Energy Resources and Technology
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Lecture - 4
Energy in Transportation

So, in the last class, I gave you an assignment, whose main purpose was not to get marks. The main purpose was to make you understand the effect of each parameter. If you vary each parameter, what is the effect on the graph and to my surprise, I noticed that practically none of you have really done it correctly. What was the purpose? I gave you one nominal set of values, for which you can draw a graph and then change one, get another graph and then draw a conclusion. If I vary this, this is how my graph changes. Then vary another. Some of you have drawn on different graph papers. Naturally, you get no conclusion, other than satisfying the fact that you have submitted an assignment; for that you get nothing. I want the concept to come out of it. So, what is the effect of the parameter B and what is the parameter, what is effect of parameter A and what is the effect of parameter t naught? In order to understand that whatever you need to do, do. So, that was expected; I expected a level of understanding and I am somewhat discerned.

So, I leave this assignment again. You have to come and submit it tomorrow. I know you have got it, but I have asked the people who came in proper time and the result I got is what I just told. It is possible that you have done it correctly; it is possible, in which case you simply bring it tomorrow and come in time.

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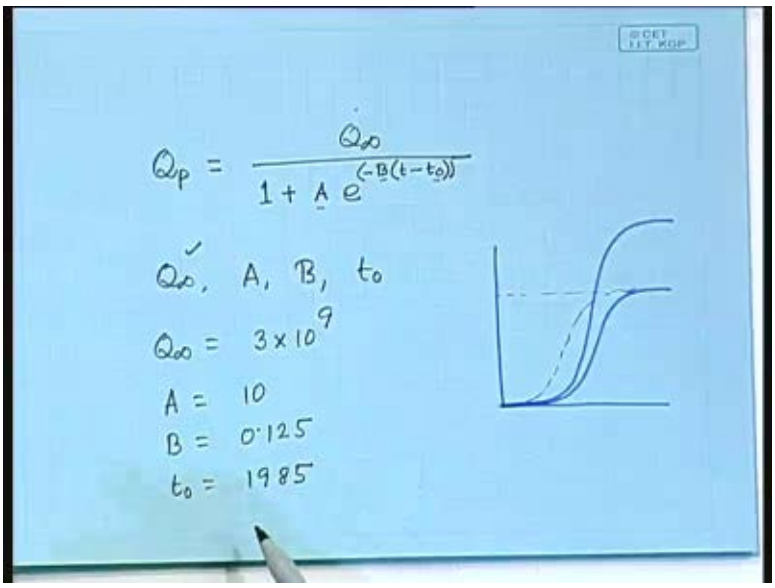

So, you have this equation through which the graphs are to be understood and again in order to understand the, in order to really be able to use this theory, in order to predict the future of oil resources, you need to understand the effect of each of these parameters. The effect of this parameter is obvious. What is the effect of that parameter? It is essentially to …., so that will be the effect of the Q naught parameter. So, I am asking about the other things. Suppose the Q naught is fixed, Q infinity is fixed, in that case, how will you make the difference between say, the Q D and Q P? Q D is the discovery and you know that that is like this. So, it goes to the left hand side of Q P.

So, if I give you the graph for Q P, what changes would you anticipate in these values, in these values, in order to get the value of Q D, right. Simple questions, right and I was expecting that you would come with some understanding of that based on the graph that you draw. From now onwards, whenever I give an assignment, I will expect an understanding to emerge out of it; not just I have submitted graph, sir. So, what do we do today? I was expecting to do on the basis of what you bring.

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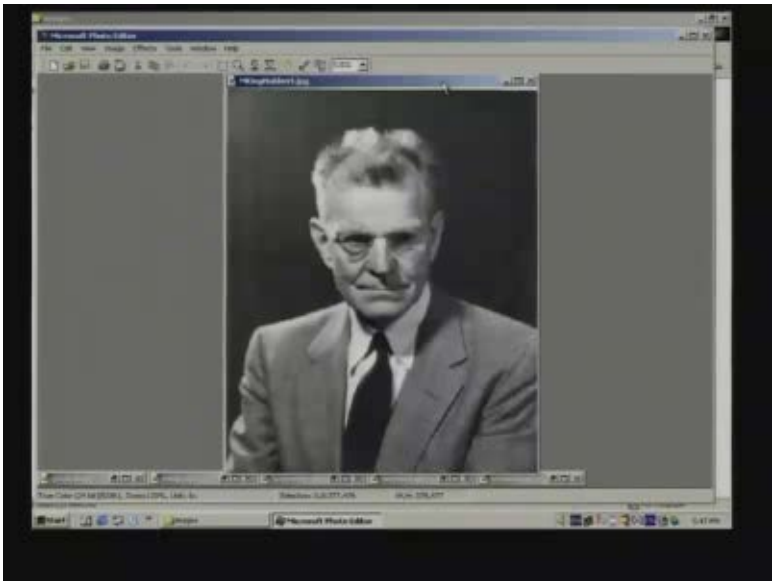

In any case, you have on the screen the image of the man who gave this theory, M. King Hubert and what the data that I gave yesterday, in the last day, actually related to the data of India and that is obviously a countries data and the oil that we use really is not really the countries production; a major part of it is import and therefore, we all depend on the worlds resources, worlds production, worlds discoveries and in that the graphs would be very important and here is the data for the worlds production.

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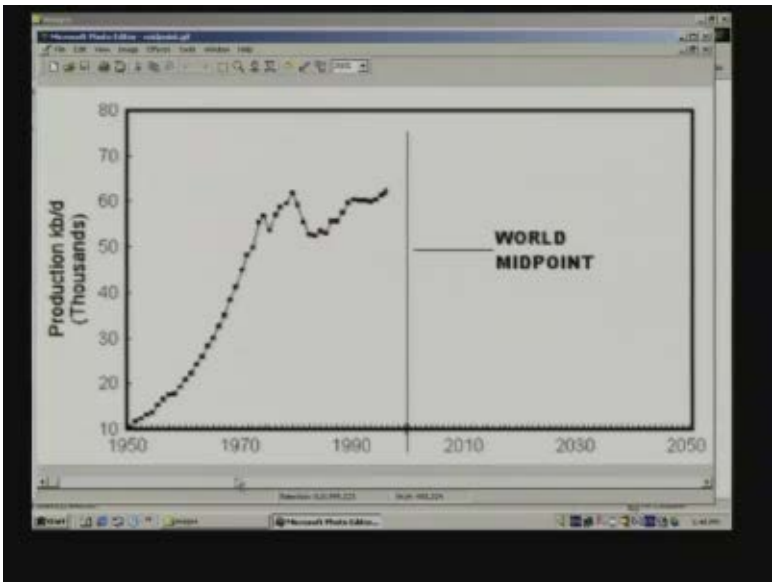

Notice the unit, it is kilo barrel per day; it is kilo barrel per day. Sometimes, in some other graphs, you will find that the units are Giga barrels per year. So, you might have to change the scale, in order to get from this scale to that. At the end of today's class, I will display this particular graph for quite some time, so that you can note down these data points. Then, on the basis of these data points which extend up to say, 1996 or so and the value of Q infinity that I will supply, which is about 1750, between 1750 and 2000 Giga barrels all over the world, the standard oil resource, what is standard, what is nonstandard, I will come to it a little later, so that is the value of Q infinity.

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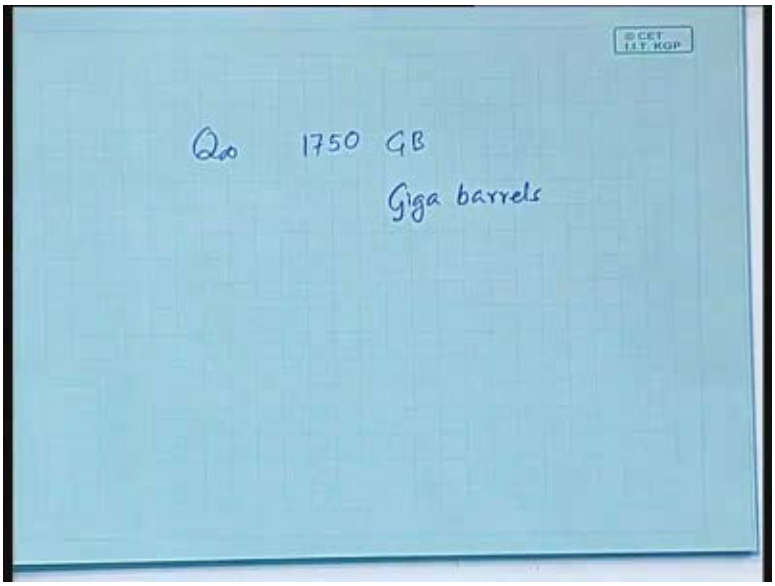

So, you assume the value of Q infinity as 1750 Giga barrels. This is 1750 Giga barrels that is Q infinity.

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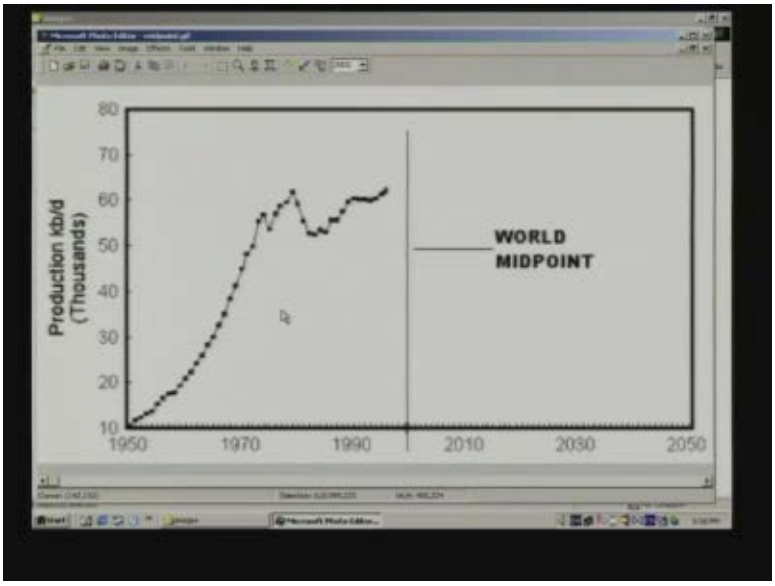

But, from the graph you will need to estimate the values, the other values of A, B and t naught. I can tell you, you cannot do that unless you understand the effect of each one. That is exactly why this assignment was given and you notice, can you see the pointer? Yes; you would notice that initially it started from 19, before 1950, yes there was use, but it increased in leaps and bounds after 1950's; that's why the graph normally starts from 1950 and it sort of rises exponentially for some time and around 1971, there is something happening due to which there is a waviness.

What happened? In 1971, there was a sudden price increase of oil and that was the sort of onset of the indication of the impending crisis due to which the use, the production went down; because, if the price goes up, the use goes down and naturally the production goes down. So, production went down and finally that was going up and down, up and down and finally that is the kind of graph that we have. So, this is the data that we have. For what? This is the data for what? dQ P dt, production rate; that is the data for the dQ P dt. This is the production rate, remember. So, when you note down these data points from there, you will have to obtain the data for the cumulative production, because that is where the graph is substituted.

The dQ P dt may have a lot of variations, but you will find that when you sum them up to get the cumulative values, it will give a reasonably smooth graph, which will be easier to fit data into. So, this is the dQ P dt graph and the unit given here is kilo barrel per day. Now, what you do? From here, first you obtain the cumulative data Q P. This is not the graph of Q D, though; you get Q P and from there, you have to estimate the value depending on the given value of the Q infinity, clear. That will be the assignment for the end of this week and this assignment you will have to submit on the next, the first day of the next week, clear and on the basis of that estimate, on the basis of that estimate, you will have to predict, number 1 - the year in which it peaks, the production peaks that means dQ P dt peaks; 2 - the year in which 75% of the oil resources of the world will be exhausted. So, these two, you know, important years, you will have to predict on the basis of the graph that you obtain, clear. That will be the assignment, but it will be instructive to have this work as has been done by others also, so that when we actually do the estimation, you are not doing it blindly. Others have also done this job and so, let me illustrate some of these. This graph, do not have to write down right now; I will display it for some time at the end of the day. No, I will illustrate this one first.

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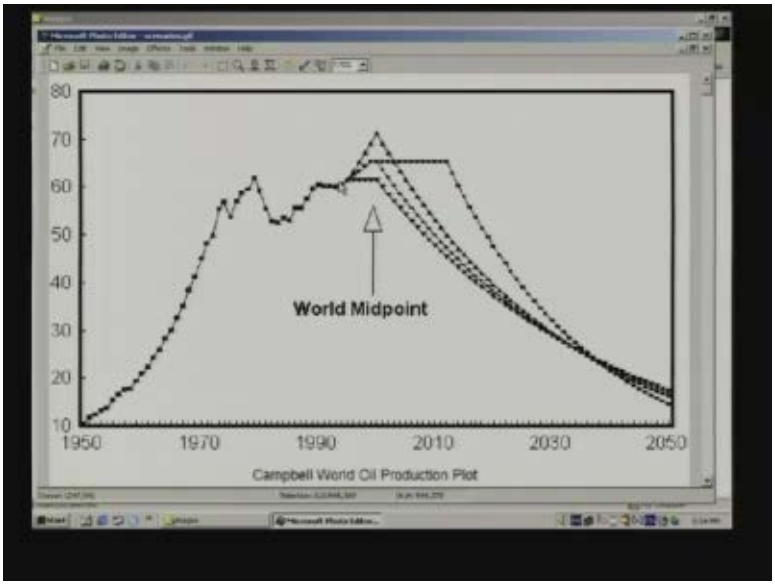

So, that curve goes up to this point. Now, after this, after you obtain the graph for the cumulative production that is smooth and rough, you can again obtain the dQ P dt over the whole cycle, right. Now, there, there can be a few different scenarios. Scenario number 1 - if the price continues to be, price of oil continues to be as it is now, say the world midpoint is say to be, in 1999, it will be somewhere here. So, here is the world midpoint. So, at that point if it remains there, the price remains there, what will happen? That is one kind of scenario and since presently the price is governed on the basis of the market forces, but it is possible to visualize the situation, where the prices are kept by some kind of an artificial mechanism, then the use will go up. As the use goes up, as more and more people buy the oil, the withdrawal of the oil from the resource, finite resource, also goes up. As a result, we have got this curve.

Can this curve continue forever? Obviously not, because the resources are finite. After sometime, a peak will be reached and you have to go down like this. If say, you have some increase of the price of the oil, then suppose, another scenario is supposing it goes up to this point to the midpoint and then, it goes down and third possibility is where you have the production, the price increase is so high, so that the production sort of reaches a plateau for some time. Here is another possible scenario that the production rate reaches a plateau for some time and then that plateau can also not be continuous forever and therefore, it drops. So, here what has been done is that for these possible, four possible scenarios the future has been predicted and you can see that the futures are not very different. Can you see that?

The futures are not very different, something that you can also do. This kind of scenario prediction you can also do based on the graphs; not very different, in the sense that you will see after what time 75% would be depleted would be somewhere here. You see, the difference is not really very large. The scenario where it was sort of forced into a plateau that means the world countries that produce oil, sort of scenario, imaginary scenario where they took a decision not to increase even if the demand increases and that will result in the increase in the price.

Whatever it is, because of that decision, it went up to that; it will result in some more availability of the fuel for some more time, alright, but not much though. So, you can see, by the year 19, 2030, not very far off, you will be in the middle of your carriers then, it is now very close to exhaustion; does not mean that there is no oil there. It is there, but then withdrawal of that oil will be very expensive firstly. Secondly, in the market oil would be so expensive that you cannot think of running cars with it, so you have to, you have to go into a different scenario, different technology.

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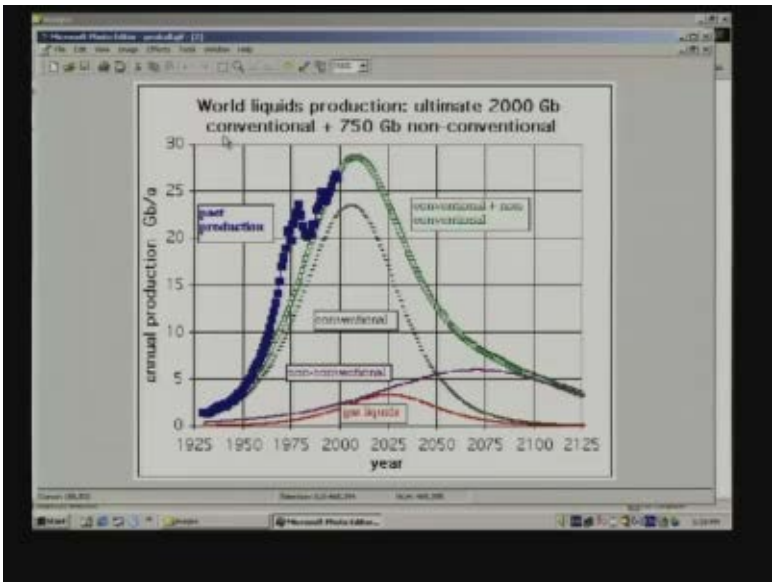

Now, let us look at this one. Here two words come in - conventional and non-conventional. What do they mean? Presently what is being done, you have the oil resource as petroleum which is a withdrawn and which is then divided into various fractional distillation products – LPG, petrol, diesel, you know, aviation fuel and stuff like that. All of these come under the category of the conventional, means they are product of, directly the product of petroleum. Now, what is non-conventional? Non-conventional are not the, here the non-conventional word that does not mean the non-conventional sources of energy; it means the non-conventional sources of oil products.

What are the non-conventional sources? For example, we have a vast resource of natural gas; many countries have, including in India. The technologies are now maturing by which the natural gas, which is methane, can be used to produce some of those liquid materials that can be used. That is one possible way of increasing the total availability. Second is, there are some relatively solid like things, like something that is called shell oil. That means these are solid like things, shell, oil shell, which again you can heat up. As you heat up, all those fractional distillation products come off. So, the shell oil can also be used as one of the alternatives of petroleum. So, all these put together are the non-conventional sources of petroleum products.

It is estimated that the ultimately recoverable resource of natural petroleum would be between 1750 to 2000 Giga barrels. Here the scenario has been drawn with 2000 Giga barrels in mind and 750 Giga barrel would be the non-conventional resources. Presently, the non-conventional resources are not used much, because it is cheaper to have, use petroleum, but this scenario is going to change, of course. So, you have the production rate of the non-conventional, you know, the black one, it goes like this; it is increasing of course, but it is likely to increase much by the year 2075. The gas liquid is likely to peak like 2025. So, these things, that are not being used much right now, will be used in greater proportions later, but right now what is being used is this.

So, this is the production dQ P dt curve for the natural petroleum and if you put all these together, you have got the total curve and that is, that has been more or less made to fit into the actual production data. The black ones are the actual production data and the square box, the graph made of square boxes, is the graph for dQ P dt for conventional plus non-conventional. Now, if you have 1750, the peak occurs in 1999. If you have 2000 Giga barrels, the peak occurs sometime later, a little later around this time, 2006 - 2007 like so and after that it is going go down. Most important and noticeable fact is that if you draw this graph, the graph is something like this, right.

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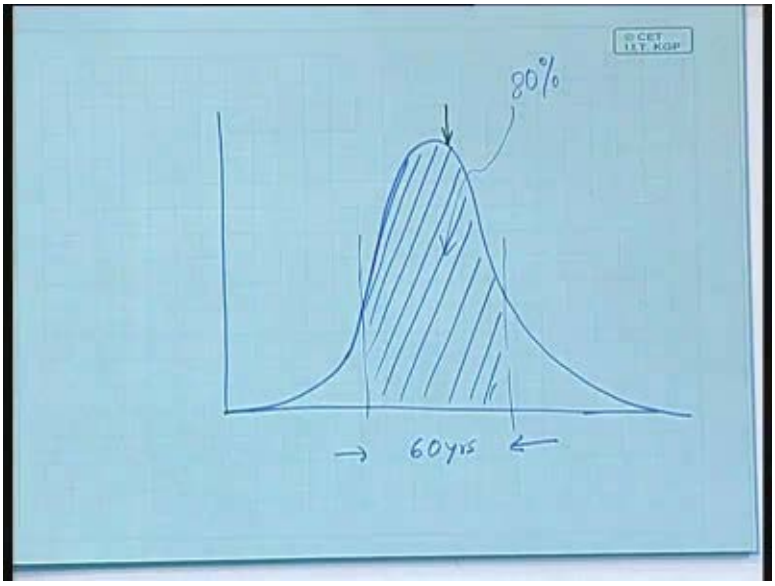

The major part of the utilization happened during a period like this. How big is this period? How big is this period? You would notice that this is only a small part. This is again only a small part. This is where the use did not pick up and this is where you cannot use it much, because of the high price. So, in between you have got a period in which the major share of the resource was exhausted and this period is only about 60 years and the area is like 80%. So, imagine the situation. This resource was accumulated over millions of years as concentrated sunlight. Sunlight concentrated over millions of years and made available to us as negentropy stocks and all that millions of years of accumulated solar energy we are exhausting; 80% of that we are exhausting in a period of only 60 years. Not even a blink in terms geological time, so that is the effect of the use of the fossil fuels by man.

It is a very significant thing and since we are somewhere here now, this means that the availability of resources will inevitably go down and if you look at this curve we would be somewhere here. So, it is going down and the inevitable effects of this down fall of the production of the petroleum, is the price rise. As the price rises, the lifestyle so far we could afford to have, like the cars, in most western countries you have got more than a car per family, this kind of lifestyle obviously cannot be afforded any further. So, one of the

confluence of this course would be, what would be the possible options, possible technologies and how would you go about it? This one I have shown already, fine. So, what are the possible options now? Where is petroleum used in the main? Petroleum products, where do you think they are used? In the main, in transportation; in the main, in transportation. By the way, one thing I did not talk about - the other fossil fuels.

Other fossil fuels mean natural gas is a fossil fuel, coal is a fossil fuel. You can have similar studies on natural gas and coal, but unfortunately such studies have not yet been done worldwide, but it is estimated that this point, midpoint for oil as it happened like, like the year 2000, for coal it will happen much later like 2075 or so. So, the coal resources are expected to last another say, 100 or 150 years. So, you have a greater timeframe when you can have relative abundance of coal. Similarly, with natural gas, natural gas has not yet been used in a large scale in the use of energy, but then its resources are also larger than the resources of petroleum, so that will be also lasting for a larger timeframe than the petroleum. So, gas and coal are something that we can rely on for a longer period of time. How long? Those quantitative estimates have not been scientifically done yet and that is why I cannot exactly pinpoint the values, clear.

So, so far, we have talked about the scientific way of estimating the availability of these finite resources for future consumption, but now that we are convinced that we are really facing a crisis, then how should we go about facing it?

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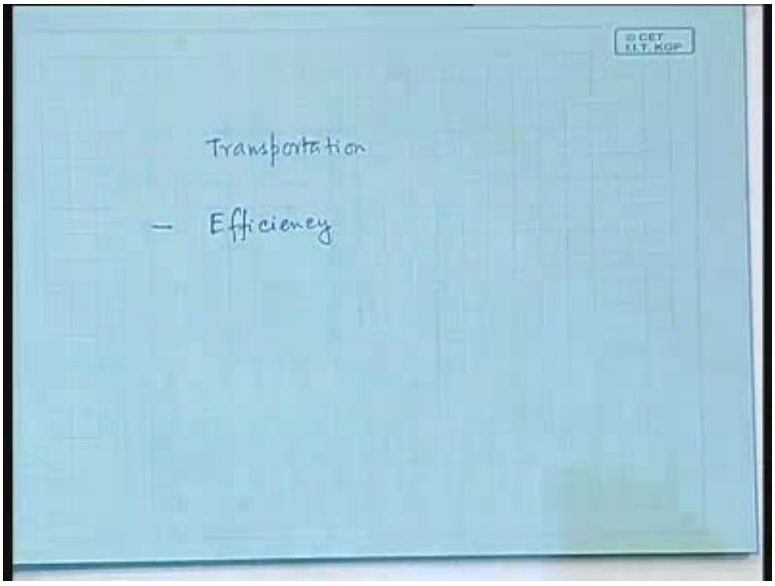

As you told, you told that the major place where petroleum products are used is transportation and so, we need to think of, any energy engineer needs to think of what are the ways of having alternative ways of transportation. There are two ways looking at it. First, what is the, what is the possible way of improving the efficiency of the transportation, so that less amount of fossil fuels are used, less petrol, less diesel is used and second way is to replace the fossil fuel based fuels to something else. So, let us consider the first option. First option was efficiency. Can you tell me what is the most efficient of way of transport? What is the most efficient? Well, you have heard of cars, buses, trucks, trains, bicycle, yes, of course; of course, bicycle is a most, but you cannot think of going from Calcutta to Delhi on bicycle.

So, your point is correct that for short range transport, therefore we need to go from fuel based transport to muscle power based transport like bicycles and that is one of the changes that are happening. The city, city transport, practically you see no bicycles in Calcutta or Delhi, right, practically none; in Bombay, none. But nowadays, the shift is towards more use of bicycles in the sense that the scenario is like this. When people come for doing the work from the suburbs to the city, they will come in trains, but will carry their bicycles. So, when they come down, they will then ride their bicycles to their work

place and that is why in most of the western countries you have the bicycle, separate bicycle lanes, right, which are not yet there in most of the Indian cities. But, this is one of the directions in which the world is going more and more use of bicycles. For example, in Berlin, it is permitted to go with a bicycle into any kind of transport; like in France, in trains, in subway, you can go with bicycles and then get down, go off. But, there we are not really talking about efficiency.

There we are talking about substitution, substitution of something that you could do with a motor cycle or scooter or a car, you are substituting that with a bicycle. So, it is substitution. But, my question was what is the most efficient mode of transport? Car, train, buses, streamers, aeroplanes; Trains? No; he is right, water transport. Water transport is the most fuel efficient mode of transport, because the friction is least. So, water transport is the most fuel efficient mode of transport. Earlier, we had a lot of water transport. In fact, the goods transport, before the advent of railways or the or the trucks and highways, used to be through the waterways. Things use to come from Delhi or Banarus to Calcutta through the waterways …. on the river, but no longer.

Now, if you have, if you want to carry a great bulk of material from say Banarus to Calcutta, what do you normally do? Simply, put it in a truck and it goes …., right. It is a say, highway, so that is a very bad way of transporting. So, now we have to move again towards more and more water based transport and that is one change that is happening in many of the European countries. They have system of canals mainly for irrigation purpose, but these system of canals are also used for transportation. The canals are not very wide though like half of this room, half of this room that wide, but on that you will find big budges going from one end of the country to other. Even I have seen the places where it is a hilly terrain it is difficult to have such canals or canals of the same, water after all goes by the same level, right.

So, if it is a hilly terrain, what do you do? There are places where there is a canal in one level, there is another canal in another level. So, how do you have transport then? Yeah, so there are systems, where there is a, there is a whole system of lifting the whole budge

from one level to the other and releasing it the other side or the other way round. Now, whatever it is, these technologies exists; these technologies exist and one way to counter this impending oil crisis would be to go more and more for water based transport, at least for goods transport. What is second in line? What is second most efficient way of transport?

Surface transport; let us, let us talk about surface transport. You have got the buses, you have got the cars, you have got the motorcycles and you have got the trains. Why? Why? Suppose you do not talk about electricity or the fuel that you are using in terms of basic efficiency of the transport mode. In this term, all of you I suppose ride bicycles, right. When the tyres do not have much air, you have to push hard, right and if you pump it hard, then you have pump place. What does it mean? The amount of energy that you have to spend depends on what? Technically, no, depends on the area of contact. The harder you pump, the less the area of contact. The less the air the more the area of contact; it is sort of pressing against the tyre. So, then in that situation, you will have a larger requirement of the power. If it is hard, you will have less requirement of the power; you experience that, right, day in and day out.

Now, the hardest possible tyre is iron tyre. The things that you have in trains, where the contact point is just a point really and therefore, in that sense, in the sense of how much power you need in order pull it, that is the most efficient; that is the most efficient.

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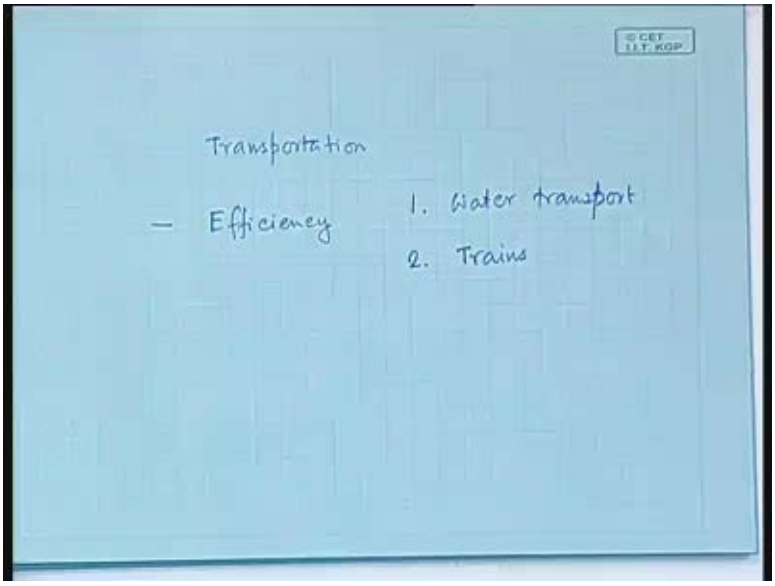

That is why the first one is water transport and second one is trains. You would notice that during the time when oil was cheap, most of the western countries, especially Americans moved away from the train based transport to road based transport. The reason yes at that time people looked at only a personal comfort and it is far more comfortable to drive your own car one place to the other, rather than going by trains, but then when the oil resources are depleting, obviously we have to go for the most efficient way of transport, surface transport, which is train.

Unfortunately, it is at this time that our nations planners are going for a major shift from train based transport to road based transport. Everywhere highways are coming up, everywhere the goods transport is going, shifting from trains to trucks and lorries; more and more you will find long distance buses rather than trains. So, it is shifting. From an energy engineer point of view is that desirable? No, obviously not. If you have to have major people transport from one city to the other, you have to have, you should have a larger number of trains to do that. In contrast what is happening is that a move away from trains to surface transport, which is as energy engineers, you should understand that is that is you know, I would say, suicidal, because after sometime you will have no fuel to run the whole city.

India has a major advantage that historically India has a very strong network of railways. Historically it has built up a very strong network of railways. That network should actually be expanded, should actually be fully utilized, but because of this pressure from the car manufacturers, from the bus manufacturers, from the people who build roads, from this pressure, things are being, things are moving away from it. The other thing is that in the western countries, wherever trains are there, in Europe for example, trains are there and the network is reasonably good, but very expensive. It is in most places more expensive than air transport. Why, because the trains have moved from being, you know, large scale people carriers to sort of luxury transport. As a result, you will find all amenities in the trains, wonderful trains, but wonderfully expensive.

So, obviously that is not the, that is not the scenario that we should aim at. Here, we should really aim at a cheap efficient train based transport. Now, in trains, obviously you have the option of moving from oil to a different resource. I will come to that; that shifting from one resource to another, I will come to that.

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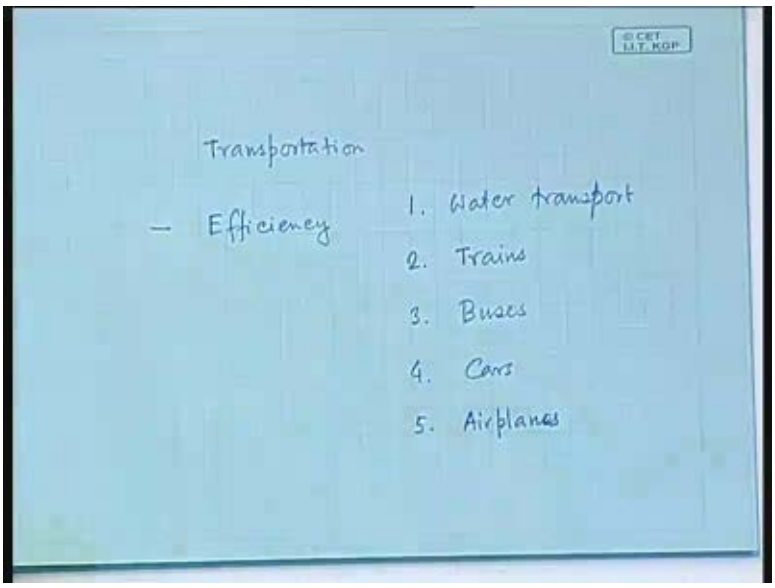

Now, let us come to the third most efficient way. What is third? Obviously, we are talking about surface transport and surface transport means buses and cars. Out of these,

obviously if you have a large number of people to be transported and transporting them by 1 bus is more efficient than transporting them by 10 cars, right. So, buses means public transport, cars are private transport. So, we should actually move more towards strong public transport system rather than private transport system. Now, you would notice that this is exactly opposite to what has happened in all western countries. Practically public transport does not exist; except for the big cities, in United States public transport does not exist. If you do not have a car you are simply stranded, you walk. It is just like that.

As a result, because of this pressure from the car manufacturers, probably this situation has happened. As a result, the whole society there is terribly expensive in terms of the oil consumption; huge amount of oil is consumed. Each American consumes his own body weight in terms of oil, probably every month or so. So, it is a huge consumption of oil. If you have to really cope with the future, of less availability of oil, then the other point is that you have to go into a stronger, much stronger public transport system and lastly you have the cars. For a very long distance transport, obviously aeroplanes are the most possible options, but they are less fuel efficient, because they require a different type of fuel which is more expensive, right. So, we are considering these.

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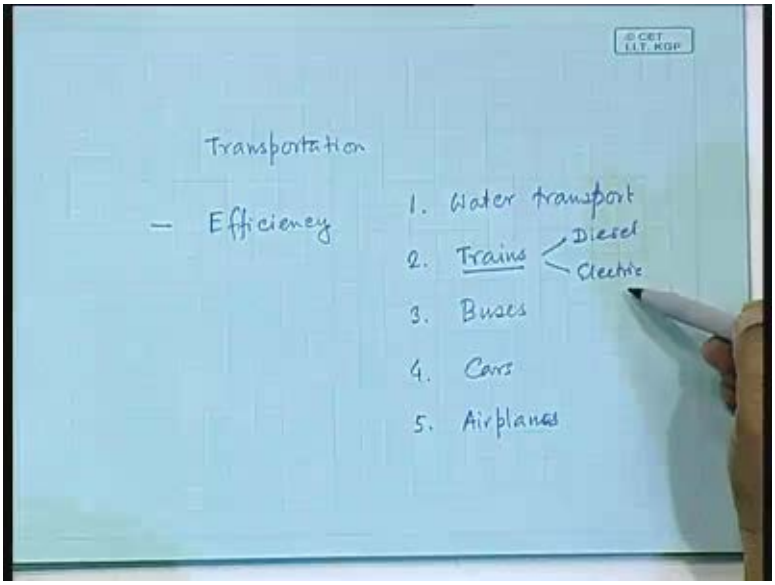

In trains, earlier the transport was by coal based trains which has more or less been phased out. Though these days we still hear talks about bringing them back, but I do not think that is feasible. So, trains are more or less running by two possible things - either diesel or electric and it would obviously be more desirable to move from diesel to electric. Now, if you are using electric, notice that electricity is not a primary resource of energy, it is a secondary resource. Primarily what creates electricity? What is used to create electricity? Coal or hydroelectric water; hydroelectric source is the renewable source, so you get it almost free, but otherwise coal. So, if you are using electricity, you are essentially using coal. As I have said, coal is a longer lasting non-renewable resource and therefore, we are better off to use electricity.

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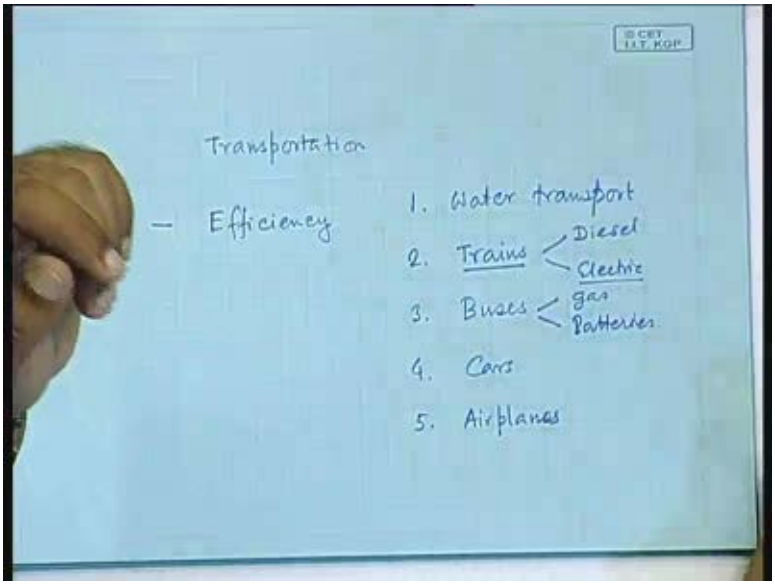

Buses - what do they run by? Diesel; what is that and that is exactly why you see the meteoric rise of the bus fares over the last 10 years. What was the bus fare in Calcutta 10 years back, do you remember? Now, it is 4 rupees, the minimum; 10 years back it was 1.50. So, you can easily see how fast the rise has been and it is going to, going to rise in further. Is there any option? Yes, buses can be run by CNG, CNG means compressed natural gas. That means you use the more larger, longer lasting resource, natural gas, which is available in our country mainly in Bombay high. It is off shore rig of the

Bombay coast and that is mainly where gases are available. That is why the pipelines have been laid, in order to transport this gas from the western region through to North to Delhi and that is why all these regions now can have gas based transport and in Delhi, it has been a rule that all buses, all auto rickshaws, all taxies, must be CNG based.

So, ever since that there has been a drastic decline of the pollution in the city of Delhi and also the fares have gone down, because it is cheaper. So, we can have the gas based transport. Can you have electricity based buses? Batteries; yes, battery based transport runs in some areas of Delhi like the old Delhi. The, what is the place called? Anyway, the old Delhi area, there are buses that run by batteries. In Bhopal, in some other cities, you have the buses run by batteries. But, there are problems. It is a viable technology. BHEL is already making those buses; Bharat Heavy Electricals Limited is already making those buses, proven technology; but it has to be charged, but that is one possibility – batteries.

Trams are also ordinary buses in city transport and we had trams in Calcutta which are now, we are hearing every day that it will phased out. The trams are completely pollution free, completely electricity based and therefore, energetically the best way of transport and moreover the contact point is again zero and therefore efficient. But, unfortunately they are slow moving, the way they have been made they are slow moving and that is why there are people who think that they should be phased out. Let me tell you that in most of the western countries trams are being brought back in. Now, in most western street cities, trams are coming back, while in some of the Indian cities trams are being phased out. You know, what west thinks today, India thinks 50 years later. So, so probably 50 years later Indians will realize what mistake they are doing.

But then, there are also possible to have bus transport by means of electricity without batteries, like have you heard of trolley buses, trolley buses? In the trams, you have the overhead wires through which you make a contact and the return path is to the rails. So, the current comes, goes through, runs the motor and then goes back. The return path is through the rail, because that is metal.

If you have buses, you cannot have that, because then you have rubber tyres. If you have rubber tyres, they are now conducting, you cannot have that. So, you have two wires going and then you can make contact and the advantage is that you can have large swiveling contacts, so that you can maneuver which is not possible in trams, because they run on fixed tracks. So, in many of the western countries now, you have the trolley buses. For example San Francisco has it, has been having it for quite long time as a major mode of transport in their city. So, buses running by electricity is another major option for India, so trolley buses.

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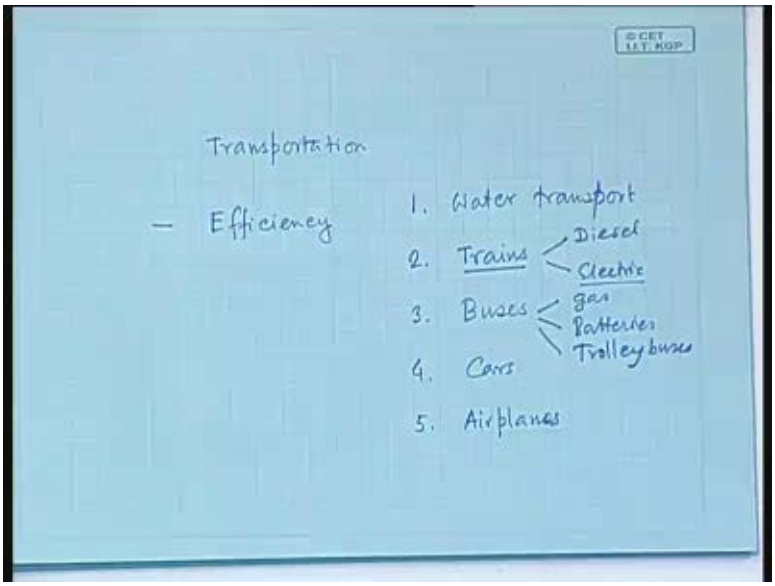

Cars nowadays, earlier you had only petrol cars and diesel cars. Nowadays there is the move towards electric based cars and most important will be what are known as hybrid cars. Hybrid means, I will come to that a little later, because you need to note down the results; you need to note down the values, so I will leave that. So, I will come to the issue of cars and other transport modes of transport may be a little later. So, let us look at, not this.

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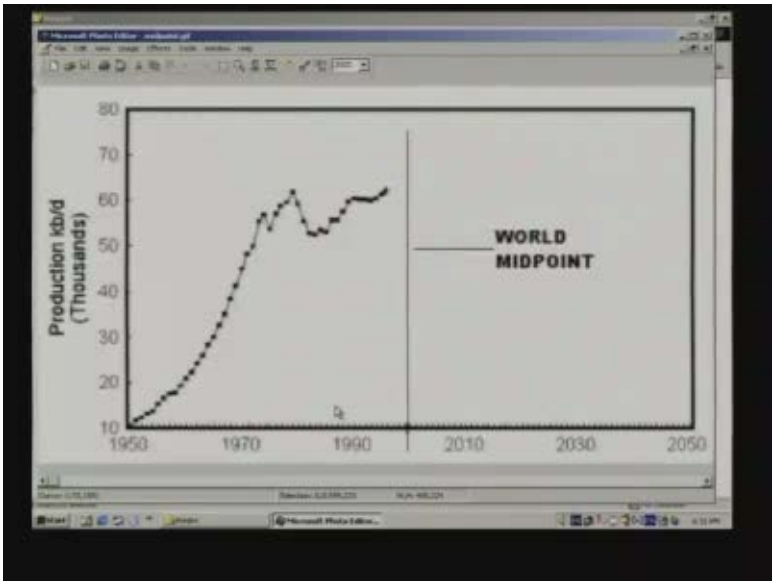

Yeah, this I will keep displayed for some time. You note down the values and use those values in order to predict the graph. Again remember, you will need to have a coordinate unit transformation, because this is in kilo barrel per day. You will have to convert it into Giga barrels per year and plot it.

Student: Can you not give it on paper, sir? That will be more …… we will Xerox and then give.

Do one thing; I can give you the file itself.

Student: Can you upload it?

Yes, I can do that.

Student: Can you upload it in your website? ……

I will upload it into my website. You download it from there. So, you note down my website address; better still, these graphs are obtained from this website.

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This website actually keeps track of this data. So, I downloaded from there. You can also download it from there. It is not necessary to use my website, clear, so you can do that and you can go ahead. So, we have some time to talk about the cars; 5 minutes ….

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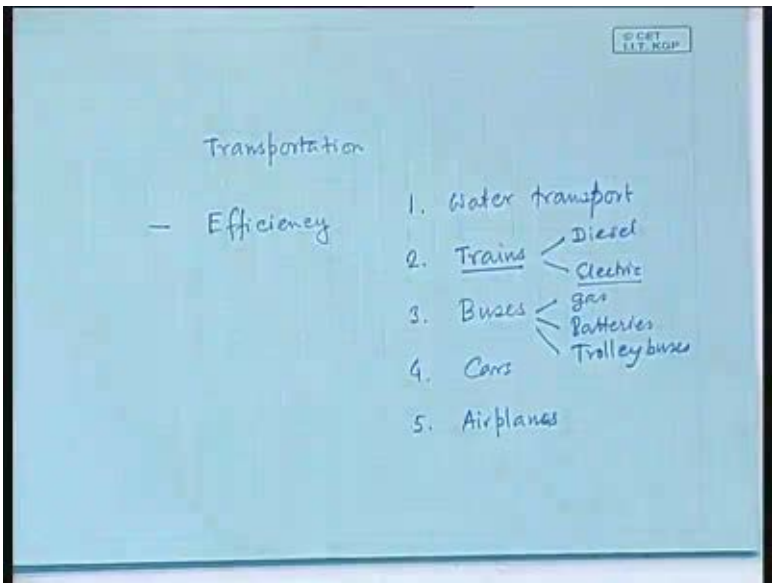

The cars or buses normally are rated at a much higher level of engine capacity than is really needed. Why because, that engine capacity is needed during acceleration and

mostly you talk about pickup. How good is the pickup? Pickup means how fast it can pickup speed; it means acceleration. So, only during the acceleration that amount of power is necessary; for the cruising it is not necessary. So, in that situation, if the engine is larger than what is really needed, then it consumes more amount of fuel during the cruising time also, because the engine size is much larger, the cylinder size is much larger than is really needed. So, the alternative is to make the engine rated only for the cruising time only for the cruising time and during the acceleration time, the power, that power, comes from another resource, namely batteries.

So, during the cruising time, when there is not that much demand on the power, you store that energy that is generated into the batteries or during the break, during breakings you extract that energy and put them into the battery and that can be used during the acceleration time. As a result, the engine itself runs at constant speed, constant power, after it started. If the power is not necessary for running, it is stored in the battery and during the cruising time, constant speed, that is the power that is used. As a result, the engine becomes far more efficient, far more efficient. So, that is the concept of the hybrid vehicle, where you have the electricity based engine as well as the fuel based engine and the two work in such a way that the fuel based engine is the most efficient and it has been found that the fuel consumption can be brought down to one third if you have a hybrid vehicle especially in city transport. In City transport, you are going and stopping, you are going and stopping; every red light you are stopping. Obviously, you spend a lot of energy in breaks. That energy can be put into the batteries and can be reused. So, that is the major advantage of the electric vehicles or the hybrid vehicles.

So, the trend now is therefore towards hybrid vehicles and electric vehicles, in terms of cars also. Mostly we will find that big cars with only one driver; that is obviously very inefficient. So, the better utilization of the space for the cars is another thing. So, that is why people are going into the concept of car pools. That is another thing that is necessary in order to save the energy. Buses, you will find, if you, if you are used to city life, you will find that mostly the buses when they are not going, then also their engines are idling; they are started. Much before they really start, they keep on pressing the accelerator to

give the indication that I am starting, please come in on board, to attract the passengers. In order to get more passengers, they stop wherever they do not really have to; they would, they run very slow. All that cost in terms of the fuel.

Naturally, the buses that run in most of the cities, especially the privately run buses, are very, very fuel inefficient and that is reflected in the price that you pay, in fares. So, there is inefficiency for which you are paying, but you are not responsible for that inefficiency. So, that is another area in which you can improve the situation. So, that is all for today. We will reconvene, but in the mean time you download this, get the data and obtain the full graph curve. That is what I want in the next week's class.
Thank you!