**Process Design Decisions and Project Economics**
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**Module - 8**
**Chemical Project Economics**
**Lecture - 2**
**Selection of the Process and Project Site (Part I)**

Welcome in the previous lecture we got introduction to chemical project economics, we saw as what are the types of projects, how projects are classified, what questions we have to answer while defining a project, and finally we reviewed several steps that we need to follow before concept is transformed into reality. In this lecture we shall see two important aspects of chemical project economics which effect the overall economy of the process, that is first the process or technology selection and second the site selection. This is a series of two lectures in which we shall see the selection of these two important aspects of the chemical project.

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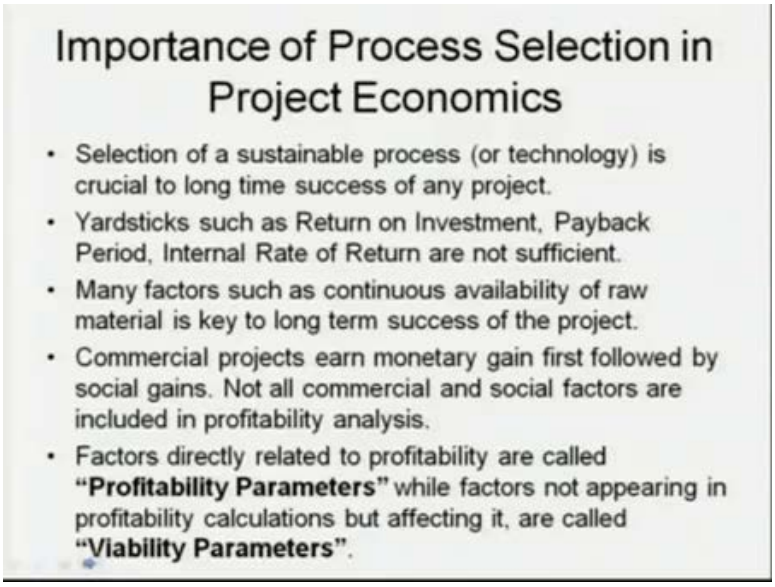


Now, selection of a sustainable process or technology is crucial to long time success of the project, when we do routine financial calculations and try to evaluate the profitability of the process. Such as return on investment or payback period or internal rate of return, all of these things we are going to see in greater detail when we start project cost

estimation and profitability analysis, but I just mention here that what are the yardsticks or the criteria for evaluation of a process.

These criteria are not enough, these are not the adequate indices of success of any project on long term basis, for instance suppose we take a project for manufacturing ethyl tertiary butyl ether as an octane booster. Now, this has become important octane booster, after the former octane booster tetra ethyl lead was banned due to the pollution caused due to lead or toxicity of lead. This will become financially attractive over a longer time life spans, let us say 10 years, 15 years, only when the two raw materials that are required, that is ethyl alcohol and isobutylene are available abundantly at a cheap rate.

So, this is something called this particular aspect is not taken into account when we do let us say the later on investment analysis, now after we decide to go ahead with project implementation based on preliminary feasibly report, that we saw in the previous lecture. We have the crucial task of selecting a particular process or technology, there might be more than one route available to manufacture a product under consideration, moreover there could be more than one process licensors which provide know how or that detailed technology for that particular route.

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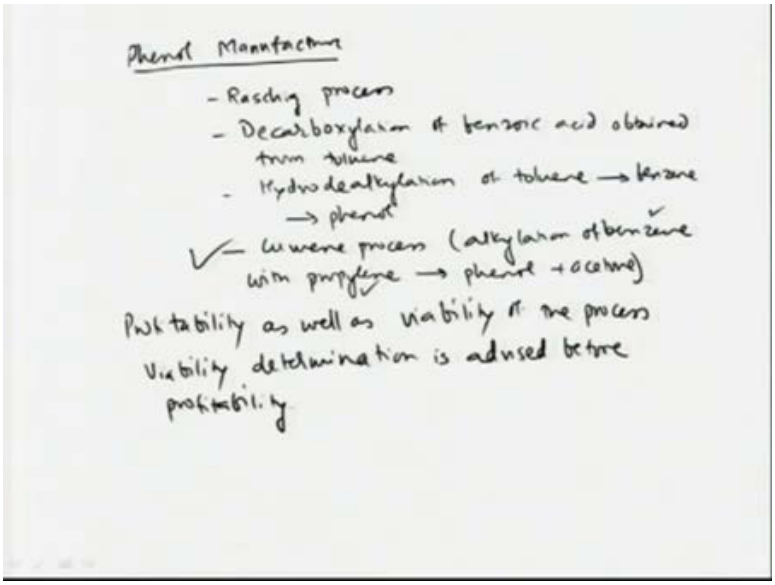


Now, example in this category will be that of phenol manufacture, phenol could be manufactured in three principle ways the Raschig process, where first chlorination of benzene takes place followed by hydrolysis. Then the second is Decarboxylation of

benzoic acid obtained for from toluene, then it could be hydrodealkylation of toluene to manufacture benzene.

And then benzene is further converted to phenol through route, other routes or it could be the famous cumene process, in which benzene undergoes alkylation with propylene to give cumene, and then the cumene is later on converted to phenol plus acetone. So, now we have option of several technologies which one to choose from, as far as phenol process is concerned the cumene process has become popular, because of large availability of propylene and benzene in the complex based on naphtha cracker.

And then availability of plenty availability of benzene as well as propylene, the naphtha reforming use benzene the ptx, so benzene is available and naphtha cracking gives propylene. So, if there is a naphtha cracking process, it can further go ahead, what is known as forward integration to go and manufacture phenol. Now, next question is selecting the process licensor many companies are available which provide the process license, so you may opt for either one process licensor for the entire technology or you may opt for one licensor that will give only cumene and from cumene to phenol another process licensor.

Therefore, the selection of process of technology is not a simple exercise, we shall evaluate here what are the criteria for selection of the process and the process licensor. Now, the main target or main aim of commercial projects is to earn monetary gain and then followed by social gains, so not all commercial and social factors are included in the profitability analysis.

So, there are some factors which determine the viability of the process, whether the process is sustainable over a longer period of time, whether the raw material that is used in the process will be available over certain period of time, whether the raw material is locally available or it is imported. If it is imported then what are the sources, what is the currency exchange rate with that particular country, so many factors come into picture, therefore it is always advised that the viability criteria should be evaluated first before the profitability criteria.

So, the factors that directly related to profitability or profitability parameters and the factors that do not appear in the profitability calculation, but still effect it significantly

are viability parameters and that point we note, that viability determination is advised before profitability.

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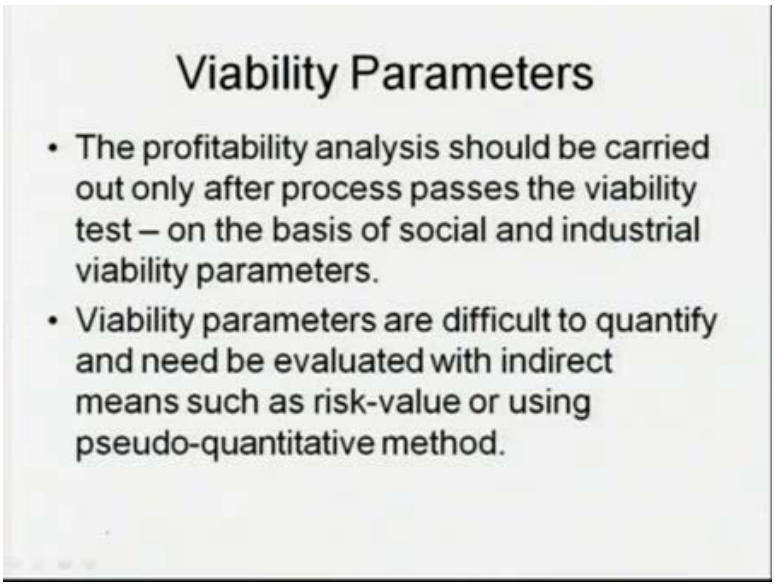


Now, let us see one by one what are the viability parameters? As I just said viability parameters are directly related to the success of the project and they are indirectly related to the profitability of the project. They are difficult to quantify, but we may assign a risk or cost value notional value to these parameters based on their relative importance, thus we have to go for a pseudo quantitative method for the evaluation of these parameters.

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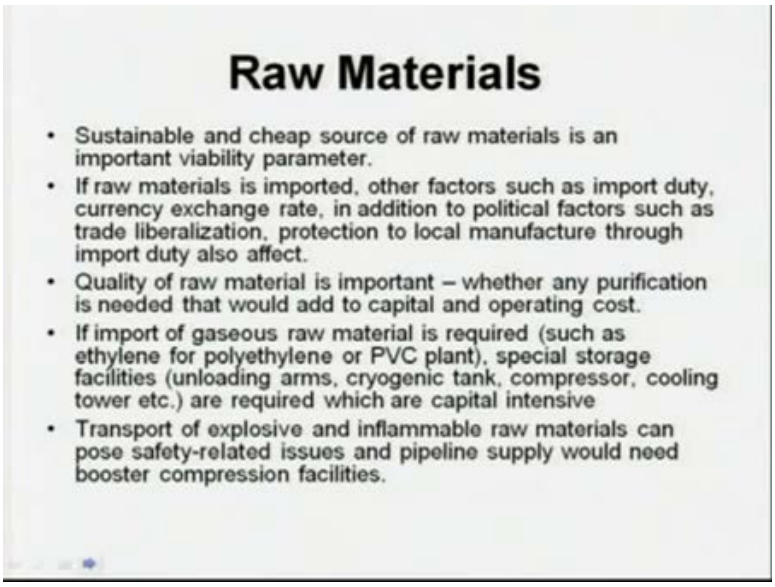

So, now, let us see what these parameters are first the raw material, as I just said that sustainable and cheap source of raw material is an important viability parameter, if the major raw material is imported, then we have to look for the import duty. That is not just today's duty, but the projected duty in future various policies of the government, that is sometimes the government may impose restriction on import on certain goods, so as to promote the local manufacturing.

So, all this factors come into picture or sometimes there is liberalization of the trade, so the product that we are manufacturing may come at much cheaper price from abroad and that will kill the business of the local people, that is one criteria that we have to consider. Now, the import of raw material may sometimes appear to be cheaper, but it will add to the working capital requirement, for example if the raw material is not up to the specification we have to go for purification facility, that will add to the both capital and operating cost. Then we have to have the facility to receive and store the raw martial at the port, that will also increase the project cost, because we have to build local ware houses near the port, so we shall see some examples in this.

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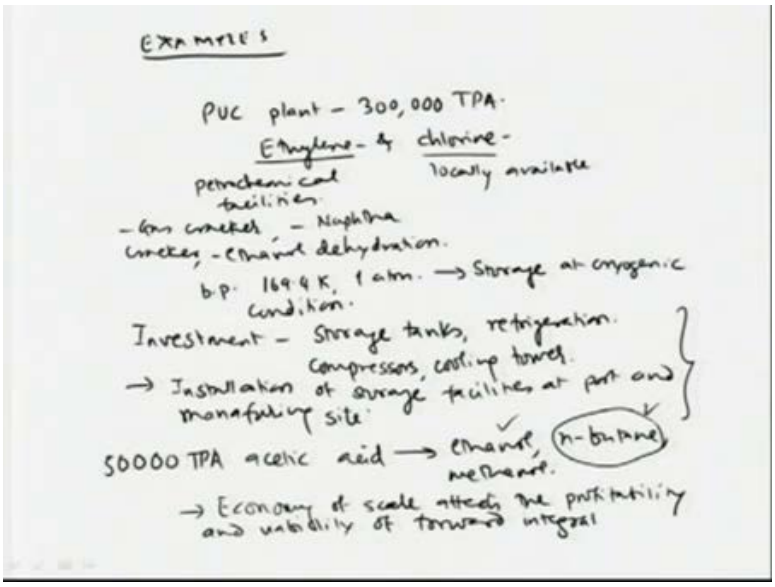


Let us demonstrate this particular aspect with certain examples, for example polyvinyl chloride, let us say the plant capacity is 300000 tons per annum and PVC plant is based on ethylene and chlorine. And let us say the chlorine is locally available, but ethylene

may have to be imported, the source of ethylene is basically cracker plan either gas cracker or ethane propane cracker or naphtha cracker or ethanol dehydration.

These are basically the petro chemical facilities, gas cracker, naphtha cracker, ethanol dehydration, now if we do not have sufficient ethylene available, then it has to be imported. Now, imported ethylene has to be stored under cryogenic condition, the boiling point of ethylene is 169.4 Kelvin at atmospheric pressure, so we need storage at cryogenic condition.

Therefore, we have to invest more capital for the storage, we have to build cryogenic tanks, we have to maintain cryogenic conditions in it, so the load on the refrigeration goes up. Then we have to have compressors, then cooling facilities, cooling tower, then we have to increase the capacity of the electric substation for this load, extra and that that has to be at the port as well as at the manufacturing site, this point we note installation of storage facilities both at the port as well as at the manufacturing site, so this is a trouble that we have to bear when ethylene is imported.

Now; obviously, if ethylene if the plant of polyvinyl chloride is located in the vicinity of a refinery, where there is sufficient availability of ethylene throughout the year. Then all of this cost are not incurred, and therefore the profitability of the process increases, but again we have to see as what is the durability of that particular is ethylene available throughout the year or only for particular period of the year, so those issues we have to deal with.

Another example is that of the acetic acid plant, let us say 50000 tons per annum of acetic acid here, we need 3 raw materials ethanol, then n-butane, and methanol, now ethanol out of these 3 ethanol is the most abundantly available raw material. It is basically manufactured from renewable raw material, and therefore the supply is more or less assured, but; however, for some reason if sustainable supply of alcohol is not guaranteed.

Than the project will recover a set back then the other raw material is n-butane, now n-butane is essentially recovered from the C 4 fraction in the distillation in refinery; however, recovery of n-butane is sometimes cost prohibitive, and therefore we have to look for other sources, that give n-butane. Methanol based root produces acetic acid via carbonylation of methanol, it means that we need carbon monoxide and methanol, that is

manufactured ((Refer Time: 14:26)) gas for producing acetic acid the other root for acetic acid.

After recovering carbon monoxide may be by adsorption, balance gas can can be fed to methanol converter, so you do steam reforming, than from steam reforming take out some C O and then balance gas you feed to the methanol converter. Therefore, methanol manufacturer can further go ahead with setting up of a large scale acetic acid project and, because he has both carbon monoxide and methanol available at his location, so he can go for the forward integration.

However, in many cases these projects are not economically viable below a certain capacity, so the economy of scale has to be taken into account that we point we note, economy of scale affects the forward integration or affects the profitability as well as viability of forward integration.

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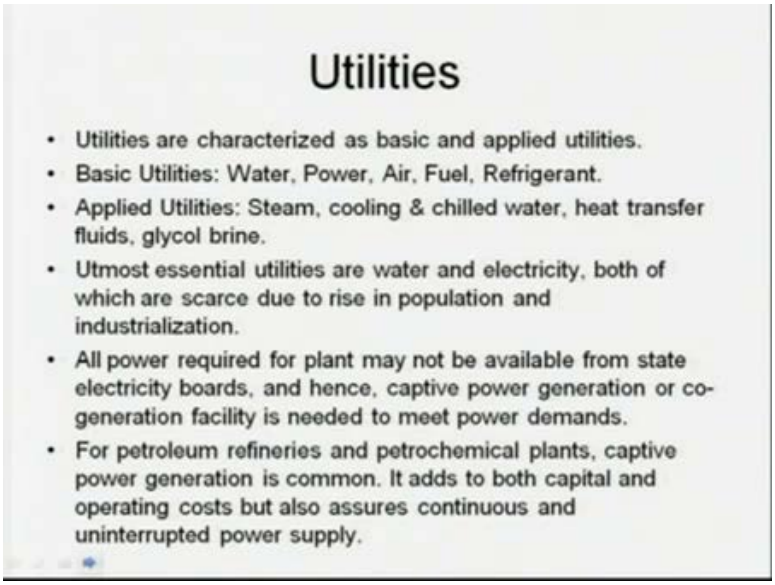


Point is that of utilities or next parameter that we need to take into account for the viability of the process is the utility, now utilities are characterized as basic and applied utility. Basic utilities are water, power, air, fuel, refrigerant, applied utilities are steam, cooling and chilled water, heat transfer fluid or glycol brine, now out of these the utmost essential utility are water and electricity.

And both of which are getting scarce due to rise in population and industrialization, therefore a company has to look for their own sources of water and electricity, instead of depending on the state electricity board or state water supply. The state electricity board may not be able in a position to meet the demand of power, therefore the project owner may have to put up his own captive power generation plant or cogeneration facility within the project to meet the demand of the power.

In most of the new refineries and petrol chemical plant captive power plants are very common, some of the generator power is used for captive consumption and rest of the power is sold to either government or directly to the people, and that brings in significant amount of additional revenue. However, this alternative calls for extra capital and operating expenditure, and remember it is not only the ability of the power, but uninterrupted continuous supply of power that is equally important.

So, if a company is getting discouraged for setting of their own power plant because of capital investment, they need to take into account that such captive power generation and consumption is going to increase their self reliance of power. Similarly, demand for water it can be partly met with the novel concept of recycling water in the plant, after treating the aqueous effluent some projects have been have already been commissioned, to recovery good quality of water for from domestic aqueous effluent originating from the city.

If the water quality is not good for example, it has high fluoride content or high silica content, we need to go for special treatment facility which may increase the project cost and operating cost. However, they increase the self viability of the project making it less reliant on external sources, large project which are based near the sea shore can think of desalination of sea water with reverse osmosis or similar kind of thing, for as a possible source of water, that would add of course, to the capital operating cost, but also give self reliance to company.

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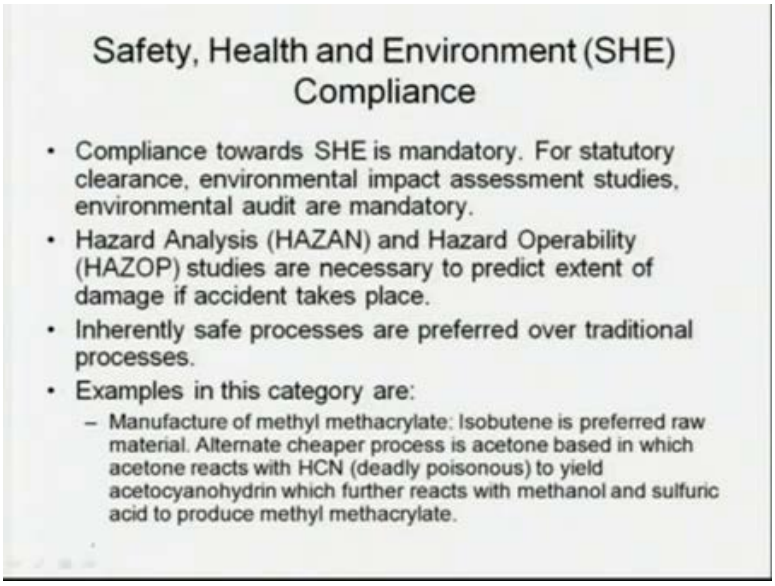


The next issue is that of safety health and environment, it is the acronym of this SHE, compliance toward the she is mandatory for statutory clearance, the environmental impact assessment studies and environmental audit are mandatory. We have to take into account the hazard analysis, abbreviation HAZAN and hazard operability that is HAZOP studies, to predict the extent of damage if accident takes place. Inherently safe processes are preferred over the traditional process, than well there are several examples in this category first is that of manufacture of methyl methacrylate. Isobutene is a preferred raw material, new raw material alternate cheap process is acetone based process in which the acetone reacts with hydrogen cyanide, which is a deadly poison to yield acetocyanohydrin, which further reacts with methanol and sulfuric acid to produce methyl methacrylate.

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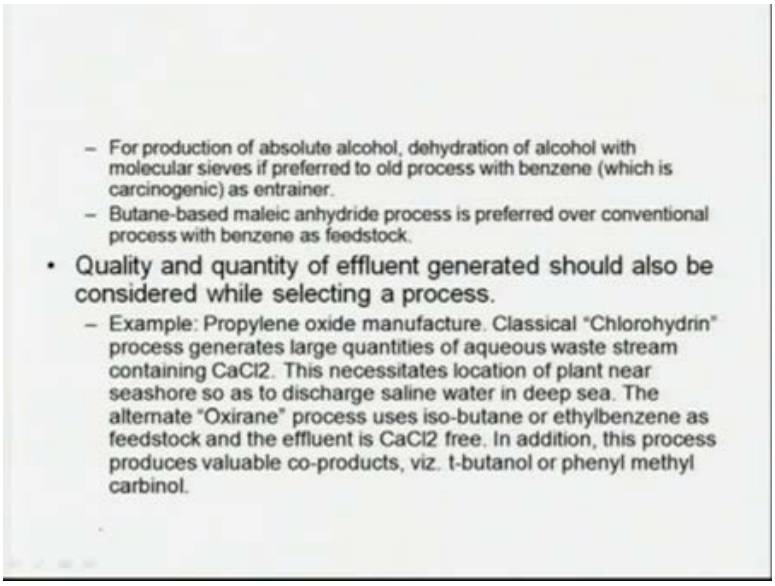


However, the new process is much eco friendly, because it is does not involve any poisonous material, it is it is inherently safe due to isobutene. Similarly, to produce absolute alcohol dehydration of alcohol by molecular sieves technique is a preferred technique to the old process of using benzene as entrainer, because of the health related issues.

Benzene is carcinogenic, for the same reason the butane based maleic anhydride process is preferred, for instead of using butane based process for maleic anhydride is preferred over benzene process, because of carcinogenetic of the benzene. While, selecting a process, we have to estimate the quality and quantity of effluent that is generated during the process.

Now, example in this category is that of propylene oxide manufacture, the classical chlorohydrin process generates large quantities of aqueous waste streams, that contain calcium chloride. This necessitates the location of plant near a sea shore, because where you will dispose of this calcium chloride, so that the saline water is discharge into deep sea. The alternate oxirane process uses iso butane and ethylbenzene at the feedstock and the effluent is essentially Ca Cl 2 free, in addition this process produces valuable co products, that is tertiary butanol or phenyl methyl carbinol, so both of these add additional revenue to the propylene oxide plant.

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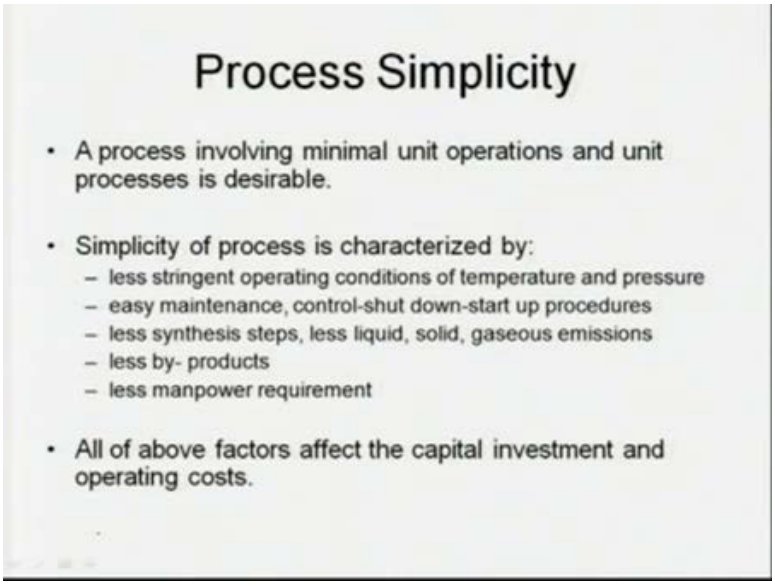


The next factor is that of simplicity of the process, how do you define the simplicity, process is essentially several unit processes and unit operations linked after one another. Like you first have the purification of raw material, then heating of raw material if it is a energy intensive process, then the reaction, then cooling then throttling if it is high pressure process, then separation through distillation.

So, all of these operations are linked one after another, so a process that involves minimum unit operations and unit processes is desirable. So, the simplicity of the process is mapped by several characteristics, first the less stringent operating conditions of temperature and pressure first, then easy maintenance control shut down start up procedure.

Then thirdly less synthesis steps, less liquid solid and gaseous emission, then less by products and less manpower requirement, all of the factors above effect the capital investment and operating cost of the process. Now, example in this category is that of cumene production via catalytic distillation unit, where benzene and propylene are reacted at about 120 to 175 degree centigrade.

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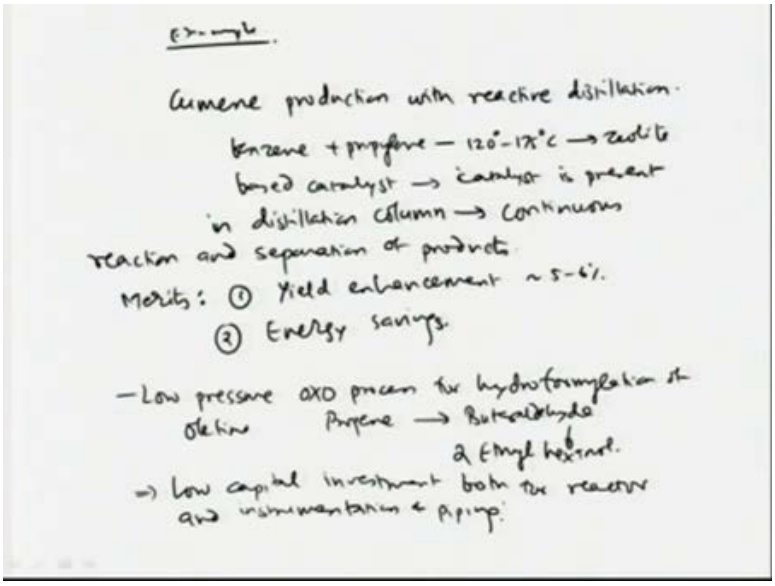


I will write that example for you, how does process get simplified how do we reduce the number of operations in the process, cumene production with reactive distillation, benzene plus propylene. They are reacted at temperature 120 to 175 degree centigrade over a zeolite based catalyst and the catalyst is present in a distillation column, so as the products form they are continuously removed from the reaction zone by distillation.

Thus the reaction that is unit process and product separation by distillation that is another unit process or unit operation are combined in a single operation, that is called as reactive distillation. And the product yield increases because of continuous removal of the product, that shifts the or forces the reaction to the product side, and therefore yield increases by about 5 to 6 percent, than compared to the previous or conventional reaction and also it saves certain amount of energy, so those points all we note.

Yield enhancement up to 5 to 6 percent and second energy savings, then another example that can be given for the less severe condition is that of the low pressure oxo process, for hydro formylation of olefine. In one process propene is used as the raw material which is converted to butyraldehyde, which is further converted to 2 ethylhexanol, now the previous process that was used the previous oxo process had significantly high pressure.

So, the low pressure oxo process not only brings down the operating conditions to low pressure, but it also helps in power consumption, so low capital investment both for reactor and accessories such as instrumentation and piping. So, these are some of the

examples of making process simpler and less hazardous, then the next criteria is that of having a backup facility.

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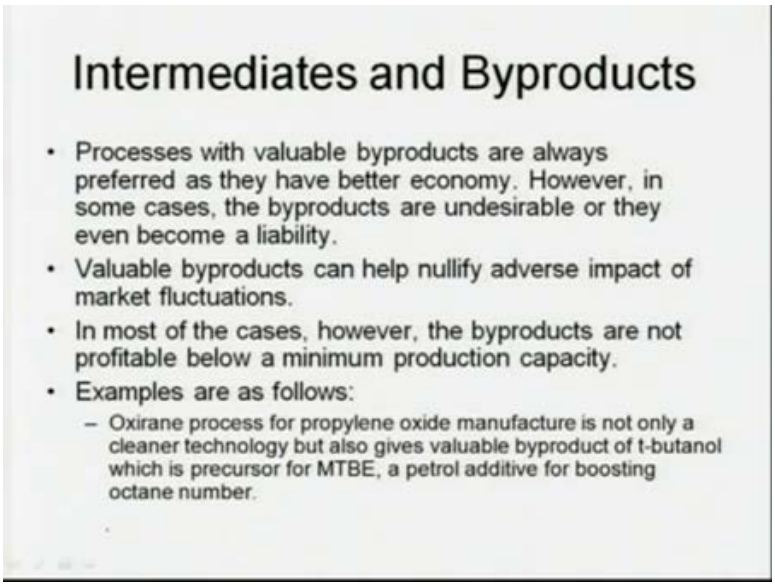


Now, if the process has a backup manufacturing facility which means the licensor himself has a manufacturing unit it always helps, for speciality chemicals especially pharmaceutical or electronic grade chemicals, where the raw material product prices are very high. And then the value addition is relatively less, then we have to have it is always desirable that the process licensor has an operating plant, because you can gain some experience from that plan not only product manufacturing experience, but also the marketing experience.

Next criteria is that of the intermediates and byproducts, processes with valuable byproduct are always preferred, because they add economy, they bring more revenue and they make the process economically attractive. However, in some cases the byproducts are undesirable or they even become a liability on the process, now let us see some examples in this the manufacture of the oxirane process for propylene oxide manufacture.

It is not only cleaner technology, but also gives a valuable byproduct of tertiary butanol which is precursor for methyl tertiary butyl ether, which is the petrol additive, so this is one example. In many cases the byproducts are not profitable below certain minimum production capacity.

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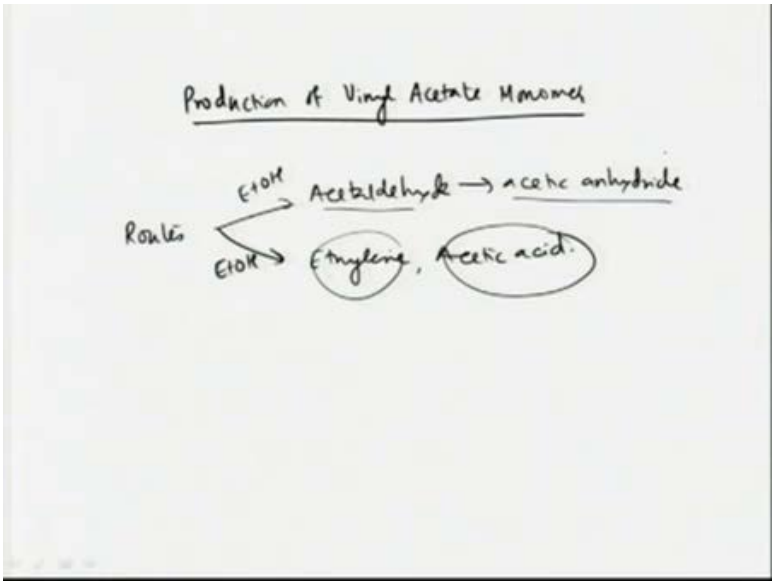


Example in this category is that of the Vinyl acetate monomer manufacture, here we have two roots, one root is based on acetaldehyde and acetic anhydride, and the second root is that of ethylene and acetic acid. Now, let us say this plant is shut down for some reason, now I something I forgot to mention is ethanol is used as a raw material in both processes, so in one hand you have acetaldehyde and acetic anhydride, in second case ethylene and acetic acid.

Suppose, the plant is shut down for some reason, then it is easier to sell the acetaldehyde and acetic anhydride in the market, rather than selling ethylene and acetic acid. Therefore, we have to whenever we are calculating the side product as well as the raw materials, we have to take into consideration the resale value, the next factor is that of catalyst recovery and reuse. Catalyst is a highly expensive component of the process, most of the catalysts are manufactured by a separate company, and then those are given to a license to the main production companies.

For example, sud-chemie gives manufactures a catalyst that is used in lurgi mega methanol process, so the catalyst manufacturing company is different and the process licensor is different. Various catalyst that are used in chemical process are subjected to spent catalyst treatment process, catalyst gets deactivated during use, and then we have to regenerate the catalyst.

This is done not only to address a pollution related problems, but also to get an economic advantage, recovery of the catalyst becomes economically mandatory particularly when noble metals are used as catalyst. For example, in many hydrogenation processes platinum, palladium, ruthenium, rhodium, rhenium, the transition metal element these are used as catalyst or these are the major component of the catalyst that are used.

For example, in case of ethylene oxide manufacture the silver based catalyst is used the latest LP low pressure oxo process propylene is hydroformylated uses rhodium catalyst to yield buteraldehyde, which is then further converted to ethyl hexanol. Therefore, it is economically advantageous to recover precious metal elements from the spent or used catalyst, therefore if the process licensor or the catalyst supplier is willing to buy back the spent catalyst. And in return give the fresh catalyst at an agreed differential price we should always prefer, it because regeneration of the catalyst by ourselves will be difficult, because these are special operations which are carried out by the companies, who have the special know how.

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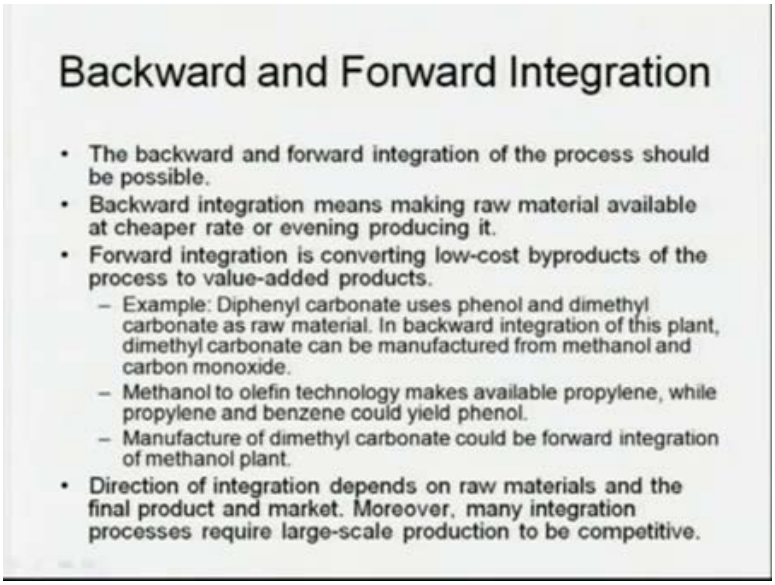


Then is a criteria of backward and forward integration, I have already given you the definition backward integration and forward integration, you should always go for a process for which both backward and forward integration is possible. Backward integration as I already told means making raw marital available at a cheaper rate or even

producing your own raw material, forward integration means converting the low cost byproduct of the process to value added products.

Now, several examples can be given, I have listed some of them like diphenyl carbonate, uses phenol and dimethyl carbonate as raw material, the backward integration of this plant like for example, dimethyl carbonate can be manufactured from methanol and carbon monoxide. So, that is possible or the phenol itself can be manufactured from propylene and benzene, and remember but all of these are commodity chemicals and they required a large scale production to be competitive.

Now, another option is that that methanol to olefin technology makes available propylene, while propylene and benzene could yield phenol that I just said, so if a methanol manufacture goes ahead with dimethyl carbonate manufacturing that could be given or it could be sited as an example of forward integration. Now, direction of integration depends on the raw materials and the final products and markets, if the raw material is available at a very cheap rate, throughout year abundant supply.

Probably would not go for a backward integration, but forward integration always helps, an example of this is bio diesel manufacture, bio diesel produces very large quantities of glycerol as the side product. Now, this glycerol is not useful for the regular outlets like for example, use in cosmetic because it is crude glycerol, it has contamination of alcohol as well as alkali which is used as catalyst in the bio diesel process of transit unification process.

Now, removing these impurities from glycerol is cost prohibitive, the glycerol which comes out of bio diesel industry is available at very cheap rate. Now, several companies like including the dove chemical company or DuPont, they are trying to see several processes or trying to they are trying to develop several processes with glycerol as a feedstock.

Where, we as bio diesel production and consumption is going to go up as the fossil fuel is exhausted and the prices are rising like anything, so bio diesel industry is bound to grow to large extent. So, large quantity even higher quantities of glycerol will be available, so companies are looking for forward integration like conversion of this glycerol into several value added products. Like for example, n butanol is 1 or 1 3 propanediol is another, so several processes are un-development.

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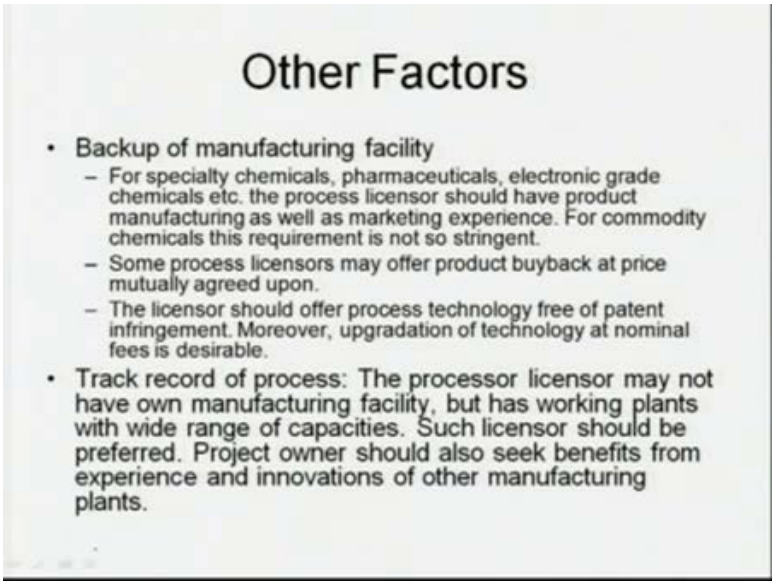


Then there are some other factors that we need to consider the track record of the process, process licensor may not have its own manufacturing facility, but working plants with wide range of capacities. Such licensor should be preferred, project owner should also seek benefit from experience and innovations of other manufacturing plants.

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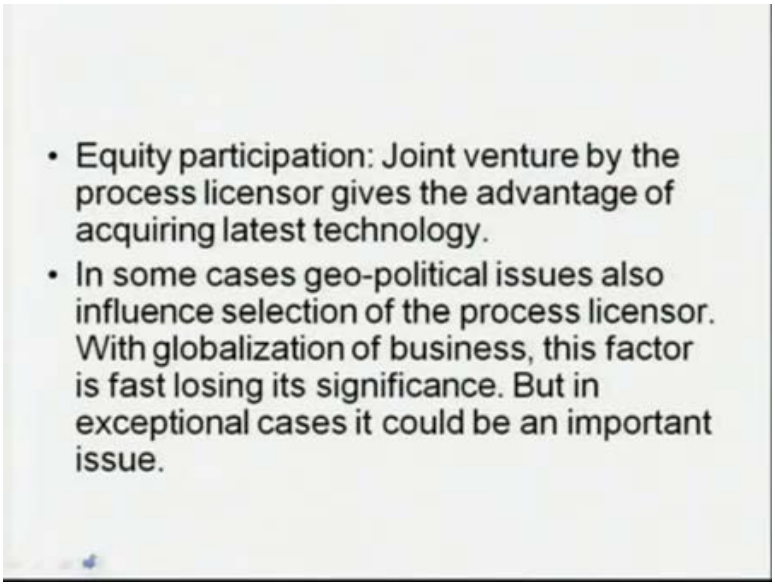


Then second is equity participation try to get some investment from the licensor himself joint venture by the process licensor gives advantage of acquiring latest technology, also it brings down the burden on local investment. However, in some cases there are political

considerations like sometimes even if you know a process licensor, you may not be able to give him the contract, because if our country the buyer country has no trade relationship with the country of the process licensor. However, now this constraint is getting diluted with globalization, but you never know that sometimes geo political issues may shape up in future, and therefore we need to make a mention of it here.

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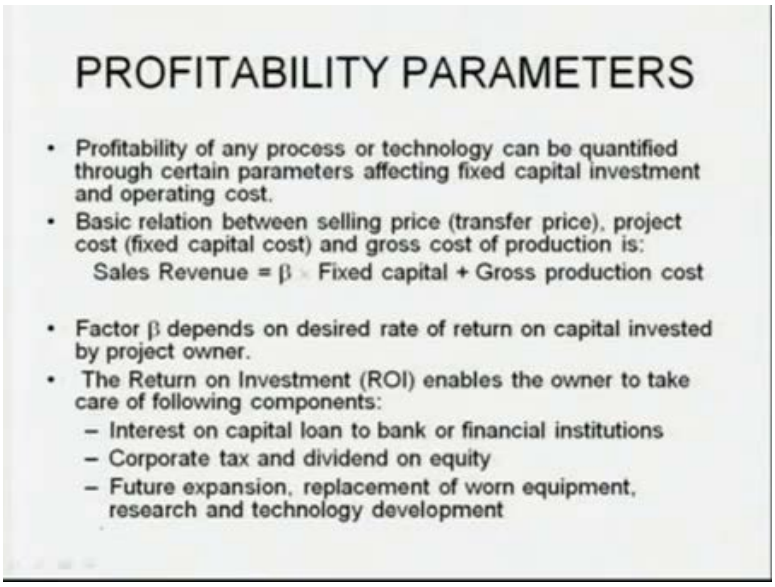


So, these were the viability parameters of the process, now let us see what are the profitability parameters, some of these I already mentioned like return on investment or payback period. These are the profitability parameters, but let see how we can quantify, profitability of any process or technology can be quantified through certain parameters affecting the fixed capital investment and the operating cost.

The basic relationship between selling price or you can also say transfer price if the product, that you are going to manufacture is an intermediate and not the direct final product which goes in the hands of consumers. Then the predict cost, that is fixed cost, fixed capital cost and the gross cost of production is related as sales revenue, that is the net income is equal to beta factor beta into fixed capital plus the gross production cost.

Now, the fixed capital is a single time cost, while the gross production cost is a recurring cost, how to bring these two cost on the same ground we shall see later in the module. But, beta is the factor that depends on the desired rate of return and desired rate of return of the capital that is invested by the project owner, the return and investment which we

abbreviate as ROI enables the owner to take care of following components. First of all the interest on capital loan to bank as well as the financial institutions from which loan has been taken then, secondly the corporate tax and dividend on equity, third the future expansion.

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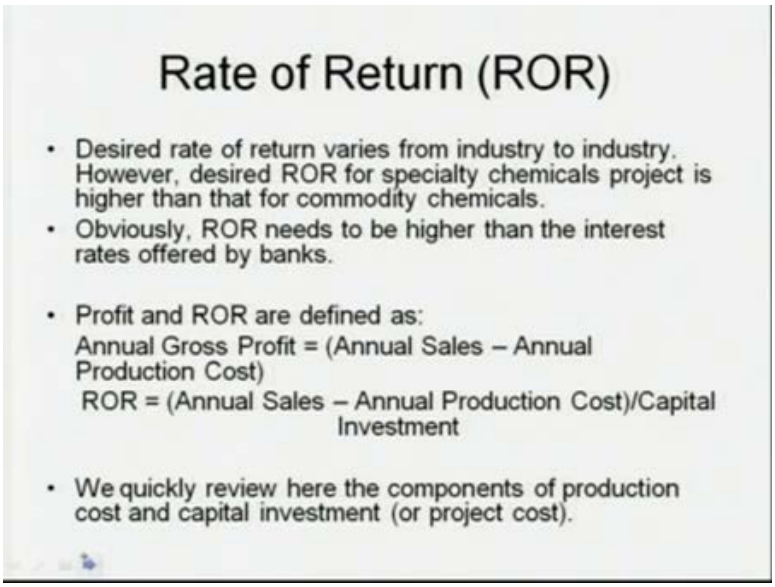


Then the loan repayment the desired rate of return varies from industry to industry, how much rate of return we should have, but the desired rate of return for speciality chemical project is higher than that for commodity chemicals, because of small scale of production and relatively less value addition. Obviously, rate of return needs to be higher than the interest rate offered by banks, if we have to attract the people to invest in our project, then we have to offer interest rate, which are higher than those offered by the banks.

The profit and rate of return is defined as annual gross profit is equal to annual sales minus annual production cost, and then the rate of return is that difference annual sales minus annual production cost divided by the capital investment, so that is a very basic definition of rate of return. Now, let us quickly review the components of product cost and also the capital investment or the project cost, we are going to have a separate lecture series on project cost estimation. Where we shall treat these the same topic in much at much greater depth, but here we are going to get only an introductory information on the factors that affect the capital investment or the project cost.

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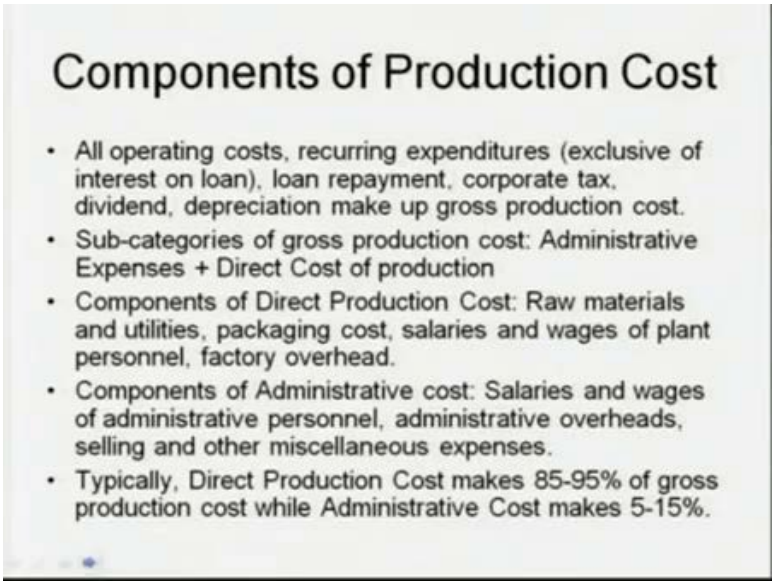


Components of production cost first of all, these production cost is a recurring cost as I said it is annual, we are not going to include in the gross cost of production things like interest on loan or a loan repayment or cooperate tax or dividend and depreciation. We are going to divide further the gross cost of production into two parts, first is a administrative expenses and then the cost of production at the manufacturing site.

The cost of production at the manufacturing site, the second component depends on the raw material and utilities that makes the major fraction of this cost about 60 to 80 percent, then the packaging cost the salaries and wages of plant personnel. And then the factory overhead the administrative cost or admin cost, sometimes it is called as it includes the administrative over head expenses. Salaries and wages of the administrative people, selling expenses and other miscellaneous expenses that are not included in the cost of production.

Now, as a rule of thumb administrative cost could be about let us say 10 to 15 percent of the total cost of production, again we shall go in greater depth in later part of this module. Now, once a plant capacity is decided the salary, wages, packaging cost, factory over head, administrative cost and selling expenses will remain constant irrespective of the technology or the process that is selected.

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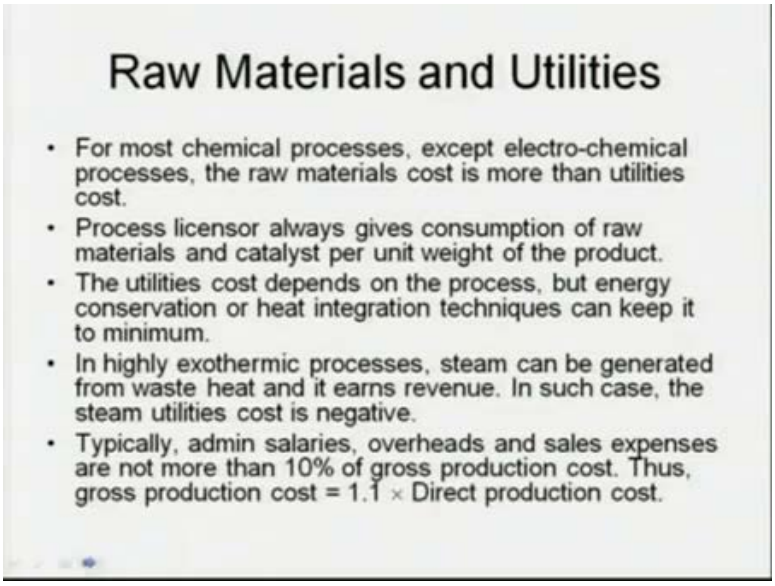


The major difference in all process being screened would come from the raw material and utility consumption, and therefore we have to take that particular factor into account more seriously. So, remember that raw material and utilities which form the major fraction of the total production cost 60 to 80 percent depend on the process. Now, let us see this particular topic in somewhat more detail raw material and utilities, for most of the chemical processes except the electro chemical process the raw material cost is more than utilities cost, electricity is expensive.

So, when we go for a electro chemical process, for example caustic soda manufacture through the membrane cells then the utilities cost is much higher. The process always gives the consumption of raw material and catalyst per unit weight of the product, the utility cost depends on the process, but the energy conservation or heat integration in the process can keep it to minimum.

So, bringing down the energy cost is very crucial to increase in the economy of the process, now some examples can be given for example, the latest technology of phthalic anhydride manufacture by vapor phase oxidation of ortho xylene. Energy integration done in such a manner that in the battery limit plant, you do not require any external power, and this process is known as the 0 energy process.

Then a radial flow catalytic reactor results in lower pressure than a conventional actual flow pack bed reactor, so let us say as a rule of thumb in methanol plant having capacity

greater than 1000 tons per day the radial flow reactor is preferred. So, as to keep down the pressure drop to minimum and hence the pumping cost the utility consumption, like a raw material is also presented in terms of the utility consumed per ton of the project.

The consumption of steam is given as x tons of steam at a pacified pressure p per ton of the product, the excess or exports steam is then given a negative credit because we earn a revenue out of it. Thus by knowing the consumption of raw material and utility one can easily estimate the total cost of production without going into greater detail, like administrative cost wages and salaries and so on and other factors that we noted.

So, just knowing the raw material and utility cost we can estimate the cost the fraction of other cost based on that, and that would give us the total cost of production. By enlarge the administrative salaries over heads and sales expenses do not cross more than 10 percent of cost of production, therefore the gross cost of production as a thumb rule can be taken to be 1.1 times the total cost of production.

So, that is about the gross cost of production, then we have to see the capital investment that is the project cost, we are again going to have detailed discussion later, but here we note some points we shall have more discussion on it some of these are project site related.

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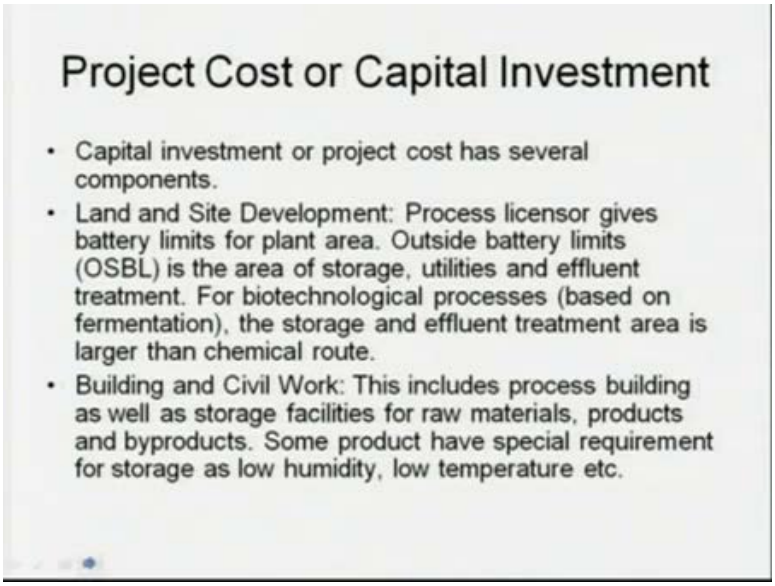

So, in the next lecture I am going to describe it in greater detail, I just list here a few points the components of capital investment or project cost, first the land and site development process licensor gives the battery limit of plant area outside a battery limits. Battery limit means the main production area of the plant, outside battery limit is the area of storage utility and effluent treatment, for biotechnological processes based on fermentation the storage and effluent treatment area is somewhat larger than the chemical route.

Then second is the building and civil work this includes the process building as well as storage facilities for raw material products, byproducts, some products may are fragile like for example, they require special storage conditions such as low humidity, low temperature so on and so forth.

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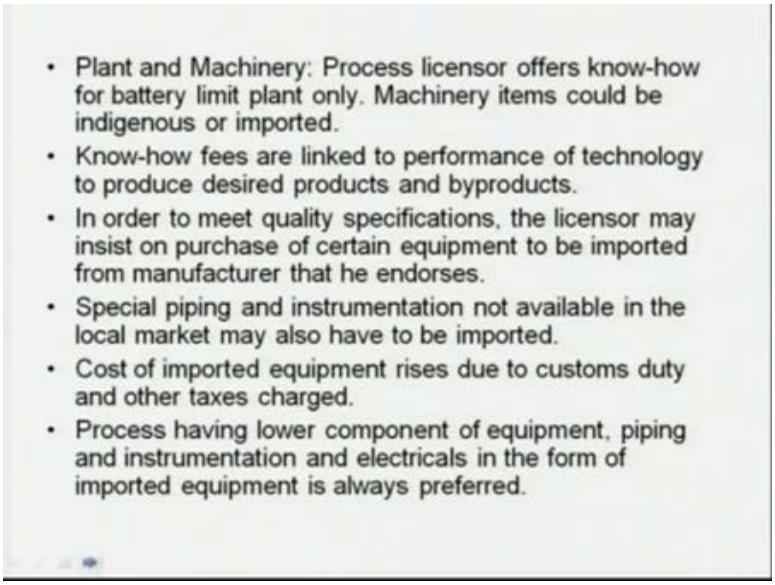


So, we have to ensure that these conditions are present in your storage facilities, third is a plant and machinery, again like raw materials and utilities the plant and machinery forms the major capital fraction of the total capital investment. Process licensor offers the knowhow for battery limit plant only, machinery items could be indigenous or imported, but the let us say for the reactor. If the process licensor has given yield on a very special configuration of the reactor, then he may insist that the reactor should be purchased from either him or the vendors that are recommended by him.

Then the know how these are linked to the performance and of technology to produce desired products and byproducts, then in order to meet quality specification licensor may insist on purchase of certain equipment as I just said or imported. Then special piping or instrument may not be available, so that also has to be imported, cost of imported equipment increases the total investment, because of the custom duty and other taxes.

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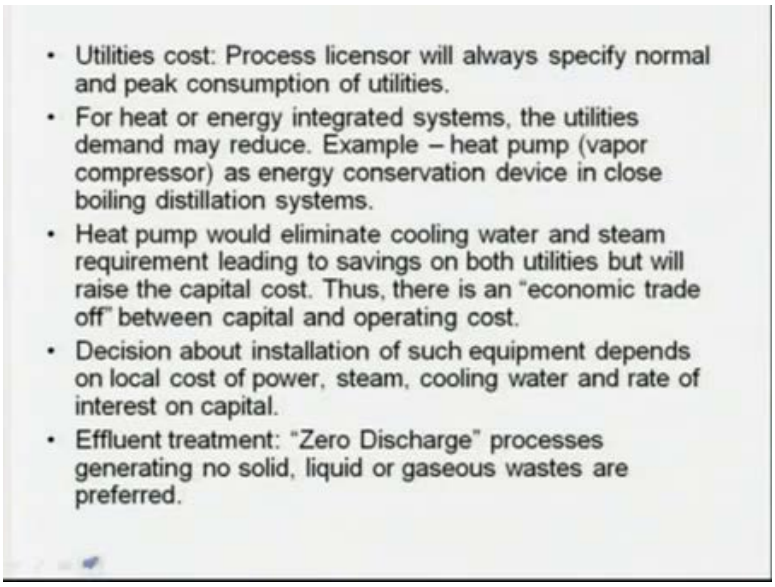


We would always try to get as indigenous components as possible, then the utilities cost process licensor will always specify normal and peak consumption utilities, we have to set up basic equipment like steam boiler than effluent treatment plant so on, and so forth. So, that is another or we have to go for heat integration heat integration itself causes investment for example, you can heat integrate two distillation columns, so that the vapours are condensed in the condenser of one column, may drive the reboiler of second column, but in order to do that you have to compress vapours.

So, cost of compressor is added, so energy integration gives you an advantage, but at added capital investment, so that point we need to note. Then the effluent treatment, effluent treatment is another major cost component, we would like to go for as low discharges as possible 0 discharge processes that generate, no solid liquid or gaseous waste are preferred.

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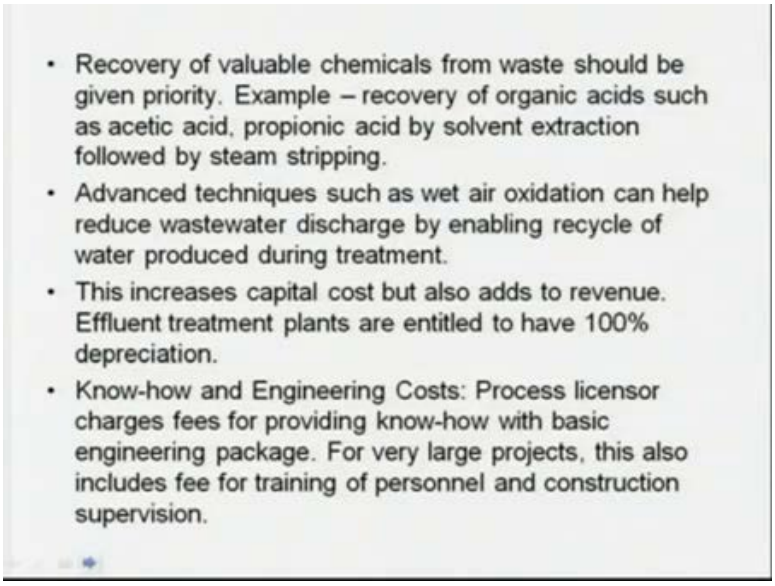


Then recovery of valuable chemicals from west should be given priority recovery of organic acids such as acetic acid, propionic acid, solvent extraction followed by steam tripping. Then of course, these all of these are going to add to capital cost also, but they give certain benefits in terms of less energy consumption. Then know-how and engineering cost the process license or charges fees for providing know-how with basic engineering package, for very large projects this also includes the fee of training of personnel and construction supervision.

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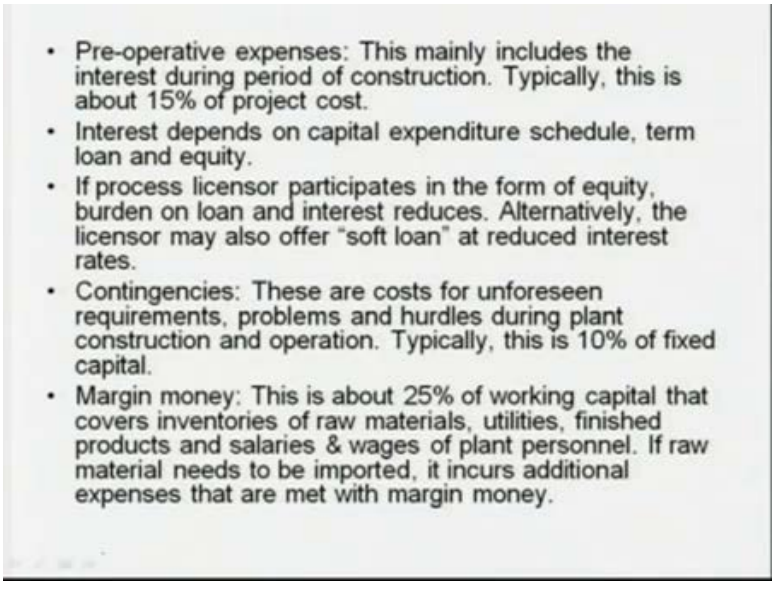

Then pre operative expenses, this includes the interest earned during period of construction, the interest that you have to pay to the bank this is typically 15 percent of the cost. Then contingencies these are for unforeseen requirements problem and hurdles due to plant construction operation, this is estimated typically at ten percent of capital investment, and finally the margin money. This is about 25 percent of the working capital that covers the inventories and raw materials, utilities, finished products, salaries wages.

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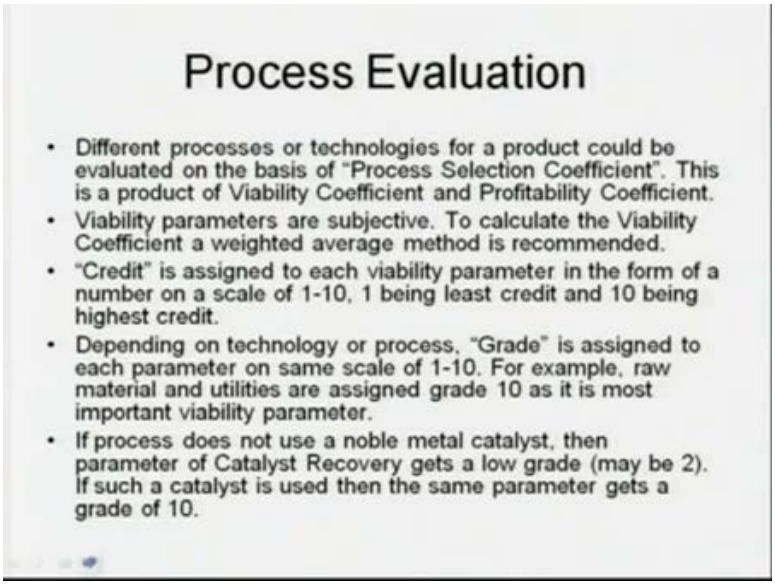


So, having done this having defined process profitability parameters as well as viability parameters, in the next lecture we shall see as how we can quantify these parameters and grade different processes that are available with us. And then go for the best possible technology selection, then in the next lecture we shall also see, how we can select a particular site for the project or what criteria we have to apply for the site selection.