Process Design Decisions and Project Economics
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Module - 8
Chemical Project Economics
Lecture - 38
Selection of the Process and Project Site (Part II)

Welcome, in the previous lecture we saw as how a process technology is selected for production of a particular chemical, what are the factors or considerations, that we need to give for selection of these various processes, various process licensers. So, those criteria were grouped in two parts; one is profitability factor, and second was viability factors or viability parameters. And then we saw the sub categories like what factors we need to consider under viability, what factors we need to consider under profitability, how much is the contribution of each of this factor to the total success of process. So, in this lecture, we take ahead this theme and then try to quantify that process evaluation criteria.

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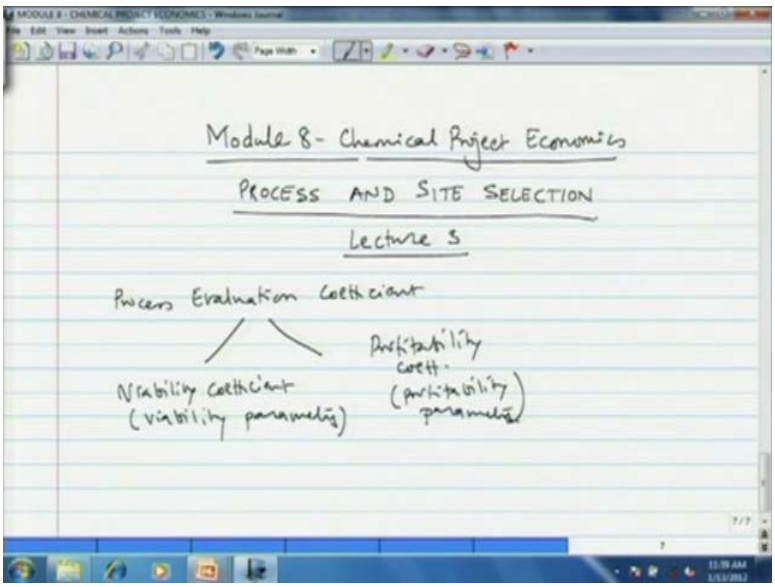

So, what we will do now is that, we will try to evaluate the process, we will try to define the process evaluation coefficient. Now, this has contribution from two entities; that is the viability coefficient, which depends on viability parameters and profitability coefficient, that depends on profitability parameters. And previous lectures, we have

listed these parameters; viability parameter, that we listed were subjective. However, we have to take away the subjective element.

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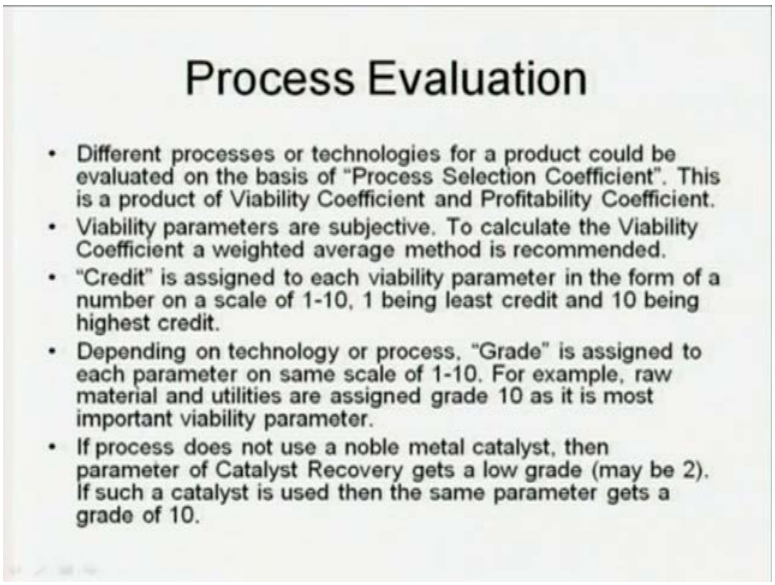

And then we need to make a weighted average method. So, we have to remove the subjectivity of viability parameter, and then try to propose a sort of quantification or weighted average method of evaluation of viability parameters that, we proposed.

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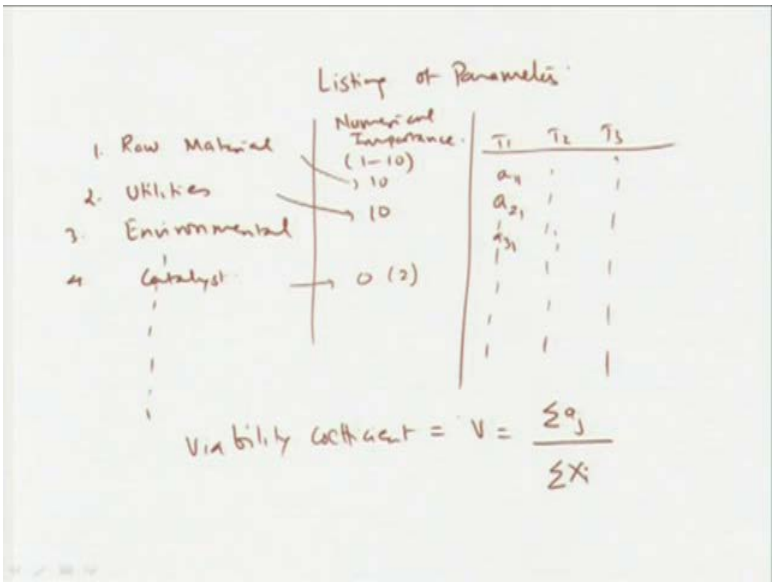

What we will do is that, we will list all these parameters. For example, the parameter of raw material then the parameter of utilities then environmental factors so on and so forth

and then we shall give a numerical importance to these, like one more factor could be the catalyst. Now, numerical importance is on scale of 1 to 10, 10 indicating most significant and 1 indicating least significant. Now, availability of raw material in utilities is being the most important viability parameter, we give that as numerical importance of 10.

If our process does not use a catalyst then the catalyst factor is 0 or let us say, if it does not use a noble metal catalyst then the catalyst recovery parameter is least significant so we can give it a weightage of 2. So, we have to, for each process, each technology that we have T 1, T 2, T 3, we have to list the numerical importance of these parameters and now, having listed all viability parameters with importance coefficient, we go ahead with assigning marks to the process under evaluation.

Now, the viability coefficient is then defined as v is equal to summation all of the marks that we give, divided by the importance. So, the marks for this are let us say, for raw material 1 a 11, a 21, a 31 like that, for each parameter we give marks to each of the technology. And then summation of the marks divided by summation of the numerical importance or the credit, gives you the viability coefficient.

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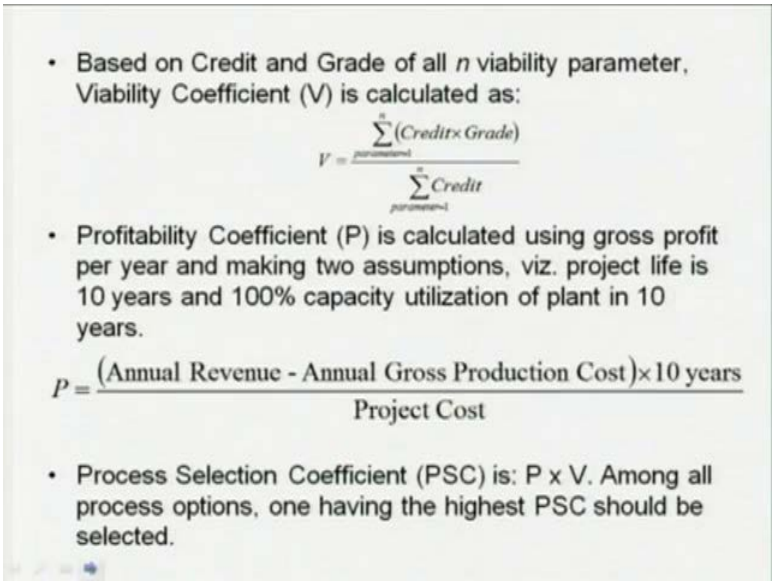

Similarly, we can also estimate the profitability coefficient. But, for profitability, we are bit luckier that, we have some quantitative definitions of profitability, profitability parameters can be directly quantified by means of projection of the profit generated by the project, over it is life span. Now, we assume that, the typical life span of a project is

10 years so the gross profit that a project makes is the annual revenue the sells into minus the annual gross cost of production that is, the gross profit that you obtain per year.

Of course, here, we are not considering the taxes and other things, this is simple net profit, that is left after you deduct the annual production cost from the annual revenue that company will earn. That difference into 10 years, is the revenue that company is going to accrue over the life span of the project and that, divided by the project cost gives you the profitability coefficient.

Now here, the project may not be able to utilize all of it is capacity right from year 1 but we can assume for simplification, that there is 100 percent capacity utilization. So, the profitability parameter P or profitability coefficient sorry is P, profitability coefficient P is calculated as the net profit annual revenue minus annual production cost into 10 years divided by the project cost.

And then the process selection coefficient is the product of the viability coefficient and profitability coefficient now, obviously the process, which has the highest process selection coefficient should be selected. However, it may happen that, some processes will have nearby process selectivity coefficient. Now, to scrutinize between these processes, we need more experienced persons or managers or consultants now, in case, the highest process selectivity coefficient for a particular technology is significantly different than others then we have to go for that particular process as our choice.

So, in that case, you do not have the problem of further scrutinizing the process coefficients so that is about our discussion on selection of process technology. We take further this theme and then we see, what aspects we need to consider the project site, the site selection is a very important pre-project planning activity. The project is constructed only once and therefore, site has considerable impact on the performance of the project during it is entire life cycle.

Relocation of the project, after a site is selected can result in enormous loss, sustainable development of machine is realized through well balanced and continuously growing agricultural and industrial sector. So, setting of an industrial project is going to bring, not only social as well as economic changes to the site therefore, the infrastructure planning and industrial growth may not go hand in hand in a country like India, vast country like India, but we have to somehow try to balance between these.

Plastering of the project should be avoided because it creates enormous burden on the semi communities that is what, is happening in our metro cities but government is promoting relocation of these projects or distribution of these projects in more backward areas. There have been instances where, some projects were required to be relocated even after site development has over, an equipment for reduction was ready for installation at the site.

And then that cause not only tremendous loss in terms of capital but also delay in project implement, project start up and therefore, such kind of delay is not disadvantageous to the project owner but also to the people. For example, if the project is a petro petroleum refinery then the production of petrol decreases similarly, production of aviation fuel, domestic fuel is hampered.

Therefore, we have to avoid this relocation by proper selection of the site we have so site selection is a very important pre-project activity, as I just mentioned. Now, in some cases, if the let us say, petroleum refinery project is has to be relocated then whatever is a discrepancy caused by the relocation or the nonproduction of that particular project, we have to fulfill by import of crude oil and that, again creates burden on foreign exchange. So, that is why, we have to make sure that the site, which is selected is the most appropriate. So, in this today's lecture, we shall see what are the factors that go into site selection, what factors we need to consider, how we can evaluate different sites that are available and then make a proper choice of the site for the project.

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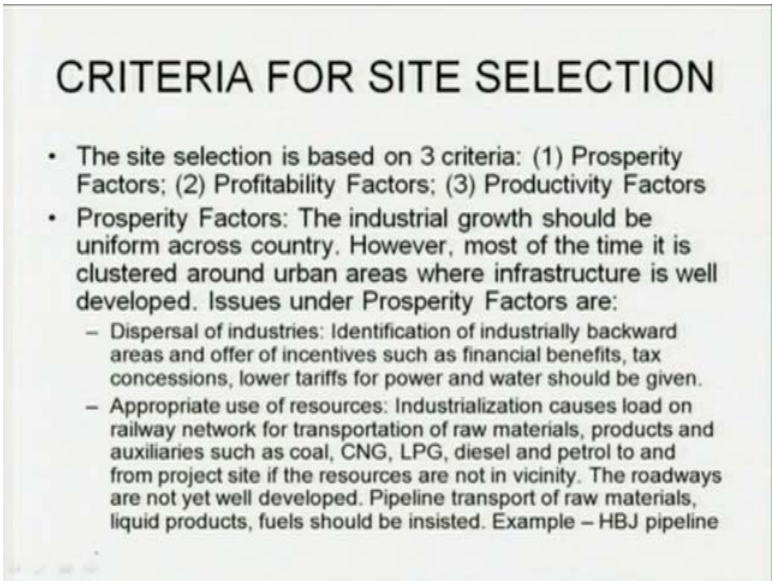

Similar to our process selection, here also we are going to do a semi quantitative analysis. The criteria for site selection are three, first the prosperity factor, second the profitability factor and third the productivity factor. Now, let us see these factors one by one, prosperity factor, the industrial growth should be uniform across the country. As I just mentioned, clustering of the projects near the metros has cause tremendous low burden on the semi communities, also the problem of pollution, heavy traffic so on and so forth.

So, the dispersal of industries is very important, we have to identify industrial backward areas and then try to implement or try to install the projects there and to do that, government may offer lot of incentives such as financial benefits, tax concession, lower tariffs for power and water. So, government is doing, government policies are trying to promote installation of or relocation of these mega projects into industrially backward sectors.

Second is the appropriate use of resources, appropriate use of resources is of considerably importance because we, our national railway network is already under pressure due to large transportation of coal, kerosene, LPG, diesel, petrol or petro products or fertilizers then secondly, even the road transport is getting burden. So, the consumption of energy sources would be too high, if the products are not produced near the market place or the plant is not located near the availability of raw material.

While location of the plant, we have to choose whether we want to go for a site, which is near the market of that product or near the raw material. The proximity factor has force the government, to consider use of pipelines for transportation of liquid products. Now, example of this is the HBJ pipeline, Hazira Bombay Jagdispur pipeline, this pipeline was envisage to provide the fertilizer plants, the crucial raw material. Now, there are certain pipelines, which are under construction for transportation of crude oil from receiving port to the site of refinery. So, that brings down the cost of storage of the raw material at the port site.

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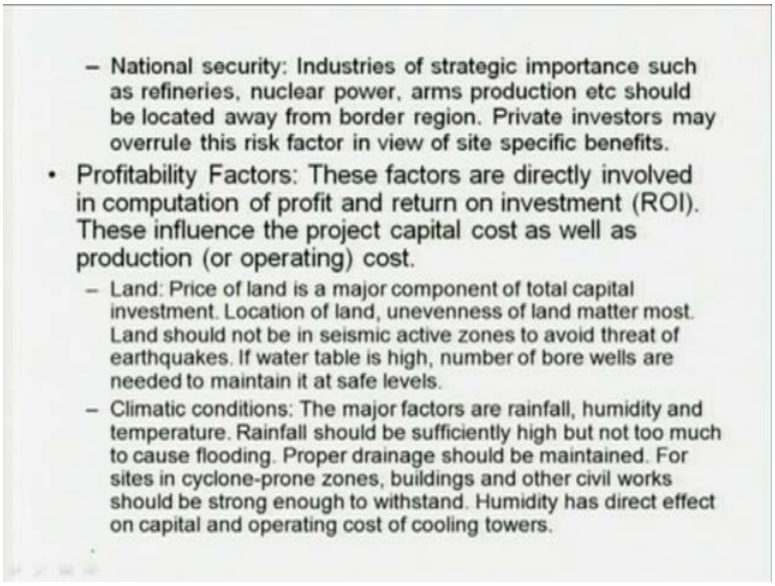

Then, the third aspect is that of, security, national security, the government has preferred to have industries of importance such as refinery or nuclear power station or defense armament production, away from the hostile borders. Now, considering weapon development program all over the world, the risk is more or less same on all locations however, it is sometimes safer to locate the project of this critical importance away from hostile border.

Many times, if the entrepreneur is a private entrepreneur, he may overrule the risk in favor of the site specific benefits. So, these are the factors, that come under the prosperity criteria or prosperity factors then we shall see the profitability factors. These factors are directly related to the competition of the profit, as in case of process

development also and the rate of return on investment and these factors also influence the project capital cost and operating cost.

So, we have seen some of these in previous lecture but we shall see now, what are the profitability factors, that are more site related factor. The first factor is of course the land, the price of land is directly reflected on the cost of the project, land contours or unhumanness of the land would have a direct pairing on the cost of site development. Suppose, you have a small convolute that is passing through the plot then you have to go for additional expenditure to divert that particular convolute or if let us say, there is small hill on the land then you have to raise it to demolish and make the plot as even as possible.

You also have to take into consideration the other risks such as the earthquake seismic areas but these things are not being given so much importance because there have been examples of big projects coming up near the sites having these kind of natural threats. The example is that of, the New Zealand synthetic fuels corporation plant, which is recently produced 14500 barrels per day of gasoline and it is located at the foot step of volcanically active mount Egmont.

We have to take certain kind of risks, although we try to reduce it as much as possible then second is the climatic condition, the climatic condition at the site has a direct barring not only on the cost of project, but also on the updating cost. So, the climatic data need to be gathered from the metrological department or the state industrial development corporation.

Now, what are these climatic condition, the first one is the rain fall, average rainfall or intensity of rainfall has a direct bearing on the storm water than a system. If there is water surge or flood, if the plants site is located in the flood areas then the entire plant may come to a standstill if there is enormous rain because of, entering of water into the plant site.

So, we have to make sure that, we know the rainfall that is available then rainfall will also determine the ground water. So, if the water supply from state industrial development corporation is limited then you have to have your own bore wells, that will be and that thing will also depend on the rainfall, the availability of that water, ground water.

So, you need to know the rainfall quite precisely then again if the site is in the area of cyclone prone zone such as the eastern region then the project owner needs to spend more money on building and civil work so as to increase their strength, which will again increase the cost of the project. The second climatic condition is that of humidity, higher the rainfall, higher is the humidity that is going to be present especially, during the monsoon period.

The relative humidity will have a direct pairing on the cooling tower, fixed cost and operating cost in case of areas with high humidity, the cooling tower may not work efficiently. So, we have to design the cooling tower, taken into consideration the average humidity, that is present at the project site. In case your products are hydroscopic then they need to be stored in dry and cool atmosphere then you have to built special storage facilities, that will also add to the cost of production as well as operating cost.

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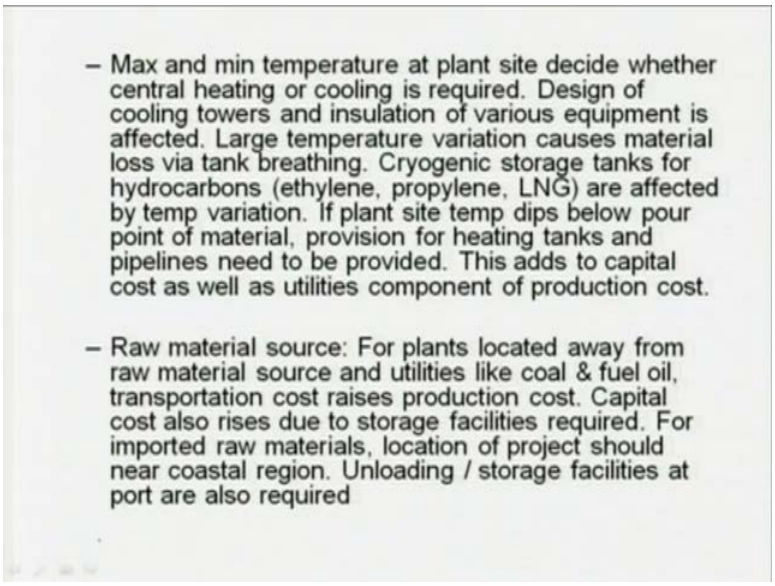

Then, the third one is the temperature, the minimum and maximum temperature at the plant site has a direct impact again on capital and operating cost. Design of cooling tower, air cooler or plant insulation is affected by temperature then the buildings for plant administrative purpose such as the worker amenities or control room may need to be air conditioned depending on the duration of hot period.

So, it is always recommended that, we list down the climatic factors and asses their impact on the plant machinery cost and also on the cost of production. Then the third one

is the raw material source, if the raw material sources are away from the manufacturing site then the inventory of raw material and those required for utilities such as low sulfur, heavy stock or fuel oil or something like that, would be higher.

So, that would add too higher capital cost for the storage tank as well as ware house, working capital requirement will then go up. If the raw materials are imported then we have to have an unloading facility, storage facility at the receiving port and then we have to set up our own facility or rent the facilities, which are already there, that will also increase cost of production. Then, if the raw materials are imported then it is easier if we have a plant site near coastal location, that will reduce the cost of local transport. In some cases, the project owner may be required to have his own specially dedicated fleet of trucks or a real tankers for the supply of raw material, which also adds to the capital and operating cost.

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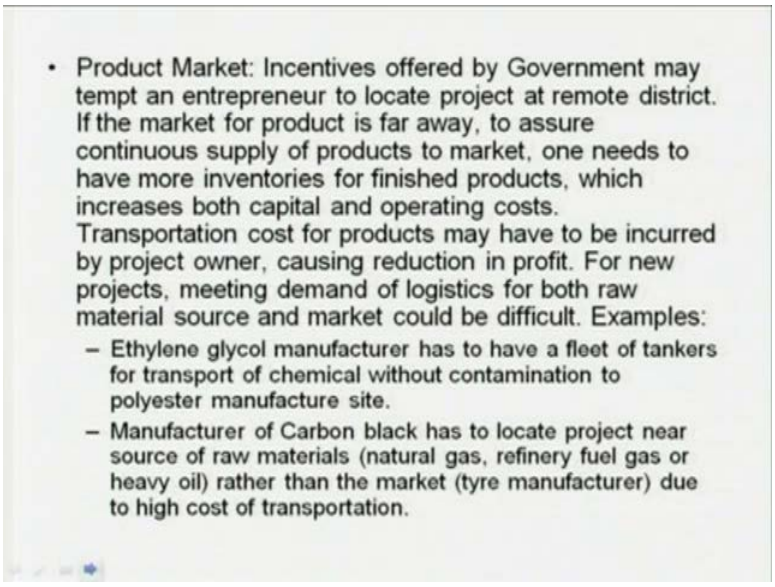

Then, the next thing is the product market, if we have to satisfy the prosperity factor, one may have to locate industry in a notified industrially backward district. In that case, we are going to have special benefits as I said the government offer incentives however, the other side of the coin is that, the raw material supply may be far away or even the market or the product may be faraway. In order to have the sustained supply of products to the market, the project owner will needs to have more inventories of finish products.

This adds to the not only the cost of up site but also, increase the working capital requirement because the manufacturer may have to store the finish goods at his own, at the production site itself. And then if the markets are competitive, if there are say let us say, many producers of the same product then the project owner may have to bear the transportation cost of dispatching the product to market place, this will also take away some of the profit.

So, for some special projects let us say, for ethylene glycol, which is used for polyester fiber, the project owner may have to have his own dedicated fleet of tankers to avoid any contamination, that will add to the cost of his capital investment. Now, another example is that of the carbon black, that is used for manufacture of tires now, depending on, what is the feed stock for the carbon black, it could be LPG, it could be natural gas, it could be refinery fuel gas or heavy oil.

So, depending on what feed stock, the factory is going to use, we have to locate the plant near the site of the feed stock rather than the market site and therefore, the cost of transportation of the finished good to the market increases. In some cases, you may have to have a special gas pipeline or fleet of tankers for fetching the liquid feed stock from refinery to your plant site.

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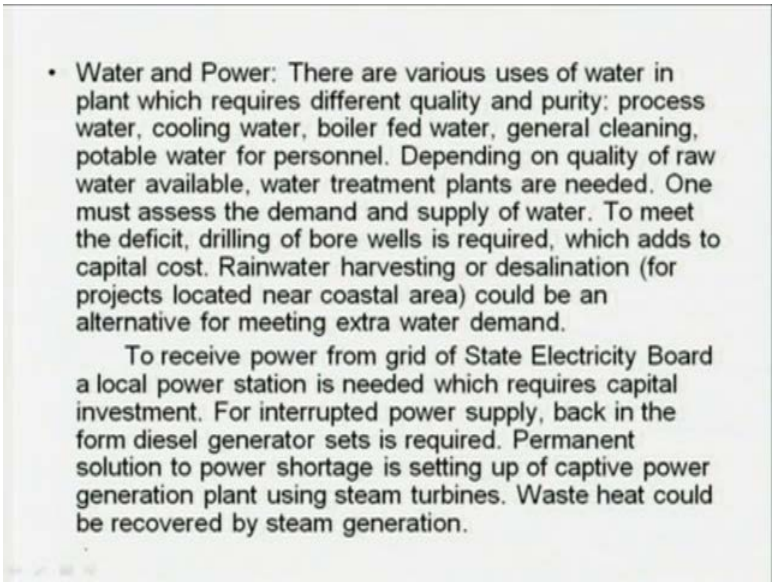

Another two crucial things are water and power, there are various uses of water in plant, that require different quality and purity. Now, water is required as process water, it is

also cooling water, boiler fade water, general cleaning portable water so on and so forth. Depending on the quality of raw water that is available, we have to set up the water treatment plants.

One must assess the demand and supply of water, if the supply of water is lesser than the demand then you may have to go for your own bore wells, we have to drill bore wells at the plant site. Another option is harvesting rainwater or water from melted snow, if the factory is located near hill areas where, snow fall is likely to occur. Now, another option is the desalination of sea water and brackish water but it is capital intensive and it is specially means, it is viable only for mega projects located near coastal areas.

Now, to receive power from state electricity board or the grid of the state electricity board, we have to set up a local power station, that requires capital investment. If you want to have an uninterrupted power supply then we have to have back up of diesel generators or the permanent solution for the power problem is to have your own captive power generation plant using steam turbine.

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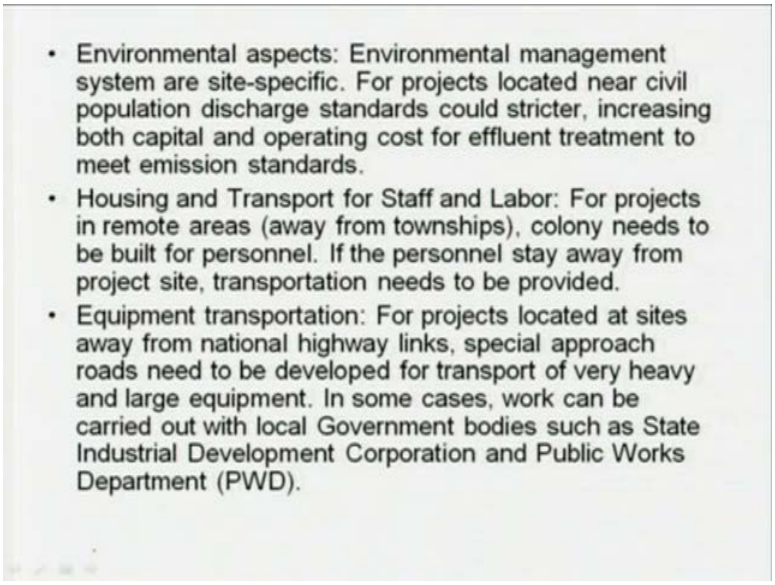

The waste heat in the plant would be utilized for steam generation and running these turbines to generate power, in some cases if excessive power production is there then power can be sold back to the government. Then the environmental aspects, the environmental management systems are site specific, if the project owner decides to go

for ISO 4000 or ISO 2000, the capital as well as the operating expenditure could go up compared to, when only local discharge standards are followed.

There are three discharges gaseous, liquid and solid, and discharge standards are site specific for example, if your liquid effluent is going to be discharged in a river then the standards are more stringent. Then next thing is the housing and transport for staff and labor, if the factory is remotely located then you have to provide special transport for your personal, to bring them to the factory site and then after the working hours you taking them back to their township.

Even in metro cities, the companies are now providing special transport to the staff and labor to avoid delays in arrival time. Then the equipment transportation, if the project is located at site away from national highway links, the project has to build special approach road from national highway links, that will add up to the cost of capital investment, that will add to the capital investment. Especially, if the equipment is very heavy and large then such kinds of approach roads are very much essential. In some cases, work can be carried out with local government bodies such as state industrial development corporation or public works development for building of the local approach roads.

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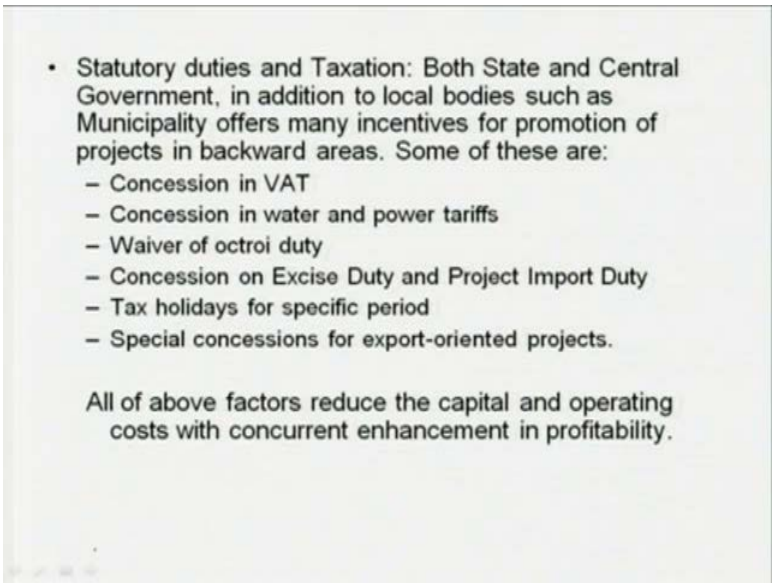

Then, comes the statutory duties and taxation, both state and central government in addition to local bodies such as municipality corporation offer many incentives for

promotion of project in backward areas. Now, some of these I already told you, concession in the VAT, value added tax and concession in water and power tariff, the local body waiver octroi for you.

Then, concession on the excise duty and project import duty then tax holidays for specific period and these concessions are even more pronounced, for export oriented projects. Because, they bring lot of currency, foreign currency to the country now, all of these factors reduce the capital and operating cost with concurrent enhancement of profitability.

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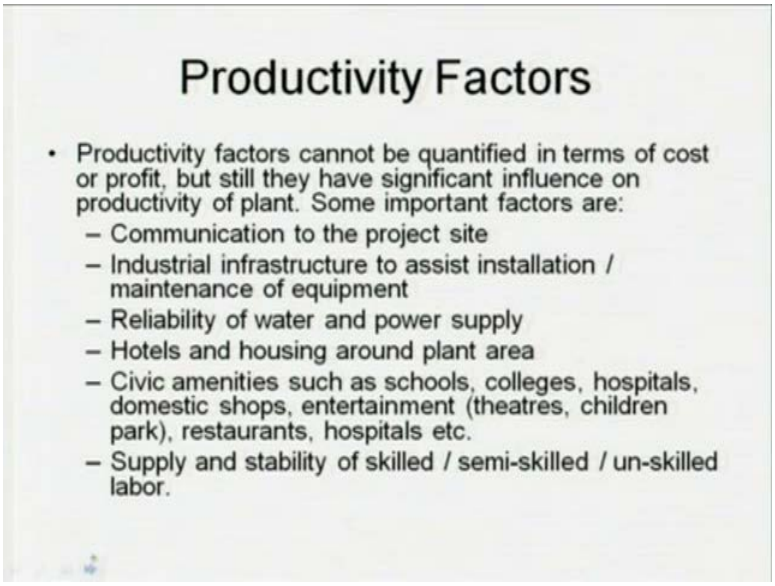

Now, let us see, what are the productivity factors or factors, that are related to the productivity of the project. Now, like profitability parameters, certain productivity parameters cannot be quantified in terms of cost or profit but they still influence the productivity of the plant considerably. Now, since these projects, these factors are important for running of the plant, we have to somehow quantify them and account for their importance in the overall analysis.

The first one is the communication, communication to the project site, communication is the basic need of any business house. It becomes important, if the project site is located away from metro cities keeping in mind with the prosperity factors, that we discussed earlier. Then you have to go for building special approach roads, that I already mentioned but overall communication has an impact, you have to have telephone lines,

you have to have fax lines or internet connections and also road, a rail and air communication to your plant site.

So, communication factor is not only important from during the construction of the project but also it is equally important during the operation of the project. The next is the industrial infrastructure, industrial infrastructure includes availability of welding facilities, cutting facilities, small work shop that have needs cutting machine, drilling machine.

If such a facility is not available in the nearby areas where, you can hire temporarily these personal to meet the demands of or needs of your installation or operation, you have to have your own facilities in the plant that will of course, add to the capital cost investment. Then the reliability of the power and water supply, as I already told that, if the power supply is not uninterrupted, if there are stripper power failures that will affect the plant productivity therefore, you have to have a capital power plant.

Similarly, for water, if the water that is supplied is not available, the water supply is less than the demand then you have to go for alternate arrangements such as drilling of the bore wells at the site. It is also possible to have an effluent treatment plant for water recycle at the expense of higher capital investment and operating cost so water recycle is beneficial in the long run, however at the beginning it will require higher capital investment.

Then, housing and hotels near the plant area to accommodate the building construction team, the special plant visitors then the semi communities. You have to have like school for the kids, for the personal high schools, collages, hospitals, chemist shop, diagnostic centers, transfer facility, some entertainment like cinema theatres, entertainment club, restaurants.

These amenities help remove the work stress or a work stress of the personnel and hectic work load, this the building of such facilities does not come under the state industrial development corporation so you have to go for your own constructions. Then the labor, availability of skilled labor and their stability has become a major issue for industries, that are located in notified backward district.

Bind large people employed as skilled or semiskilled persons in the project constitute about 20 to 25 percent of the work force, during farming or harvesting season these workers get transfers to the farms. So, absenteeism is high so frequent social and village functions also trigger absenteeism, this affects the production so you have to have certain back up.

Then surface transport, surface transport you may consider the real transport then sea transport, easy moment of the raw material catalyst in other chemicals and finish products to and fro from the site is very important. Road link is must as I already said, proximity to national highway makes site accessible, even further grade link, construction of special grade link for large volume or tonnage of material is very helpful. Then finally, the proximity to airport, if the airport is located near your area then; obviously it will help a lot.

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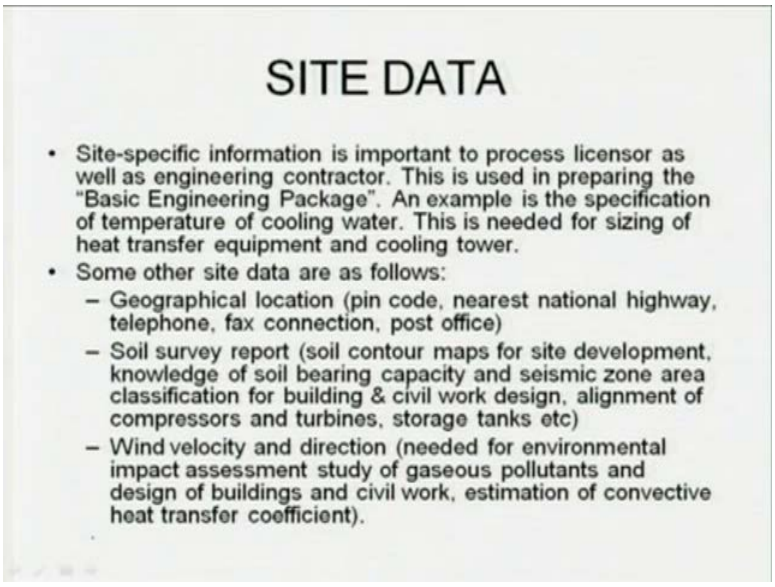

Then, we have to also gather some site data, site specific information is important to process licensor as well as the engineering contractor because this is used for preparation of the basic engineering package. An example is the specification of the temperature of cooling water, this is needed for sizing of the heat transfer equipment and also the cooling tower then unarise temperature, humidity, etcetera.

In addition to this basic climatic data, we need also some additional data that is, the geographical location of the plant, the nearest national highway, telephone, fax

connection, post office then the soil survey report. Soil contour maps for the site development need to be prepared, the knowledge of soil bearing capacity and seismic zone area, classification for building and civil work is very important.

Especially, if your reactors and other plant equipment is very heavy then soil bearing capacity is very important. If the soiling bearing capacity is not high then there could be a sinkage of the land, which could distort the or which could damage the equipment. Then alignment of the compressors and turbines then the location of proper storage tanks, their capacity and again this requires the size survey report.

Storage tanks, the volume will be high, the total weight of the storage tanks so the soil bearing capacity should be high at the site of the or the site, at which you would like to build the storage tanks. Then the next aspect is that of mean velocity and direction, it is needed for environmental impact assessment, study of gaseous pollutant and design of building and civil work then estimation of the convective heat transfer coefficient for naturally cooled equipment.

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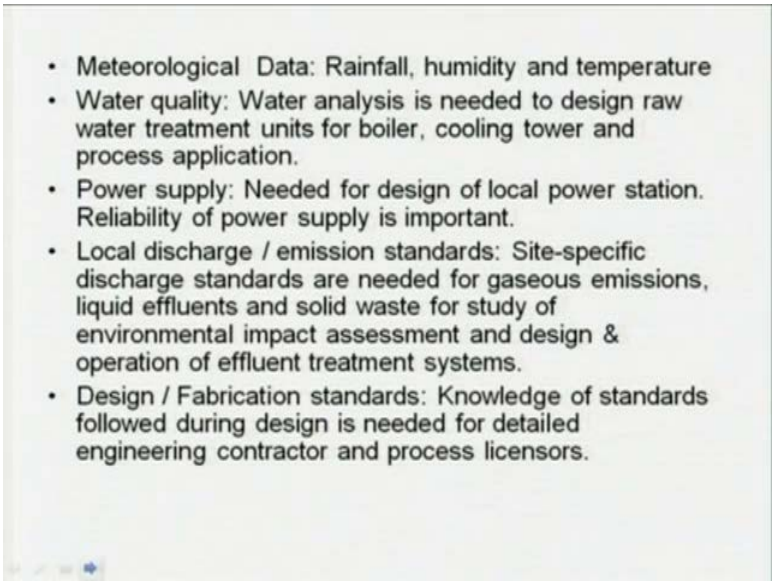

Then, the meteorological data, that already set a rainfall humidity and temperature, the water quality, power supply, load, local discharge and emission standards, site specific standards are needed for the gestures emissions, liquid effluent and solid waste, for the study of environmental impact assessment and design and operation of effluent treatment system. Then, we also need to know the design and fabrication standard, knowledge of

standards followed during the design is needed, for detailed engineering contractor and process licensor.

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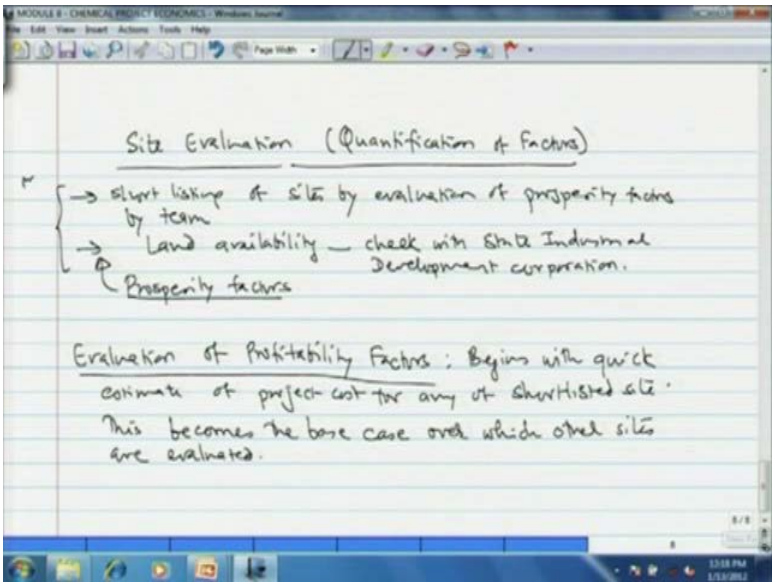

Now, having done this, we have to somehow arrive at a quantitative site evaluation, how do we quantify the factors, that are involved. We have three factors, prosperity factors, profitability factors and productivity factor now the first one, the prosperity factors now, it is always desirable, in order to prosperity factors are all subjective. So, there is little way we can, there is no way we can quantify them in so how do you estimate the prosperity factors.

For that purpose, we have to form a team of two or three senior engineers, having design and construction experience. One of them should be civil engineer, who will asses the civil aspect like site specific and location specific then the second one should be a management graduate and third one has to be a chemical engineer. And together, they can prepare a questionnaire and collect the relevant information on all of the factors, that are related to prosperity, for about the various sites that are under consideration.

They can have dialogues with the local existing industries so from their experience, they can gather information about the site deficiencies then there could be local hostility towards the chemical project. Then therefore, they have to, the team has to interact with the local civic bodies and in this process, they can shortlist some of the sites and then further data for this sites could be assessed. One important aspect is the land availability,

for this you have to check with the state industrial development corporation so this is as per as the prosperity factors are concerned.

Now, let us see the evaluation of profitability factor now, profitability factor evaluation begins with estimation of the project cost for any one of the shortlisted site by the team, after a assessment of the prosperity factors. That point we note, that evaluation of profitability factor begins with quick estimation, we need not go in their detail, quick estimate of project cost for any of the shortlisted site. Now, this becomes the base case over which, we shall evaluate the project cost of other sites.

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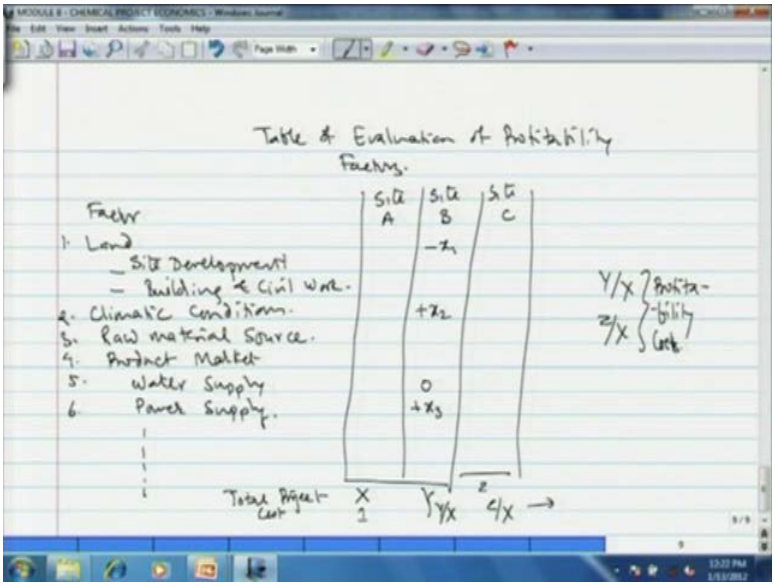

So, what we do essentially is prepare a table, we list the profitability factor and the project site. The first factor is land then in the land comes site development then building and civil works then the climatic condition then the raw material source then the product market then water supply, power supply so on and so forth. And then we list different sites, the base case sites, site A and then we list only the differential cost for any of these factor for other sites for example, site B has already a well establish land where, we do not have to go for any demolition or fill or something.

So, here, it could be a negative factor, minus x or minus x1 then in case of air conditioning, if the plant site is located at very humid and hot area then we have to go for consideration air conditioning. So, cost of air conditioning increases so that is plus x 2 then if it has sufficient water supply then it could be 0. If it has less power supply then

the demand then you have to set up plant, so in this way, you list only the differential cost for this different sites, as related to the base site. If the total cost for site A, the total project cost for site A is X, if site B is Y, site C is C then we have to take a ratio, that this coefficient, profitability coefficient will be Y by C. Here, coefficient is 1 and then C coefficient will be, for site C if the total cost is Z then it will be Z by sorry Y by X, not Y by C, Y by X, Z by X so that is the profitability coefficient.

The profitability factors affecting the operating cost and cost of production are listed, their contribution is tabulated and there, we have to go for, the total effect of profitability factory is the sum of the above operating cost and annulus cost authorizing out of capital expenditure. And then we go for calculating the expenditure coefficient, as I just mentioned that, you go for, you just divide the each total project cost at different sites, taking base case as 1 and evaluate the profitability coefficient so like Y by X, Z by X are all the profitability coefficient.

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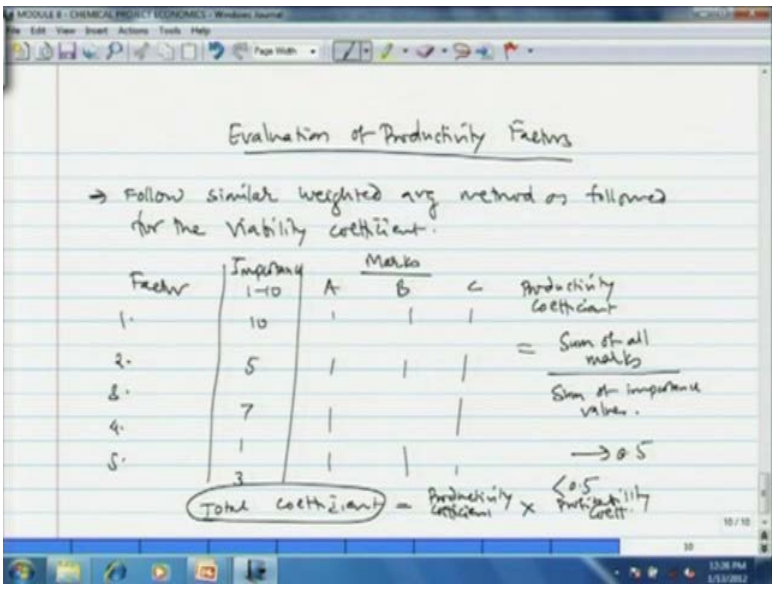

Then, we have the productivity coefficient, productivity factors now here, we follow a similar methodology, as we did for selection of the process. The process viability coefficient and profitability coefficient that depend on, follow similar weighted average method, as followed for the viability coefficient. So, you list all the factors, that come under the profitability factor criteria and then you assign them, importance on a scale of

1 to 10, 10 is highest importance then 1 indicating least importance and then you give marks for each of the site site A, site B, site C.

And then the productivity coefficient will be the sum of all marks divided by sum of the importance values, in it may so happen that, all three coefficient or the productivity coefficient, prosperity or the two coefficient, not three the productivity coefficient and the profitability coefficient may not be high for the same site. How do we choose between them, we make up our mind that, any site that is having productivity coefficient less than 0.5, may not be acceptable this in turn, mainly depends on the policy of state government and project implementation time.

How do we go, like we may select a minimum coefficient for each of these factors, productivity each of these coefficient like, we discard the processes which have productivity coefficient less than 5, we discard the processes which have profitability coefficient less than 0.5. And then we have to choose the one, that is the best further, the total coefficient or effective coefficient could be taken as a product of productivity coefficient and profitability coefficient.

And then we choose the one, which has the highest total coefficient value, numerical value so this is how, we have seen today that, we can evaluate different sites for a particular project. The success of the project is highly site specific and therefore, the selection of the site is a very important activity for the implementation of the project. Having dealt with the criteria for process or technology selection as well as site selection, in the next lecture, we shall deal with the estimation of the project cost.