

Opportunity

A pharmaceutical company releases new drug product

Need

If the company does not, business is likely to decline

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1.3 Need or Opportunity (Step 1)

- Possible solutions can be precluded by '**not stating the need properly at the beginning**'.

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1.3 Need or Opportunity (Step 1)

- Three situations that opportunity arises :

① Innovation or expansion of facilities to distribute a current product

② The sale of a product, not made by the firm, is rising.

③ Research and development within the organization

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1.4 Criteria of Success (Step 2)

- The expected earning power of a proposed commercial project is a dominating influence on the decision to proceed with the project
- In commercial enterprises, the criterion of success is showing a profit. (ex : providing a certain rate of return on investment (ROI))
- But, in public projects the criterion of success is the degree to which the need is satisfied in relation to the cost, monetary or otherwise.

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1.5 Probability of Success (step 3)

- Plans are always directed toward the future. Thus, only probability, not certainty, is applicable.

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1.5 Probability of Success (step 3)

Probability : $$\mathrm{P} = \int_{x_1}^{x_2} y dx$$

Max probability : $$\int_{-\infty}^{+\infty} y dx = 1$$

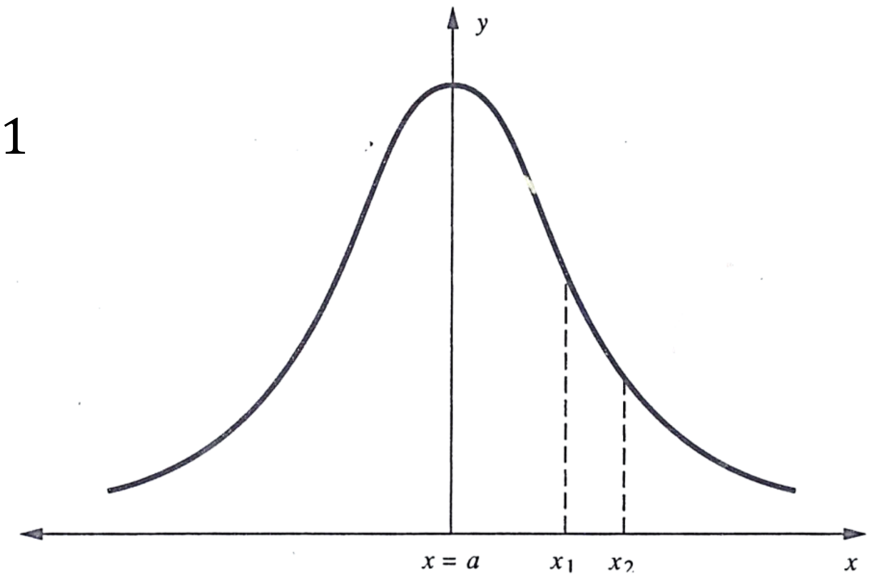

Fig. Probability distribution curve

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1.5 Probability of Success (step 3)

Equation for Probability distribution curve :

$$y = \frac{h}{\sqrt{\pi}} e^{-h^2(x-a)^2}$$

The maximum value of the ordinate :

$$\frac{h}{\sqrt{\pi}} \ \ at\ x = a$$

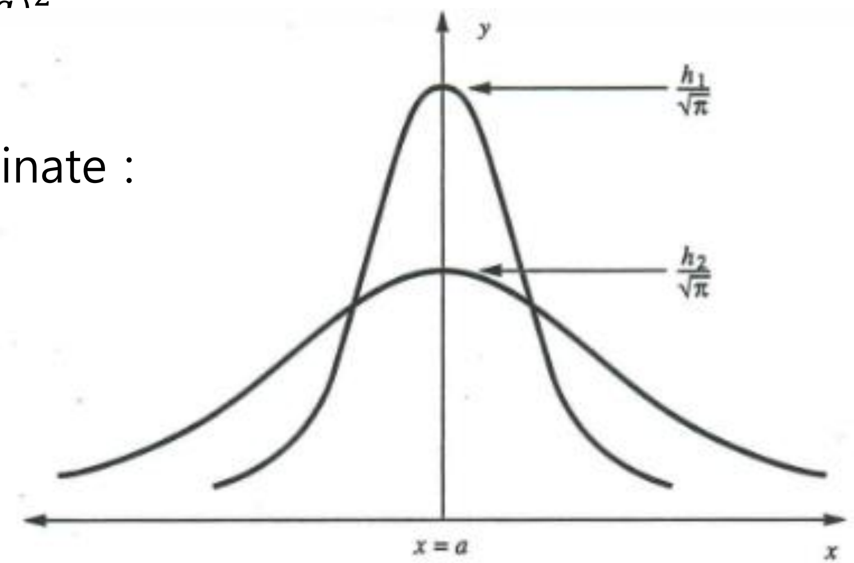

Fig. Probability distribution curve

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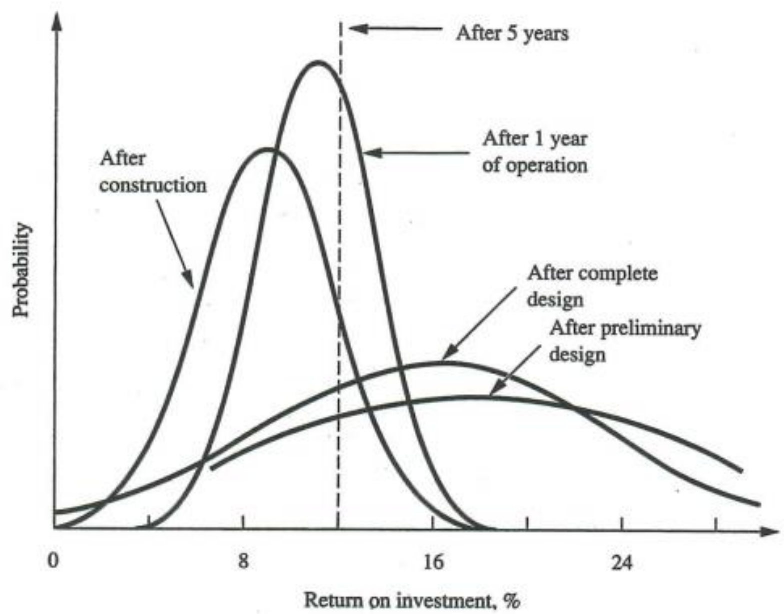
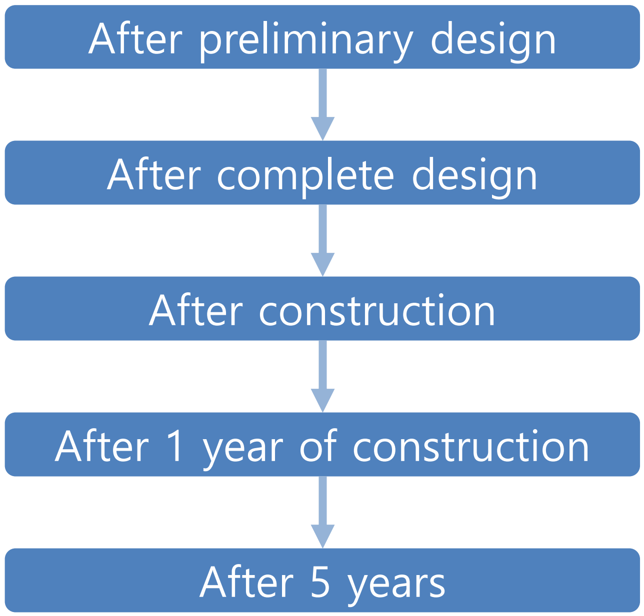
1.5 Probability of Success (step 3)

- Example) Suppose that a new product or facility is proposed and that the criterion for success is a 10 percent rate of return on the investment for a 5-year life of the plant.





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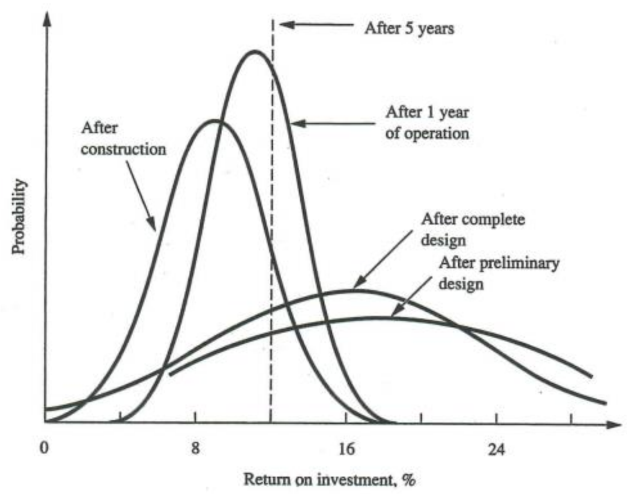
1.5 Probability of Success (step 3)

- After a **preliminary design**, Since rough figures were used throughout the evaluation, the distribution curve is flat, indicating low confidence in an expected percent of ROI , e.g., about 18%.
- If the probable ROI after **complete design** were, e.g., 16%, the confidence would be greater than the confidence in 18% figure. This is because costs have been analyzed more carefully.



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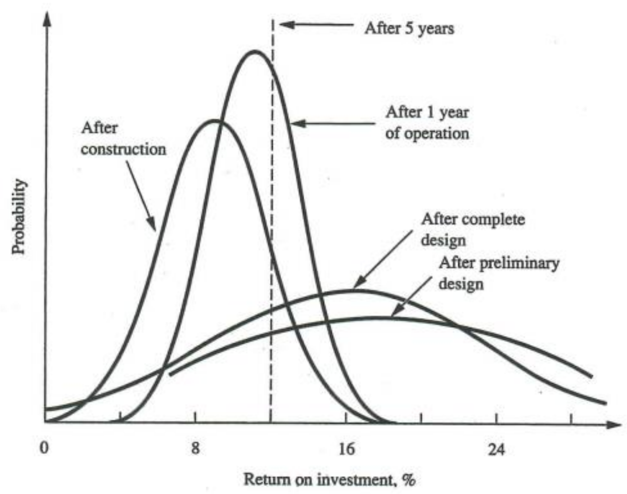
1.5 Probability of Success (step 3)

- The distribution curves **after 1 year of operation** and **after construction**, show progressively greater degrees of confidence than the confidence at the design stages.
- **After 5 years**, when its life cycle coming, the ROI is known exactly. The distribution curve degenerates into a curve (almost linear) that is infinitesimally thin and infinitely high.



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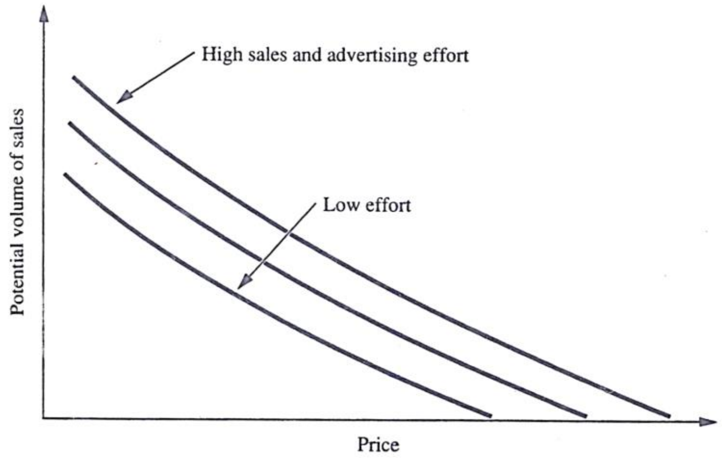
1.6 Market Analysis (step 4)

- With an increase in price, the potential volume of sales decreases until no sales can be made, and vice versa.
- The sales-volume to price relationship affects the size of the plant or process because the unit price is often lower in a large plant.
- Thus the market and plant capabilities must be evaluated.



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1.7 Product or System Design and Cost Estimates (step 5)

- System design lies between the study and analysis of individual processes or components and the larger decisions.
- Design is applied to the act of selecting a single part (ex : the size of a tube in heat exchanger) to a larger component (ex : the entire heat exchanger products).
- Our concentration will be on **thermal systems**.

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1.8 Feasibility Study (step 6)

- The **feasibility study** refers to whether the project is possible.
- Infeasibility may result from unavailability of **investment capital**, **land**, **labor**, or **favorable zoning regulations**.
- If an undertaking is shown to be infeasible, either alternatives must be found or the project must be dropped.

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1.9 Research and Development (step 7)

- Research efforts provide the origin or improvement of the basic idea.
- Development work may supply working models or a pilot plant, depending upon the nature of the undertaking.
- Placing R&D in a late stage of decision suggests that an idea originates somewhere among the stages and is placed at the doorstep of R&D for transformation into a workable idea.

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1.10 Optimization of Operation

- The facility was designed on the basis of certain design parameters which almost inevitably change by the time the facility is in operation.
- Thus, The next challenge is to operate the facility in the best manner in the light of such factors as actual costs and prices.

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1.11 Summary

- The main topic of this lecture is **designing thermal systems** where energy is transferred and converted.
- The purpose of the study is to emphasize the **advantage of systematic planning**.
- the **flow diagram of decision making** is presented and represents 7 steps of the decision in engineering undertaking.