Non-conventional Energy Resources
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Lecture - 07
Consequences of Energy Consumption

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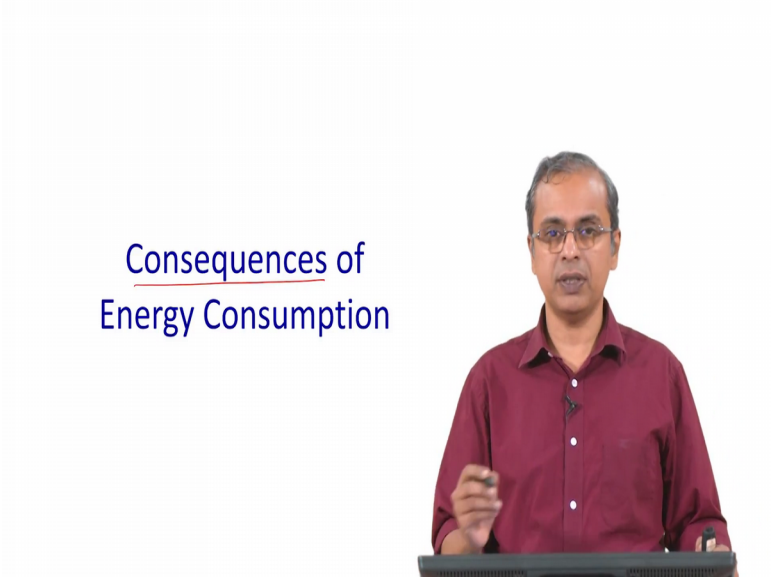

In the last several classes we have seen that as as a you know a civilization we are using a lot of energy, increasingly in the last say 100 years we have been using a lot of energy. Basically for you know industrial applications, for transportation applications and for residential applications. And we have also seen that a significant amount of this energy is coming to us from fossil fuel based sources or at least carbon based sources basically carbon based sources and so we also done a calculation on you know what is the percentage of carbon dioxide that is there in the atmosphere, what happens if we continue using energy the same way that we are doing both in terms of quantity as well as the type of source of the energy which is basically fossil fuel which means we are adding more carbon dioxide into the atmosphere.

We also looked at the factor the additional factor that you know not only we are putting carbon dioxide into the atmosphere we have also been side by side cutting down our forests. So, when you take all those into account it seems like carbon dioxide we are

facing a situation where carbon dioxide keeps going up in the atmosphere and that's something that we need to look at to see if that is of any issue or consequence.

So, we also saw in our calculation that you know if we keep this up in less than 100 years we can double the amount of CO_2 in the atmosphere. So, and based on other circumstances that could be much shorter than 100 years to 100, I mean we came up with a number of about 86 years it can be much shorter than that based on the exact set of circumstances that we take into consideration, so all that was there. So, in this class actually what we will do is we will focus much more on these consequences of energy consumption. We will look at a few different factors and also see what this means in the short term what this means in the long term. And I think these are these classes that we have done so far including what we will do today I really set the base or the background for all the technologies that we will look at even from our immediately succeeding class.

So, from the next class onwards we will start focusing on specific forms of energy that we can start incorporating into our energy mix and how we would go about doing that. So, all that is coming up in the next few classes, but today we will sum up all these statistics that we saw so far by looking at this one other aspect that we have not we have hinted at we have sort of glimpsed at in some ways which is the consequences the specific consequences that we are likely to have based on our energy consumption pattern. So, that's the idea of this class.

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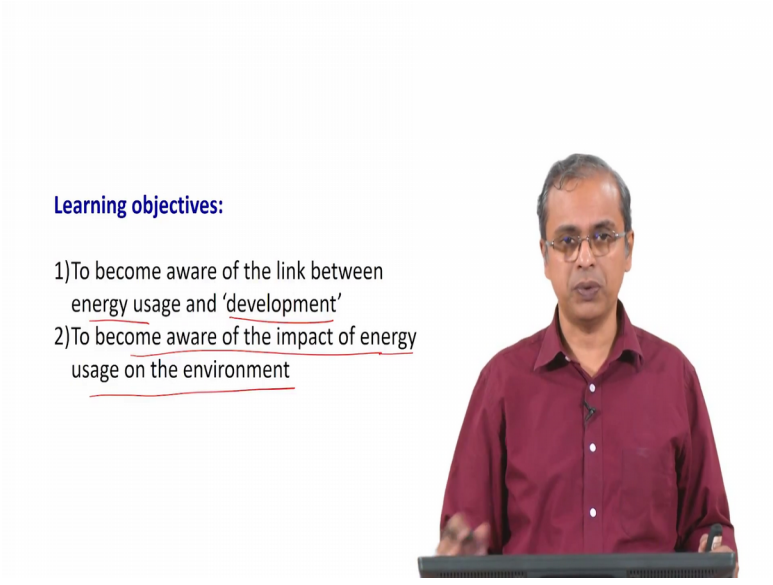

Our learning objectives are quite clear in this context we would like to become aware of the link between energy usage and development. And I put development within quotes because even the idea of development has some common connotation and even in industrial sense of you know people associate certain things with development, but if you take humanity as a whole and you really take the opinion on of a lot of different people many people will even have arguments on exactly what we are defining as development. But generally the mass you know large fraction of population believe that certain types of activities and trends represent development.

So, having you know bigger houses, more amenities in the houses, more comfort level, more control on our comfort level things like that those are more ways to entertain ourselves more food to eat all these things get considered as development, more infrastructure more places to go, more places to travel, more things to do typically more gets associated with development. And this people will have both philosophical arguments as well as you know technical and economical arguments on whether strictly more is development. So, there is I think definitely some value in looking at this idea that more does not necessarily mean better more does not necessarily mean development. But generally that's the idea. So, let's not argue about that at the moment we just assume that you know there is this concept of development that lot of us have a feeling for. And so, we would like to understand the link of energy usage with development.

I have stated in the past that you know energy usage is high development seems to be high and that sort of I will try to put a little bit more specific you know examples in front of you. And then we would look at that and then having understood that we would like to also become aware of the impact of this energy usage on the environment.

Okay so, impact of energy usage on the environment because if there is no impact on the environment and we are all fine then really this whole discussion is meaningless. I mean this there is no point in it in the sense sure we can use energy there is no problem with it everybody is fine everybody is comfortable with the energy they use, why should we do anything about it, why should we look at non conventional sources of energy is if we can wait till fossil fuels get completely exhausted then we can think of other ways of dealing with this or parallely we can do it, is there any reason to be more urgent about this idea of you know looking at non conventional sources of energy.

So, so that is got to do a little bit atleast significant bit of that has got to do with the impact of our energy usage on the environment and on that basis we like to see if there is reasons to look at this in a more urgent manner then you know sometimes is stated in a both in you know certainly in international circles some people feel that you know it is not necessary to address this that urgently. So, we will think about we will look at that and see if as technical people as scientists who are looking at this information do we think there is a reason for concern. So, we will do that.

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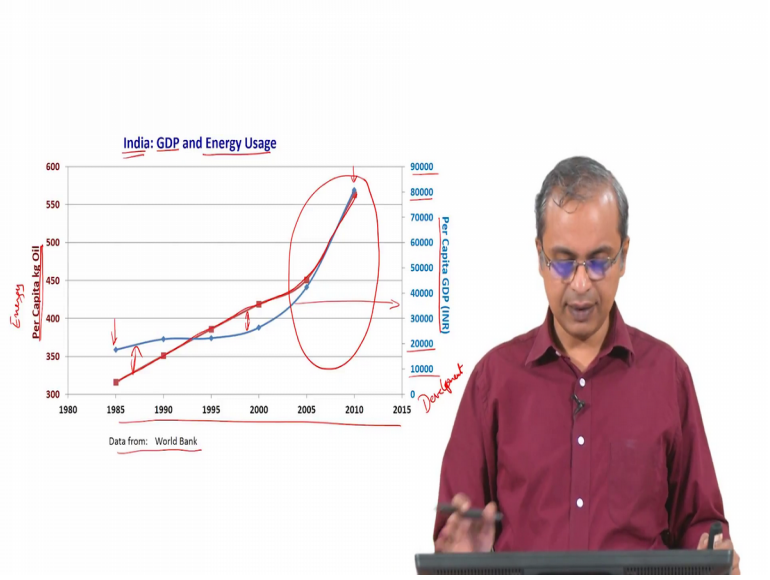

Okay So let's look at you know sometimes we look at in international data, sometimes we look at European data, American data and so on. But it is possible also to look at different sources of data and get something that's maybe relevant to the Indian context. So, here I have got on the same graph two different pieces of information, that is put up the first is for India this is all for India, the first is GDP which stands for gross domestic product GDP and so that's what you have here on your y axis on this side. And this is per capita GDP, GDP so that is divided by the population total GDP of India divided by the population of India.

GDP stands as I said for gross domestic product. I mean you can get into more economic kind of you know discussion on what GDP is. In general it means the total value of all the goods and services produced by a region. Okay so, let's say we produce cars we produce some software engineers who do some back office operations for somebody

things like that. So, what is the value of all those things that we have produced? We have produced so many cars that costs so much, we have produced so many televisions it costs so much, we have produced so many engineers who are doing so much work for other people that costs so much.

So, all that we add up and then you come up with some number. So, in India total amount of goods and services produced and you know, therefore, delivered it will come to some value. So, that will be the GDP of India. And then you divide that by the population. So, that you know per person in India how much are we contributing in terms of something that is being produced here or some service that is being produced here, delivered here. So, GDP is one parameter. There are some other factors that we have to look at we are not really looking at the full economic detail of this thing in any great detail we are just looking at some broad idea here.

So, there are other some corrective factors we have to put to really compare GDP of different countries and so on. So, we are not really getting into that. But basically this represents some kind of development. So, whereas, previously let's say many people were unemployed, not much work was going on there is not much product being prepared here which was sold anywhere, there were not much services that we will, let's say we were producing and delivering let us say 30 years ago. So, at that point our GDP would have been low and then relative to that if you have now started producing much more delivering much more to the world, to ourselves to the world, you know more services more goods etc then our GDP has increased right. So, GDP in some ways therefore, represents its development of region because it means more money is coming into the region they producing something that people are buying they are getting income. So, they able to live better lives, live better lifestyles, so improved lifestyles as we would like to think.

So, GDP is an indication of how you know well off that region is, how developed that region is and so on. So, these are this is a parameter. So, generally if we say some development is happening GDP is growing up. So, every year they will calculate for the year, 2016, 2017 etcetera they will calculate. So, this is per capita GDP in Indian rupees. So, this is 90,000 rupees you can see here, this is 10,000 rupees down here. So, if you see as if you see the blue line here this is the GDP, the blue line represents the GDP here with respect to this data here. So, you can see that you know in around the year 1985 we had a

GDP of about 20,000. So, around the year 1985 our GDP was about 20,000 and then if you look at the year 2010 our GDP is about 80,000.

So, we are looking at you know 15 plus whatever 10, 25 years our GDP has gone up by a factor of 4. So, from 20,000 rupees per person it has gone up to 80,000 rupees per person. So, that is just to give you an idea of what this GDP is and that's happening. So, generally it has gone up you can see this blue curve it is steadily you know it starts out low and then it keeps going up. So, that is one aspect of it now on the other y axis that I have here in the same time scale is there on the x axis. So, the time scale is all at the same and this is data from the World Bank some data that's available which we have which I have taken and plotted here

So, if you see here on the other y axis that we have here is the per capita kilogram of oil. So, as I mentioned you know you can look at the energy that is being used by people and you can quantify it in different ways. So, typically the more scientific way of saying this is to put it in Joules, but you will find many data resources out there which are talking in terms of oil equivalent that is equivalent of that many barrels of oil that many kilograms of oil etcetera. So, that data is more readily available. So, for the moment I have just used that on this y axis. The in some ways the exact value of this is not very relevant to us the trend is more relevant to us. So, that's the point that I would like to indicate here that's what the aspect of this graph that I would like to highlight.

So, if you look at this brown line that is the per capita kg oil consumption in this is not I mean this is oil for energy, energy usage in terms of you know elective which is oil that is converted to say electricity, used to run automobiles everything. So, all of that energy consumption is what this are, this other y axis effectively represents energy, this y axis sort of represents development.

So, if you take this into account you will see that the oil consumption is also steadily going up. So, you see this steady increase of oil consumption and that goes up. So, that is the oil consumption behavior. You can see here even though there is some they don't exactly overlay each other you can see that the general trend of both is the same, both of them started off at distinctly lower values in the 80s and have steadily gone okay. So, therefore, this graph sort of highlights is this is one of the places where you can see this link between energy consumption on a per capita basis and GDP on a per capita basis.

So, the more energy we consume the more wealthy we become because we are using that energy we are not just wasting that energy. We using that energy to do something and therefore, that link is beginning to show up. And in fact, even though you see you know some variation out here and maybe some variation out here actually when you get to this kind of a region you know past say the year 2000 or something they start lining up much much closer to each other because we are sort of liberalized our economy we don't have any artificial controls for the most part and then you start seeing the linkage much much better. So, that is something that you will see. And so this is what is seen and this is not unique to India this is true anywhere around the world for the most part you will see this anywhere around the world I have just picked up data which I could find for India so that we can relate to it better and I have put it up here for comparison.

So, in summary this graph that we see here show's us that there is reasonably good link between improving GDP of a region which means development of the region and the consumption of energy in that region okay. So, that is the point of this graph. So, we will revisit this graph as necessary, but for the moment that's the message of this graph and we will look at what else we have here.

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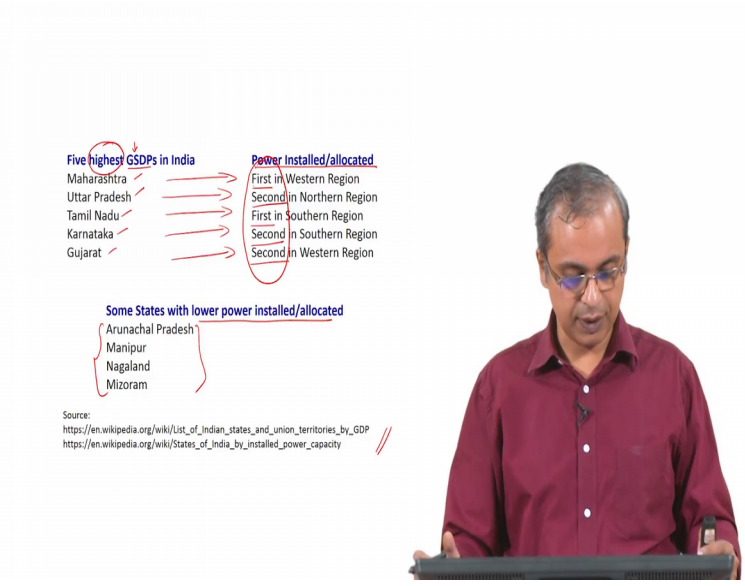

So, that was data for the whole country. Just to emphasize this idea little bit more if you look at the states Indian states and you look at the, so I have got here the five highest

GSDPs which with the S simply stands for the state. So, goes gross state domestic product.

So, if basically we are distributing this now amongst the various states each state is doing something. So, that contributes to the whole country. So, now, we have split it up between states just to understand what's happening here and you take the five highest GSDPs in India. So, this means these are the 5 states which are producing the most products and services and goods in the country okay. And therefore, presumably are the more developed states relatively the more developed states. Obviously, you can look at the states and say maybe they can develop even more that those issues are always there and that kind of a discussion is always possible, but still these are the most developed states in the amongst the most developed states in the country. So, we have Maharashtra, we have Uttar Pradesh, we have Tamilnadu, Karnataka and Gujarat. So, these are the states that we find which seem to have the higher levels of you know contribution to the GDP of the country.

If you now look across here and look at the power associated with these states in terms of installs or allocated power. So, this is power capacity that is been installed in that state or allocated to the state because the state is using that power okay and then you look at what it is relative to other states in that region. You find for its example Maharashtra is the first in the western region, if you sort of distribute this as western southern you know eastern and northern Maharashtra is the first in the western region, Uttar Pradesh is second in the northern region, Tamilnadu is first in the southern region, Karnataka is second in the southern region and Gujarat is second in the western region.

So, you see very distinctly this relationship these are all the highest GDPs highest contributors to the India's GDP and they are all here first second, first second, first second that's what you see right. So, there is you can clearly see here that you know these states which are if you saw the overall graph for India, but if you get into the detail of what how things are happening within India you can clearly see that the states which seem to have the higher GDP associated with them or higher contribution of to GDP associated with them are also the ones that are consuming more power in in their respective regions, the most amount of power in the respective regions.

Now, if you look at in the same context if you also look at the states that have very little power that is being allocated to them or being used by them you will find that those states are the following Arunachal Pradesh, Manipur, Nagaland, Mizoram these are the places where relatively less power is being utilized. So, the reasons could be very complex there many reasons why this may be happening, but clearly these are places that we generally look at as a nation and feel you know more development should occur here. We should be focusing more resources into these states so that they develop and come up on par with the other states. There is so much scope for development there.

So, and as you can see that you know that that idea that is there in our mind that you know these are places which could really you know get some assistance and get an opportunity to develop much more, are also the states which are actually at the moment consuming a lot less power. So, clearly this data that you see in front of you of the states that are seemingly doing better with respect to development and the states that are seemingly requiring more assistance to do development as they; have as of today are also you know reasonably aligned in similar manner with respect to the energy usage.

So, if you stake India as a whole over the last several years as well as the state wise distribution this information really stands out that a development is intricately related to energy usage. So, that is the point that I wanted to highlight. And again this is the source of the data you can go and look up this data in greater detail. So, I have just taken specific aspects of the data available at these sites in all the classes that we are seeing in specific I site the resources, I take the data that is relevant to what we are discussing and I am presenting that here. So, you can see that link and if you want you can go to these sites and get much more detail about all the different states and what you know what is the kind of power that they are using.

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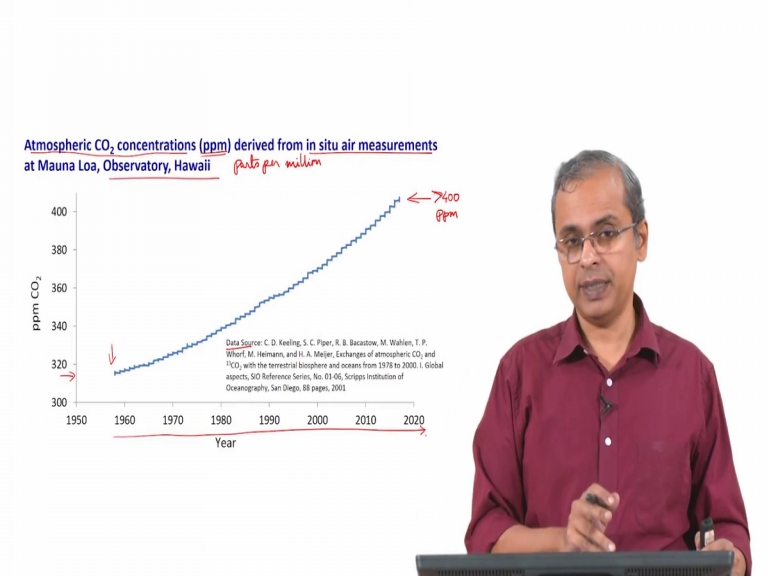

Okay so that is about energy usage and how that is linked to development or how development is related to energy usage. So, that is one aspect of our discussion for today just please keep that in mind we will come back to it and in short order.

Now, we will look at something else. We spoke about a in an earlier class the idea that you know as you keep consuming energy if you don't make any changes to the source of energy, this course is about non conventional sources of energy right. So, clearly there are some conventional sources of energy and that's what we discussed in some of our earlier classes. So, if we don't change the source of our energy which is mostly carbon based sources then as time progresses we will keep on adding more CO_2 to the atmosphere right. So, this is a general idea that we saw numbers to convince ourselves that this is a reasonable idea it is not a figment of our imagination, it is a very reasonable idea to understand and accept that if you keep consuming energy and if you in the manner that we are currently doing so, and if the source of energy is the same if you take these two parameters together then it is inevitable that CO_2 in the atmosphere will keep climbing up on top of this if you cut trees it makes it even worse.

So, this part we had as a general concept in our mind and we also did some calculations with respect to that. And we saw that you know in a very short period of time we could be doubling the amount of CO_2 in the atmosphere and that short period of time is just our lifetime. So, that is the strong message that we had at that point now we look at some

data. So, this data is actually based on atmospheric CO_2 concentration, in parts per million ppm is parts per million. Okay so, this is derived from in situ air measurements from an observatory in Hawaii. So, they take measurements of the air and they look at the CO_2 concentration in air. Now, this is a measurement that is been going on from sometime in the 1950s. So, sometime in the 1950s onwards this is been going on and they have systematically collected data.

So, sometimes you know wonder about this long term data collection and you know what is the purpose of it they keep on recording rainfall they record temperatures they record so many different things, but it is so useful only when you look at data in this time scale you know when you look at you know see 60 years of data 100 years of data and so on. Then you begin to see patterns which would be very difficult for you to see on a day to day basis it is should very difficult to for you to see on a week to week basis or a month to month basis only when you spread it across 50-60 years you begin to see a trend.

So, for example, in this graph you see a trend where we are you know sitting at about around you know 315 ppm parts per million somewhere in the mid nine mid to later 1950s and then we are now just past 400 ppm. So, this is greater than 400 ppm. So, we have steadily moved from something that was around 315 ppm to something that is 400 ppm. So, you know that is already you have added about 80 plus ppm right. So, we have about one-third more we have added or little of that order or one-fourth at least we have added more. So, we have seen a increase of carbon dioxide by a reasonable factor which is you know 25 percent of what was already there the increase itself is of that order. So, this is the data source they have been compiling this for many many many years and you can see this up look this up if you wish. So, it has gone up to greater than fourth of 400 ppm in this timeframe okay.

So, this idea that carbon dioxide in the atmosphere is increasing is not a myth it is not something imagined it is definitely happening there is scientific data from various sources which confirms that there is steady increase in carbon dioxide content. Now, this is a measurement that was made in the atmosphere from somewhere in the 1950s still you know it is ongoing measurement. So, you have most recent data also available here.

You will see some variation through each year you will see some slight variations as it goes by, but overall the trend is always up. So, trend has been steadily up and if you look

at you know industrial level revolution everything we are all looking at you know into the you know 20th century. So, this sort of fits the idea that we are consuming more and more fuel and we are consuming more and more energy and steadily the amount of CO_2 is going up. But this is data that as I said you know is about 60 years timeframe and it is interesting to step back and see in perspective what is the perspective of this data because this is just data of this time scale we will see the perspective of it. The perspective is simply what you see here in the first two lines here that data which we saw in the previous plot is from air measurements right. So, that started only in the sometime in the 1950s and from there they have been doing this measurement which is what you see in this plot. But there is a way in which they can figure out how much CO_2 was there in the atmosphere much before this when nobody was making those measurements, that is actually done in an interesting way.

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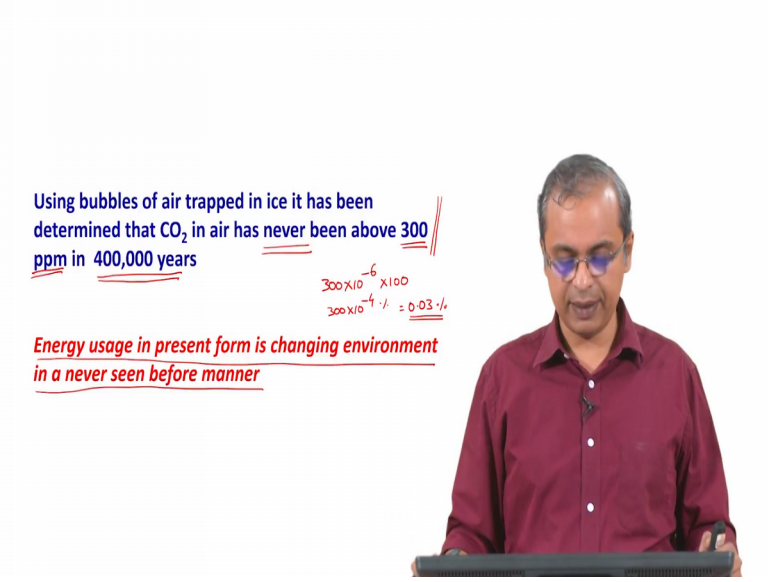

The drill you know ice core samples in places like you know say some places which are undisturbed places say in Alaska or Antarctica or some places like that where you have layers and layers and layers of ice over 1000s of years. So, when they drill that core you can actually see in that core bubbles of air that were trapped in that ice core which were which was the air that was present when that ice was formed okay. So, you in these cold places layers of ice keep on building and therefore, this whatever air was there gets trapped, but it doesn't melt enough to escape it just stays there next layer of ice comes next layer of air gets trapped and so on. So, they have been. So, the air has been trapped

in ice for 1000s of years 100s of 1000s of years. So, when they drill a core which is basically you know like a tubular structure a tubular set of ice, I mean a tubular collection of ice they will just drill all the way in and they will pull out this tube of ice long tube of ice they will get and then they can take thin sections of that tube of ice and analyze it for a how much air is present there and what is the composition of that air.

So, when they do that they can accurately tell you how much CO_2 was present in the air 1000 years ago, how much CO_2 was present in the air 5000 years ago etcetera when none of us were ever there to make measurements right no measurement was there nobody was recording anything etcetera. It is data that has been sitting trapped in the ice that we are now able to measure and we have the scientific understanding to say that this is dated on this year this is dated on some other year and something like that.

So, it is very fascinating to know that by looking at the ice and then looking at the air trapped in the ice and the composition of that air you can go back for 400,000 years this is 50 years is nothing 400,000 years of data is available as actual hard data not some imagined data, actual hard data where measurement has been made in a rigorous scientific manner with samples that are available even now you can go look at the sample and you know make the measurement. So, 400,000 years of data is there on composition of air. And the most fascinating thing and strong point that stands out when they look at this data is that in 400,000 years of the existence of earth never ever has the amount of CO_2 in the air been over 300 ppm okay.

Never ever in the last 400,000 years never ever before has the amount of CO_2 in the air been more than 300 ppm, 300 ppm is 300 into 10 power minus 6 parts and so this is in percentage. So, this is into 100. So, this is basically 300 into 10 power minus 4 percent this is 0.03 percent right yeah. So, 1 2 3 4 5 yeah, you will get 0.03 percent. We calculated 0.04 we saw that our you know current atmospheric percentage of carbon dioxide is 0.04 percent, but basically we see that the percentage of CO_2 present in the air was never more than 0.03 percent in 400,000 years of the history of the planet and if you look at this data here, we are now at 0.04 percent.

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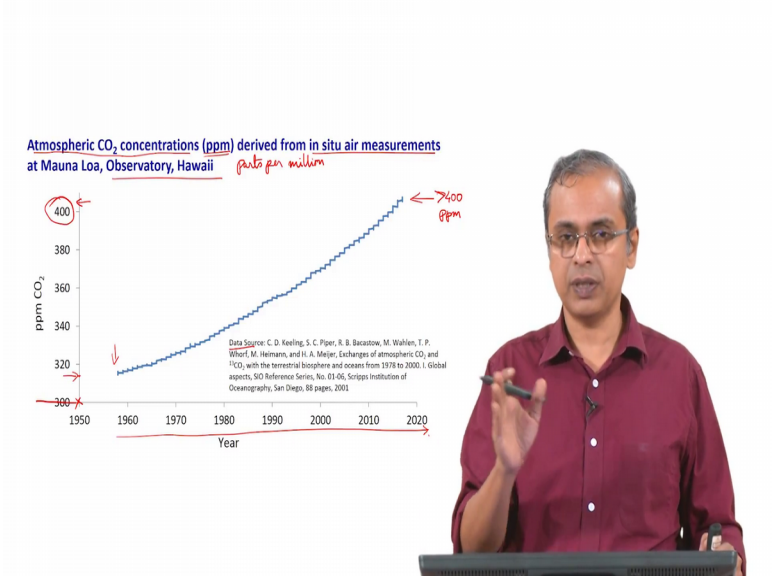

In the 1950s we had already crossed 0.03 percent, 0.03 percent is here 0.03 percent is here. So, for 400,000 years we never crossed this point in this axis we never crossed this point in this axis for 400,000 years. And now we have already come here in 1950s and now in year 2000 as we approach year 2020 we have crossed 0.04 percent right.

So, we have done something in this you know 50 odd years that has never happened before in this planet for 400,000 years. So, that is a phenomenal change it is not something minor at all by any means of imagination something that the planet did not do for 400,000 years we have done to the planet in the space of 50 60 years. And it is something that we are you know it is around us we are breathing this air we are doing everything in this air it is there in our air. So, that is a phenomenal thing that we have done in terms of the impact it is not a positive thing we have done, but it is a you know significant thing that we have done significant change we have done to the environment which has not been done by nature in 400,000 years.

So, that's the point that we have to keep in mind. So, that's what I am highlighting here energy usage in the present form its changing environment in a manner that has never been seen before. So, it's never been seen before the environment has never seen these conditions before. So, we are creating a new set of conditions in this planet which this planet has not experienced to our knowledge okay. So, maybe in the early formation of the planet the conditions might have been something different, but ever since these

400,000 years you know that's almost half a million years that we are looking at that we had you know even before our ancestors showed up here this 200,000 years ago that our homosapien kind of people started showing up twice that timeframe nothing of this nature has happened that we are doing in this current generation. So, it is not something to be taken lightly if you understand what the consequences of it cannot be taken as something that is you know can be ignored and looked everywhere

It's not just CO_2 that we are worried about CO_2 is just one parameter in the air. So, what if the CO_2 is 0.04 percent that is the I think that is a fair question to ask. So, what, so what if it is 0.04, 005 why does that matter.

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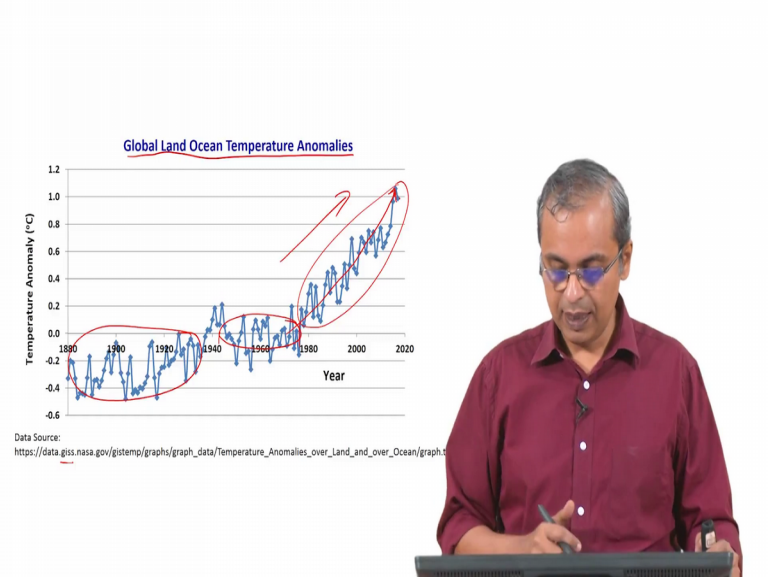

Well it matters like this it is got to do with the fact that the amount of CO_2 present in the air seems to be very closely linked to the temperature of the land and ocean. So, so there is a record of this you can see this is from the Goddard institute which is a NASA based institute and they have a global land and ocean temperature anomaly record.

Okay so, what is this, what is an anomaly? Anomaly means, that is some variation some change from normal some change from normal. So, to do this they treat this data between 1950 and 1980 as some kind of a 0. So, they treat that as 0 and temperatures above that are given positive value as a positive anomaly and a negative anomaly okay. So, if it is colder it is marked as a negative anomaly if it is a hotter, it is marked as a positive anomaly. So, if you see here past that time frame that temperature has only been going

up okay, this is unendingly going up there is no there are just cyclic variations within you know a small deviation within the year kind of, but the general trend has always been up.

So, there is also scientific reason to believe that if you have more CO_2 in the air then the heat that comes in from the sun comes with certain you know wavelengths and then when it's reflected back from the earth it goes back and slightly different wavelengths and then when it is absorbed and rereleased and then it comes off comes back from the earth it is at a slightly different wavelength. And CO_2 has a way of capturing that energy and therefore, that energy is not leaving the planet, as effectively as it would if you had less CO_2 present in the atmosphere. So, that understanding is there independent of any other discussion in this context.

So, we do see that in the last several years CO_2 has been going up, in more particularly we it is going up to levels that have never been seen before by this planet and on top of it in last few years the temperature has been going up again in a manner that has never been seen before its steadily climbing up in that is relative to what has been around for a quite some time okay.

So, there is a strong reason to believe that the amount of CO_2 that is present in the atmosphere is affecting the temperature of this is a land and ocean temperature together. In fact, this is a bit of an average what you are seeing on your screen the land temperatures are actually higher the increase on the land temperature side is actually higher on the ocean side it is a bit lower the average is what you are seeing here. So, this is for the planet as a whole. So, this is anomalies, but that is just as I said the anomalies that are there since 1880. So, you can even see here from 1880 whatever records that are there if you look at all the records that are there since 1880. Clearly we are all holding temperatures in this reach regime which are all higher than what was held about a 100 years ago right.

So, continuously it is higher see always there are likely to be fluctuations maybe weather patterns change there are some fluctuation you can always argue about that and that may very well be true. But when you see year upon year year upon year year upon year over several years the trend is only upwards, average trend is upwards then there is some reason for concern and that trend is very visible here. You see nothing like this before out

here and steadily you see a trend up out here right. So so, that trend cannot be ignored. So, that is the point that we have to become aware of become alert to.

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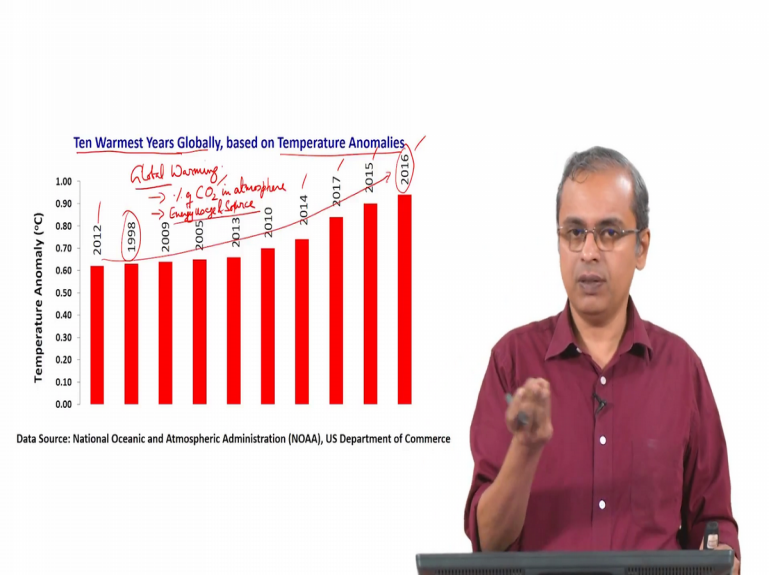

So, if you would, in fact, that is just data across from 1880 to almost you now 2020 right So, we are looking at about close to 140 years of data roughly we are approaching there. But if you look at the data another striking thing stands out which is sort of visible here the fact that these are the higher temperatures on our right hand side of our graph, but if you actually take let's say the 10 warmest years globally based on temperature anomalies, the 10 warmest years faced by this planet for all the data that we have available those 10 years are all there since 1980; 1908 and 2016 was actually the warmest so far. And in fact, you can see the most recent years here 2012, 2013, 2014, 2015, 2016, 2017.

All these years are here. So, the last 5 6 years have been amongst the warmest years seen by this planet in 140 years. So, that's again you know these are all data that we cannot just look away from we cannot just you know ignore and say oh forget about it all this there is no real truth to it the trend. The way in which this data shows up is just too strong and too clear to you know avoid, so that is the point that this data makes that you will see this trend okay.

So, you can see that you know this increasing temperature is there of course, this is across slightly different years, but still that the fact that they are all there in the last 10

years. So, now, this is what we are referring to both what you see in this graph and what you see here these two are what we are basically referring to as global warming.

So global warming is what these two pieces of data are indicating. And this is intricately related to the percentage of CO_2 present which is related to the way in which we use our energy. So, energy usage and source okay, all of those things right, global warming percentage of CO_2 and energy usage and source the source of energy. If you take all of those into account we see a picture that we need to be alarmed about that we need to do something about it now. So, what if there is global warming, these are all the questions that we need to understand, so what if there is energy usage who cares CO_2 goes up, so what if CO_2 goes up temperature goes up, so what if temperature goes up well if temperature goes up global warming happens then the entire weather system on the planet begins to behave differently.

Actually it has a lot of impact on a wide range of things. So, if you want more details there is a documentary on this which is very interesting to see it is called an inconvenient truth. So, if you get a chance an opportunity you please see, it's called an inconvenient truth which shows you this data in much more detail and with a lot of more examples which you can look at and I will provide you a link in the I mean I already some little bit more information about it in the course, but basically its it gives this detail all this discussion much greater detail. But basically you see that one of the major impacts of global warming is that the weather patterns of the world become very different.

Generally it seems to indicate that the weather pattern becomes more severe okay. So, what is happening is generally the winters are becoming worse winters, summers are becoming worse summers, the rainfall is becoming worse rainfall. So, in the sense that the severe storms are there severe drought is there, severe rainfall is there severe, snowfall is there everything is becoming severe. So, that seems to be the trend because if you look at the number of storms that are coming the ferocity of the storms the droughts that are happening you will find that that's generally true, if you compare it with all the data that is available for the say the last 100 years that this is generally happening. So, it in that sense we see it's an impact that is coming back to us it is not a hypothetical impact that is there somewhere else this is an impact that is coming back to us.

Now, if you look at the in the context of this course that is the reason why we are looking at non conventional sources of energy because we would like to, we appreciate the fact that people would like to develop we appreciate the fact that people therefore, need sources of energy. So, we have to contribute as scientists looking at non conventional sources of energy we also have to contribute as a population by using non conventional sources of energy. So, if you can use the solar panel, if you can do something with some other form of energy which helps you conceive I mean provides at this part of the energy that you are using then it is in a way you are contributing to helping the planet have a better situation which helps not just the planet it helps you it helps your children it helps generations down the road right.

The way we are currently using energy and the current impact that it has will create a highly unsustainable situation even 100 years down the road. So, our own you know say grandchildren would have great difficulty on the planet because of situation which we can control at this point in time or at least we can do something to control at this point of time, but we may be looking the other way you may not be doing enough to stop it. So, if you look at it internationally you will find that especially in nations such as the United States where the per capita consumption of energy is very high we know that you know say China, United States, India and may a few other countries are consuming a lot of energy that we saw, but particularly the per capita consumption is high in United States.

So, there is great reluctance to do anything to cut down this energy consumption because they are comfortable with a certain lifestyle and certainly it is not politically a popular decision. So, at least some of their leaders do not like to mention global warming, they would like to actually pretend that there is no global warming and they would like to pretend that you know there is all the data is not necessarily correct. But the problem with that kind of approach is that it is an assumption on their part that if you don't look at the issue the issue will somehow go away, if you don't you know discuss about the issue if you don't address the issue the issue will somehow go away.

Now, in a in a strange sort of way this is true. So, in the sense that if you do n't do anything about global warming in a strange sort of a way it will go away and the reason I will explain is as simple as this. In some fundamental sense we have to accept the fact that a mankind is not it is not really a match to the overall you know capacity of nature, specifically because we are part of nature it has got nothing to do with you know relative

power and whatnot we are part of nature. So, we cannot do something to nature without it coming back and affecting us directly it is not that nature is separate you can do something and it will somehow adjust we will somehow adjust and then we will live out our lives it doesn't happen that way we are very much a part of nature. So, what we do if it damages nature it comes back and hit hits us.

So, in many ways global warming is a problem that will be solved. So, it will get solved there is no question about it. The only question is will it be solved on our terms under our control or will it be solved on natures terms under natures control. Right now by avoiding doing anything when some of the political leaders avoid doing anything and they just say you know let's not make new cars, let's not worry about making cleaner cars, let's not worry about energy efficiency, we will do whatever we want, let's not change our factories if once you take that path they are basically pushing the planet to a point where nature will take its own action to solve this problem.

What do I mean by this when you look step back and see that global warming results in severe storms, severe droughts, severe flooding, severe snowfall there is a direct consequence of these events if you read the recent news and wherever in any city you see a massive you know rainfall or flood or whatever that happens big cities have been completely shut down. So, London has been shut down, Mumbai has been shut down, New Orleans has been shut down many major cities around the world have been shut down simply because of a massive flood that comes massive snowfall comes it shuts down a city.

So, what happens when you shut down a city? Everything in the city comes to a halt, there is no industrial production nothing nobody talks of jobs at that point nobody talks of how many cars came out of the factory at that point everything stops nobody can go anywhere the entire city comes to a halt. So, indirectly for that period of time for that 1 week or 10 days that the city is shut down the greenhouse emissions from the city are killed right more or less you are shutting down the greenhouse emissions of that city and therefore, nature is finding a way to stop us right. So, we have never maybe thought of it in that way, but that's exactly what is happening nature finds a way to stop us it hits back in a way that we are not able to handle because we are part of nature and we are you know we are trying to do something that we are in a very ignorant sort of way. So, it

comes back and shuts us down. So, when cities get shut down clearly whatever they are contributing to global warming shuts down, comes down.

So, if we ignore the problem and we don't do something to slowly gently no stop the CO_2 production control the CO_2. So, that you know the nature can we can live in harmony with nature we will push the nature to the point that nature will shut us down therefore, CO_2 will come down therefore, global warming will come down. But this is not something that is going to be pleasant if we allow we push it to the point that nature has to force us to stop, it is much more pleasant and much more sensible much more responsible if we do it in a manner that we control what we are doing right. So, therefore, it is very important that we look at non conventional sources of energy, it is very important that we incorporate these non conventional sources of energy in our lifestyles.

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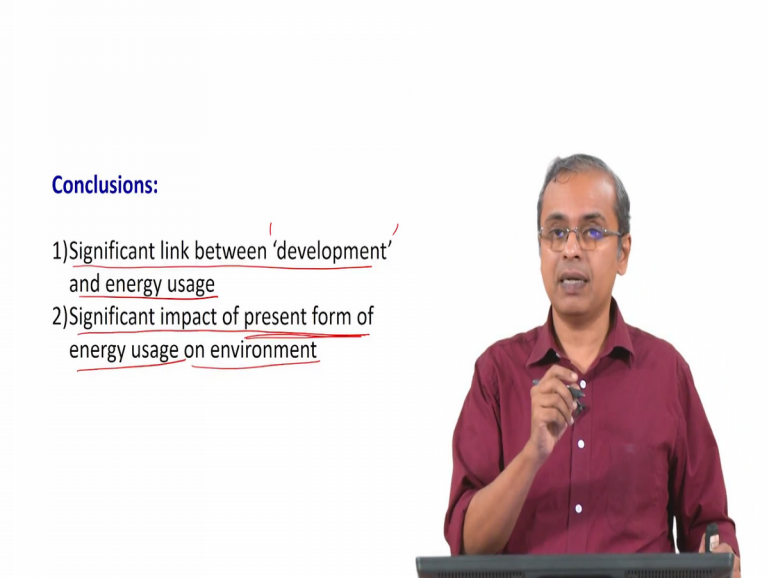

So, in conclusion what we have seen in this class is that there is a very significant link between development what we consider as development and energy usage. We saw very clearly that Indian GDP has been steadily climbing Indian energy consumption is has been steady declining. We also saw very clearly that the states that are seemingly the more developed states are which are which seem to be contributing more to India's GDP are also amongst the largest consumers of energy in our country. So, this link although I highlighted it in the Indian context is true internationally and generally better GDP means higher energy consumption.

The second thing that we saw is the there is a very significant impact of the present form that's the most important thing you should remember of the present form of energy usage on the environment. It is not that energy usage is bad you can go bicycling all you want that is also energy usage you are using your energy to transport yourself all around the place that is not contributing to global warming in anyway, I mean or at least not in not in any manner comparable to what would happen if you took you know a diesel powered vehicle and drove all around the place right. So, consuming energy is not the problem, consuming energy in the present form is the problem right. So, that is a very important message that we have to keep in mind.

So, even when you know even when political establishments anywhere internationally say oh jobs will be lost in a fundamental sense that is wrong no job is lost if you stop producing a polluting car and replace it by producing a clean car right. So, nothing is lost there you are just producing a different car. Just then the mindset should be there that instead of producing the polluting car we will produce the clean car. So, that is the mindset. So, we have to have policies that force companies to stop producing the polluting car and start producing the clean car that's all it is. It does not mean that a job is lost that it does not mean people are going to live you know without any livelihood and all, but that leadership is necessary to make that decision.

So, the present form of energy usage has a very significant impact on the environment. A significant impact is an understatement because it's an impact that that is making changes that were not present for 400,000 years in this planet right. So, it is creating situations in the planet that is sort of unseen in this planet in you know such a long period in time.

So, these are two major points that we have to keep in mind which further emphasize our need and our necessity to focus on non conventional sources of energy and to see to what degree we can increase the usage of non conventional sources of energy in our lifestyles. We saw already in our earlier classes that it is already there to differing degrees and that as you, but the still the percentage is small. It is also important to remember that you know if you look at biogas as a non conventional source of energy that is not particularly helpful because you are simply taking one carbon source which is fossil fuel and replacing it by another carbon source which is carbon that you have grown in your backyard. So, that is not particularly a very useful way to do it. So, you have to sort of go

away from carbon as a fuel you have to go away from a process where producing carbon dioxide is part of your you know energy production process. So, carbon dioxide production must stop in as a matter of routine, right now as matter of routine we are producing carbon dioxide for our energy.

So, if you say non conventional and start using things like you know a vegetable waste, and know things like that burning those kinds of things to generate energy that is not useful, we really have to look at non conventional sources of energy that are also clean only then we make a difference okay. So, those are some points that we need to look at and, these are the major conclusions of our class today.

So, with this kind of a background we will begin looking at specific forms of energy that we can utilize, which are there abundantly we have just not looked in those directions we need to start use utilizing them and benefiting from them.

Thank you.

KEYWORDS:

Consequences of Energy Consumption; GDP of India; Per Capita Kilogram of Oil; Energy consumption on a per capita basis; GDP on a per capita basis; Gross State Domestic Product; Atmospheric CO_2 concentration; In situ Air measurements; Increase in CO_2 content; Ice Core Samples; Anomalies; Global Warming

LECTURE:

An alarming impact of the present form of energy usage and it’s significant effect on the environment is discussed in this lecture. An impact that is making changes that were not present for 400,000 years in this planet. The consequences of such changes and possible solutions are discussed.