Chapter 6

The Industrialization Process: Preliminary Projects

Industrialization can be defined as the set of processes that are required to move from research and studies, to a production system which is capable of delivering a product according to the pre-defined specifications, and responds to a business requirement, in accordance with a budget, timeline, and the ethics of the company [DAL 07].

The transition from research and studies to construction consists of steps that involve specific skills, techniques, diversified working methods, and pluridisciplinary teams.

The terminologies mostly come from the United States where they accompanied the extraordinary development of the petroleum and chemical industries in the 20th Century and the war effort necessitated by World War II.

After the development phase which is essentially a laboratory phase, the client *designs the process* in stages that take different names according to the companies: e.g. feasibility study, preliminary projects.

Depending on the case, *starting from this step*, the client can make use of what is commonly known as engineering and design departments, engineering companies in the process industries, or manufacturing engineering in the manufacturing industries (Figure 6.1).

Chapter written by Jean-Pierre DAL PONT and Michel ROYER.

The term *process engineering* does not always have the same meaning for the client and for the engineering firm; the client looks for something "conceptual", whereas the engineering firm needs something "concrete".

Let us consider the example of a process for manufacturing latex, which is used for coating paper. The reactor is designed by the chemical company: the design is complex and is necessary to obtain a valuable emulsion of nanoparticles. The reactor is manufactured by a vessel manufacturer with whom the chemical company will work in order to define the best means of cooling or the most appropriate means of cleaning. The mixing system represents an important part of the know-how involved: it must take into account the design of the polymerization vessel.

This example illustrates the interdisciplinarity of knowledge and skills necessary for physical implementation and provides an initial overview of the importance of the equipment. Many tasks are outsourced to subcontractors; this is one of the roles reserved for the engineering firms to coordinate and direct.

Globalization, and the extensive use of computers beginning in the 1960s have standardized the basic concepts regarding the vocation of engineering itself, which includes *process engineering*, *basic engineering*, *detailed engineering*, and construction. We will further discuss these concepts in Chapter 9 which is dedicated to engineering.

The upstream phases, where research is still very much involved, are less codified as they are still unclear and uncertain. A lot of material facts are missing. It takes considerable flair to understand the validity of the issues: the question is whether to continue or not! The various players in the field do not proceed in the same way, do not use the same terms, and do not put the same contents into the same words! We will discuss this in more detail in what follows. The important thing is to know it!

Initialization is the source of the project. The company is "interested" in a concept and a vision of the future. It is followed by feasibility studies and preliminary projects to materialize into what is called "Basic Engineering".

Research and studies are expensive! A well-managed project requires contemplation at the end of each step before starting the next one. This is what is called the *validation process*. This process determines the continuation, discontinuation, and reorientation of the studies. We want to move as quickly as possible "*to be first on the market*" because competition does not wait!

At each assessment process, people try to determine, as far as possible, the full manufacturing cost of the finished product, the total amount of investment needed, envisage the profitability of the project, the risks, and the chances of success. *The decision to invest is a key step.*

The company takes the risk of raising funds. There is a transition from the field of studies to completion. *Time is a terrible judge!*

Construction can take months or even years. It is during the startup phase that one will see whether the selected technical solutions are valid, whether the tool works as expected, and whether the product meets expectations.

The commercial success, however, will take time. Sales do not saturate the plant immediately. It can sometimes take months or years for the company to start making money. Construction is done for the long-term; it raises the question of what will happen to the market, if competitors are going to develop a more efficient process starting from more available and/or more "green" raw materials.

The job of the industrialist and the entrepreneur although it may be exciting, is difficult and risky!

Stopping a project under construction is a huge waste with heavy financial consequences and a black eye on the image of the company. It requires courage to stop a project when one has motivated teams, raised hopes, negotiated with customers, and "mediatized" the project. This decision is painful but sometimes beneficial.

Investing is a practically irreversible act, a bet on the future, particularly for projects where the cost represents a significant proportion of revenues and especially of the available funds [DAL 07].

All the functions of the company should be involved in the major projects:

– first of all, the *business* (i.e. the business including sales and marketing) has to sell the products obtained from the production facilities. This is the purpose of investment in order to generate profit to pay off the expenses incurred in the project;

– the R&D functions, industrial function, and engineering have to validate the technical solutions, working methods, choice of the project team, and the contractors, especially the contractor in charge of building the plant;

– human resources have to allocate the necessary resources to the project and accompany the changes induced by major projects in the organization;

– the finance department has to raise funds;

– logistics, purchasing, and communication;

– the production function that will inherit the investment.

The top management bears the ultimate responsibility: it is they who decide to invest, postpone or abandon the project, or reorientate in view of the information provided.

Much confusion arises due to a lack of understanding of the nature of the projects, their degree of progress, and the accuracy of costing. A management board who is told that a plant costs 10 million dollars with an accuracy ranging from −20% to +40% will never retain the three figures 8, 10, or 14 million dollars, but only one: 10 million dollars.

One of the major misunderstandings is the confusion between the studies and the project. From our point of view, a project suggests that the company has basically "decided to go for it", that is the funds are at least budgeted for in principle.

We will focus on the upstream steps preceding the *process engineering* step in section 6.1, that is on the part of the industrialization process that applies to the process research and preliminary projects. *"The downstream steps of process engineering"* will be discussed in Chapter 9, which is dedicated to "Project Management Techniques: Engineering".

6.1. Steps of industrialization

The main steps of the industrialization process are illustrated in Figure 6.1.

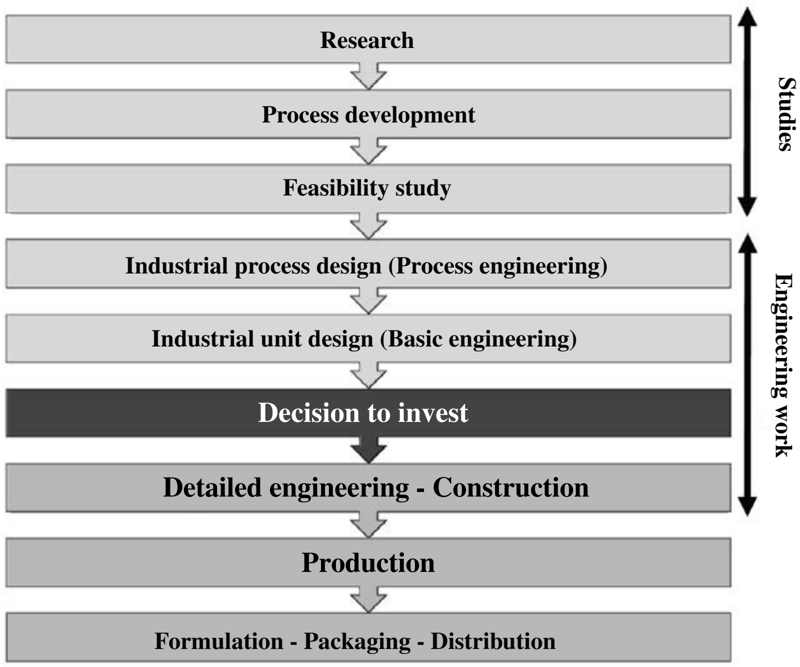

Figure 6.1. *The steps of the industrialization process: from the laboratory to production and distribution*

Before describing each step, industrialization includes two distinct phases separated by the decision to grant credit:

– the study phase that ends with basic engineering;

– the completion phase that begins with the detailed engineering and ends with the start up of the installation.

The following describes a complete process which starts from the research. Very often, the manufacturer improves an existing plant and the contribution of the research is then different. The manufacturer is actively involved: we are dealing with his tool! This case will be discussed in Chapter 13, which is dedicated to "Management of Change".

6.2. Bases of industrialization or process development

Chapter 5, "Foundations of process industrialization", written by Jean-François Joly, described in detail the work done in the laboratory to learn the bases of industrialization. This step consists of the acquisition of data necessary for the definition of industrial equipment and their operation: chemical kinetics, diffusion, mass transfer, heat transfer, momentum analysis, phase diagrams, thermodynamic equilibria, and so on.

At this point, the definition of the major equipment results in a functional specification, prior to any data sheet. It also concerns mastering the break-even points, particularly those regarding the:

– product and its value of use;

– safety (deviations of reactions);

– environment (effluent toxicity, treatment, recycling, revalorization, etc.);

– capacity and yield (catalyst poisoning, clogging up of equipment, estimation of recycling, etc.).

Beyond the control of critical points, work simulation and optimization are undertaken to find a technico-economic solution and to reduce the risks.

Process and product developments are conducted in parallel. The equipment and processes used to produce the first samples and product lots for pre-commercialization purposes are not always consistent with the final industrial process. A product can be purified in batch, whereas in the industrial facility, it may be crystallized continuously. So called laboratory research studies done by chemists usually precede the process development and feasibility studies that precede the preliminary sketches of the process flow diagrams.

6.3. Feasibility study

Feasibility studies are aimed at defining the essential characteristics of the process in order to determine the total amount of investment and full manufacturing cost of the finished product.

It refers to selecting technology in order to meet the requirements of the *business*, making comparison tables between different solutions, assessing the technological risks, strengths and weaknesses, and assessing the *reliability* of the process and its impact on the environment in the broad sense. It includes:

– the establishment of simplified diagrams and the costing of the total amount of investment (order of magnitude);

– the validation step, the purpose of which, is to choose the process technology.

6.3.1. *Design of the industrial process – preliminary engineering – preliminary projects*

This is the phase where everything is at stake! It requires a lot of involvement from the client; everything else will ensue from it!

This is the stage of preliminary projects for which the initial technology was selected; it must be reinforced by model tests, pilot tests, selecting the principal equipment, selecting a manufacturing site, and considering its advantages and constraints.

This is actually the validation step of the industrialization base, thereby ending the development phase of the process and the product, and enabling the production of samples that are provided to major customers. It includes:

– the approximate calculation of the investment and of the full manufacturing cost, the determination of the time required for project completion and the profitability study;

– the technico-economic justification of the project carried out by an *ad hoc* committee.

The expected decision consists of moving toward the basic engineering step and stopping or reorientating the studies. The client wants to know the profitability of his project as soon as possible. This profitability will depend on the production cost (dollars/kg, dollars/tonne) and the total amount of investment.

If the variable cost of the product (raw materials cost) is the first available cost, then the fixed costs or overheads will be dependent of the amount of investment that will determine the depreciation costs, maintenance and the manpower costs. This last item will largely depend on the design of the plant: its degree of automation, layout, and staff productivity.

The profitability study should be conducted right from the beginning, that is starting from the preliminary studies. The result of this study will often imply the continuation or discontinuation of the project.

The preliminary study should not be limited to one type of operation, one type of equipment, material, and so on. Instead, it must help to open up the field of optimization by selecting the most appropriate equipment and propose alternatives.

The steps of engineering as such include:

– *process engineering*;

– *basic engineering*;

– *detailed engineering*;

– the *construction* and the *start-up* steps will rely as already mentioned on the skills of specialized contractors.

They are carried out by the general contractor appointed by the client to study and eventually build the installation. We will address these questions in Chapter 9 which is dedicated to engineering.

Figure 6.2 is another representation of the industrialization process. Depending on the companies, the names used for different steps and their breakdown may vary. Here, the preliminary study is divided into a feasibility study and a preliminary project. This figure illustrates the transition from one step to the following step. The black triangles correspond to the validation processes.

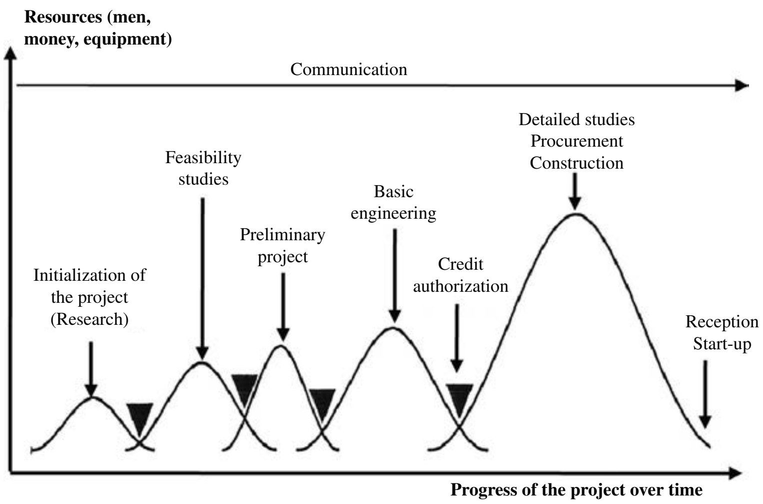

Figure 6.2. *Example of an industrialization process*

The area of the "bump" provides an idea about the (human and financial) resources and the time required for its achievement. Each "bump" has a leader who is the researcher at the beginning of the project, followed by the process engineer who plays a major role in the feasibility and basic engineering studies. The basic engineering step involves about 20 different engineering skills. The construction phase requires all sorts of crafts such as carpenters, pipe fitters, masons, welders, lifters, and so on.

Two types of project, fast track and sea serpent, are extreme cases with respect to the smooth management as described above.

The fast track project: in this case, one wants, knowingly or unknowingly, "to jump the gun". Almost everything is done at once. The project manager should be either an undisputed leader or else a dictator. "Blunders" are to be expected because the traditional systems are not respected; only one supplier is consulted or the order is placed with the one who has the shortest term.

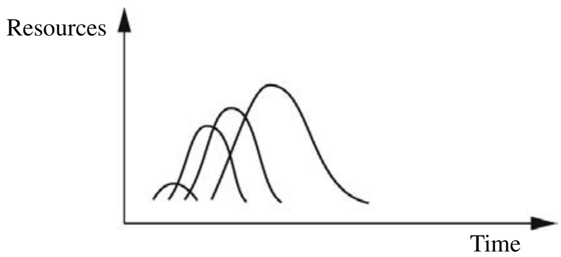

Figure 6.3. *The "fast track" project with integration of the steps*

The psychological impact on the players of the project is great, sometimes with unfortunate consequences. This type of project is justified only in extreme cases where it is necessary to have an installation as quickly as possible. Such an approach is obviously expensive and risky; one has to do, undo, and consume hours of engineering!

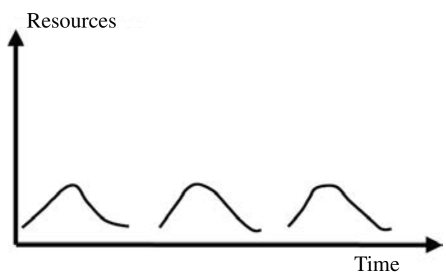

Figure 6.4. *The sea serpent project*

The sea serpent project: on the contrary, this project shows discontinuities in the steps. The file is stored in a drawer, the project team is dispersed, and another team takes over when the project is relaunched. This type of project, synonymous with indecision and lack of discernment, does not motivate teams.

Figure 6.5 is another representation of the industrialization process. It shows the sequence of the eight steps of industrialization over time.

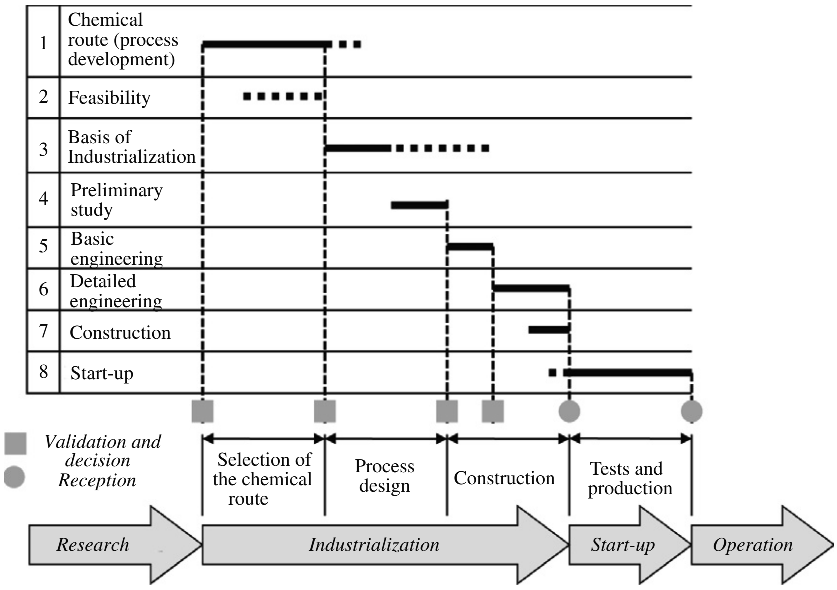

Figure 6.5. *Representation of an industrialization process*

One condition for success is continuity in communication between the different parties involved. The steps must overlap partially. As we move toward downstream, the more different skills the project needs. The core knowledge of the company is mostly concentrated toward upstream in its research centers and engineering departments.

The research chemist in charge of the process will probably be assigned to other research activities at the time of construction that can last for several years. It is important, however, that he keeps an eye on his “work” and takes part in start-up to avoid deviations in design. He can be called on sometimes to redo a few additional verification and optimization tests.

Along the same lines, the operator must be assigned to the project early enough so that he can share his experience with the engineering and design department in order to avoid questioning the technical solutions that would have been implemented without his knowledge.

There is a difficulty at the company level here, where the company has a tendency to “diminish” the resources allocated to the project manager in order to reduce its costs. All these difficulties are intensified during the transfer of technologies abroad.

6.4. Cost and typical duration of industrialization studies

Table 6.1 shows the orders of magnitude on the typical costs of industrialization steps of a large organic chemistry plant. The costs are provided based on the probable final cost (PFC) of the installation. This cost will be known only when the project is completed and possible changes are made to the installation so that the specified performance is obtained. Normally, an allocation called “contigencies costs” included in the PFC, typically a few percent of the PFC, is included in the installation cost.

Steps	Accuracy of the estimate	Cost of studies in % of the PFC	Objective of the step	Documents needed	Comments
Order of magnitude	± 50%	Variable	Orientation/ Selection Continuation/ Discontinuation of R & D.	Simple description of the process. Preliminary outline. Material approached.	“Back-of-the-envelope” estimate or better “grocery” calculations.
Feasibility	−20% + 40%	Variable	Check if the process is viable.	Process flow diagrams. Equipment list. The site is retained.	Helps detect what remains to be done, therefore to orient the “process development” phase.
Preliminary project	± 20%	0.5% to 1%	Check if the basic engineering is justified.	In addition to the above the edition of process and instrument diagrams (PID). Layout. Specifications of the main equipment.	The site is defined. There is “philosophy” of Buildings. Instrumentation. Electric network.
Basic engineering	± 10%	3% to 7%	Request for credit authorization.	In addition to the above and “frozen” PID plans. Main equipment defined	This file accompanies market studies, risk assessments, and audits.

Table 6.1. *Typical costs of the steps of industrialization and related documents (large chemical plant, for information only)*

We note that the cost of studies increases rapidly with the desired accuracy for the PFC. Let us consider a process unit of a PFC of 100 million dollars; the study may cost from 500,000 dollars to 1 million dollars for the preliminary project and from 3 million dollars to 7 million dollars for the basic engineering study! The need for validation steps is better understood! Major projects that are aborted weigh heavily on corporate resources.

The more progress in the industrialization process, the more accuracy is required and the greater the need to involve additional specialists and crafts. Engineering companies have references, but in important cases the estimate requires a specific job.

Let us consider the case of a very important piece of equipment such as a stainless steel distillation column several meters in diameter and several dozen meters in length, which works under pressure. The assessment of its cost may require the development of a specification sheet by a project engineer and a call for tenders from boiler markers; all these have a cost! *Accuracy is expensive!*

6.5. Content of an industrialization project – conceptual engineering

A key aspect of the project is to define its content (*project scope*). The accuracy of costing is mainly based on the fact that *nothing* has been forgotten rather than the accuracy of costing of individual elements.

The industrial function of the company is to materialize the ideas of the *business* and R&D upstream. Its first task is to find process units that can meet the requirements. These units may exist within the company or can be found outside from subcontractors. They may need an adaptation called *revamping*.

If these units have to be created, which means investment, it is essential to implement *conceptual engineering*. Right from the beginning of the study, this visualizes the installation type and defines its key features.

A project, sometimes a simple idea at first, needs to mature and take shape. It often takes time and, sometimes, a lot of work to get the project accepted at the company level. *A large distance separated the announcement of the Apollo program by President J.F. Kennedy and the landing of Eagle on the Sea of Tranquility on July 20th 1969!*

Technology forms the basis of everything. It will give the essential characteristics to the project.

In chemical synthesis, the chemical route, that is the base reaction, will generate a different process unit if the reaction occurs in vapor phase at 200°C in a fixed bed reactor or in liquid phase at 100°C.

The origin of technology, be it from research, existing in an operating plant or purchased from a licensor, will strongly influence the work to be done downstream.

In general, a project can be broken down into several parts, some are easy to define like the tank farm, while others require in-depth studies. It is important to manage what is defined and what is not separately, and not to waste resources to looking for illusory clarification. To do this, a few principles are set:

– dividing the project into technically homogeneous sections, for example, a crystallization plant which is necessarily followed by a means of solid/liquid separation and a dryer;

– a tank farm normally easy to define;

– highlighting the high-impact "shadow zones", either in terms of investment, or in terms of operating costs;

– defining the essential elements of the full manufacturing cost: a single raw material may represent the first 80% of proportional costs and 50% of manufacturing cost;

– defining the key elements of the total amount of investment; the distillation column mentioned above can itself represent a significant percentage of the total amount of investment;

– establishing a list of major technical difficulties.

Figure 6.6 shows an example of the breakdown of an industrialization project.

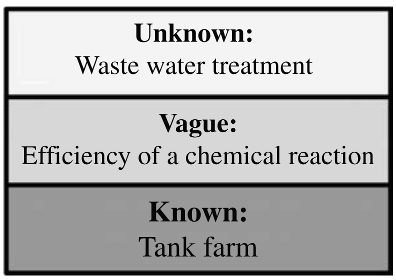

Figure 6.6. *Breakdown of a project: from the known to unknown*

This approach goes hand in hand with the search for human resources and skills, thus the setting up of teams whose role and composition vary greatly during the course of the project.

The project will take shape based on the interaction between: business, research, engineering, and production.

Generally unclear at first, the project will become consistent and materialize. The first assessment of the cost and total amount of investment, hence the first assessment of the profitability, will have an immediate impact on the development of the business. It can be decided whether to stop or continue the business by changing the objectives, i.e. its scope.

6.6. Typical organization of an industrialization project

The project is said to be initialized if it is recognized at the company level. The company then plans to dedicate resources and to place the project in a multiyear plan.

When the project enters the primary step, which is costly and decisive for the future, the company (client) must set up an appropriate structure of the type shown in Figure 6.7, which will be confirmed after credit authorization. Other types of organization are also possible.

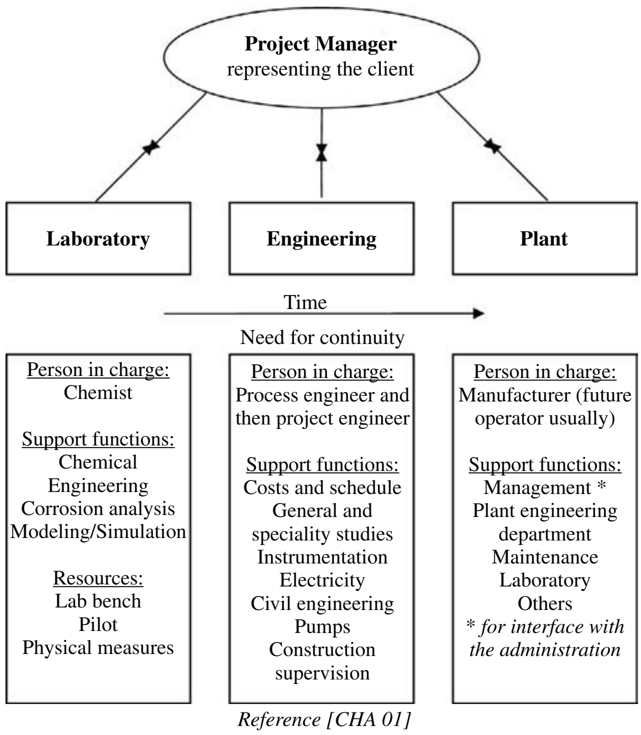

Figure 6.7. *Typical organization of an industrialization project*

In this type of organization, a project manager is assigned to a project. This means that he has been freed from other activities and signs on to the project! It is very important that the project manager is appointed at the preliminary stage even if he is not allocated to provide 100% effort to the project; *this is the step where major decisions will be taken that will impact the future.*

The reconsiderations are expensive in terms of time and money which amounts to the same thing: *time is money!* This also means that the company confirms the importance that it gives to the project and allocates resources to it!

Figure 6.7 shows that the project manager takes over from the research manager to the extent that he will “appropriate the laboratory studies”, check their validity, finance other studies when needed, and ensure that the handover is carried out under good laboratory conditions to the process engineer(s) in charge of the process development phase and subsequently the *process engineering*.

The project manager representing the company (client) is the person with whom the engineering design department or the contracting engineering firm prefers to deal with. He will oversee *all* the project activities including the stages of study and implementation.

As pointed out already, the manufacturer, who will be in charge of the installation, must be involved early enough in the project and must be in agreement with the solutions adopted. If the future manufacturer is the project manager, then the issue is resolved *ipso facto*.

Under each essential stage of the project, we have included the typical skills required.

At the “laboratory” stage, the person in charge is often a chemist. He will be assisted by experts in modeling/process simulation, and catalysis and corrosion. We can refer to Chapter 5 written by Jean-François Joly for more detail.

As stated earlier, engineering by itself includes about 20 skills or crafts: process engineer, project engineer, cost engineer, instrumentation engineer, control engineers, experts in vessel construction, piping, and so on [CHA 01].

When the project enters a concrete phase, it is important that future operators such as those responsible for maintenance or instrumentation take part in some meetings including validation meetings, especially if the installation is expected to be set up in an existing site. This will avoid unwanted reconsiderations thereafter.

6.7. Business/industrial interface

We have mentioned that studies are expensive. Normally, it is the business unit that will ultimately pay for the costs associated with the studies. It is therefore important to explain the mechanisms brought into play by industrialization, to evaluate and announce the costs and deadlines. It is necessary to decide along *with* the business, whether to go forward, knowing that discontinuation will demobilize and disperse the teams (sea serpent).

6.7.1. *The questions posed by the business to the industrial function*

Gradually, as development takes place, the *business* needs to know the evolution of the following elements:

– the full manufacturing cost;

– the total amount of investment;

– the period of availability (which can vary considerably depending on the size of the project);

– the chances of success of the operation and its risks.

What the business looks for is gains and customer satisfaction; the two are interrelated.

The industrial project or preliminary project rarely has only one technical component. Apart from the problems related to safety, the environment, and marketing constraints (like registrations, permits, and so on), the overall success may be dependent on the success of operations conducted in parallel, such as:

– contract to supply a strategic raw material;

– selection of an industrial site.

One of the key functions of the project manager is to maintain consistency and cohesion of the project by taking into account all the socio-economic constraints.

6.7.2. *The questions posed by the industrial function to the business*

Gradually, as development takes place, the industrial function needs to know about any changes to the following elements:

– the quantities to be manufactured (volumes, tonnages) over time;

– the average selling price: adequacy between volumes and selling prices;

– the specifications of the finished product;

– the lifetime of the product (accumulated turnover).

The forecast tonnage and the number of manufacturing steps will strongly influence the characteristics of the production facility and therefore the strategy to be implemented.

We can move either from a pilot plant to one or a series of multipurpose plants, to a dedicated installation, or from a batch process unit to a continuous process unit.

Quality in the broad sense (performance) is a permanent concern, firstly because it should be achieved during the start-up, and secondly because any change may alter the process and thus the installation.

Problems as mundane as bulk or drum shipment alone can weigh down heavily on the total amount of investment if it becomes necessary to add a packaging line, a warehouse, or storage bins or silos.

6.8. Typology of industrialization projects

Industrial projects differ by their technical characteristics, the total amount of investment, the host site, financing packages, and the type of the client company (in partnership or not) to name a few critical aspects.

Many projects are actually prototypes. A nuclear power plant, a steam cracker, a thermal power plant, a cement factory, a multipurpose fine chemicals plant, a tank farm, or an air compressor with a flow of 50,000 m^3/h at 6 bars, will have completely different technical characteristics, and will require different competencies, expertise, and working methods.

The client, with the help of his project manager, must identify the techniques to be implemented from the beginning, which will lead to the selection of appropriate engineers and experts. Real-life experience in similar cases plays a major role.

6.8.1. *Parallel projects*

While the main project proceeds, the other projects, known or unknown by the project manager for confidentiality reasons, may have a life of their own. It may involve deals at the highest level between the client company and a potential partner to establish a *joint venture*, where the partner will provide the capital. This may be a contract related to the supply of an essential raw material, negotiating with a foreign government for funding assistance, and so on.

The decision to invest may depend on the authorization for the release of the product when it comes to drugs or products for plant protection. It is very difficult for a project manager, from a managerial and psychological point of view, to lead his project knowing that other battles are taking place where, in most cases, he is not involved. This is what we call parallel projects.

6.8.2. *Small scale projects*

In the above sections, we deliberately focused on "big projects" – to make things precise – greater than 30 million dollars with regard to the great organic chemistry. These projects need to be highly structured.

Small projects are often difficult to manage; they are often the "nemesis" of engineering firms because they cannot be staffed like large projects with their numerous experts, whereas the *duties to be performed are the same*! They need to be managed by versatile and resourceful professionals, who have no fear of taking risks and are looking some form of independence.

There is a whole domain dedicated to small companies that specialize in "technological niches" and operate close to their bases. The management principles remain the same, again it is necessary to implement them!

6.9. The industrial preliminary projects

The preliminary projects or preliminary studies constitute a stage in the process of deciding the future of the project: to continue, stop, or continue differently. The preliminary project must:

– throw light on the future;

– propose alternatives to the question(s) posed;

– be consistent;

– highlight the risks and difficulties;

– reflect the consensus of the project team.

It is expected that the preliminary project gives:

– the total amount of investment, whether to manufacture a new product, modify an existing process, ensure compliance of an existing unit with regulations, and so on;

– the full manufacturing cost of the new or improved product;

– profitability or justification of the capital expense.

In all cases, an idea must be given or the completion deadlines, the means to implement, not to mention the risks (that are feared) and opportunities (that are hoped for), must be specified.

The technical (industrial) preliminary project is only an (essential) element in the decision process: the sales representatives and finance people have their say.

6.9.1. *Origin of industrial preliminary projects*

This section is especially for students who have to work on preliminary projects as a part of their curriculum.

In the industrial world, these are, traditionally, marketing and the R&D and innovation teams that are always ready to listen to customers and search for new markets for existing products, or detect the need for new products, who are at the beginning of the preliminary projects.

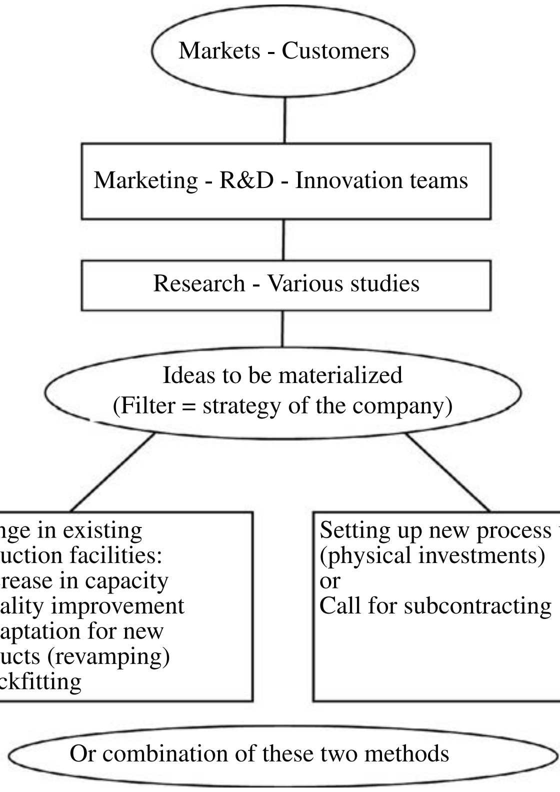

Figure 6.8. *Origin of industrial preliminary projects related to business*

The field of demand may go from a change of packaging, for example, moving from a 200 liter drum to a 5 liter can (which will perhaps require the investment of a new filling station), to developing an entirely new product which will require research and engineering studies and major investment.

The following questions have to be answered: manufacturing cost, total amount of investment, deadlines, time limits, risks, and so on.

6.9.2. *Perception of a preliminary project by the various players in the company*

A preliminary project may be perceived very differently by the stakeholders of the company. It is important that the person in charge of the preliminary project takes into account the different approaches at risk of creating malfunctions with heavy consequences within the organization. We all know them "*I said it, they did not listen to me, this was to be expected* ...".

Case study: let us consider the real example of a preliminary project of industrial rationalization. A plant has 5 outdated and little instrumented process units; an engineer is asked to study the grouping of 5 control rooms into one.

Before	After
5 process units 5 control rooms 2 control room attendants per control room	5 process units Only 1 control room 3 control room attendants
2 × 5 × 6 (shifts) = 60 people	3 × 6 = 18 people

Table 6.2. *Example of an industrial rationalization preliminary project*

Before rationalization, there were two control room attendants (operators in control rooms) working 4 × 8 for each control room, that is a total of 60 people. Rationalization would lead to a lay off of 42 people.

The annual savings in manpower is about 1.5 million dollars per year, for an investment of 4.6 million dollars (order of magnitude). The *pay-back* takes about 3–4 years.

NOTE.– *The pay-back represents, in a simplified manner, the number of years required to recoup its money; the expenditure is divided by the annual gain*.

The project has two essential elements: a physical investment based here on the instrumentation (sensors, data processing, hardware, software), but the project also requires human consideration to define the new jobs, the training of personnel reclassification, updating operating instructions, internal and external information, legal aspects, and so on.

The different players in the project may have the attitudes summarized in Table 6.3.

Features	View points and questionings
Finance Department	Return on investment: – 3 years *pay-back*? – profitable project? Should money be granted to this project? Would it not be better to invest the money elsewhere?
HRD	Human and labor issues; social unrest due to downsizing.
Planning and Strategy Management	Future of the plant if project is not implemented.
Plant Manager	Strongly for or strongly against or in between; future of the plant versus social unrest and lay off of excess staff.
Technical Department (Industrial)	Outdated equipment, lack of reliability, safety, preparing for the future, brand image.
Business	Pros: – the plant will be more “open for viewing”; – showcase for customers; – products of better quality. Cons: – risk of being out of stock in case of human and/or technical problems; – increase in full manufacturing costs (financial depreciation is more adequate).
Top Management	Must examine this project and decide ...

Table 6.3. *Role of different players in the project*

What should be learned from this case study?

This project clearly has two essential components: a technical component and a strong social and human component. It is not attractive from a financial perspective as its pay-back is long. The commercial value of the products, i.e. their contribution to the profit of the company, and their impact on the business is a major deciding factor.

From a technical point of view, the question arises in keeping outdated process units “alive”. If the decision is taken to implement the project, the technical and human aspects should be managed harmoniously.

The project manager must maintain the cohesion of the project at the company level in accordance with the decisions taken at the highest level by involving the stakeholders of the project at each and every step of validation.

6.10. Selection of production sites

Site selection is critical, the decision is irreversible, at least for a very long period. Rolling back would lead to exorbitant costs. Some criteria may be an upfront elimination factor such as the proximity of dwellings in the case of manufacturing dangerous products.

ESSENTIAL CRITERIA FOR THE SELECTION OF A NEW SITE	
Market	Proximity to customers and the market size (customers do not buy if not local).
Access to energy	Cheap energy (if energy is an important part of the full manufacturing cost).
Land layout	Availability of cheap, readily available, flat, and remote land if it is difficult to completely eliminate the pollution specific to the industrial mode: noise, odor, dust, truck traffic, and so on; the wind rose is important.
	Possibility to create buffer zones around the site.
	Soil quality that will be determined by conducting analysis with an appropriate networking.
Water management	Availability of cooling water.
	Outlet for wastewater.
Logistics	Ease of procurement of raw materials and distribution of finished products: roads, railways, waterways ...
Financial aid	Financial support, tax abatement, contribution to staff training, other aids.
Intellectual environment	Presence of universities, training centers.
Social environment	Quality of life, education for children (crucial elements in the case of expatriation).
	Quality, stable manpower, union issues, wage levels, and so on.
Regulatory aspects	Regulatory constraints.
Miscellaneous	Protection of the know-how (can be a discriminatory factor).
	No long-term unwanted neighbors.

Table 6.4. *Essential criteria for selecting a new site*

The essential criteria in the case of selecting a new site (*grass root*) are proposed in Table 6.4.

In the case of insallation on an existing site, other criteria to be considered are as follows:

– the host site has the required know-how, therefore the appropriate human resources, and it provides utilities and services (maintenance, fire protection) that will reduce the investment;

– the over-the-fence process units provide the raw materials or receive the finished goods *over the fence.*

An evaluation grid can be made by weighing the above criteria. It is necessary to estimate the impact of key factors on the cost of the product. A snapshot is not enough; it is necessary look ahead and imagine the potential changes. In a city like Shanghai, if care is not taken, a plant in the open countryside today may end up in the city in 10 years!

6.11. The consideration of sustainability in the preliminary projects

Chapter 8, “Methods for design and evaluation of sustainable processes and industrial systems” written by Catherine Azzaro-Pantel, also addresses sustainability aspects but focuses primarily on the process aspects. What follows is more about a systemic approach at the company level.

More and more large companies rely on outside companies to evaluate their results in terms of social and environmental responsibilities. The economic result – the profit – is no longer enough. Even though it is always essential for the company to survive, it is no longer the sole indicator of good management, or we could say good leadership; the company likes to see itself as a responsible and moral person, or a corporate citizen. This notion requires the establishment of performance indicators of sustainable development specific to the company’s business, indicators that must be known to all, accessible and verifiable.

In the United States, some consulting and management firms analyze the rate of sustainability of firms and advise their customers whether or not to buy *stocks* accordingly. Some companies go to the extent of asking their *stakeholders* to assess the validity of certain investments! The company owner has to lead the company by taking into account the return on invested capital and sustainability as well.

Table 6.5 presents the principal sustainability indicators. It is a summary of the methods developed by Hertwich *et al.* [HER 97].

Sustainability indicators	Definition
HHS *Health Hazard Scoring System*	Assessment of the toxic effects and risks of accidents at the working places
MIPS *Material Input Per Service unit*	Sum of material flows involved in the manufacture of a product or service
SEP *Swiss Eco-Point*	Relative load of pollutants compared to an acceptable total load by taking into account a factor of environmental shortage
SPI *Sustainable Process Index*	Surface necessary for sustainable functioning of a manufacturing process
SETAC *Society of Environmental Toxicology and Chemistry*	Sum of the flow of pollutants with similar impacts, expressed as a potential equivalence
EPS *Environment Priority System*	Damages caused to the environment expressed in monetary terms

Table 6.5. *Principal sustainability indicators*

6.11.1. *HHS indicator*

Objective: to reduce health risks and accidents in the workplace, which can lead to injuries or pollution.

Principle: the classification of risks associated with a chemical product present at a given site according to the quantified criteria of toxicity (HP) and estimated site characteristics (F):

$$HHS = HP \times F \qquad [6.1]$$

– HP is a number, the product of the chemical risk H by the nature of the phase P (liquid, gas, or solid);

– H is a number between 0 and 9, the product of the effect (lethality, minor effect, etc.) by the dose causing the effect;

– F is a number based on the judgment of an expert.

Scope of application: assessment limited to only the potential impacts associated with the production site, excluding the upstream (production of raw materials) and downstream (waste treatment).

Categories of risks: there are seven categories (toxicity by oral means and by inhalation, irritation of the skin and eyes, carcinogenicity, flammability, and reactivity), which are organized into a hierarchy according to a method of decisional analysis (AHP) developed by the EPA.

Advantages: simplicity (requires a short training course) and availability of material safety data sheets (MSDS).

Disadvantages: purely qualitative and dedicated to a specific site.

6.11.2. *MIPS indicator*

Objective: reduction of mass flows used in the manufacture of a product.

Principle: measure of the total mass flow required for the production over the entire cycle of the product or a service.

Field of application: basis for LCA and *eco-labeling*, the MIPS is for sustainable operations (remanufacturing, recycling, and material flow optimization).

Application examples: services, catalytic converters, yogurt, and regional economies.

Advantages: simplicity (material balances), expression in quantified form (mass), extension to the entire lifecycle, specific or not to a site, a good educational tool.

Disadvantages: demanding in data (LCA), implicit non-consideration of effects on health (toxicity) and the environment (GHG) with a risk of pernicious results. Thus, the method will involve the replacement of a significant amount of non-toxic product by a small amount of highly toxic product!

Examples of deliverables: 1 kg of paper consumes 65 kg of water, 30 kg of air, and 3 kg of wood and chemical products.

6.11.3. *SEP indicator*

Objective: to reduce emissions of specific pollutants by dilution and to reach acceptable levels in a given region.

Principle: assessment of the polluting load based on the contribution of each source to an acceptable total load and a scarcity factor (critical polluting load):

$$SEP = [\text{relative emissions}] \times [\text{environmental factor}] \qquad [6.2]$$

– relative emissions: ratio of the emission flux of pollutant of a process to the absorption capacity of an environmental compartment for this pollutant (acceptable load);

– scarcity factor: ratio of the total pollution load irrespective of the process or the product studied in the given environmental compartment, to the absorption capacity of the latter for the pollutant in question.

Example: for a target of 20% reduction in CO_2 emissions at the national level in 8 years, the scarcity factor is:

$$100/(100 - 20) = 100/80 = 1.25 \quad [6.3]$$

Advantage: introduction of the scarcity factor.

Disadvantages: identical assessment of various pollutants, and difficulty in determining the acceptable load.

6.11.4. *SPI indicator*

Objective: to define processes integrating them into the ecosphere on a sustainable basis.

Principle: to determine the area required for a process to be sustainable based on the generation of renewable resources and the degradation of effluents in compliance with all forms of life. The choice of the "area" factor is based on its relationship with solar and sustainable energy.

Advantages: simplicity, use of data that is available very early in the development of process, quantitative results are expressed in unit of area.

Disadvantages: lack of consistency since the data include not only the environmental hazards but also economical, technological, and political risks.

Examples: assessment of technologies on renewable materials, and selection of process improvement in the electronics industry.

Application: calculation of the SPI based on the production of 10 kt beet ethanol:

For comparison purposes, the SPI for 10 kt of fossil oil (expressed as carbon) would be about 4,000 km^2/year, which is 30 times more.

– **Consumption of raw materials:** 151 kt sugar beet obtained with a yield of 4.9 kg/m^2 site coverage:	S_1 = 31 km^2/year
– **Consumption of energy assumed to be renewable:** steam (14 GWh/year) and electricity (50 MWh/year) site coverage:	S_2 = 3.8 km^2/year
– **Manpower:** 12 people to be provided with clothes, fed, and sheltered site coverage:	S_3 = 0.2 km^2/year
– **Discharged effluent:** COD of 694 tons/year, based on rainfall of 1m/year and an average oxygen content. The dissipation of 1 kg of COD requires 140 m^2/year site coverage:	S_4 = 97 km^2/year
Hence **SPI** = $\mathbf{S_1 + S_2 + S_3 + S_4}$ =	**97 km^2/year** for 10 kt of ethanol

Table 6.6. *SPI indicator in the case of production of 10,000 tons of beet ethanol*

6.11.5. *SETAC indicator*

Objective: reduction of all environmental impacts in the broad sense (production, transportation, usage, end of life).

Principle: three-step process:

– step 1 - classification: identification of impacts generated by the pollution and depletion of resources by *stressor categories*: greenhouse gases, acidification, human toxicity, and so on;

– step 2 - characterization: determination of the intensity of the impact of the above *stressors* on the environment, human health, and resource depletion;

– step 3 - assessment: balancing and summation of the impacts into a unique index based on judgment by experts.

Advantages: rigorous, extensive, and in-depth analysis with a final quantified result.

Disadvantages: extremely demanding in terms of data and therefore expensive with the risk of having only very vague data in the case of data shortage (use of hypotheses).

6.11.6. *EPS indicator*

Objective: determination and quantification of the impacts on five *safeguard subjects*.

Principle: definition of five safeguard subjects (human health, biodiversity, production (e.g. fertility), resources, and esthetic values) for which the cost borne by the company to avoid damage is assessed. A scale value is defined, expressed in ELU (Environmental Load Unit): 1 ELU = Euro 1 (€).

Advantages: quantification of damage (an advantage when compared with the SETAC method). Assessment is based on the independent analysis of local conditions.

Disadvantages: demanding in terms of scientific, technical, and social data.

Scale of values:

– human health: 1 death = 106 ELU;

– biodiversity: extinction of a species, small animal or plant = 1,015 ELU.

Application example: comparison of the environmental impact of two materials for the construction of an automobile (in ELU).

Material	**Steel**	**Composite**	**Gain**	**Gain in %**
Production cost of the material	9	2	7	78
Manufacturing cost	1	1	0	0
Fuel consumption	40	24	16	40
Complete automobile	50	27	23	46

Table 6.7. *EPS indicator applied to the automobile*

The environmental impact of an automobile is two times lower when steel is substituted by a composite material. The impact on fuel consumption accounts for 70% of the gain (16/23).

6.12. Tips for conducting preliminary projects

6.12.1. *Capacities of the installation*

The capacity is clearly an essential basic criterion. Here again, a long-term vision is necessary; lack of vision, which is sometimes unavoidable, requires precautions to be taken during the risk analysis.

A very small and hardly expandable process unit, which will quickly saturate, will result in shortfalls. The customers may tend to turn toward equivalent products.

A very big process unit will see the full manufacturing cost aggravated by fixed costs and high depreciations.

The question arises of operating the plant round the clock, 24 hours a day, 7 days a week or 2 shifts per day-5 days a week, or on a daily basis only.

Should the process unit be polyvalent (multiproducts)? Can it be reconverted for other manufacturing purposes and is it easily expandable? Fine chemical companies know how to solve these problems by installing cascades of batch reactors connected to tank farms for raw materials, working in use products and finished goods. The polyvalence in this case is part of the specifications of the project.

6.12.1.1. *Rated capacity*

The rated capacity is the production that can be expected over a long period, expressed either in tonnes/day or in tonnes/month. This notion is sometimes the source of misunderstanding! In particular, it should not be confused with the notion of maximum capacity, which is greater than it.

It is in fact necessary to consider the production loss over a given period, due to:

– compulsory shutdowns: maintenance and cleaning (e.g. clogging of devices in the case of polymerizers, exchangers);

– off-spec products during the phases of start-up and shutdown;

– the possibility of product degradation during operation at reduced rates due to the increase in residence time.

A coefficient called *stream factor* (SF) is also introduced:

rated capacity = maximum capacity × stream factor

6.12.1.2. *Production by campaign*

Example: in a process unit that operates in batches, two products A and B are manufactured successively according to the following diagram:

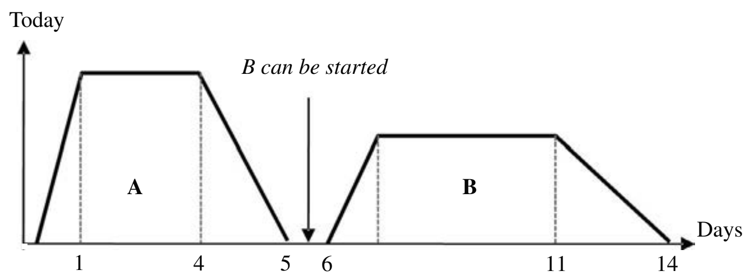

Figure 6.9. *Two products manufactured by campaign*

The production of A requires a certain number of days to reach the rated capacity and then a certain number of days to shutdown, clean, and prepare the installation to produce B. The capacity of the installation for A and B in tonnes/day can be different.

6.12.1.3. *Multistep products with use of different process units*

In some types of discontinuous process units, the batch undergoes several transformations, by successively passing from one process unit to another. This holds true in the case of fine chemical process units where a raw material will react with other raw materials in successive reactors, for example, the oxidation process unit is followed by a nitration unit, which in turn is followed by a hydrogenation unit in a specific process unit.

The identification of limitations in the production capacity of each process unit (bottlenecks) makes it possible to define the occupation time in each process unit.

6.12.2. *Description of the process and essential characteristics*

Chemists, biologists, and physico-chemists are the project managers of this first stage of the industrialization of a process that constitutes the establishment of the chemical route of the product. But process engineering must confirm and define the unit operations (reactions, separations, product engineering, recycling) of raw materials into finished products. The process engineer has questions about the:

– reaction: chemical, catalytic, electrochemical, biochemical reactions, and so on, agitation and mixing;

– separation: distillation, extraction, adsorption, absorption, membrane separation, crystallization, precipitation, decantation, filtration, dewatering, drying etc.

– product engineering: drying, granulation, atomization, extrusion, compaction, emulsification, prilling, agglomeration, coating, pelletizing, flaking, freeze-drying, micronizing, saturation, etc.

– transportation, packaging, storage.

The project engineer wonders whether this is industrially feasible, if so at what cost and whether there are any possible alternatives. This is a step of *interaction* between, on the one hand, the chemists, biologists, physico-chemists, and on the other hand, the process engineers. The description, comprehension, and modeling of phenomena, the analysis of products, their structure, and nature result in unit operations, which form the bases of the architecture of an industrially feasible process.

At this stage of industrialization, the equipment is not set, but only the functions to be carried out (reaction, separation, etc.) are defined, the nature of the input and output products, the flow rates or quantities used, the conditions in terms of temperature and pressure, and the amount of heat exchanged.

6.12.2.1. *Block diagrams*

A block diagram is a functional diagram, and a simplified graphical representation of the process involving several units or steps, not to mention the treatment of effluents. It also enables us to carry out simple mass balances that provide general information on the consumption or production of products and energies.

It is made up of rectangular blocks connected by lines of action. The minimum information required for a block diagram is as follows:

– name of blocks;

– name of the input and output flows of the system as shown;

– direction of flow between the different blocks.

Such a diagram makes it possible to describe in one page (two if necessary) what it is about (executive summary). An example is shown in Figure 6.10.

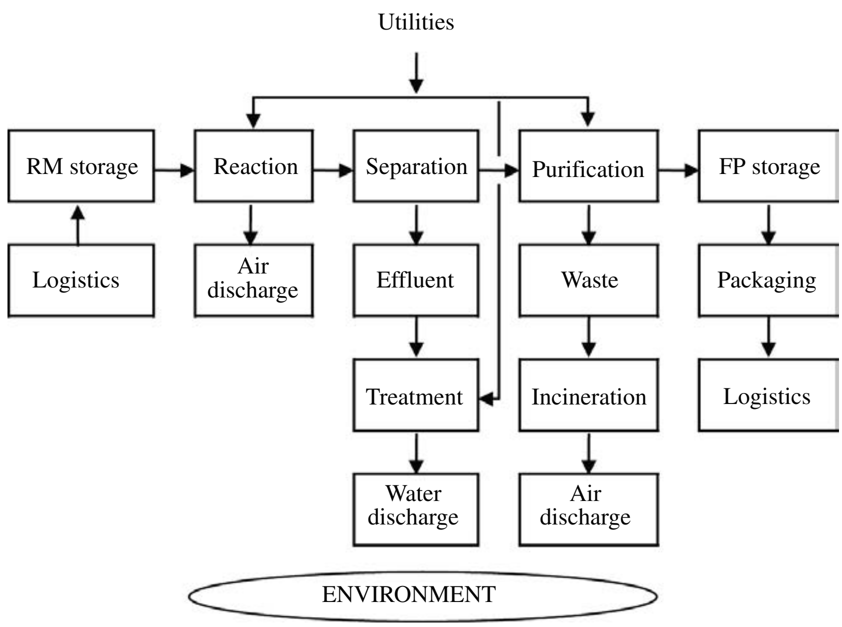

Figure 6.10. *Example of a block diagram*

The block diagram may also contain some additional information such as characteristics of the blocks, mass flow and energy flow rates, as well as the operating conditions (temperature, pressure).

6.12.2.2. *Simplified process flow diagram*

A simplified *process flow diagram* is a diagram used in chemical engineering to describe the flow and principal chemical reactions of the process. It presents the key input and output flows with their names and flow rates, thereby making it possible to establish the material balance (reduced to 1,000 kg) and specify the yields identified by the study.

An example is shown in Figure 6.11.

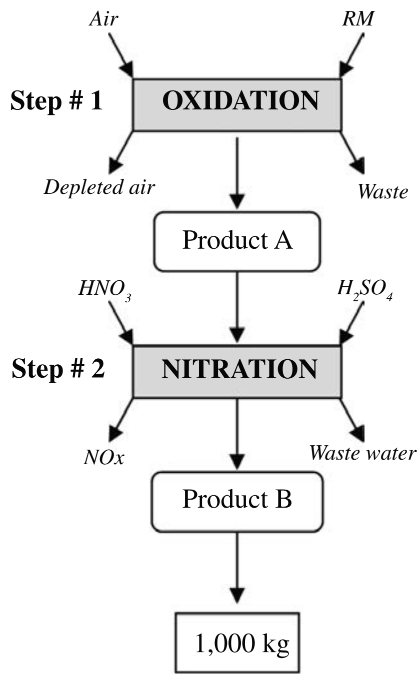

Figure 6.11. *Example of a simplified process flow diagram*

6.12.2.3. *Summary table*

At a single glance, the summary table (Table 6.8) should make it possible to:

– see the key products that are the basis for calculating the full manufacturing cost;

– have the material balance of the process unit on key products and utilities;

– know the procurement needs (e.g. number of trucks per day);

– know the load of the wastewater treatment plant (WTP).

	Unit consumptions (per ton)	**Nominal consumption (per hour)**
MP # 1 (kg)	890	2,500
MP # 2 (kg)	210	590
Steam utilities (t)	2.5	7.0
Electricity (kW)	3.2	9.0
Organic waste		
Wastewater		

Table 6.8. *Summary of unit consumptions and emissions*

6.12.2.4. *Essential features of the process*

After completing the above steps, it is important to analyze, in retrospect, the process as a whole by answering the following questions:

– what are the important points?

– where does the *innovation* (if any) take place?

– are there any notable breakthroughs?

– what is that, *a priori*, does not pose any problems?

– are products that are particularly aggressive used?

– do safety and respect for the environment necessitate special precautions?

– does one know how to do it? (skills of the company?)

– how does one face *competition*?

EXAMPLES.– Reactions at very high pressure, complex chemistry, difficult separations, and devices with unusual volume (stirring power, size of graphite heat exchangers, etc.).

6.12.3. *Risk analysis*

A risk analysis process should be implemented right from the feasibility stages, very early in the project. This is a continuous process that must accompany the project till the end.

The management of *technical, organizational, or business* risks should lead to the following questions:

– have the risks been identified? Can they be identified? What are the methods used?

– what does the company intend to do to bring the risks to an acceptable level? What is acceptable?

EXAMPLE OF TECHNICAL RISK.– Performing tests at a larger scale or over a long duration.

Competitive risk is a major risk that is difficult to assess! *Can competitors do better? If yes, in how many years?*

6.12.4. *Regulatory risks*

Any implementation must comply with many regulations, codes and standards that vary from country to country. It is up to every trade association to comply with them.

In developed countries and in most of the developing countries, any new installation or modification of an existing installation requires a study of the impact on the environment and the procurement of a construction permit and production license, without which, it is illegal to lay the foundation stone.

These constraints will have, in most cases, a crucial impact on the design of the work and the deadline for completion; the construction permit, also referred to as *permitting* is very often on the critical path of the project. In China, *permitting* is something of an obstacle course; not less than 20 “offices” have to stamp all sorts of documents.

Most often, it is necessary to consider these constraints right from the beginning of the project. Licensing (in the broad sense) can be the key factor in the design, manufacturing start-up, or sales agreement stages.

Regulatory risks can be classified into three categories (Table 6.9) for which answers to the inherent questions are sought.

Regulatory risks		
A	Safety	Design of the plant?
		Proximity to dwellings?
		Working conditions?
		Maximum allowed doses (concentrations) (selective, for 8 hours etc.)
B	Environment	Effluents: treated at the plant or to be sent to the WWTU (waste water treatment unit) of the plant, to the WWTU of an industrial complex or a city
		Classification of waste (hazardous or not)?
C	Approvals/Codes	Is the license for marketing and export available?
		Are Good Manufacturing Practices (GMP) in place?
		Is it approved by the Food & Drug Administration (FDA)?

Table 6.9. *Table of regulatory risks by categories (indicative)*

6.13. Modification of the project scope

The project scope can be changed for many reasons:

– the customer still does not know what he wants: his own constraints could have changed over time;

– the costs are too high, which is a recurring phenomenon! It is necessary to cut down the “costs”.

Cutting down the “costs” may involve reducing the capacity of the installation, while providing opportunities for expansion, building the bare minimum, knowing that it will not please everyone, especially future operators.

The call for subcontracting can prove to be very useful. This may involve getting part or all of the product manufactured by companies who specialize in it. The fine chemicals industry often uses batch installations of subcontractors who have “batch” reactors, with different means of separation (distillation columns, filters, grinders) and appropriate tank farms. Distillation, grinding, crystallization, formulation, waste disposal, and packaging (putting in bags, drums) can easily be contracted out.

The question of knowing what the company wants to do by itself, what it wants to contract out, or make into a JV (joint venture) often arises due to the risks that the company faces from competitors from developing countries. Subcontracting often involves taking the risk of compromising its independence, losing its know-how, or not achieving it.

Everything is a matter of judgment! Life means risk!

6.14. Host site

An industrial site may encompass a single process unit or several process units belonging to different companies that mutualize the production of utilities, the treatment of effluents and logistics. This can be a real industrial city as in the case of countries such as Germany (Ludwigshafen), Brazil (Camaçari), and China (Jiling).

An industrial *site* has *advantages*, *disadvantages*, and *constraints*. A site consists of men and their history, therefore a culture, know-how, and trades. A large petrochemical site actually has little in common with a large fine chemicals site, although both "deal with" chemistry.

In section 6.14.1, we will briefly discuss the essential characteristics of an industrial site on the assumption that a new process unit has to be established.

6.14.1. *Essential characteristics of an industrial site*

6.14.1.1. *Human aspects*

The skills of the operators, and the technologies, that they can master, are some of the most obvious characteristics of an industrial site. For example:

– the site knows how to nitrate and hydrogenate but does not know about chlorination; there is a chlorine "culture"!

– the maintenance department knows how to deal with glass, graphite, and special steels equipment;

– service instrumentation has broader competences in automation and process control systems.

The population pyramid of the staff, its *turn-over*, that is its replacement rate and level of training should be considered upfront.

The frequency rate of accidents, absenteeism rate, occupational illnesses, and the nature of social conflicts are all indicators of well-being or malaise and of the job atmosphere in general.

The "employer/employee" relationships, union issues, employment contracts, remuneration policies, the flexibility of operators, and the working conditions (shift work, day work) will affect the fixed costs. *In the United States, the fact that a site is union or non-union is of particular importance in the operating aspects of a plant.*

6.14.1.2. *Regulations*

They vary greatly between countries and even between the states in the USA. Various taxes, statements of all orders, construction licenses, commissioning licenses, marketing licenses, import licenses, export licenses, and so on, are the problems that have to be faced. One cannot do without the experience of "locals", which is indispensable to move in the impermeable administrative jungles in "foreign locations".

6.14.1.3. *Master plan of the site*

The master plan of an industrial site is a *long-term vision* of possible changes in the site in line with the strategy of the company [DAL 07].

The first idea is the division of the site into a checkerboard with roads that intersect at right angles. This is an arrangement which by its rationality pleases the eye.

The different units are arranged logically by taking into account:

– the functionality of each unit;

– risks, pollution, and regulatory distances;

– the flow of products, fluids, and people;

– safety issues, the impact of the units on each other (Domino effect), the possibility of evacuation, fire fighting, and so on;

– the need for shelter zones;

– the creation of buffer zones: remoteness of hazardous or polluting process units from dwellings and thoroughfares;

– presence of flames (kilns, flares, dryers, boilers, etc.);

– development plan for future process units.

6.14.1.4. *Support functions*

There are many support functions including:

– administration: management, payroll, accounting, external relations, and so on;

– safety service (risk management), fire protection, and protection of property (security);

– infirmary and first aid center;

– changing rooms;

– maintenance, undoubtedly one of the most important technical functions, whether subcontracted or not.

Others include:

– electrical services, instrumentation, and automatisms sometimes grouped under the same umbrella in small organizations;

– inspection;

– analytical and application laboratories (customer service);

– IT department;

– logistics (shipping and receiving) including material handling equipment, hoisting, and warehouses;

– WWTU (wastewater treatment unit);

– means of incineration of hazardous products;

– approved landfills.

6.14.1.5. *Utilities*

The utilities include:

– electricity (voltage);

– emergency power supply;

– steam (high, medium, and low pressure);

– energy sources: coal, gas, fuel oil, hydrogen, others (wood, hydropower etc.);

– water (cooling towers, ground water, chilled water, deionized water, etc.);

– brine (temperature level);

– air (instrument, service, and respiratory);

– nitrogen;

– hot oil (temperature, vapor/liquid phase).

An unreliable supply of utilities can severely impact an installation, namely:

– the process safety in the case of exothermic reactions that can lead to runaway reactions;

– the product quality in the case of heat sensitive products like fermentation products.

6.14.1.6. *Basic chemicals*

Chlorine, hydrogen, carbon monoxide, carbon dioxide, oxygen, and various solvents (valid for large sites or sites near large industrial complexes).

6.14.2. *Impact of a new process unit on an existing site*

As already mentioned, the implemented technology is the essential characteristic of a means of production. Technology here means pieces of equipment and their operating conditions.

There may be synergy between the new process unit and the host site. Without repeating the "identification" of a site as stated above, the new process unit can make use of the experience of the host site and its infrastructure taken in the broadest sense. In contrast, the new installation may generate additional risks and create disruptions in the working conditions.

For example, the new process unit operates round the clock 7 days a week, whereas the plant works in "2 × 8" shifts only.

EXAMPLE.– *The maintenance personnel of a plant in the Grenoble region are accustomed to using graphite material. A new installation uses glass material which is admired by the visitors; the products circulate. But glass is fragile! It cannot withstand rough handling! The glass material is gradually replaced with a graphite material. Culture is difficult to change!*

6.14.2.1. *Particular case of human resources*

The layout of a new process unit in an existing site generally requires additional human resources, hence the creation of new fixed costs called direct fixed costs and absorption of existing fixed costs. Please refer to Chapter 2, which is dedicated to "The Two Modes of Operation of the Company – Operational and Entrepreneurial" for more details on this.

Needless to say, any new installation is generally very well regarded and sites will fight among themselves to take advantage of what can be considered as an opportunity.

The project manager in charge of the new process unit should establish the fixed costs involved in the full manufacturing cost. In order to do this, he must define his needs in manpower in terms of quantity and quality, which is more difficult than it first seems! It is in fact with the receiving plant management and more particularly, the future manufacturer that he has to work. If this work is not complete before the decision to invest, unpleasant surprises are to be feared!

In order to acquire the necessary new human resources, the site has to plan for hiring and training, which leads to additional costs.

We recommend the establishment of predictive organization charts which include new and shared positions. A new process unit does not usually require a new plant director, but some of the costs of site management will be "allocated" to the newcomer. It is also necessary to know what this represents!

Case study

Let us consider the impact of a new process unit on an existing site in terms of organization of manpower. To make things clear, let us draw an organization chart (Figure 6.12) including a new process unit denoted by "unit 2" which is annexed to the production manager "C" who already manages a process unit called "unit 1".

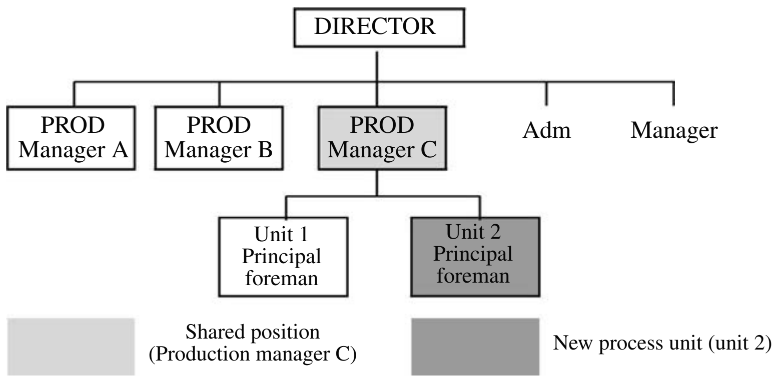

Figure 6.12. *Organization chart including the impact of a new process unit*

Additional needs in "unit 2" production amount to 35 persons as follows:

– supervisors: 1 principal foreman and 2 day first-line supervisors;

– workers: 5 shift operators × 6 = 30 shift and 2 day workers.

The additional non-manufacturing needs, amount to 12 people as follows:

– laboratory: 1 shift technician × 6 = 6 shift positions;

– maintenance: 2 mechanics;

– electricity: 1 day electrician;

– instrumentation: 1 day control room attendant;

– logistics: 2 forklift truck operators.

The total additional needs amount to 47 people.

The layout of a new process unit has the following consequences:

– creating jobs;

– improving the site balance by sharing the post of the process unit manager with the two process units 1 and 2.

6.14.2.2. *Other impacts: waste, effluents, and utilities*

Any installation generates all sorts of effluents. The host site must manage this installation physically and *administratively* (environmental studies, various permits); it also requires utilities.

Waste: the consideration of the future of wastes is an integral part of the process approach. The points that have to be addressed are the following:

– the physico-chemical characteristics, dangerousness;

– process treatment;

– internal destruction (incineration);

– external destruction (price, accountability).

Effluents: as in the case of waste, effluent treatment is a part of the process. The following questions require a suitable response:

– is (are) specific treatment(s) necessary?

– can the existing treatment plant "take over" the new process unit?

– is it necessary to:

- separate the process water from cooling water?

- install a storm water basin? Water storage in case of severe contamination? Including fire water?

Utilities: everything mentioned above obviously applies to the utilities. It is very unpleasant to be told, when one least expects it, that one must invest in a new boiler. A new installation may receive low pressure steam that may be of no use to it. It may also require new energy balances to be found. Each scenario is a particular case.

6.15. Reporting

The project manager needs to inform the stakeholders of the project, the level of progress of the project under his responsibility. This is what we call reporting, which has a broader meaning that just a report. Reporting not only informs, but also raises questions, which involve the project players, thereby giving rise to comments, and looks into the future.

Reporting throws light on the future (to use a nice expression). It announces what will be done and requires a tacit or *formal* agreement of this work from recipients on the decisions to be taken.

It highlights the difficulties and opportunities. Reporting *is an essential tool of project management*.

In the following two tables, we include many items to be considered: these are in fact *checklists.*

The first *checklist* (Table 6.10) has a strong technical nature and is primarily used in the development phase (see Chapter 5 by J.F. Joly).

The second (Table 6.11) has a more industrial connotation, which is the phase of “Feasibility study, site search, and production aspects”.

The content obviously depends on the level of progress! There may be umpteen reports! All the sections are not required to be included! All do not have the same importance.

6.15.1. *Technical checklist*

The technical specifications must be very detailed and must not leave out any information. It is based on the four main characteristics.

6.15.2. *Executive summary*

Executive summary has a broader sense than just a summary. *The* executive summary *encompasses, in one page, what each “stakeholder” of the project must know and understand, whether he/she is a technician or not.*

Thus, in the example provided in section 6.9.2, the people involved in HR affairs must be informed of the progress of the technical project.

A trader does not have to know the type of catalyst that can improve the efficiency of the reaction but that a breakthrough may be the cause of improving the full manufacturing cost of the product for which he is responsible.

Composition of the technical specifications (process development phase)		
A	Bases of the study	
	Information sources	Laboratory reports
		Literature, patents
		Plant tests
		Technology purchase
		Similar experiences
	Technical bases	Is it time to move to the pilot scale?
		Is it possible to conduct large-scale tests?
		Scale-up factors?
		Has the stationary state been reached during tests?
		Lifetime of the catalysts (is the study long enough)?
		Effect of recycling (accumulation of impurities)
		Corrosion tests to be pursued
B	Raw materials (RM)	Are they properly characterized and defined?
		Have the tests been carried using “real” RM?
		What are the analytical methods used?
		Safety and security of RM procurement?
C	Specifications of the Finished product (FP)	Are they properly characterized and defined?
		What are the analytical methods? (caution with the Performance Products for which the product qualities of the product can be difficult to assess)
		What are the tests involved?
		Solid products: Is the sample representative (particle size, caking, etc.)?
		Product stability (*shelf life*)?
D	Residues, Intermediate products, Waste and Effluents Specifications	Quantity, Quantities?
		Toxicity? (attention, the toxicity of an intermediate product (cancer) can result in the termination of the study: Ethics of the Society)
		Feasibilities of treatment and elimination?

Table 6.10. *Checklist of project/specifications*

Typical plan of a "reporting" (Feasibility Study Phase)		
1	Executive Summary	
2	Technical specifications	Technical basis
		Raw materials
		Finished Product Specifications
		Residues, waste, intermediate products, and effluents specifications
3	Installation capacity	Rated capacity
		Duration of campaigns in case of multipurpose units
4	Description of the process and essential characteristics	"Block" Diagram
		Simplified Process Flow Diagram
		List of the main RM
		Essential characteristics of the process
5	Technical risks	
6	Regulatory risks	HSE
		Registrations, Regulations
7	Project scope modification	
8	The co-products	
9	Host site	Constraints and opportunities of the host site
		General characteristics of the structure
		Layout
		Organization of work/manpower/jobs of the site and its culture
		Utilities
		Waste
		Effluents

Table 6.11. *Typical reporting plan*

The *executive summary* may include the following items, given for guidance:

– A: recall of the initial project scope;

– B: update on the project;

– C: technical data;

– D: industrial feasibility;

– E: risks and opportunities. Hard spots:

- technical,

- regulatory (construction permits, regulations, etc.).

– F: HSE aspects;

– G: full manufacturing cost, total amount of investment, profitability;

– H: Follow-up:

- continue as planned, reorientate,

- short- and long-term essential activities; deadlines of major decisions.

The industrialization process is complex given the amount and variety of criteria and parameters to be taken into account.

It is a process that greatly affects the future of the corporation; too many projects neglect it! They want to move quickly, too quickly, to the completion stage. Knowing how to find the best compromise is an art. Professionals should consider gaining experience in manufacturing! It will help them greatly should they move to corporate positions later in their career.

6.16. Bibliography

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