Process Design Decisions and Project Economics
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Module - 8
Chemical Project Economics
Lecture -36
Introduction to Chemical Projects and Their Economic Aspects

We are now entering module 8 of our course, which is the final module that is the Chemical Projects Economics. In this lecture we shall get an introduction to an extremely interesting topic of the economics of the chemical project, chemical project have a special status in the sustainable development of our country because our society we need chemicals in our day to day life in several forms such as die, soaps, detergents, cosmetics, food preservative, pharmaceuticals, fertilizers. Then fuel stuff to run our cars and vehicles and two wheelers, various metals that are there in our house, in case the synthetic fiber the textile that we wear plastics, paints. We cannot imagine our life without chemicals, how do chemical pants differ from the other process plants that are there.

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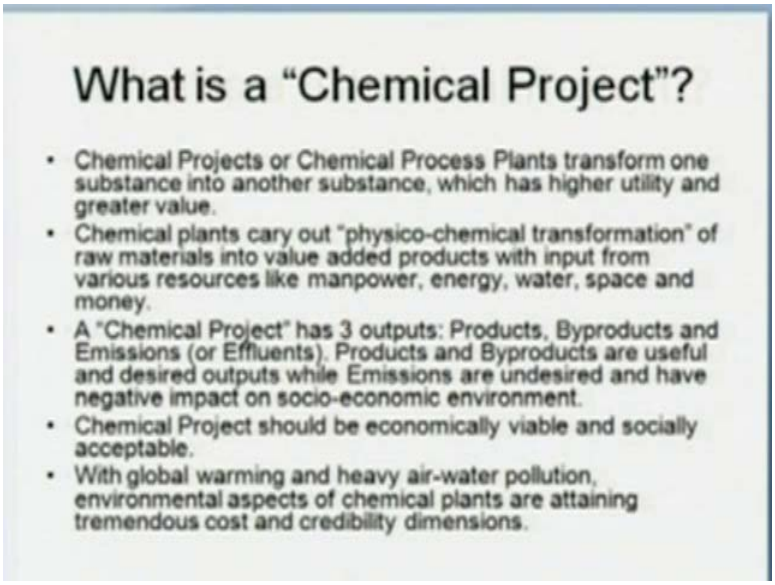

Chemical plants deal with physic chemical transformation as a substance into a raw material into value added product with input from various other resources such as manpower, energy, water, space and money. As we have seen in the module of fluid

synthesis the entire chemical manufacturing process is the combination of various unit processes and unit operations that are connected each other.

For instance, in case of the refinery the crude oil is first distilled to separate various fractions, such as the liquefied petroleum gas that is carbons hydro carbon that is c 1 to c 4 those carbons can give 1 to 4 carbon atoms. Then the naphtha c 5 to c 10 then the gasoline which is c 5 to c 12, then the kerosene which is in the same range, then high speed diesel. And then this operation is carried out in by a series of distillation column, so the distillation is the major unit operation of the refinery industry; however, further in the petro chemical plant, the raw material are different.

For example, benzene is the major feed stocks of the petro chemicals. So, how a major route benzene is the reforming of the naphtha the skin reforming of naphtha in that process naphtha is converted to aromatics, benzene, toluene and xylene with aromatization as the unit process. And then there is separation of these aromatics like benzene, toluene are easily separated, but separation of the xylene isomers is difficult. So, the artho xylene come first and then there is the isomerization of meta to pare and then Para xylene becomes the feed stock for therapy delegacy.

Now, chemical project differ from other projects such as automobiles manufacturing project, hydropower generation project, high way construction, dam so on and so forth. Because, these projects transfer 1 substance into totally different substance, for example, the natural Gas methane is converted into methanol, in case of the methanol plant. Of course, there is the intermediate step of stream reforming of methane to generate the synthesis gas hydrogen plus carbon monoxide and that is contacted over suitable catalyst to give methane methanol. So, this kind of thing is very unique to chemical industry.

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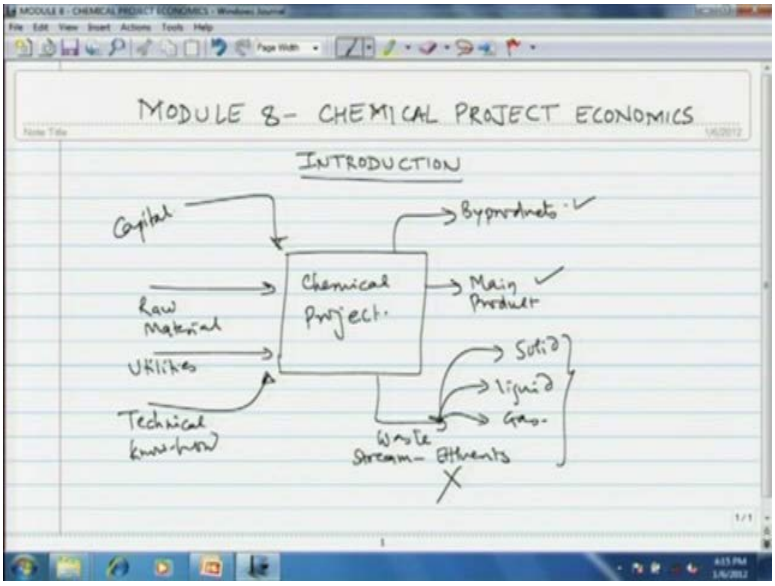

If you draw simple flow sheet of chemical project as we have seen in the flow sheet synthesis module. A chemical project has several inputs first the raw material, then utilities, then the technical know how and then the capital money. And then there are several outputs the main products, the bi products which could be desired or undesired. And then we also get several waste streams which are known as effluent which are in all 3 forms solid, liquid and gas.

The products and co products are useful for the growth; however, the effluent has the negative impact on a society. Therefore, the chemical project involve the technical aspects of producing a product from the preferred raw material selectively and efficiently. So, you would essentially would like to go for a 0 discharge process, in which there are no effluents, all the raw material is converted into some product or bi product.

Toxic explosive are the toxicant explosive nature of many chemicals can cause some several harms or cause several accidents and loss of life and wealth. Therefore, would like to avoid the effluents as much as possible, so that could be the major target or the major objective of design of chemical project. It is not about converting one material to another material, but as efficiently as economically as possible.

Chemical plants often require large quantities of water, so they cause burden in on the society in which they are established chemical plant often require large quantities of

water. And then they also required electricity water is required both in productions process as well as utilities like steam and cooling water, the water that is rejected from the chemical plant, becomes accuse effluent steams.

It may contain bio degradable or non-biodegradable complex molecules therefore, we have to go further waste treatment, the waste streams are not treated properly to meet the stipulated local discharge standard. They can cost considerable damaged to the environment and also to the social and cause several social and economy problems downstream of the plant.

So, we would like to avoid all this aspect while designing a chemical project, the gaseous emission into atmosphere can cause devastating effect on human health as well as the plant and animal life. So, you have to see to it that the gaseous emission are below the prescribed limits environmental related issues associates chemical projects are assumed in tremendous cause and credibility dimension as time progresses due to stricter emission standards pertaining to gaseous and gaseous liquids and solid pollutant to have quality of life.

Chemical plants many times handle or generate flammable exclusive materials, some times as fuel, some times as plant chemical they are transported, they are received, uploaded, stored, handle at times under high pressure temperatures. So, any of the processes a leakage can occur which can cause tremendous damage, like the Bhopal gas tragedy is a very vivid example of such or the scale of damaged when proper handling and storage is not taken care of.

The scope of the chemical project is extended from earlier like only chemical project to even power project based on liquefied natural gas. So, we have large storage of large reserve of this natural gas in the north eastern reason, safety related region. This are arising out of huge achievement and storage of LNG might necessities larger location of area for project and re locations of the villages. So, acquisition of the land, rehabilitations of the people is another major issue or associates with any project, so chemical projects are no exception to this.

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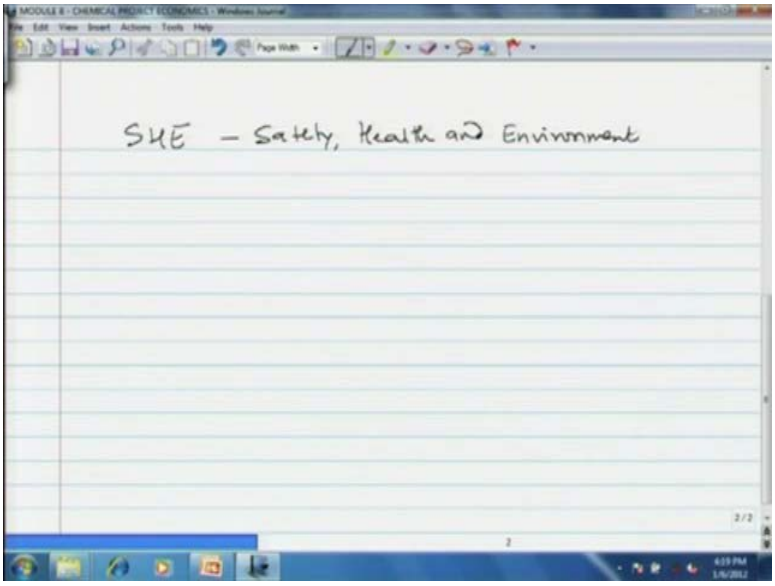

So, these aspects give a total different dimension of safety health and environment issues what as known as SHE issues Safety Health and Environment.

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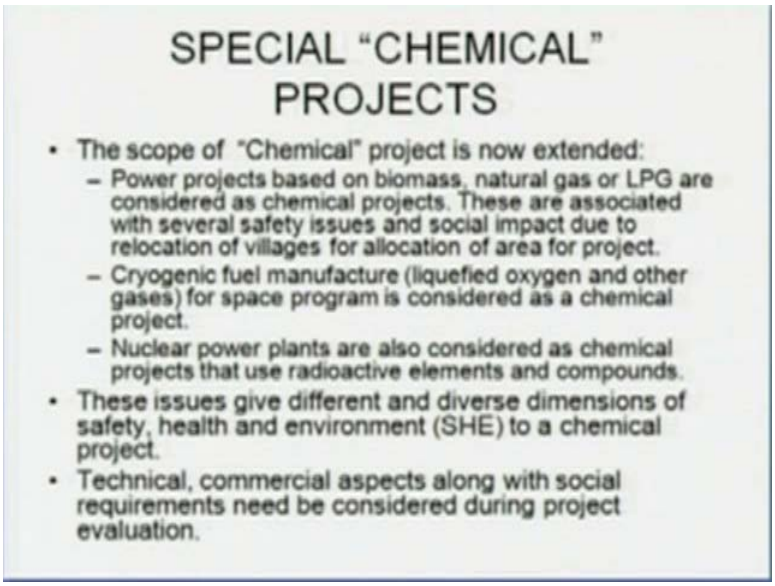

Technical commercial aspects along with social requirements need to be considered during project evaluation and then this SHE is the major aspect.

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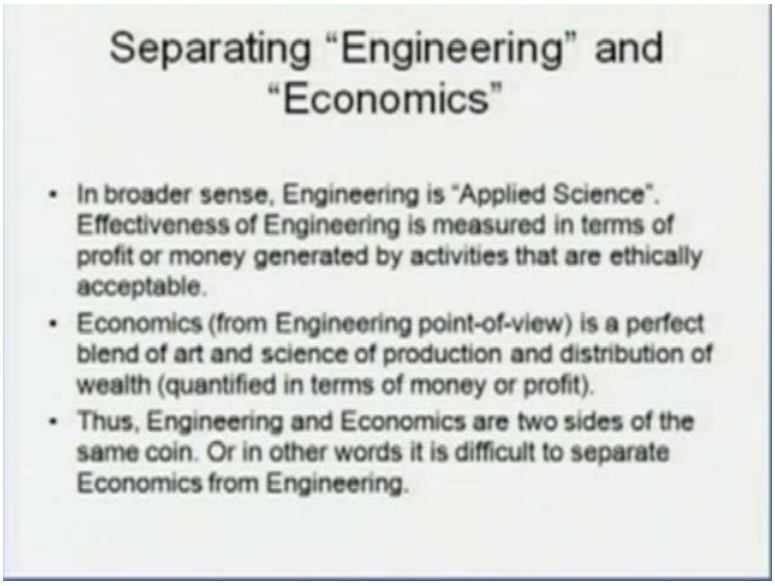

Let us try to see what is engineering and what is economics? So, far you have had courses in core chemical engineering, such as mass transfer, heat transfer. In this course, we are trying to couple a completely different subject to engineering, that is economics. Now let us see the difference between them, in the balanced product sense engineering is applied science effectiveness of engineering is measured in terms of profit or money that is generated by the activities that are ethically acceptable.

Economics from the engineering point of view is a perfect blend of art and science of production and distribution of wealth quantified in terms of money or profit. Therefore, if you see these arguments, then you can conclude that engineering and economics are 2 sides of the same coin or in other words very difficult to separate economics from engineering or engineering is incomplete without having the proper economics background.

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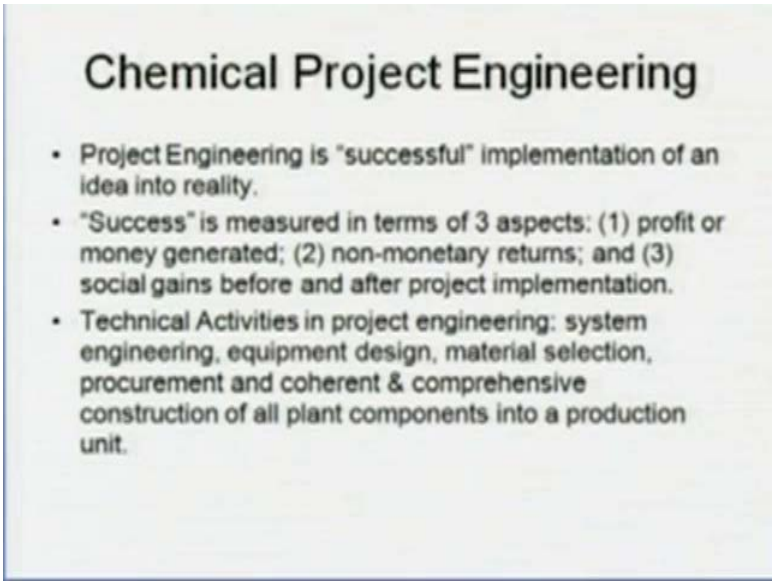

Let us see what is chemical project engineering? Chemical project engineering could be termed successful implementation of an idea into reality, when we say success. Then obviously, comes like what is defined as success, the success is measured in terms of 3 aspects first profit or the money that is generated and second the non-monetary returns and third the social gains that are obtained before and after project implementation. The technical activities in the project engineering are system engineering, equipment design, material selection, procurement and coherent and comprehensive construction of all plants components into a production unit.

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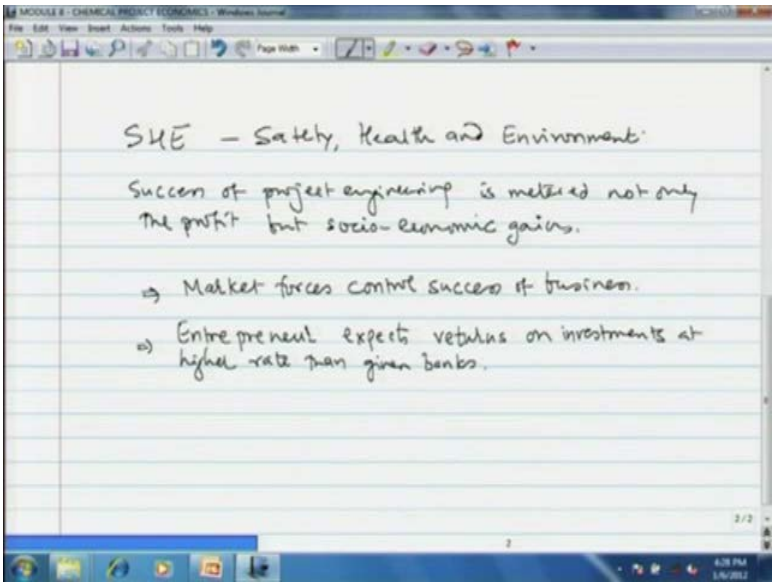

So, that point we note success of project engineering is metered not only on the profit, but also socio economic gains. Engineering of the chemical project is coordinated combination of technical and non-technical activities. Now the technical activities we are already seen, now the non-technical issues include obtaining all the statutory clearances required for from various authorities, such as the pollution control board, the state electricity board, the procurement of land and plot and finally, the timely arrangement of the required finance to implement the project.

These are important because the timely construction of the project is controlled by the availability of the sufficient money as and when required. So, that capital you have to make sure, perfectly sure of your funds before you even start thinking of the chemical project. Delays, often cost, project cost, overrun and then if your competitors enters the market before you, then you may use the control over the market.

The ability of the project to generate enough profit to return, all borrowed capital for the project with interest to financial institution and dividend equity holders has to be proven a paper a priory with detail techno economic feasibility report, in addition to risk analysis to avail the finance from various sources. In we are going to have module on financial analysis of the chemical project.

We shall see the capital cost, operating cost and then various measures in assessing the profitability of the process, but this is something which is very important that first of all you have to prove the profitability on paper before we go actually into the project. Apart from financial aspects, there are legal and statutory matters that need to be addressed. For example, there may be legal matters pertaining to conversion of land into nonagricultural plot, there might be some public interest integration against the project.

So, we have to take care of all these things, then the side specific clearances have to be obtained before you actually start the construction activities. And many time the market forces control, the success of any business proposition. Market forces are very important, very often market has to be developed as in case of specialty product such as detergents, toiletries, cosmetics etcetera during project implementation.

Hence, it is to be watched and the project is to be modifying capacity and contends accordingly, whenever you are starting the project, you have to see that is market in the surroundings. For example, the project suppose the project in southern India and the

market for the product is northern India, then you have to take into consideration the cost of transportation and the actual price of your commodity in the north Indian market.

At a time we have to also take into consideration what are you are your competitors from the local area? And then whether you are product stands in terms of quality as well as price in comparison with the local competitors. The time factor is very important time factor plays the important role in success of chemical project, because of 3 reasons first long delay increases the interest on borrowing.

If the all capital does not do belong to you, if you have borrowed for capital either from the banks like IDBI or if you have borrowed capital in the form equalities from peoples to pay. You have dividend and interest and larger the delay larger there interest on the borrowing. Second project extension can change your market opportunities, as I just mentioned if your project is not complete in time, your competitors enter and they capture the market and then the market whole goes down. And finally, the delay in implementation can increase the project cost, we see several examples in where the cost of the projects have increased or even doubled in time because of the delayed that has occurred. And obviously, all of these will affect your profitability adversely.

So, it should be noted that the interpreter is looking forward to generate profit through the project rather and at a rate higher that obtains from banks. Suppose, some person is investing money in buying shares of your company, then investing in your company than you have to make sure that he to encourage him to invest to greater and greater extend. You have to pay dividend at higher than those paid by bank.

So, banks are competitor in the dividend that point we have to note, interpret your aspect return on investment at higher rate than given by banks. It is thus seen that chemical project engineering and economics are not separable. And this is the topic that we address in this particular module of this course. So, this module is other unique to all the courses that have been offered in the chemical engineering domain of NPTEL.

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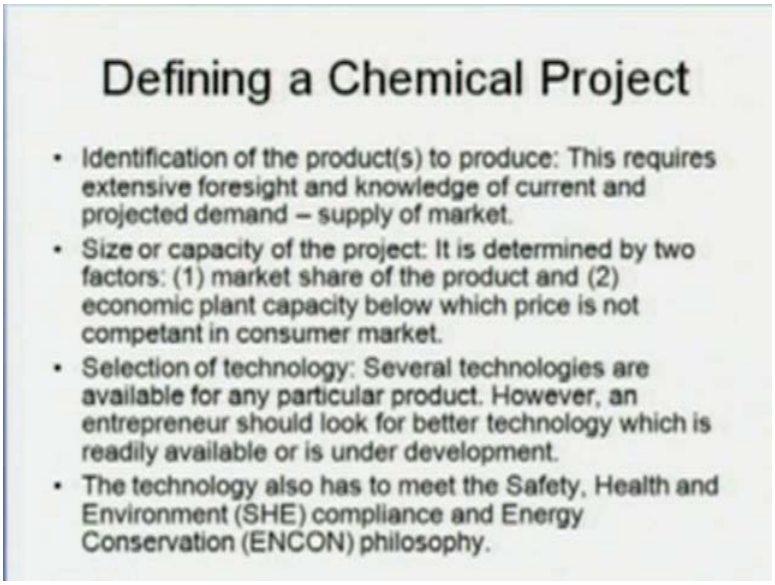

Now let us see what are the pre project activities before you undertaking the project what are the activities that you have to do? Defining in a chemical project we can say, project whether it is chemical otherwise has to define before we takes step to implement it. Now this basic requirement needs to be address mainly are entrepreneur or managers that are of engaged in cooperate planning.

Now what are the questions that come up while defining of chemical project the first questions is what to produce? You had to first identify the products or a series products. Now this will be require extensive force sight knowledge of the current as well as projected demand supply of the market, remember that it take some times to a build particular plant let us say 3 to 5 years.

So, when you decide to produce a particular product you do not have to consider the current demand and supply, but the projected demanded supplies after 3 years or 5 years when your plant will be operations. And than how much of the market that you are able to access, that is important thing. If this step goes wrong than lot of valuable to time in the project is lost and there is the history of several project of concept failing at this particular first position, then what should be your main product.

Than next question that we face is the production capacity, size or the capacity of the project. it is determine by 2 factors, first the market share of the product and second economic capacity below which the prices not competent in there consumer market. Now

remember there is always economy of scale, if you put up 10 tons per day plant and it is put of 100 tons per day plant the per ton production cost goes down as the scale of production is increased.

However, there is the limit as how much you can increases the scale. So, you have to do market analysis, you have to see how much share of the products market share you are going to achieve from the your production. And then you have to decide economic capacity of the plant and you have to decide that particular capacity below which the price is. You have to identify plant capacity below which price is not competent and then design plant is higher than that particular capacity.

Now there are examples where the markets were found to be far below than expectation after plant was established and also the capacity of plant had to doubled in few years to meet the overwhelming response from the market. So, you need to contact I expert which are severally years of experience who can predict the market trend with the sufficient accuracy. So, that is the second question in defining of a chemical project.

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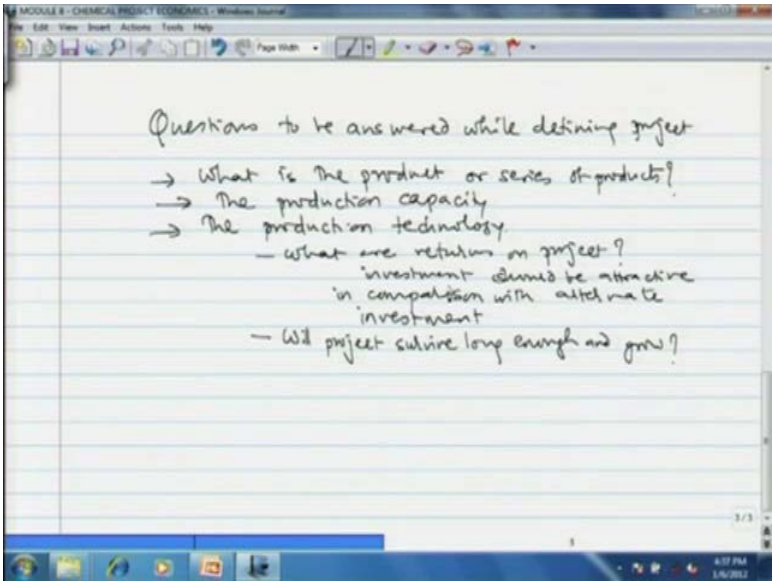

The third question is how to produce? So, that question be note before who had questions to be answered while defining project, the first 2 question that we just discuss what is the product or series of products and second is the production capacity. Now third question the production technology how to produce? Now for any product we are in 21st century for any product it will be several process available.

So, before you decide to go for chemical project it is good idea to look for the technologies that are available in the project. So, if you have done that homework if one has a technology than you safe effort or technology search, but even than you should always see whether any better technology is available. And Secondly, is there any new technology that is underdevelopment, this is the necessary because investing into project.

It should be established that products the project will not be technology pushed into dustbin. Why, because of the limitations or the constant government constant. So, safety, health and environmentally issues, the energy conservation issues, than the quality management issues, than the land that is required. So, you have to make sure that your technology is competent not just because technology itself, but also the other related aspects that we just mentioned safety health issues and non tell issues so on and so forth.

So, when these basic questions are answered the more important question about the project cost and finance will have to address. So, before you go for detailed analyses make sure that your technology is competent in every aspect. It is not only just low in the production cost, efficient in terms of desired products, but it should also have least ignition it should have least hazard conditions so on and so forth, to meet all the criteria or constant that are imposed by the government.

The total project cost is typically the fix capital investment plus working capital. So, the cost of productions gives you an idea of day to day expenses. Now than after you decide technology you have to you face too more questions. First what are returns on the project? What is the raw material that you have to used and what is the cost of the product that you produce? So, that difference gives you a value and is the value additions sufficient enough to make the investment attractive that is the questions.

Investment should be attractive in comparison with alternate investment, I just mentioned if you had to attractive investment for buying shares of your company, you have to promise him dividend at a significantly higher rate than those offered by nationalized banks or even the cooperatives banks. Than the second question that will come is that will project survive long enough and grow.

Now this questions is very tricky very; obviously, the returns on projects are possible only in there sufficient market for your product. And your product has to be stand for the competition from other manufacturer, the market you will allow growth in demand

which can be best met by expansion of the plant capacity. What is the optimum capacity? The optimum capacity as will be determine by the market forces; however, you should be able to go for change in production your production capacity should be flexible to meet the projects demand.

So, that is thing project grow; obviously, if the demand increasing or you are able to capture more and more share of the market by expanding in different parts of the country or having collaboration with other companies, local companies, local dealers so on and so forth. So, these are the questions that we have to answer while defining a project. Having on answered this questions the next team is the type of the project or classification of the project.

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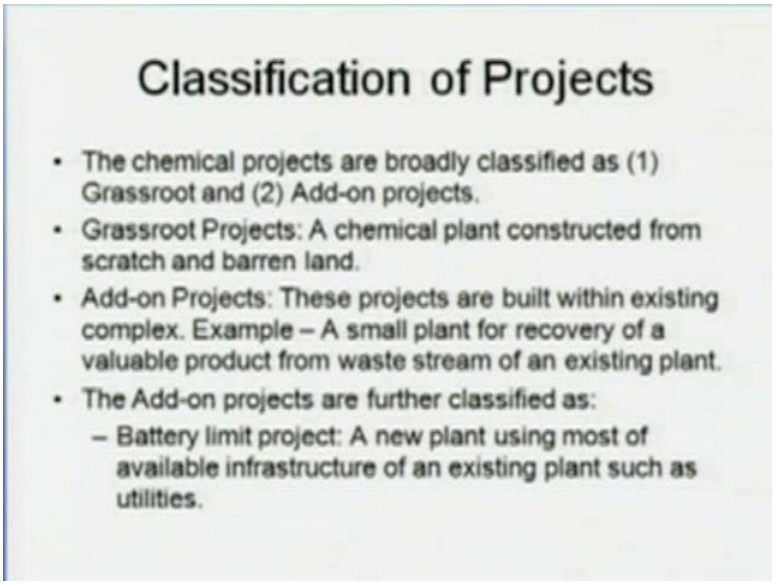

The chemical projects are broadly classified as either the grassroots project or add on project. What is the grass root project? Grass root project is a plant design from scratch, plants constructed from 0 level and almost on the barren land starting from land requirement and side development is referred to as green field or grass root plant. So, there are several examples of it gas cracker complex, IPCL in Nagpur thane, it was build on a land that was partly agricultural and partly hilly environment.

And then you have to see that it gets the proper feed stocks from various sources, than you have to go infrastructure development, water after you have to make sure of water, power ability housing and education facilities for your personal. However, every green

field project may not necessarily include the development of the entire infrastructure. Therefore, you can at the start of the plant you can post pond some of the activities in the later period of the project. So, that is the grass root project, the second type of project is what is known as the add on project. Now this projects are built within existing complex, an example of small plant for recovery of value able product from waste stream for of an existing plants. Now, whether to go such as plants depends on the financial condition of the company.

If company has sufficient financial reserve to go into new venture, than all of this projects fall into the category of add on projects. So, that is it, this project add on project could be of several sub type. What are these? One is what is known as battery limit project? The battery limit project by definition is new plant using most of the available infrastructure of an existing plants such as the utilities, administration, building, security, tanks or the storages facilities the effluent treatment plant so on so forth. The example of this is plant to manufacture technical grade fumaric acid by scrubbing of gases of thylicane hydride plant using ortho xylene is feed stock. So, this could be as a battery limit plant. Then the next category is that of forward integration, forward integration is essentially a project based on the products of existing plants as raw material.

Suppose, you have several has bi products of your company which are not, so harmful, which can be further upgraded to different value added products. In that case you would to like go forward integration of the company by installing new plants. Now example of this is if a phenol manufacturer decides to set up a biphenyl a project based on phenol and co product acetone. Then this particular activity could be deemed as a forward integration of the existing plants.

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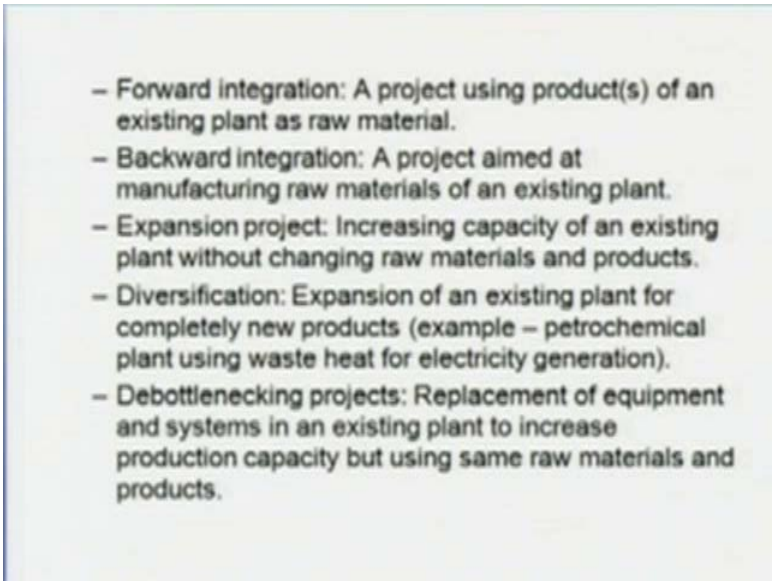

Then the third sub category of add on project is that of back integration, if the project owner decides to manufacture the raw material for their existing projects. Then it is it can be deemed as the backward integration of the process, of the plant. And example of this category is that of di phenyl carbonate, when di phenyl carbonate is while being manufacture using phenol and diethyl carbonate by an eco friendly and safe technology.

And the owner decides to set up plant to manufacturing diethyl carbonate than that activity could be deemed as the backward integration. Then the fourth sub category of add on projects it is the expansion of the project. Here it is simple addition of more capacity to existing facility keeping the product and raw material same. That example, could be adding naphtha cracker to the cracker compromise to enhance the ethane capacity, it could be called expansion project or also know as horizontal integration.

The fifth type of add on project is that of diversification, the project owner may totally diversify into different product range. Like for example, petro chemical producer like 1who does steam reforming of naphtha to produce aromatic, in could go for diversification in power generation, power generation. We in India tremendously short of power, so any 1 who is generating power is going to make lot of profit.

So, that is why we see several traffic company setting the power plant beside the refinery, so that could be the sort of diversification. And then this electricity they can use not only for captive consumption that is to meet the internal energy demands, electricity

demands of the process, but they can also sell it to the government and the people. And the 6 type of add on plant what is known as debottlenecking project.

Debottlenecking project can be defined as replacement of equipment and system in an existing plant to increase the production capacity, but using the same raw material and the products. An example of this category is the existing distillation tower with all ring spat in material, could be replaced with meta filament wire cross packing or what is known as IMTP Interlocks Metal Tower Packing which have low pressure drop as well as lower HTP High equivalent Theoretical plate. So, that you get the product of better quality. So, these are some of the example of add on projects. So, let us see what are the other factors that are involved in the classification of chemical project. If we see the broad classification then we can classify into 3 categories, based on 3 different criteria.

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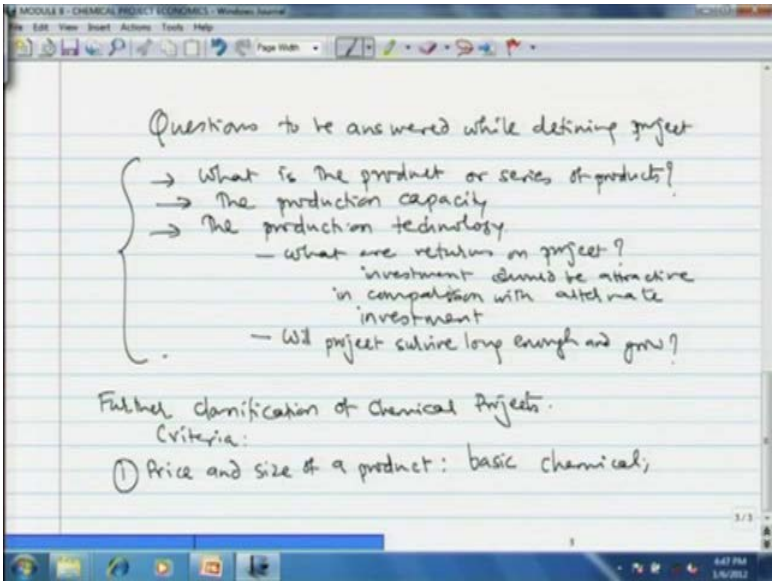

Further classification let us say we write further classification of chemical projects criteria first is price and size of the product. Now here product are classified as basic chemical like basic chemical could be methanol, ethanol, methane, ethane, ethylene this are the basic chemical. Then the commodity chemical could be fertilizers, could be soap, detergent or specialty chemical, specialty chemical could be pharmaceuticals.

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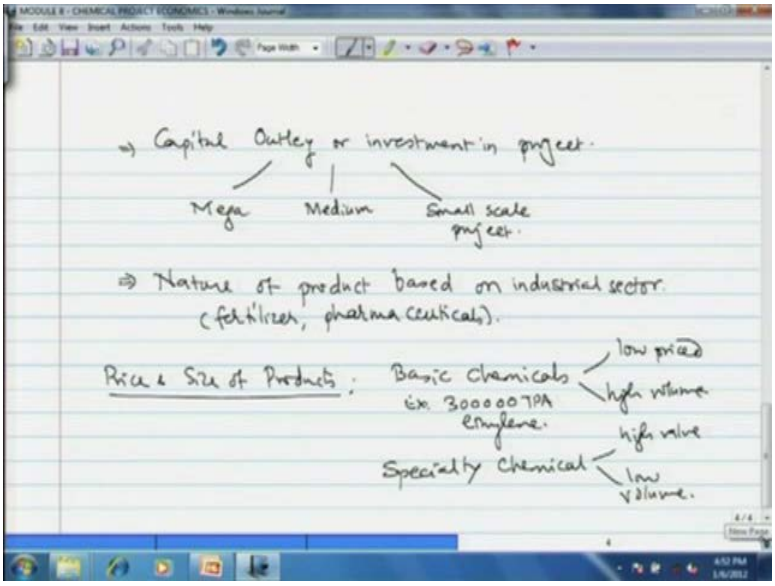

The second criteria is that of capital outlet or investment of the project. Here there is 3 categories first is mega project involving thousands of cores. Then medium size may be few hundred core and a small scale project which could be up to hundred core. Of course, these are brood classifications, then the nature of the product based on the industrial sector, this fertilizer or pharmaceutical. Now let us discuss each of this criteria in greater detail, now first the price and size of the product.

As I just mentioned basic chemical are the building blocks of the chemical industries and these are consumed in large quantity and by themselves. And they do not have direct consumer application; however, they still control there in market. Therefore, they are produced in bulk to meet the market requirement and to derive economic benefits of size. So, the basic chemicals are low price chemicals, high volume chemicals. So, examples I have already given like, methanol, ethanol, ethylene, propylene, benzene, sulphuric acid.

This project need large investments and the capacity are also quite high. For example, 300 tons per annum of ethylene, commodity chemical are produce in quantities in similar range, but the production rate is typically less than 100,000 tons per annum. Now as I said these are commodity chemicals are basically fertilizers urea, phenol, polyvinyl chloride, polymer or something like acidic acid. Now these also have direct or indirect impact on the market, market forces the government prices.

And therefore, they have to have certain price range in the unique price specialty chemical are high value chemical and low volume that point we note. And many times technical know how of the specialty chemical is quite graded, most of the thing patented and not available as regular technology. Then the project capital outlet as I have already said mega rate is typically, in the range of 10,000 core, thousands of core, large project could be between 1000 to 10,000 core. Normal project could be between 100 to 1000 core, small project could be in the range 25 or 50 at the most 100 cores so on and so forth. So, that is the criteria of the project outlet, then the criteria of industrial sector.

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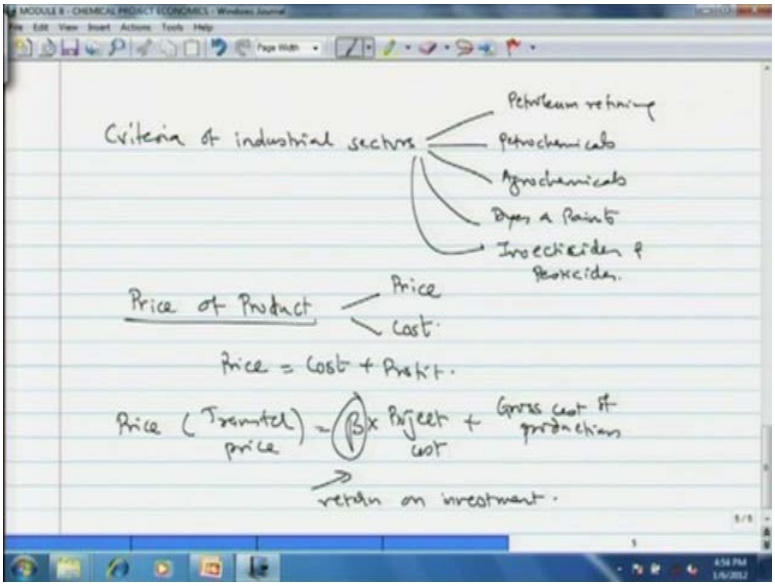

Industrial sector could be grouped in several broad industrial industries. So, we can group industries into several sectors like for example, petroleum refining is a 1 sector, then the petro chemicals is another sector, then agro chemicals, then descend paints so on and so forth. One more category could be listed has insect sites and pesticides. Then next is price particular product, we know 2 words in common mans language price and cost.

Now literally this could be synonyms, but when we talk in economic language the view of you they are different. So, how these are related price is essentially cost plus profit, now how do you define the price of the product, purely on the economic consideration. That can be done as price which is the transfer price is equal to beta constant into the project cost plus gross cost of production. Now this factor beta essentially implies the

return on investment and beta has to be at least 1 minimum value. Let us see briefly activities that are from project conception to project commission.

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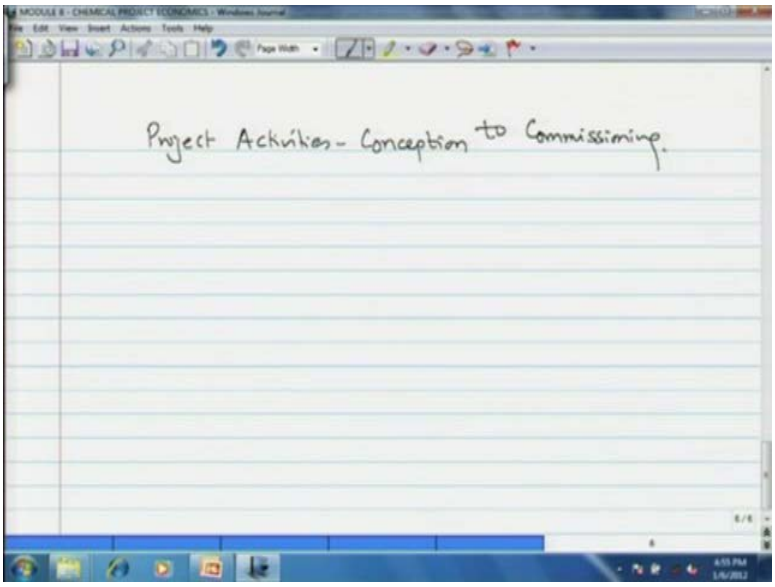

The project goes through various steps and sequences before it is fully implemented. Some of these take long time and almost to and fro before it is confirmed and the action mainly in the terms of commitment or expenditure is taken. We shall try to see different activity, that are there.

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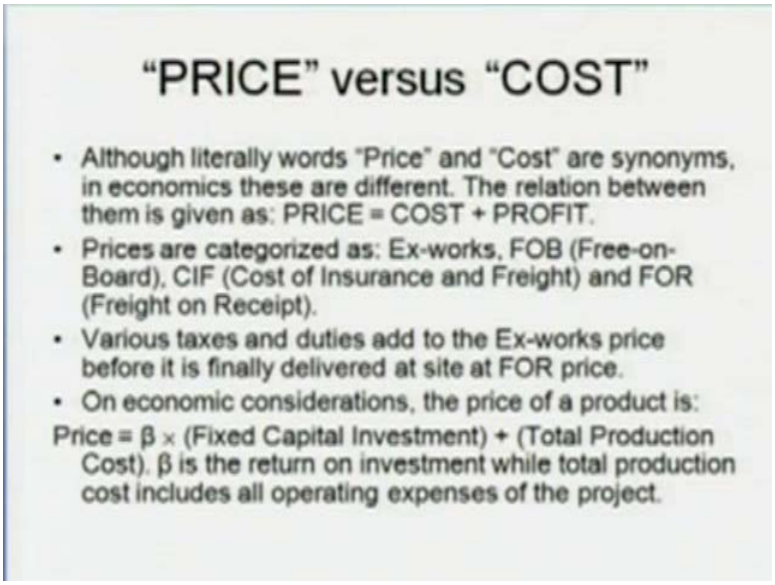

We only summarize for greater discussion we will see in the next lecture.

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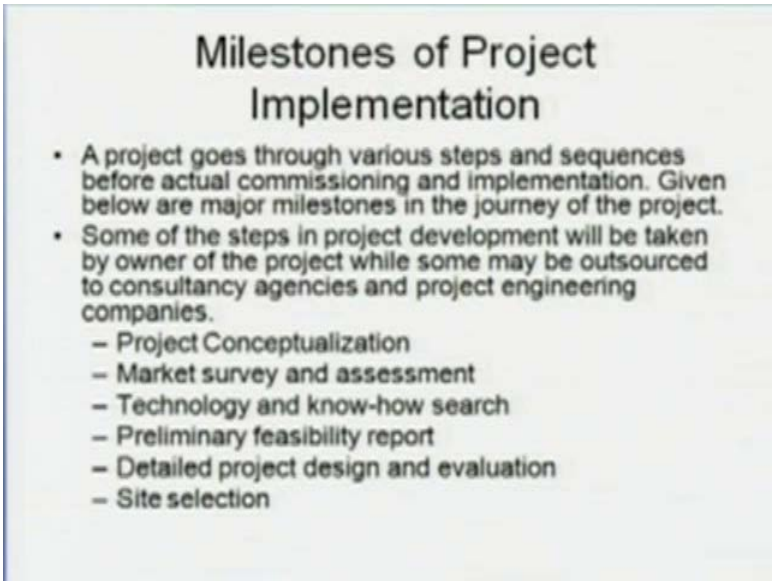

The mile stone of project implementation, some of the steps as I said in the project development would be taken by the owner of the project, while some may be outside consult agencies and the project engineering companies. Now it all though we know may not be available with the project owner. So, things like sight survey sight assessment this could be aligned to this kind of job given to project engineering companies. Now the first is project consumption, project can be conceived business in market opportunity new material and technology that are available.

Then consumer feed back opportunity made available by global politics are simply out of statutory composition such as to treat an west existing unit. Like example of this category is the government policy of making petrol led free. So, instead of tetra ethyl led the manufacture of ethyl tracery butyl ether ETBE started as the octane booster in the petrol. That could be the seed for the project conception such kind of policy. Then the second is the market potential, we have to consistently look for market potential.

And it has to be established for propose product by the way which they study this has to supplemented later with more enable field study, when large expenses is all to incurred on the project. Then the technology search this, I have already mentioned that it is good idea to do the home work of technology search before you decide to take up a project, but although you have information available on the available technology. You have to

look for developing technology or technologies that are recently or very newly implemented.

Then the preliminary feasible report, this report has to be prepared to add the investment decision. It is found worth going ahead then the detailed market potential on the desk study as well as field study may be commissioned. Remember doing market survey no simple job, you have to contact experts you have to pay them lot of fees. Therefore, before you go into that make sure very, very sure that your project is profitable and it is worth going far.

So, that will be that is done by the preliminary expense report, then the detail technology in evaluation. Now with help of competent engineering project companies, you have to go for a detail technology process selection. Then you may have to sign MOU memorandum for understanding to be executive at this stage with the process know how licenser and you have to find detailed engineering contract. Then comes the task of site selection, site of the propose project need to be selected.

Site of selection is the different topic in this particular module, I defer greater discussion later in this module. Then preparation of detail physically report, this results in what is known as the bankable document to obtain loan from financial institution. And then statuaries clearances, we have to obtain several clearances approval from central government as well as state government agencies, local statutory bodies, such as ministry of environment, ministry of finance, ministry of forest and so on and so forth with the help of hazard.

Hazard analysis and hazop the hazard operate ability studies, environment implement studies may also have to be taken into consideration. Then you have to go you have to look for a contractor, contractor for know how and detail engineering contract should be signed with a process licenser to supply of know how contract should be signed detail engineering by contractor. Many times the contractor is recommended by the process licenser, so that saves you some job.

Then come the very important factor of project financing, find large project is not totally financed by the promoter or investing the entire capital project owner may not invest entire capital. Some capital may be his own, some may be bowered by bank, some may be bowered in the form of equity. So, that financing should make sure before you go

ahead. Then the project engineering, now this project engineering involve detailed engineering.

Then procumbent, procumbent of all equipment, then extraditing inspiration services followed by the construction of plant and finally, comes the project commissioning that is after construction is completed the mechanical commissioning of plant is carried out. This is followed by process commissioning during which the guaranty runs are performed by the process licensor. And then the project is handed over to the production personal, remember if the plant is designed for capacity. Let us say 1000 tons per day, it may not achieve that much of capacity in the first year.

So, the capacity increases over years, so may be in the first year plant operate only to 60 percent of capacity. If the other factors not like for example, utility like pulling tower or steam generating plant. If those do not go in hand, then it need not be the all construction may be complete and then you start. You can start the production before the entire construction is taken over, but to a lower capacity that is always visible. So, that is what is know as project commissioning, in the subsequent lecture we shall take issue pertain chemical relate economic such as the first of all estimation of the cost, then the second profitability analysis then the deprecation and then the other factors.