Non-conventional Energy Resources
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Lecture – 06
Details of Energy usage in each sector

Hello, in the last class, we already started looking at the consumption of energy by you know human beings around the world across various activities that we are traditionally involved in. And so, we have some broad idea of how the energy consumption is happening in this class what we will do is we will take it and add more detail to it, we would like to look at the details of energy usage in each sector. So, there are different sectors as we saw last class which broadly define the places where we are using this energy. So, you look at the details of energy usage in each sector.

The whole purpose of this discussion of energy consumption is mainly to get a good idea of you know where are the possibilities of non-conventional energy sources you know taking an active part in the usage of our, in the usage pattern. And also how much of an impact is it likely to make, where is it likely to make the impact I mean is it in your house, is it on the road, is it in a distributed form, is it localized to one location many such aspects are there which we need to be aware of. Because we are trying to understand this whole you know science and technology of non-conventional energy sources; and having this picture really helps us as we proceed from one technology to the other and look at the functional aspects of each of those technologies right.

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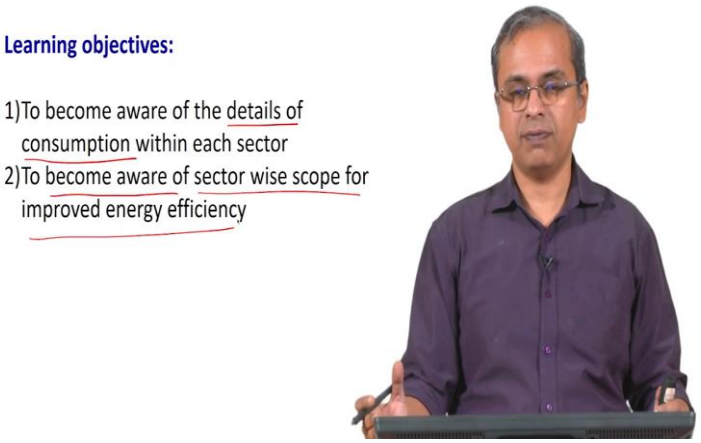

So, for this class the learning objectives are as follows. We would like to become aware of the details of consumption within each sector. So, details of the consumption broadly you have seen how it is distributed across sectors, but there is lot more finer detail in how energy is being consumed in each sector. And it is interesting to know these things because often we do lot of stuff without realizing the level of detail that is involved in what we are doing, and how many finer parameters affect the end result of something that we are doing, we just do some broader stuff because we are busy with something else.

So, this kind of an analysis helps us alerts us to those details, and then you can decide you know how much of importance you want to give to a detail or you don't want to give some other detail and so that's your choice, but we need to know what it is. So, that is what we look at to become aware of the details of energy consumption within each sector. And to therefore, to use that detail to become aware also of the sector by scope for improved energy efficiency.

So, in each sector maybe there's some places, there is a better chance of doing having an impact some places maybe it is bit more difficult to make an impact because of various reasons. So, those kinds of things that that broader picture of what is happening in the energy sector as we use the energy is what we would like to look at in this class.

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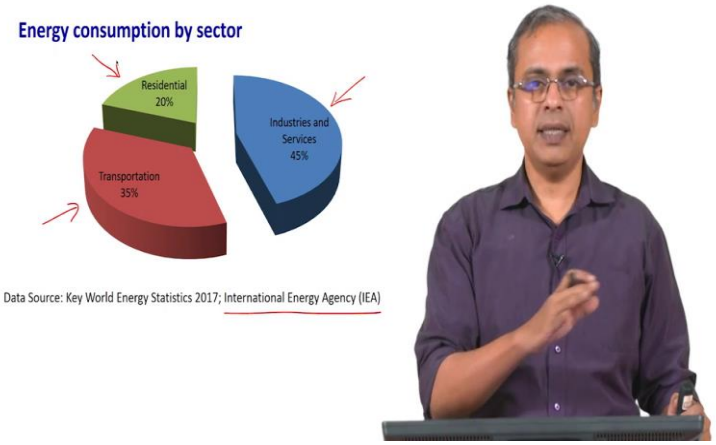

So, last class we saw this, the split of energy this pie chart which essentially shows you that you know if you take 100 percent of all the energy that we use then 45 percent of the energy, we use is getting consumed by industries that we have set up in various places and various services. So, services include you know the shops you go to things like that all those commercial services so to speak all that involved is the industries and services sector.

Again you know these are all numbers and data that we get from various international agencies so for example; the international energy agency is one source where you can get a lot of information and data; and then based on what data you are interested in you can collate it in different ways. So, I have put it together in the in the manner that you are seeing here based on numbers that you can get off of IEA database.

And so, if you want you can actually get more detail, you can split this up in much more detail if you want, but this is broadly what I felt is appropriate to discuss, so this is what I have put together here. So, industries and services take up of about 45 percent of this energy usage; 35 percent is in the transportation sector everything that we do everywhere we are commuting we are consuming energy.

And 35 percent of the total energy consumed by human beings is being consumed in the transportation sector for us to go to different places. And 20 percent is in the residential sector, so this is our homes and what energy we use. I mean this is as I said as I

mentioned before and I will also mention here is that this is the sort of the average international average across the planet, you can see significant variations based depending on whether it is a developed country or a developing country underdeveloped countries, so you can see some variations on that basis.

Even within a nation especially a nation as diverse as India you can find the energy pattern in you know big metropolitan cities, energy consumption pattern in big metropolitan cities and industrialized towns very different from say the rural sector I mean in villages in somewhat remote areas in the nation, so so that distribution is always there. So, that is something that we should also be aware of we need all these things.

So, when we propose a technology and we say you know this technology will be useful we have to acknowledge the fact that some technology may be, useful , very useful in a city situation, some may be very useful in a you know say a village situation. And both are equally important it's not that one is any less important than the other, but that thought process should be there. I mean what is it that's happening in a village what is it that's happening in a city and is this technology appropriate only for the city, only for the village, may be appropriate for both those kinds of things we should keep in mind. And then accordingly we propose projects based on that we try to implement those projects and see that our people benefit, so that's the idea here. So, these are the three broad sectors that we consume energy.

So, what we will do now in this class is we will look at each of these three sectors in much more detail, and see what are some details of that of what is involved within that sector, and then you know get a better feel for what is also possible in that sector. So, we will start first with the industries and services sector.

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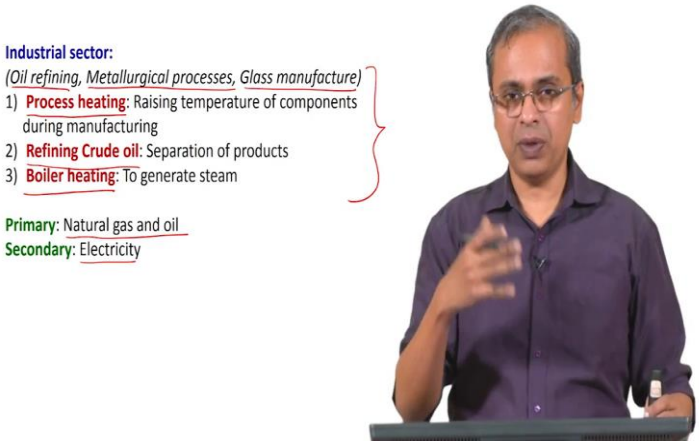

So, if you see the industrial sector which consumes a lot of energy; major plants that are there in the industrial sector are associated with oil refining, so that is one major location or a kind of a plant which industrial plant which is consuming a lot of energy and it is situated in many places around the world. Then this is a huge number of metallurgical processes, so steelmaking for example. So, steel plants consume a lot of energy and similarly any other metallurgical plant where metal extraction is happening.

So, some you know some ore is there, that ore is mined, it is taken to some metallurgical plant of appropriate design, and there it is converted to the metal and then that is the metal that we say that is supplied. So, there is a vast number of industries out there which are using metal for their products, it could be anything, it could be your chair, it could be the vessels that you use for eating, it could be the panel of the automobile, it could be various parts in the automobile lots of stuff. There's just amazing amount of use of metals in the world around us and they all start from metallurgical plant somewhere.

So, there's some extraction plant and there is you know refining plant etcetera which helps you get the metal in it's you know in its metallic state. Otherwise, it's typically an ore as an oxide of some form in its oxidized state. So, you have to bring it to its metallic state and then and use it for whatever purpose you want, but typically those plants need a lot of energy. So, therefore, that is also a major sector I mean within the industry that is another major sector. And things like glass manufacture other manufacturing plants

various manufacturing plants of various sorts are using different kinds of different amounts of energy. So so, broadly these are some major a major you know industrial processes that are consuming a lot of energy.

What are they consuming that energy for, the place, where one of the places where they use it the most is called process heating. In many plants, in both nationally as well as internationally, the procedure that is involved in making that product, whatever is a product that they are trying to you know bring out of the door. At the end of the day at the end of the day that from the factory some product comes out of the factory, there will be many steps in that product, which require. Some part of the product to be first heated up to some temperature. And at that temperature some activity will happen on that part may be its shape will be changed maybe some other thing will happen to it and then and then it is cooled down.

So, there is a lot of plants around the world which require this step that is the step involved where some part or many parts are first heated up and then that heated part something happens to it and then it is later cooled down and then you proceed with it. So, this idea of this heating and then doing something is called process heating. So, raising of temperature raising temperature of components as part of the manufacturing process. So, this is process heating it is there in a wide range of manufacturing you know industries and so it's a very common sort of location or a step in the industrial process where a considerable amount of energy is being utilized, so that is something that we need to keep in mind.

Then there is a refining of crude oil. So, I mean we are using oil for energy I mean right we are using a lot of oil and coal and whatnot for energy electricity for energy a lot of things we are doing but just getting that crude oil to be refined that itself consumes a fair bit of energy okay. So, where the crude oil actually has all these fractions that we use later, it could be petrol or it could be diesel, it could be you know kerosene, it could be tar at the end of it a lot a lot of different things are there right.

So, all of those have to be separated out, so that is a fairly sophisticated involved chemical plant that is put in place to do this and, so that consumes lot of energy. Many places again there is a heating process involved then some holding temperature holding time and something else is done and then you get this processing. So so, all this is going

on that is refining of crude oil which helps you separate the products out of the crude oil and take it for various end uses. And finally, there is this boiler heating.

Okay so, boiler heating is primarily there to generate steam. So, it is steam generation is the primary purpose of it, it is typically closely linked with power generation. So, you have a boiler, which generates steam and then that steam is sent to some turbine and then in the turbine you generate electricity. So, the first step is this boiler heating that water has to be converted to steam, so that is the first step in essentially this power generation process. Again lot of energy is consumed in this process.

There are some interesting you know aspects of this that is you know in some places the byproduct effectively becomes the main product. I mean these days it is not surprising to meet people who are associated with say the sugarcane industry okay, who feel that the sugar that you get out of the sugarcane which is what we as you know general public think that's the main product. You know sugar gives sugarcane gives you sugar and that's like the main product that registers in our mind as the product of that industry.

But lot of people are associated with their industry actually find the waste of the sugarcane after you have extracted the sugar to have much more value than the sugar itself from an economic perspective, because they use that waste to heat boilers and then generate electricity. So, there's an entire industry that depends on that waste coming off of the sugar industry and that waste actually gives them more value in terms of money than possibly the sugar does. So, many of them actually would will refer to the sugar as a byproduct rather than the leftover material as the byproduct.

Although as common public, we think that you know the leftover material waste material, the waste part used for energy that's the way we think of it, but it almost seems like they want to generate the waste because they need to generate, the electricity that's just one I mean it's it's thought of that way. It's just a thought process I mean if they are all both products, you are using it for different purposes. So, it's just a thought process in terms of what is the economics involved and of course, that can change that can change based on circumstances.

So, the point is boiler heating is a very important aspect in the general scenario of energy consumption around the world. In this case, boiler heating is also enabling you to do further energy generation, but generally as you can see here these are the three major

locations or steps or processes where industries are consuming energy. If there may be lot more processes, but these are some major steps major processes that are involved. Generally for all of these things, they are using a primary source of energy is either natural gas or oil. So, natural gas is typically piped into various industries and that is how the natural gas is used for this energy generation, I mean to for generating the heat which is then used for any application that you are trying to put it to useful.

Many industries prefer natural gas and oil because that is something that they can you know sort of predict predictably get a supply of many places it is also available relatively cheaply and this is only in a relative sense. So, they have that access to this energy and they are able to use it, so that is the idea of this usage of primary I mean usage of natural gas or oil for their energy. Generally, electricity is not the preferred choice of you know energy in industries, because it is usually a processed form of energy see electricity you are typically not getting electricity off the ground, I mean you know you don't dig a hole and then get electricity from there.

So, you are taking something you are typically you are taking some fewer maybe coal may be natural gas etcetera then you are running a plant based on it that plant generates electricity. So, in all processes, the efficiency is never 100 percent. So, if you had some amount of energy in that coal in a big block of coal, when you convert that block of coal electricity you are actually going to get less energy.

So, you had say let's say 100 joules available in that block of coal maybe you will get only some say 50 joules or something or even less 50 joules or 40 joules or something like that is what you will get as electricity. And that electricity then has to be transmitted to the location where it is going to be used that transmission process which uses all those you know high tension transmission lines that you see in many places that transmission process also has a considerable amount of loss associated with it. In fact, that's a fair bit of loss; so at the end of the day, so you are paying for that loss also.

So whatever, when you start off with that original coal or natural gas and whatever 100 joules that you had maybe in the end you are using only some 10 joules or 20 joules out of it. So, I am just giving you a number to give you an idea, but the point is every step in this process is different decreasing the efficiency. So, when you use electricity to do a job, you are actually using the energy in a bit of an inefficient way especially if that

electricity has been generated using some fossil fuel. So, therefore, many industries don't feel comfortable directly using electricity, they feel it's an inefficient way of doing things, it's also and more expensive way of doing it, but still a typical industrial plant does use electricity for a variety of applications within the plant.

And so, there are there is a lot of machinery that transform of electricity. So, electricity is definitely used in the industry, but it is secondary it is not the primary way in which energy use is used in the industry primary sources natural gas or oil. So, this is these are some details associated with the industrial sector. As I said we put this 45 percent you know energy usage in into the industrial and services sector generally the services is all other services that we use other than our house you go various places you use lot of services. So, those are those services we will just see briefly what we are referring to here.

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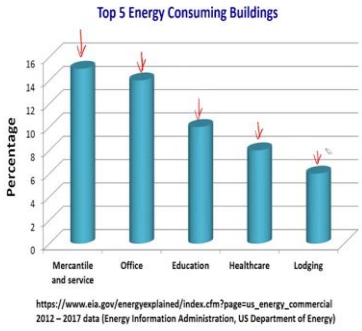

So, for example buildings, buildings consume energy. And all buildings are serving us in some way mean other than our house which we will treat as a residential you know place where we are using the energy; other than our house the other buildings are all other services that we are accessing where the energy is being consumed. So, you can think of all sorts of buildings here, this is in based on some kind of broad classification okay, you have some you know buildings that I have listed here, mercantile and service, office, education, healthcare and lodging. So, these are some broad services that many of us use

when we go to a city or we know use services even in our hometown or home city and these are the kinds of services we access.

So, what is this, this is you know the first thing is typically things like malls, malls and you know shops of a different nature where we are going and buying goods and so on. So, it turns out if you look at the percentage of energy usage across the spectrum, the malls are the ones that are consuming the maximum amount of energy. Malls and you know you know because it's a huge building centrally air conditioned, typically or centrally climate control is probably their more appropriate term to use because based on if it's a cold country then it's kept warm; if it is a warm country then it's kept cold. So, all these things are done.

So, some climate control is there, there's a lot of you know escalators there this they are trying to all those shops are trying to catch your eye. So, they have fancy displays lot of you know bulbs and so on lighting that is set up there etcetera. So, typically the malls are consuming lot of energy. So, you can see here in fact this is only the five different types of buildings that I am listing here so in fact, if you see here this is about 15 percent this is also just about 15 percent. So, about I mean if you add them maybe about 30 percent and this is 40, this is 45. So, this is about 55 something something like that. So, only 55 percent of the energy usage across the services sector is represented in this plot that you see.

There's another 45 percent which consists of other kinds of buildings, which are not listed here this is the top five that I am listing here, so that's why if you add them up in terms of percentage they had already come to a little over 50 percent 55 percent something it will come. So, just so you know that it's not that there is some error here, but that's there are other buildings we have not listed them here because top five are listed here. So, malls consume a lot of energy.

Next comes our offices our offices also consume you know throughout the day they are on; almost all the offices these days you find the there are very there are not sufficient buildings which are designed keeping natural lighting in mind, the buildings are typically most of them have artificial lighting inside the building. So, you have plenty of you know either tube lights or CFL bulbs or maybe led bulbs, but all over the building you have this. And so, it's considerable amount of energy spent on lightning, lighting all

these places, you have computers that are operational you have various other things that are operational inside an office. So, offices also consume a lot of energy.

The third is educational sector education is usually typically schools are not set up in as fancy away as offices are set up, there's a little bit more academic environment there, we set up something basic there we of course, want our children and you know students to feel comfortable. So, we are not, but the focus is not luxury. The focus is functional you know clutter free environment which is comfortable for the students to learn, so that's the kind of focus there. So, relative to offices that's a little less energy that is there.

A healthcare uses a fair bit of energy. Healthcare again I mean it's a hospital environment, so there may be cleanliness is very critical certain types of equipment would be consuming fair bit of energy, rest of it will be relatively less energy intensive, so that's what you will see. And finally, there is lodging where you go to a you know hotel somewhere and book a room when you stay and the kind of energy they are consuming is I mean all those sectors put together. And how many of them that are there and all of that if you take into account, what kind of facilities they provide that's the next sector that that is there. So, this is the you know split of energy across buildings that we tend to commonly visit or use and this forms the you know services sector so to speak for the energy consumption.

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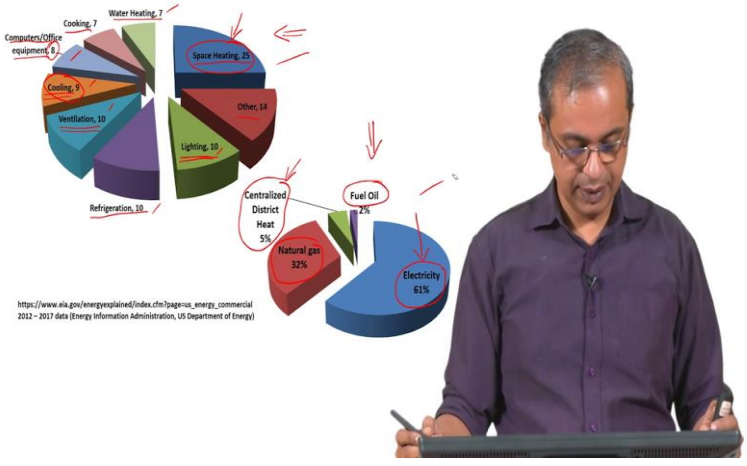

So, if you see here now now that we have seen the building sector there are a couple more details that I want to add to that; one is where is the energy coming from and within the building how is the energy being used. So, these are two things that I would like you to get a feel for. So, some of this of course, depends on as I said whether it's a cold country or it is a hot or a warm country kind of thing. So, if you take a typical building you find that you know at least in colder countries there is space heating takes 25 percent, so one-fourth of the energy being used in many buildings space heating.

If you come to a hot country like many places inside India quite hot in summer then air conditioning is the one that will consume a lot of energy typically air conditioners are consuming a huge amount of energy. In fact, increasingly as the air conditioners have become more affordable our energy consumption has gone up because naturally all of us want to have a comfortable environment in which we would like to work or live and therefore, the use of air conditioners has gone up and I mean along with that the energy usage is also gone up. I mean whereas, previously we were all just simply using ceiling fans now that is been replaced by an air conditioner, so that's something that we do. Other is some other sectors that are there we would not get into that, but there is still some 14 percent not shown here which comes under that sector.

Lighting, so lighting is another place where buildings use extensive amount of power as I said you know a lot of lighting is there people I think only now that it has gone through the cycle where you know people have become more energy conscious, conscious of energy conservation processes. And therefore, they are actively looking to see how you can reduce the amount of energy that we are using. If you take maybe even 15 years ago or 20 years ago the focus was first to get to you comfort, people want comfort how do we deliver the comfort. People want I mean some nice environment how do you deliver the environment that was more the focus say 15, 20, 30 years ago.

Now as time goes by and we become more conscious of the impact of our usage of energy we look to also in addition to the comfort, how can we do this in an environmentally friendly way, how are there better ways to do it? So, in this mean time as time has progressed from a point where we didn't have access to many facilities, to a point where we had lot of facilities aimed at our comfort and then now we are now moving to more you know that comfort with an environmentally conscious you know behavior going along with it. In that middle, middle point when lot of energy was

consumed or the focus was only comfort we gave up certain ideas which we were traditionally following. So, for example, traditional old buildings focused a lot on natural ventilation, natural ventilation and natural lighting I mean how do I ensure that enough sunlight comes into each room how do you ensure enough breeze comes into each room. So, this was our focus in much of the earlier construction that we did.

But as we came to much more you know comfort oriented requirements being met in densely populated cities where you know if you open the window, you are only getting polluted air coming in. So so, then climate control became the big deal. Everybody started talking of climate control, so that it doesn't matter how it is outside. It doesn't matter, if it is hot outside; it doesn't matter if it is rainy outside; it doesn't matter, if it is night day, it is a cloudy day, windy day nothing matters inside you will have exactly the same environment within some small variation. You have the same whatever you consider as a comfortable you know operating situation you will have exactly that situation inside. So, today lot of efforts are being made to correct this.

So, one place is lighting, lighting a lot of lighting has come which is artificial lighting; and not just artificial lighting because you know the focus was more on the look of things and also and there it's only a matter of perception. So, people have you know played up this idea that direct lighting is considered not as fashionable it is not considered that sophisticated.

So, a lot of people want reflected lighting diffused lighting, they don't want a tube light to be putting light straight on you. So, they don't want a bulb to be putting harsh light straight on your face. So, they take the bulb or they take the tube light or the CFL lamp and actually make it first point upwards. So, it is not pointed towards you. So, you don't even see the bulb, you don't see the bulb at all it. It is pointed towards the roof, it you know reflects off the roof and then diffuse lighting comes to you that is that is considered more sophisticated form of lightning.

Of course, this is again as I said you know perception, you can choose to ignore it I mean in your house or in your you know school, you can choose to not have all this kind of fancy stuff, because lightning is lightning. I mean if you have that rational kind of view then you get the lighting and you are satisfied with it and that should be fine. But because diffuse lighting and you know aspects like this get caught into all the fashion of

buildings, and you know the styling of buildings and things like that a lot more energy is spent in lighting a place.

So, while I mean a given square footage of a room could perhaps be you know lit very well using two tube lights or two you know what we say CFL, CFL bulbs if you want to call it or two led bulbs. If two of them would have been sufficient to light that room very well because you are using diffused lighting, you are probably using 5 such lights or using 10 such lights. So, you are unnecessarily wasting a whole lot of energy just to create this artificial look which you have I mean artificially convinced yourself or somebody else is artificially convinced you that is the better way of lighting the place. So, this is the problem.

So so, you have to keep in mind when these trends come you have to ask yourself whether this is a reasonable trend rather than this blindly follow saying today it is a trend to setup the lighting this way. Therefore I will set it up that way I mean people who are in the you know sales division of any company will sell their product I mean you cannot blame them they are trying to sell the product. So, they will tell you diffuse lighting is beautiful and they will try and set up ten different lights in your room, so that you have a beautiful environment.

But if you ask yourself if that's the environment you want and is it really the environment that you are happy with and satisfied with, and is see the correct way to get yourself a good environment then perhaps you can do things differently right, so that is now number one. And also you know natural lighting to what degree can you get natural light into the room, so that you don't need all this artificial light. So, anyway lighting takes up ten percent of this energy usage that is the significant.

Refrigeration in all buildings you have refrigerators for various purposes it could even be a lab where you keeping some chemicals, so refrigeration is commonly there in most buildings. Ventilation again exhaust fans exhaust fan is maybe a crude a crude way of saying ventilation. But you know they have all this entire the system of a piped air flow which takes air off of a room, sends it out make maybe makes it coolers throws out some of the bad air add some fresh air and then brings it in lot of stuff is on with respect to ventilation.

Again because in olden days we used natural ventilation this was not an issue. Now, we are using all piped stuff everything is piped you pipe in air you pipe in electricity you pipe in water everything is piped and so there is some you know energy associated with sending it in and pulling it out all this stuff. So, ventilation uses energy.

Cooling of different kinds typically air conditioning. So, if it is a cold country, so you see cooling is a smaller fraction; heating is a larger fraction of their energy usage this is you know averaged across the year if you take it this will this is how it will be for a typical cold country. Typical warm country it will be opposite, you will have lot more time when you need the air conditioner air conditioners on. And you may never need spaced heating or very rarely used space heating if at all right, so that is the way you see it.

Computers and office equipment lot of you know you have computers, you have printers fax machines telephones all of these are consuming power that is only about 8 percent of the energy that is being consumed. And you should also keep in mind that all these things are becoming more efficient with time computers 10 years ago were extremely inefficient with respect to energy because they were using CRT tubes. Now, it's all led displays and they are all extremely energy efficient, so that is relatively speaking they were very vastly energy efficient.

Then there is cooking and water heating. So, all those hot water geezers that we use consume this 7 percent heat at energy that we have seen and of course, the cooking that we do. So, this is averaged across the buildings. So, you know a wide range of buildings and doing wide range of different things in the services sector, but this is sort of the split of energy usage. Again here and all you know if you use solar heating something like that solar water heating and this water heating percentage can come down. So, this is the usage, this is where it is being used in the buildings. So, this is how it is being used.

Where does this energy come from in from which sources is it coming from in typical buildings because it is you know set up in a city and that's the kind of setup that we are looking at in this distribution, much of this energy that you just saw is coming from electricity. So, unlike the industrial sector, where you know the heating of the components is important for heat treatment and so on this is actual usage directly in the form of electricity. So, computers use electricity. So, if you look at it space heating may use some natural gas something it might use, but most other things lighting is using

electricity, refrigeration is using electricity, ventilation systems have exhaust fans or different kinds of blowers involved they are all using electricity, air conditioners use electricity. So, all of these are using electricity that we just saw. If you look at computers and office equipment that uses electricity, water heating is often using electricity.

Cooking also based on what kind of a you know stove that you have you can often use electricity some of them I think more although the more traditional once are typically using gas some amount of electricity is used there also. People have microwave ovens which are electricity based, they make coffee with the coffee machines that are electricity based, all are you know mixi, mixers blenders grinders all those things use electricity. So, wide range of things are using electricity. So, therefore, naturally in building kind of a situation, unlike the industrial kind of situation, significant amount of energy is in the form of electricity that's what is happening.

Natural gas is used much smaller fraction, but this again you know depends on the country. As I said a country where there is a lot of heating going on this heating aspect is going on space heating aspect is going on typically many of them you are using a natural gas for the heating, so that's what is typically happening. But that's not the only way they do the heating, but natural gas is often used for heating, it is also used for cooking most of us are using some form of gas for cooking.

In European countries and in you know say United States and so on, the gas is actually piped to the house, they don't bring cylinders and keep it in the house, but just the way you have water pipe to the house you also have gas pipe with house. So, you typically they will have electricity connection water connection and gas connection, those are three things that are I mean any supposedly modern house in a European setting or American setting will typically have these three connections and those are necessary for keeping the process running.

There is also a small amount of you know this is not again not really relevant much in the Indian context which is district heat and fuel oil usage, but fuel oil we also use to some wave for various purposes, but district central heating again this is more cold country oriented statistic so not really relevant to us. What it basically means is that the typical cities and know other infrastructure that is there in cities and towns may also involve some heat supply of different forms directly in some centralized way so that

means, that is there, but that's usually a much smaller percent. Because typically when you are supplying heat lot of heat is wasted in the transmission process by the time you get it to that location and so on, so that is not really the best way to do it so, but that it also exists it's not a zero is the point that is also done.

So, this is how energy is consumed in the house consumed in buildings not residential sector in buildings this is how it is consumed, and not necessarily in the residential sector more the commercial sector as I said. So, if this involves malls it involves shops in it involves you know restaurants you are going to schools that you go to hospitals that people we said how all those take things taken into account. This is the kind of split of energy usage that you just saw here and this is how that energy is being supplied. So, this is what we see all right.

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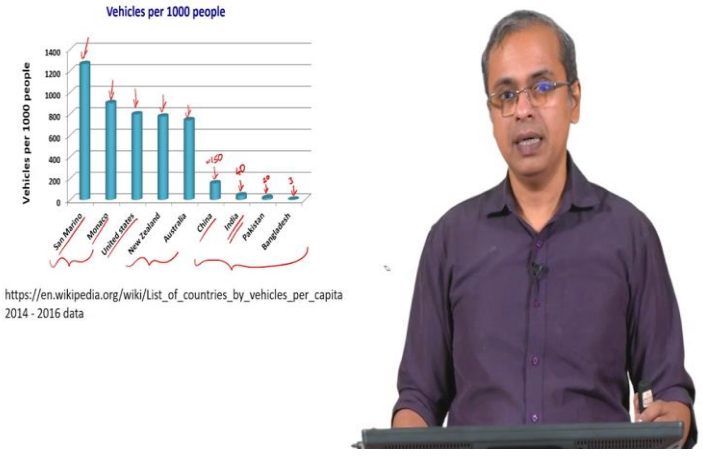

We have seen now the industrial and services sector which involved the industries that are making stuff and the services sector which uses which involves all the services that we use typically in the form of an office etcetera that we visit to get some job done. So, how the energy is used there what are some concerns there where it Is come from is all that we just saw.

Now, we move to the next sector as I said the next biggest sector is the automotive sector okay. So, of course, we see automobiles all around us; in all modern cities I mean place is just calling with automobiles from different kinds two wheelers, four wheelers in

Indian context. Three wheelers which is not so common in you know say European or American context, but certainly in Indian context it is very visible two wheelers Asian context you will see three wheelers. So, some interesting statistics to look at okay.

So, how many vehicles are there in that country for every 1000 people that are present in the country. So, this is a statistic that people often look at to get a sense of what is the vehicle density there and you know how much of an impact vehicle related technologies might make theirs and so on. So, usually in all cases you are looking both at a per capita concept and also as a total concept. So, this is sort of on a per capita basis or, but instead of a per person basis it is a per 1000 people basis.

So, interestingly you will find that there is this country San Marino which has more vehicles than it has people that's very interesting right. So, it has more vehicles than then it has people. So, it facts it has about 1200 plus vehicles for every 1000 people that are present there, it means that every person on average owns more than one vehicle in the entire country. The entire country every person is owning on average more than one vehicle.

And actually between San Marino and Monaco you are actually looking at two small countries. So, in a way it's a bit distorted data because it is not really common data of in the form of a common population this these two nations are two tiny nations which are there in Europe there extremely tiny nations the present in Europe. And to give you an idea of how tiny there as a nation, you are looking at you know each of this nation has a population of somewhere between 30,000 and 40,000 people that's it that's the kind of population they have 30,000 to 40,000 people it's a very small population. In fact, if you go to some large university, the population of that university itself may be 30,000 or 40,000.

So, if you look at it that way it is just a it's like a university campus kind of thing that is now become a nation I mean that became a nation long ago and has maintained its nationality. So, naturally it is not it doesn't have the level of diversity it's a small you know controlled population so to speak. So, it doesn't have the level of diversity that many of the larger nations is let's say such as you know even the united states or India or China or any of those bigger nations have.

We have wide diversity in the kinds of people who are present in our nations what background they have what economic factors are involved in their lives that background is not really there in these tiny countries, they are a very different set of people from a statistical standpoint I mean. So, they are at one end of the society in the statistically and they have become a country, so that's the way it is and that's the reason why these two countries which are both two tiny countries located in Europe have this distinction of having the largest number of vehicles per 1000 people.

So, one has you know over 1200 vehicles for every 1000 people and the other has close to 900 vehicles for every 1000 people and. So, they actually have much more we typically talk of automobiles in you know the link has always been with the united states because there is extensive amount of automobile usage is there, but they actually have more per 1000 people than the united states, but as I said they are too tiny countries. So, it's not I think in order not at all relevant in the grand scheme of things, but it's interesting you know that such a thing exists.

Amongst the larger countries, you see United States here leading the number of vehicles for every 1000 people. So, you have. In fact, over 700 vehicles over 750 vehicles or of that order for every you know 1000 people. So, this basically means that you know for every year, so 750 vehicles is it is like you know every household definitely has a vehicle. So, between for every two people certainly there is at least one vehicle that's available and for every four people there is two vehicles, three vehicles even available, there are three vehicles available for every four people that are present in the United States. So, any household of four people has three vehicles in the United States, so that's a pretty large number I mean three cars in a house of four people is a pretty large number, but that is how it is.

New Zealand is there and you can see you know these are two arch rivals New Zealand and Australia in at least in the common sense of you know cricketing and any other rivalry, you talk of use it and in Australia. New Zealand beats Australia in this they are slightly ahead knows know ahead of Australia in terms of owning vehicles they have more vehicles per 1000 people then Australia does. And then we have the all are you know ourselves and our neighboring countries China, India, Pakistan and Bangladesh.

Just to give you an idea you know of the numbers involved here China is at around 150 roughly 150 vehicles for every 1000 people. India is at around 40 vehicles per 1000 people. Pakistan is about half of us it is about 20 vehicles for every 1000 people and then Bangladesh is only about three or four vehicles for every 1000 people. So, you can see significant variation right here right, so even in our neighborhood between China, India, Pakistan and Bangladesh, significant variation in the number of vehicles for every 1000 people.

This also means that this is the place where there is considerable scope for growth. See if already there is a household of four people like in the United States four people already have three vehicles the their temptation or inclination to go and buy a fourth vehicle is distinctly less relatively speaking because they already have vehicles and they are do you know park those vehicles drive those vehicles.

So, they the opportunity to buy another vehicle decreases nothing prevents them from buying a vehicle, but it generally decreases. Whereas here you have a huge population that doesn't even have one vehicle. So, if we say 40 people in 1000 own vehicles there are 960 people who don't own a vehicle, so that much opportunity is therefore, vehicles to be sold in India and India, Pakistan, China, Bangladesh all these places and corresponding to that if there is reasonable wealth then people start buying.

So, certainly in China and India there is great scope for you know growth in the automotive sector, and India is one of the largest if not the largest you know fastest growing you know automobile sales in the world, one of the fastest if not the fastest growth sector for automobiles in the world. So, that's why a lot of automotive companies are extremely keen and looking at India depending on the year the statistic may change, but it is easily amongst the fastest growing such sectors in the world, so that is what it is. So, this is vehicles per 1000 people. Of course, as I said this is per capita and. So, it can get distorted by places like San Marino and Monaco.

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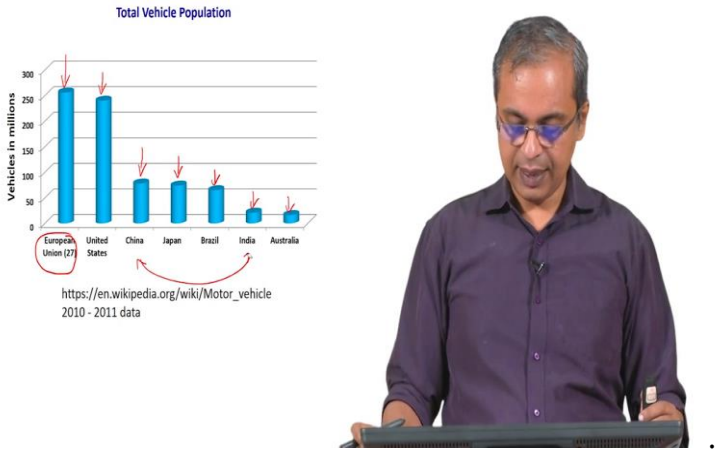

So, if you look at a little broader picture which is the total vehicle population total number of vehicles present in the world. Then you find European Union, which is when we have not seen European countries too much in many of accepting I mean San Marino and Monaco that we saw in the last slide.

If you not generally seen them in great detail, in many other of the statistics, that we have looked that's because each of those European countries is individually relatively smaller than many of the countries that we are discussing. Then certainly in comparison to India china and United States and even the Russian Federation, typically these countries are much smaller.

But if you take them as a unit together as the European union which consists of about 27 countries then they do have a lot of vehicles they have a total of nearly 250 million vehicles in the world yeah in their country. United states is also almost there just below there, still in there you know close to about 230 million vehicles and so on. And then you have China at about say 60 million vehicles around there they have a similarly Japan also has 60 million vehicles are in present in that country.

Brazil and then you have India and Australia which is which are relatively less in comparison. Of course, always the comparison is between India and China because we are we have very similar population you know overall population is very similar, so a lot of comparison there.

We had at least in this these kinds of parameters we tend to be as of today we are behind china in the numbers that are out there in terms of how they have expanded their you know the sales processors and the ability of people to buy things and so on. So, that is how the know distribution is. Interestingly we have a nearly I think 1.2 billion vehicles automobiles 1.2 billion automobiles in the world that's a huge number. I mean there is a massive number or population is about you know seven and a half billion worldwide population is somewhere in that range it is and 1.2 billion vehicles are there in the world which is a very large number.

And clearly that is therefore, the automotive industry it's a big industry right. So, a lot of people are buying automobiles, there is a lot of scope to buy automobiles I mean if you look at as I said we saw the statistic of 960 Indians out of every thousand who don't have an automobile, and invariably there is an aspiration to buy an automobile people want an automobile for various reasons.

I mean it for shear transportation is one you know convenience and comfort of transportation flexibility of transportation and so on. So, and plus also there is all these other aspects associated social aspects associated such a status symbol and so on. So, there's a lot of scope lot of scope to increase these numbers and so that is definitely this is a sector that needs attention both in terms of the technologies that go in the terms of kinds of energy that is used and what new things can be done with it .

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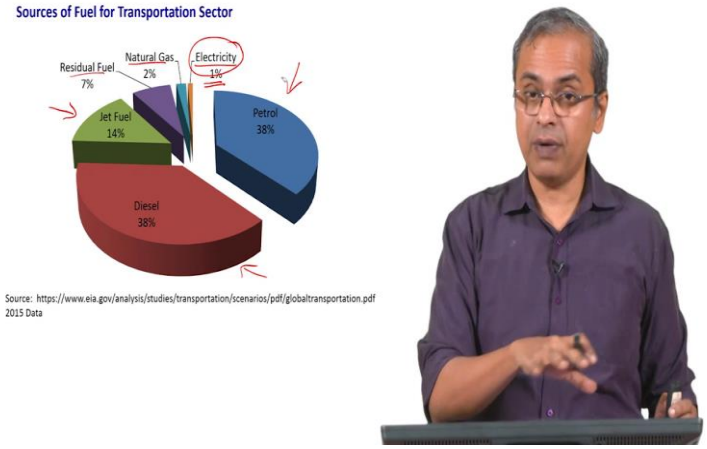

So, where does the fuel come for it as you may imagine you know almost 80 percent is only these two petrol and diesel, almost 80 percent of the vehicles out there are petrol and diesel and that is that meets perfectly well with our you know common experience. You go I mean in India anywhere you go typically buses and know many vehicles many taxis are typically using diesel.

The cars private cars also several are diesel, but increasingly petrol has also started becoming equally popular you know for a long time it was primarily petrol, but then diesel caught on because it was lot cheaper and people felt that that's a better way to go. But with the pricing which has become much more dynamic these days the distortion and diesel pricing relative to petrol pricing is fast disappearing. So, people no longer see that great benefit that they get by getting a diesel vehicle, where there upfront paying additional money and then the fuel is not that much cheaper.

So, except for some taxi side kind of services where it still makes sense maybe economic sense in the lifetime of that vehicle that diesel vehicle is good, generally people find petrol vehicles much better and so they are cleaner with respect to emissions generally much quite a relative to sound production and so on. So, petrol has also again pre caught it's you know share in the market or at least holding onto its share. So, about 80 percent of the fuel consumed in the automotive sector is coming from these two, this is what is happening.

The other major place where fuel is consumed is jet fuel. So, we don't realize it, but the number of planes out there in the world is actually huge, in several tens of thousands of planes airplanes are out there being you know which are flying around the world as we as we speak.

So, this is a sector that is growing in a big way again it's a sector that serves a section of the population. So, many places especially in in countries like India there is a large fraction of the population which has not gone in aeroplanes which is never traveled to an aero planes may never even have visited an airport. This is a very large fraction because only seen planes in the sky somewhere in the sky I would never actually traveled by it, but still that's the sector that is becoming more and more affordable.

Lot more Indians are travelling by aeroplanes than they did even 20 years ago. 20 years ago a middle class family in India had really no expectation of ever flying, the costs of a

flight ticket to say even from sage from Chennai to Delhi it was so exorbitantly high that most families had no expectation of affording it and it was a luxury well beyond their needs. Today that is distinctly changed as we approach the year 20-20 most people in India in the in the middle class sector of India can certainly go by flight if they wish to. I mean it is quite affordable and you have all these you know pricing variation fluctuations as you on a given in on any given day that you can book flight tickets which are only marginally more expensive than the most expensive train ticket. And therefore, people are able to afford flights and if you actually travel to by any of the flights that are these days flying across in India invariably the flights are full. So, you are rare it is rare to see a half empty flight or you know several seats empty itself is very rare invariably it's all running full.

So, it's a sector that is very significant, but as a common person we often don't immediately think of fuel usage associated with that sector because it is not a sector many of us are using on a daily basis. Whereas, buses cars and you know auto rickshaws or two wheelers we use daily. So, we associate that diesel and petrol usage from that perspective, but aviation fuel which is a form of kerosene kind of fuel is quite significant and 14 percent of the fuel is coming from there.

You have some other kinds of fuel that is here residual fuel, which is I mean a fuel which is after the processing it is available and it is used for specific purposes which we are not going to get into in great detail. But we also have natural gas because lot of emphasis has been there in recent times that natural gas is clean much cleaner form of fuel than other forms of fuel. So, there has been a push to use natural gas for fuel for automotive sector.

And finally, what I want to draw your attention to is electricity. So, electric vehicles although you hear so much about them in the news, they constitute only one percent today it's only one percent of this entire sector that is in the electricity you know field using electricity as a source of energy. 99 percent is not that oh even if you take natural gas as being somewhat alternative, it's not, but even if you consider that as something new even that put together is only 3 percent.

So, we have to keep that in perspective. So, as the sector grows if you make a difference here in terms of how electricity can be used in the automotive sector, you are making a huge difference. If this one difference, if this one percent can claim to 10 percent that is a

massive difference and that's also represents a scope for that industry it means it's not saturated there is such a vast room for it to grow into. So, that is the promise of the non-conventional energy in the sector, but it is not yet there it is far from there it is only at 1 percent.

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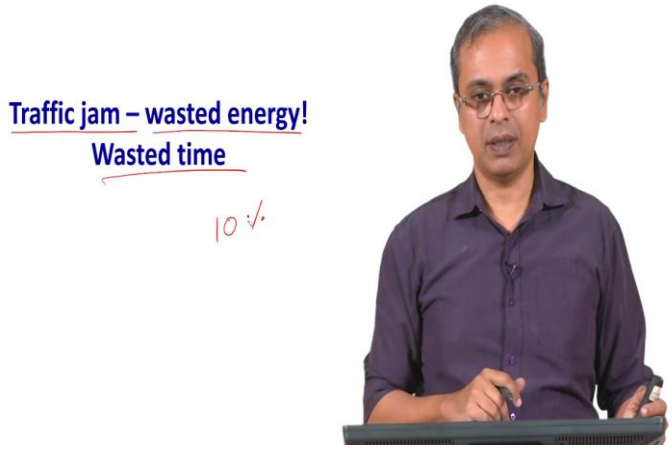

In this context with respect to the automotive or sector the other point that we have to keep in mind is this idea that if the infrastructure is not good, the road infrastructure is not good if the traffic management is not good. There is a significant amount of energy and time that is wasted simply in traffic jams. In fact, one estimate puts it that in some countries that up to about 10 percent of energy, 10 percent of the energy that is being used it is just being burnt simply because cars are just sitting there in a traffic jam running idle. Everything engine is on people are sitting there because they have to have the ac on or something engine is on and all the vehicles are just parked there.

So, you just converted that entire roadway to some kind of you know powered air conditioned space, and you have just switched on all the ACs and sitting there wasting your time and wasting your energy. So, that is the unfortunate reality many densely populated areas. So, if interest is there to you know improve our overall energy efficiency as a as a society, we have to look at this also that the traffic how the traffic flows whether the ways to you know make it easier for the traffic to flow for people to move is very critical and because it makes a difference. It's not simply even if you make

all everything electric vehicle and you make all those vehicles just sit there on the road and waste their energy there is not good enough. So, you have to do something more comprehensive and so this is some is the factor that we have to keep in mind.

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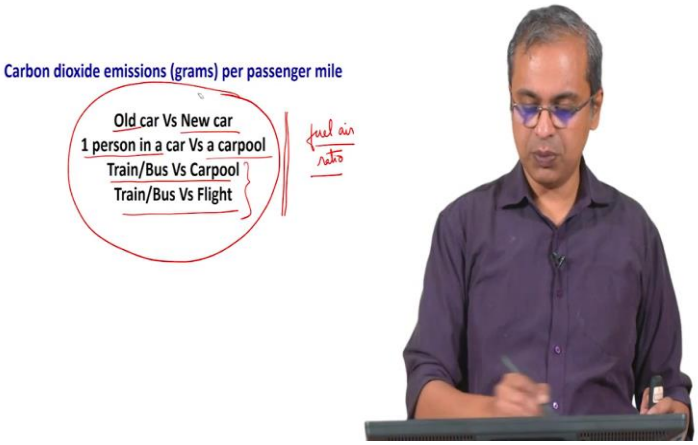

I will also point out that you know there is when we say automotive sector we sort of sweepingly come treat everything as equal, but there is a wide variation. So, if you take an old car versus a new car, now some people stick on to their old cars from the 50s, 60s. Because there is some charm to it, there is some history to it and some you know may be sentimental reasons associated with it and that that is fine I am not you know questioning those aspects of it.

But if you look at it purely from efficiency, emissions and all those perspectives many of these old cars are as polluting as you know 20 new cars or something like that you know the new cars are vastly more clean in the way they burn the fuel. And that has got a lot to do with how much fuel goes into the engine and how much air goes into the engine, there is a fuel air ratio.

So, fuel air ratio this decides how clean you are burning the fuel, how much of the fuel you are completely burning okay. So, sometimes unburned fuel is sent out in the exhaust or you are not completely getting the energy out of the fuel. So, lot of things are dependent on this fuel air ratio and how the engine works and what temperature it works a lot of things are there involved in this realm. And as a result and all the considerable

thought process has gone into the design of newer cars. So, newer cars are extremely well tuned to consume the fuel in a very efficient way and they change the way in which they consume fuel based on your operating conditions.

So, if you are on a highway and you are smoothly driving at some speed then it it adjusts the engine parameters in; some way if you are continuously going accelerating decelerating accelerating decelerating in a traffic situation, it adjusts the engine in a different way. So, all these adjustments and fine tuning possibilities have come only in their very recent years, old cars had one set point they would more or less run in the same set point. So, many operating conditions they were wasting huge amounts of fuel. So, from pollution perspective old cars or vastly more polluting the new cars.

Similarly, one person in a car versus a car pool; a car pool means multiple people in the car. So, on a per person basis carpool typically consumes lot less energy and therefore, many cities internationally strongly encourage it they give lot of incentives for carpooling. So, for example, in some cities where there's considerable traffic jam, they have a separate lane. If more than one person is there in the car if more than one person is the car you can take that lane that will be empty even though all the other lanes are blocked this is empty you can drive long distances in this thing.

So, that is a carpool concept and then there is always this public transport train bus versus the carpool and train bus versus flight, interestingly these are all very similar really somewhat close in terms of their energy efficiencies okay. So so, this kind of detail is there even in the choice of vehicle, mode of transport and how you utilize transport in a city condition.

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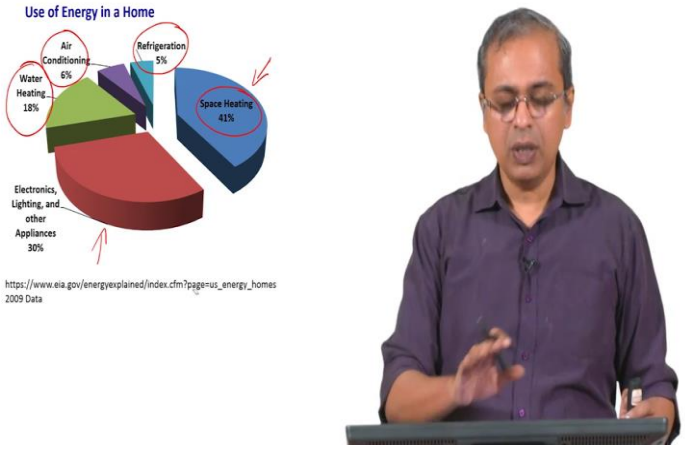

So, all these details with respect to the transportation sector I will close with this slide which is focused on a use of energy in a home. And you can see here a sort of similar to the some of the detail that we did in the other sector of services sector when we looked at the industrial and services sector. Similarly to that you have you know space heating which is a significant part, you have electronics lighting and other appliances which constitutes 30 percent of the energy used.

Refrigeration is there, air conditioning as I mentioned you know this again is against the space heating here depends on whether it is a coal country or a warm country etcetera, and there is water heating all those hot water geezers that use so. So, very similar to what I showed you in the services sector maybe the exact percentages are different, but you see that kind of a split in how the energy is used and so that gives you some idea of where you can intervene to make it cleaner.

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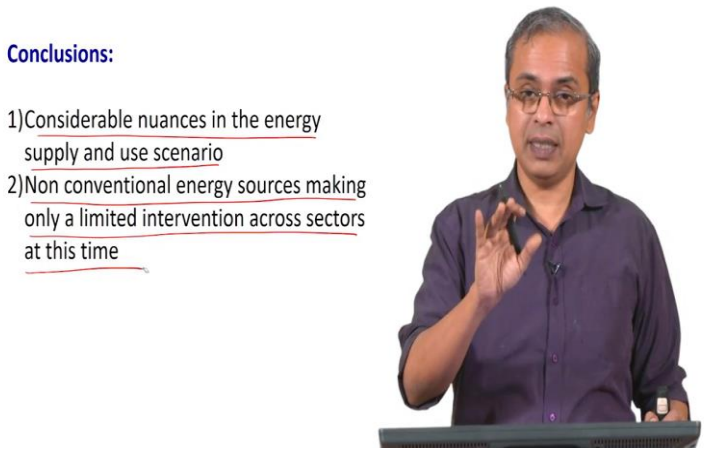

So, broadly what have we seen we have seen here the three major sectors of energy usage, the industrial sector, the transportation sector and the household sector and or the residential sector. And we have seen lot of detail lot of detail in what is happening in each of those sectors in terms of where the energy is being used how is the energy being supplied and what what form of energy is being supplied to it.

So, what we find is there is considerable nuances, fine detail nuances fine detail in the supply and use scenario how it is being supplied and how it is being used in the in all these sectors in these three sectors. So, sector wise there is a lot of detail involved, lot of issues involved, you cannot just sweepingly say I will put something and it will happen I mean everything good will happen it doesn't happen that way. You have to really address the specific peculiarities of that sector and only then the you know full benefit of whatever it is you are trying begins to accumulate in that sector.

And then non-conventional energy sources and as of today as of now are only making a limited intervention across these sectors at this time okay. So, they are making in intervention lot of people are investing time, energy, research and you know production processes are being put in place to introduce these non-conventional energy sources into various sectors, governments are pushing actively to get this done. So, lot of things are happening, there's a lot of economic considerations here, government is trying to assist to tilt the economic balance in favor of these you know cleaner forms of energy. So, that

they get adopted faster and then perhaps the sense of scale and the advantages of the scale begin to appear sooner. So, all this is happening, but as of now they are making a very small impact, but the expectation is that they will make a greater impact over a period of time. So, I would like to conclude with this that you have seen this sectors you have seen all the details and you have a better sense now of what is possible with it.

Thank you.

KEYWORDS:

Energy Consumption in each sector; Scope for improved Energy Efficiency; Industries and Services Sector; Steel Plants; Boiler Heating; Educational Sector; Vehicle Density; Automotive Sector: Transportation Sector; Household Sector

LECTURE:

Details of energy consumption and supply within each sector like Industrial, Transport and Household is elaborately discussed and statistically represented in this lecture.