INDIAN INSTITUTE OF TECHNOLOGY MADRAS

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NPTEL ONLINE CERTIFICATION COURSES

ECOLOGY AND ENVIRONMENT

Module on

Energy & Environment

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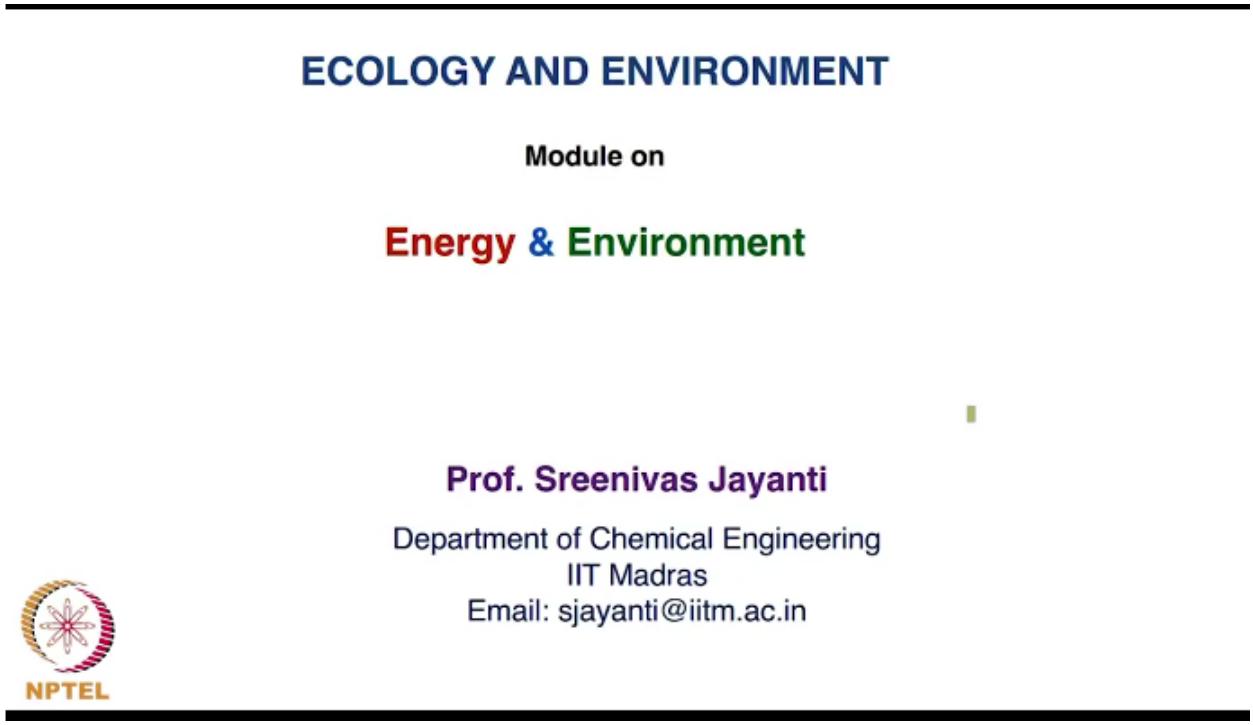
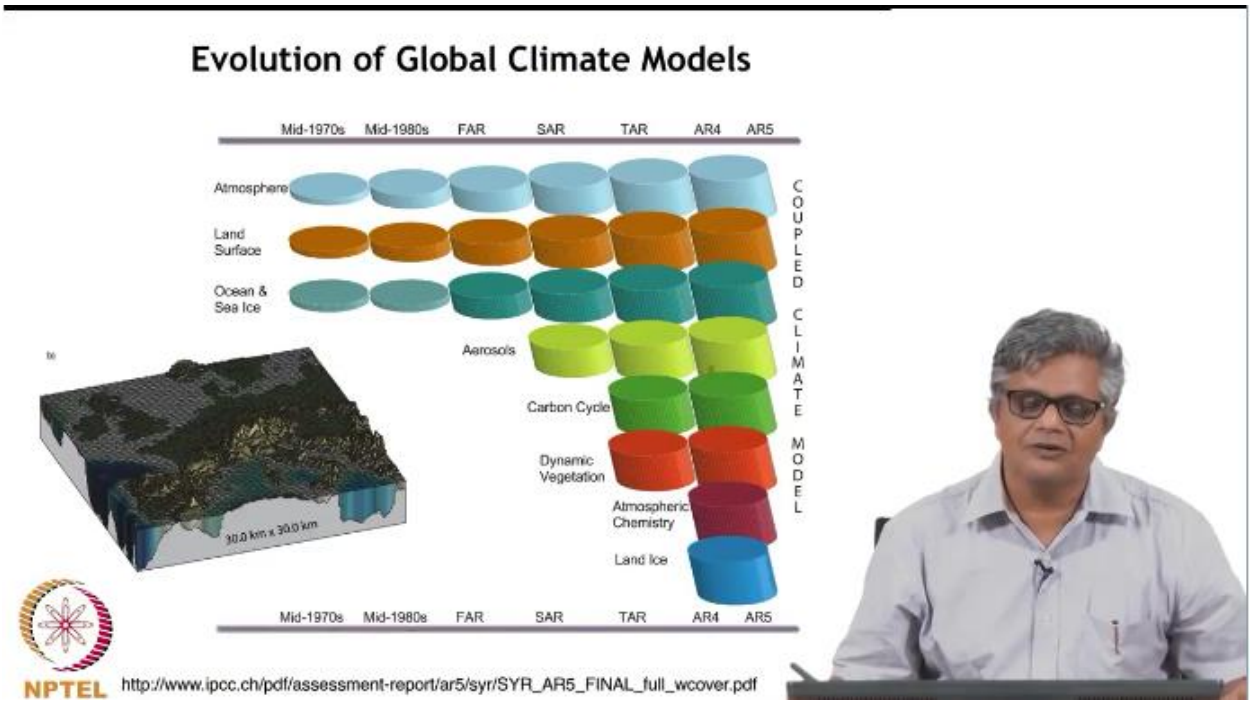
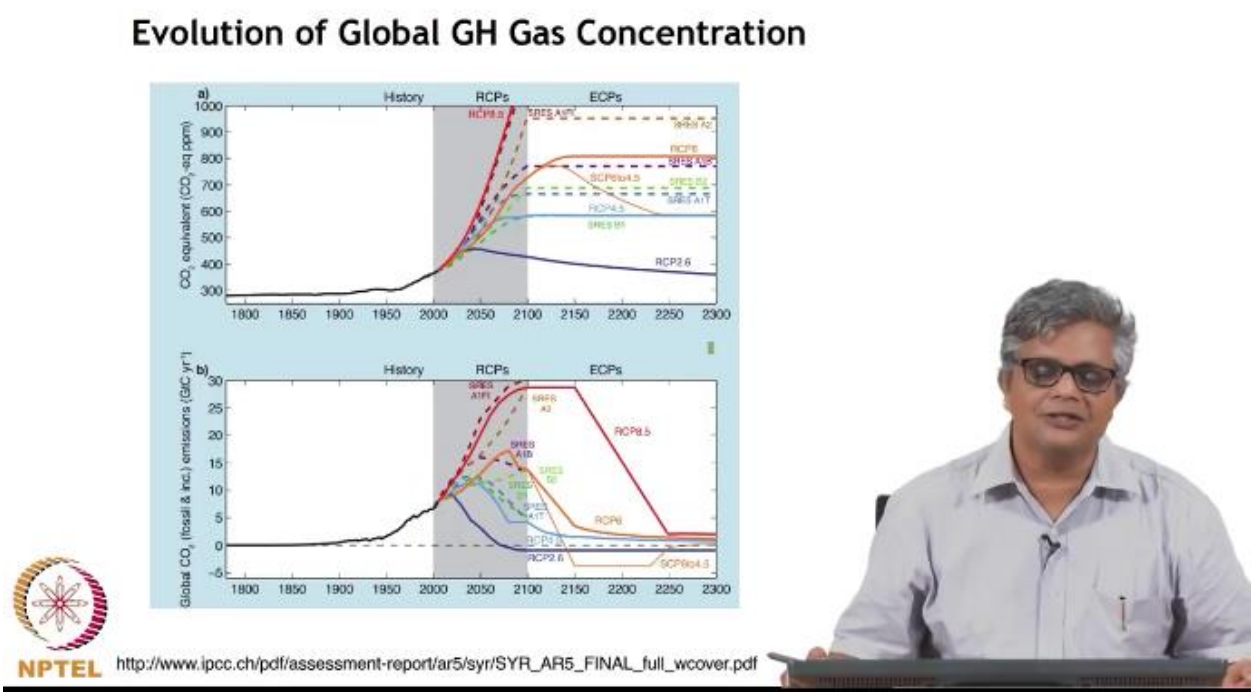


Okay, welcome to the last lecture on this module on Energy and Environment which is part of the Ecology and Environment course. My name is Sreenivas Jayanthi. I am from the Department of Chemical Engineering at IIT Madras. I have my email address given here sjayanthi@iitm.ac.in, in case you have any queries.



In our last lecture, we looked at global climate models which have become increasingly complex to treat a number of factors which influence the the global warming as a as a phenomenon, including the interactions between the atmosphere, the land, the sea, the deep oceans and components of the atmosphere like aerosols, clouds, and all these things.

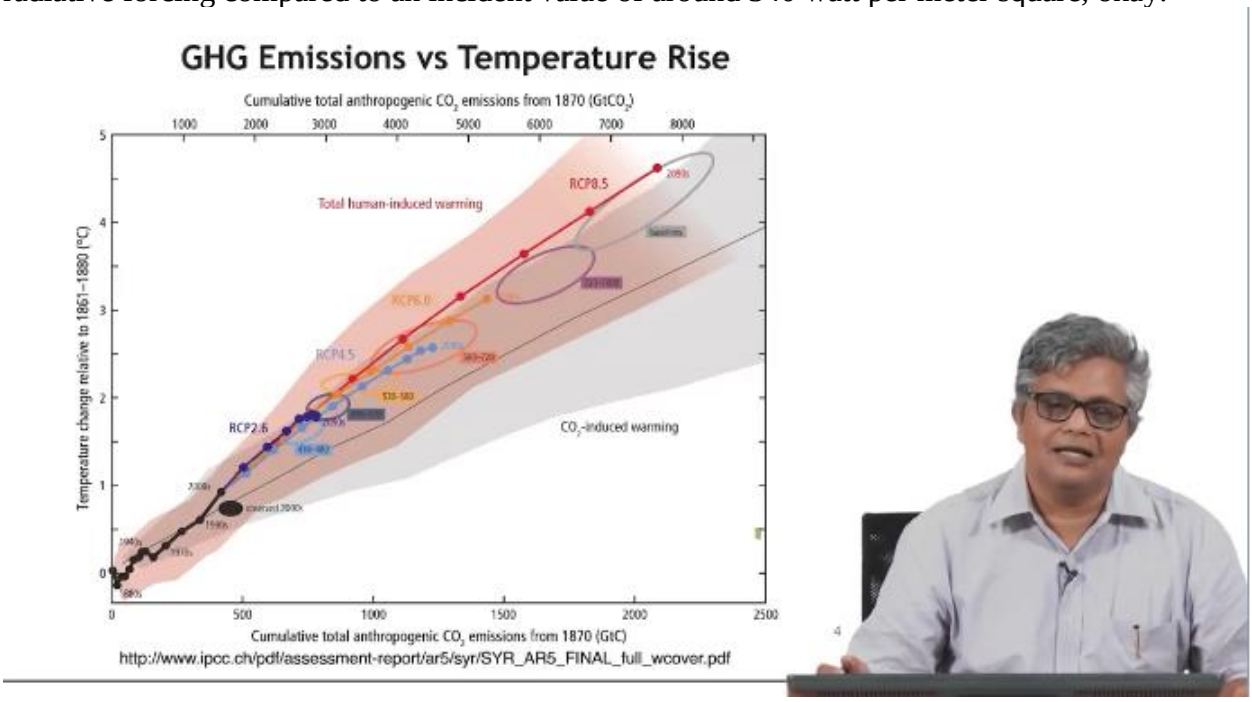


And have made predictions of the evolution of the greenhouse gas concentration and emissions over the past several 100 years. And including into the future going for another 200, 300 years, and all of them, many of them pointed out that the current rate of emission of fossil fuel related

carbon dioxide and other GHG gas emissions is such that it has been increasing over the past 50 years at a much higher rate than what it has been for the past several centuries.

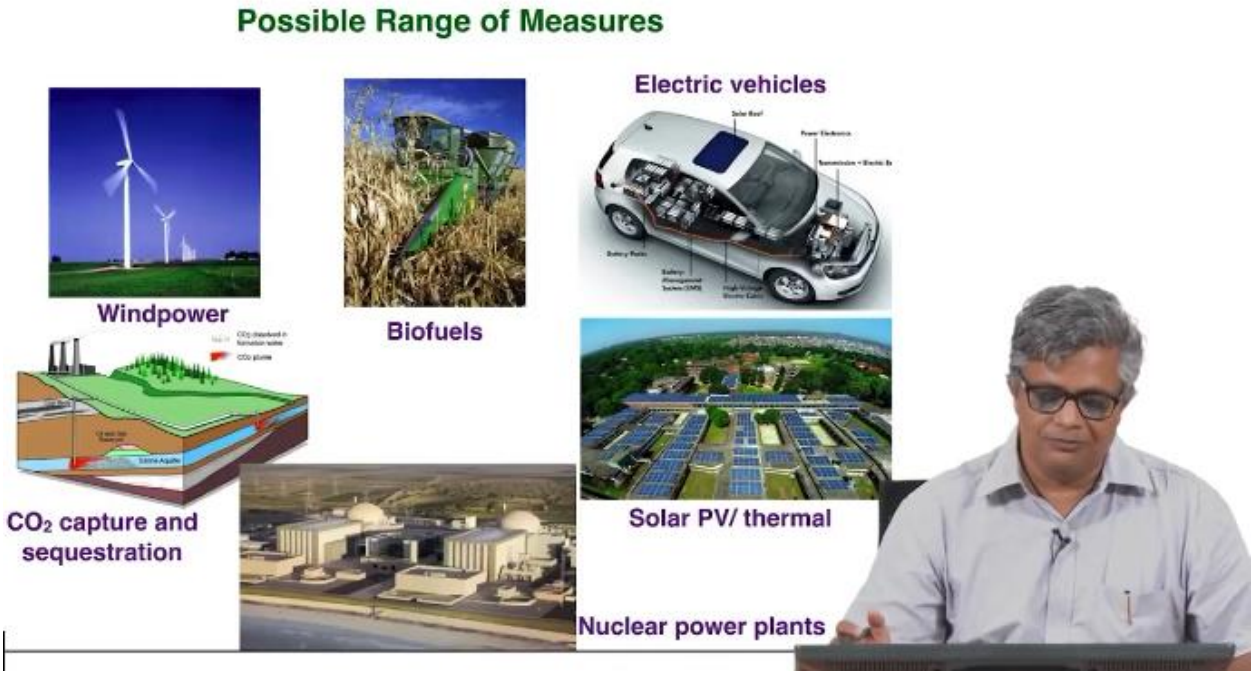
And since this trend is expected to continue because of a number of socio-economic factors related to energy use, it is expected to continue to increase. And that if we allow it to increase like this, then you can have trebling of carbon dioxide concentration within the next 100 years. And that if you wanted to reduce the carbon dioxide concentration then there can be number of pathways and if we are able to curtail the emissions to just about slightly higher than current levels by about 2020 and then go down at carbon, reduced carbon path and down this negative carbon path then by the end of this 21st century, by the 2100 we could get down to a concentration of carbon dioxide which is steadily increasing and by 2300 we will get back to below 400 ppm level. So, if we were to cut down carbon dioxide emissions and go into negative carbon dioxide emission rates by the end of this century, and if you sustain it for a couple of centuries then by 2300 we will again go back to sub 400 ppm concentrations of carbon dioxide which is what was there, before the industrialization era.

But if we continue and go down by the end of 2150 that is in another 130 years, if we go to a decimated carbon dioxide concentration levels about tenth of what they are currently, in slightly more than a century then we will get into a path where we will have reached the carbon dioxide concentration of 550 ppm. And that will be maintained for another 200 years. So, even to maintain carbon dioxide concentration of not more than 600 ppm which is twice the pre-industrialized era level of carbon dioxide, even for that we have to go down to one-tenth of carbon dioxide emissions rates from anthropogenic sources as what they were in 2010. And if we delay this further and further as in RCP 6, and RCP 8.5 you can see the level of carbon dioxide going up to 1000 ppm or higher. And this imposes a fairly strong radiative forcing and RCP 8.5 means that 8.5 watt per meter square and RCP 2.6 means that 2.6 watt per meter square is the radiative forcing compared to an incident value of around 340 watt per meter square, okay.



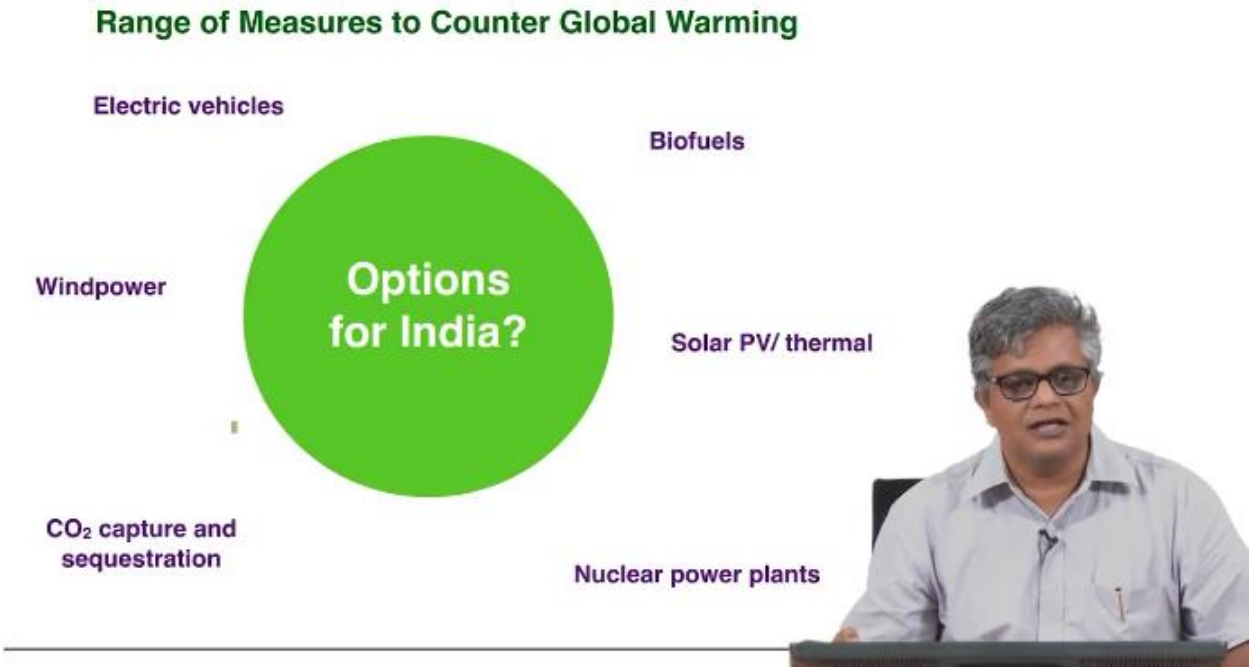
So, something like that can have a large effect on the global atmospheric temperature which is shown in this particular path. In this particular graph where we have on the X-axis, total anthropogenic carbon dioxide equivalent emissions since 1870 in terms of gigatons of carbon here and gigatons of carbon dioxide which is multiplied this value, gigatons of carbon multiplied by 44 by 12, okay, and this is accumulative amount from 1870. And what we have here on the Y-axis is the temperature change since the average of over 20 years around 1870, so, that is temperature average between 1861 to 1880, okay. So, now we can see that as of 2000 we are somewhere here, we have emitted a total of slightly less than 500 gigatons of carbon, and we have about 0.7 degrees centigrade temperature increase. If we go down the route of 2.6 radiative forcing so that is when we will have cut down and gone into negative carbon dioxide emission rates by the end of this century, then the total emissions would be about 800 gigatons of carbon and then increase would be about 1.5, 1.7 degrees centigrade.

And if we go into the higher level and reach this by 2090, we reach 1200 gigatons of carbon then the increase would be like 2.5 degree centigrade, and this is radiative forcing equivalent of 4.5. And RCP 6 is where we are looking at carbon dioxide concentration of around 600 ppm, and that would mean a temperature increase of close to 3 degrees. And carbon dioxide concentration leading to radiative forcing of 8.5 watt per meter square by 2090, that is close to the end of this century here, we would have reached a temperature increase of four and a half degree centigrade, okay.

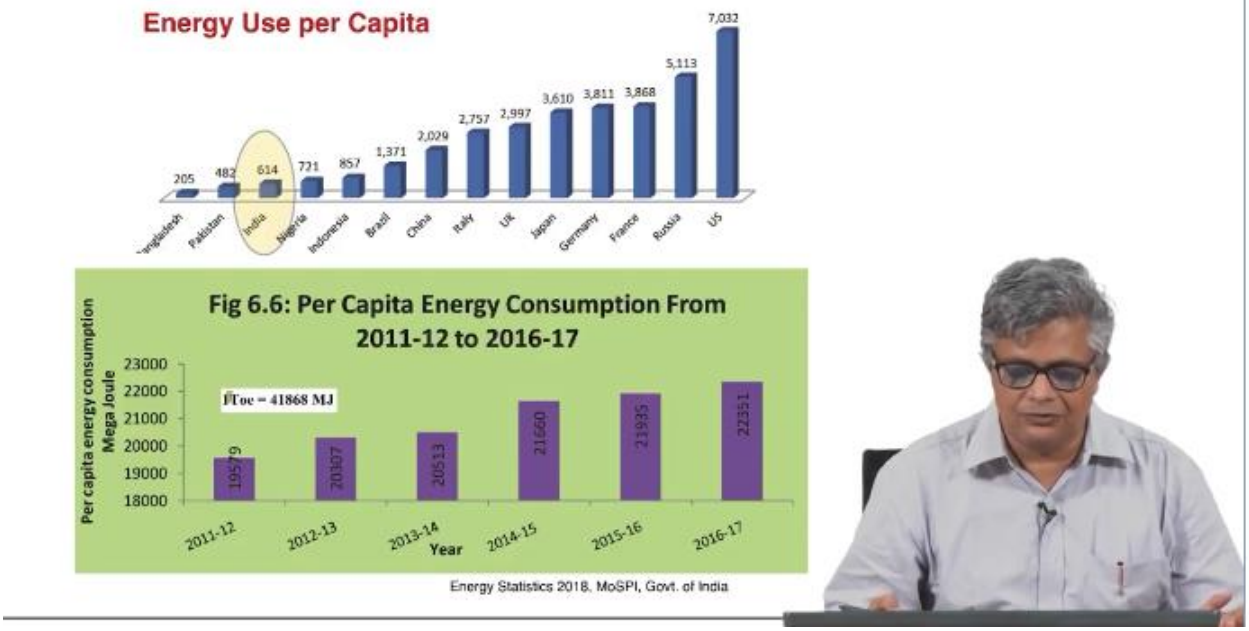


So, these are the kind of temperature increases that could be happening, and many of these are related to anthropogenic sources. And so we have seen in the last lecture that number of ranges, number of measures are being contemplated to reduce the anthropogenic carbon dioxide concentration. Since many of the carbon dioxide concentration emissions are related to generation of electricity, people have been looking at wind power here and solar power here, and since a significant portion of GHG gas emission including methane, nitrous oxide is related. Transport sector, people are looking at electric vehicles and biofuels, and of course, nuclear

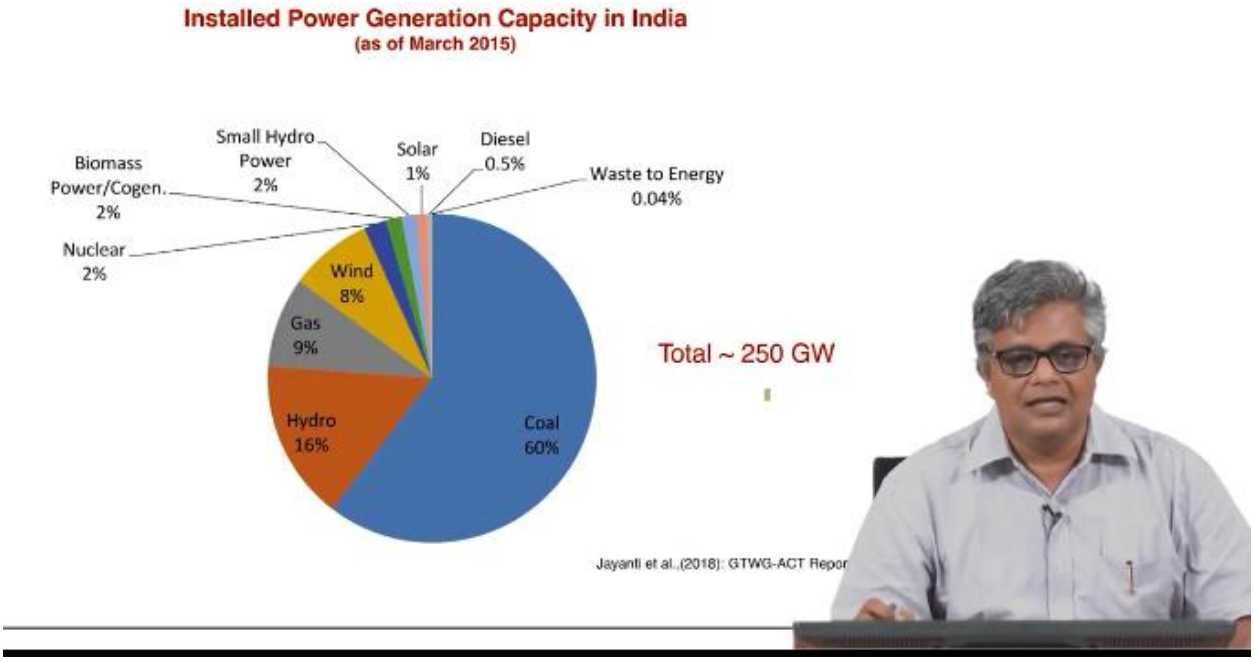
power is also a clean power generation from global warming point of view. And from all the industrial sources and continuing use of fossil fuels, people are looking at carbon dioxide capture in sequestration in geological sequestration as a primary means by which a significant amount of carbon dioxide emitted from this stationary emitters can be prevented sequestrated from getting into the atmosphere in a quick way, that is in 20 years times this technology could be ready and implemented, some form of this technology is already being used in enhanced all recovery type of petrochemical operations. And most of the infrastructure for making this carbon dioxide capture and sequestration is already in place at smaller scales in the petrochemical industry, and it is been under practice for 30, 40 years on a commercial scale. So, there is a possibility that something like this can be implemented. So, these are all the kind of measures that have been contemplated at global level.



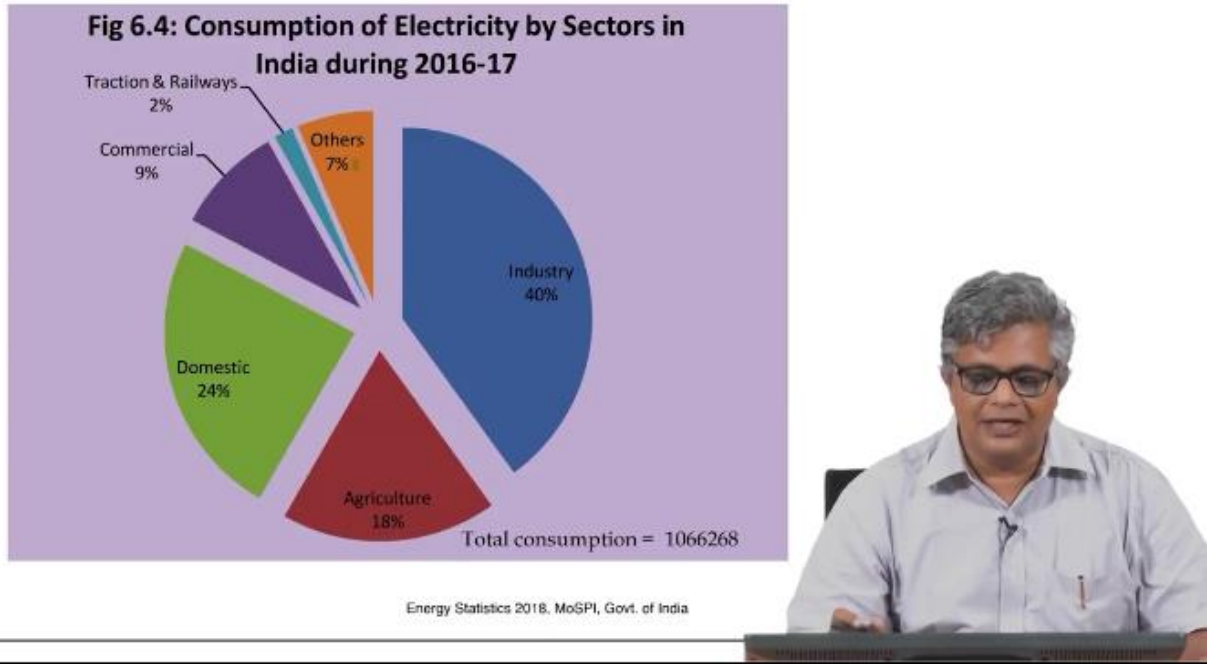
Now the question that we would like to ask in this lecture is what are the options that we have to counter global warming and to counter to preserve our environment in India. What are the options for India? Among do we have electric vehicles, biofuels, solar PV, wind power and nuclear power and other carbon dioxide capture mechanisms like biological sequestration in the form of afforestation and all those kind of things, different land use options. So, or all of them coming.



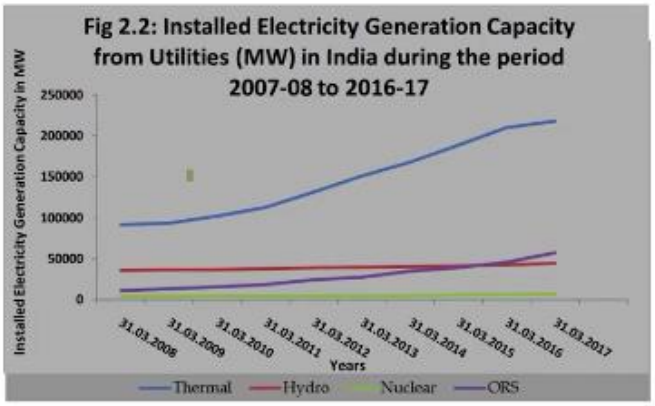
Let us take a quick look before we look at what options we have. Let us take a quick look at where we are currently with respect to India and energy usage. We have seen right in a very first lecture, are energy use per-capita is about one-third of the world average. And so we have quite a long way to go in terms of energy usage, and that is reflected in the per-capita energy consumption over the last five, six years. You can see that in 2011 and 2012 financial year it is about 20,000 megajoules and in 2016-17 it has risen up to 22.3 megajoules so it is been going on at a fairly steady pace and we also saw projections earlier that in previous lecture that this trend is expected to continue because economic prosperity strongly linked to energy consumption.



When we look at our total installed power generation capacity, we have fairly bleak look from the global warming point of view and from the environment effect point of view. Of course we have a total of 250 gigawatts of installed electricity generation capacity and out of that coal accounts for 60% and gas which is a fossil fuel type of thing which emits carbon dioxide accounts for another 9%, and hydro and wind these are free from CO_2 emissions, they account for about a quarter and solar as of March 2015 is only 1%. And so, we have negligible biomass for electricity generation, and so we have a huge dependence on fossil fuels.



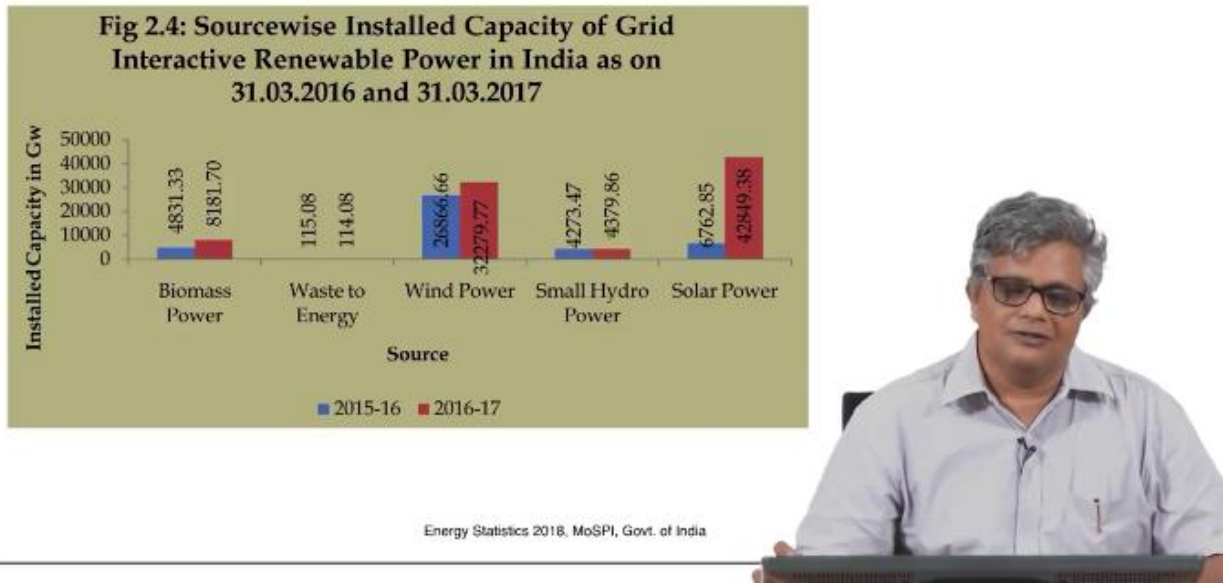
And the consumption of electricity which is again an indicator of how much more we need. We have about 40% going into the industry which reflects the increasing manufacturing waste that is seen in many sectors in India, many of which consume lot of energy. We have domestic consumption of 24%, and agriculture is 18%, commercial is 9%. So, all these things are expected to grow as we pursue economic prosperity and creature comforts and increasing job opportunities for our hugely young population. We have millions, and millions of young people and all of these will have to seek careers, so that means you need to have industry, you need to have commercial activities and service sectors which are main job creators.



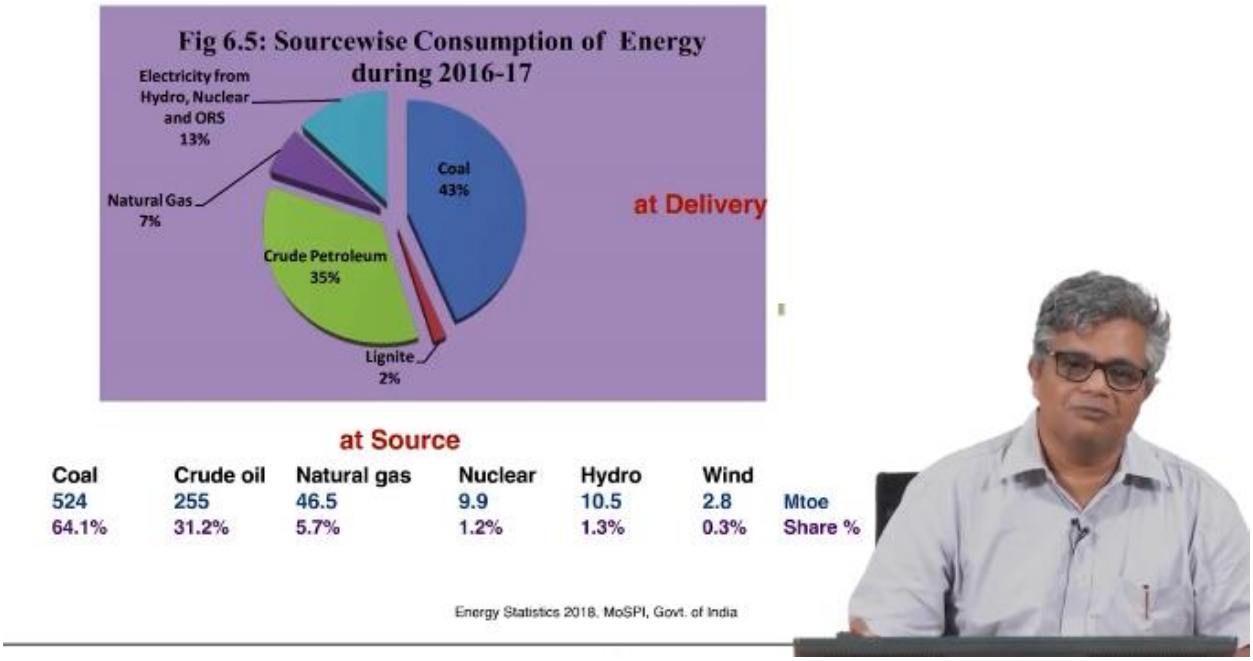
At the end of March 2017, thermal power plants accounted for an overwhelming 70.83% of the total installed capacity in the country, with an installed capacity of 267129 MW. Other renewable Sources (excluding hydro) come next with an installed capacity of 58680 MW, accounting for 15.56% of the total installed Capacity. The share of Hydro and Nuclear energy was only 11.81% and 1.80% of total installed capacity.

Energy Statistics 2018, MoSPI, Govt. of India

And then we also have to produce a lot more food, so agriculture is something that is needed and then domestic usage will also be increasing. So, for all these things we see increasing need for this. And this is reflected also in the installed power generation capacity over the past decade, and you can see that there is been a steady increase in the thermal power generation, so that is coal type of power generation that has been steadily increasing. Whereas hydro has become fairly constant, we have used, exhausted, most of the major hydro-related power generation. And you can also see that other renewable sources that is very small, so the renewable sources in terms of solar and wind and biomass contribution to electricity generation is very small in India, and that is an unfortunate thing. Sorry, that other renewable sources installed in terms of capacity is increasing, and nuclear is the thing which is a very small, it is expected to be rising somewhat with installation commissioning of new power plants which are on the anvil, okay.

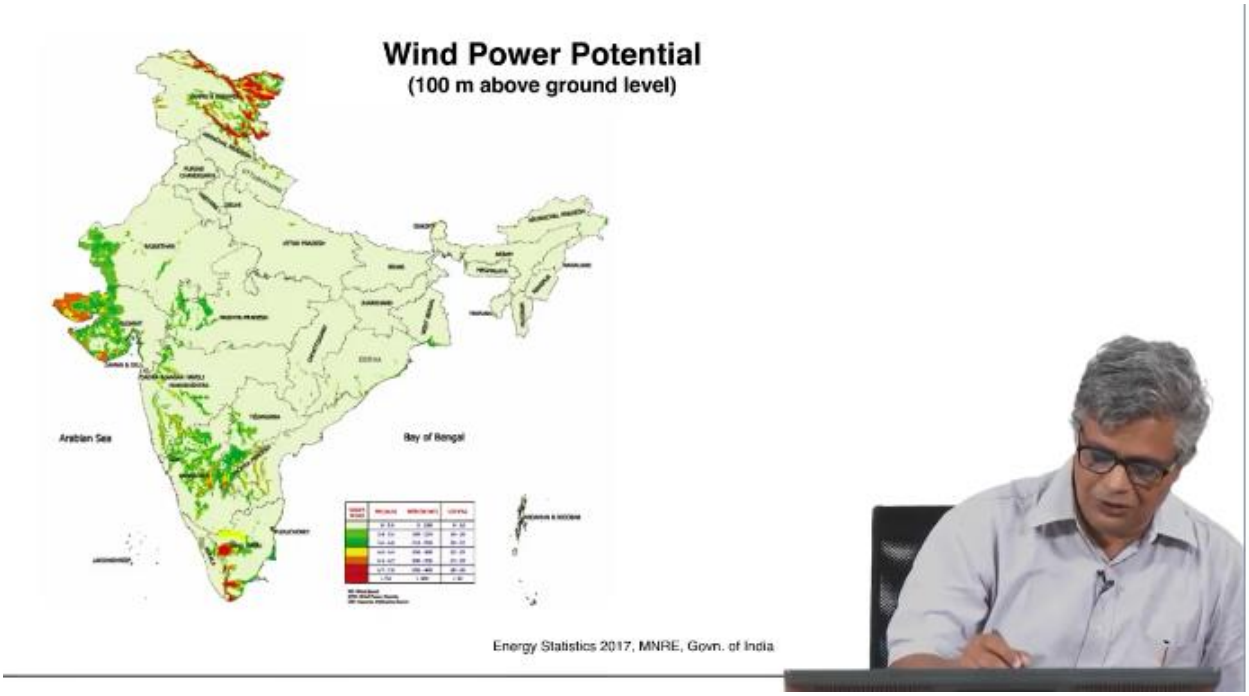


And again, when we look at installed grid interactive renewable power, so that is renewable power sources like wind and solar connected to the national electrical grid so that they can make significant contributions to the electricity generation. There is increase between 2015 which is in blue color and 2016 which is in reddish color, and you can see that biomass power has increased, waste to energy is negligible, wind power has increased from 26.8 megawatts to 1000 megawatts to 32 something thousand megawatts. And small hydro has not changed much, solar power has increased from 6.7 to 42, so solar power is the one which is rapidly increasing. With respect to wind power, we have reached a stage where the easily available, easy picking have been harnessed, and we have to go for more demanding wind type of installations, wind extraction, wind generation, and extraction sides and technologies.

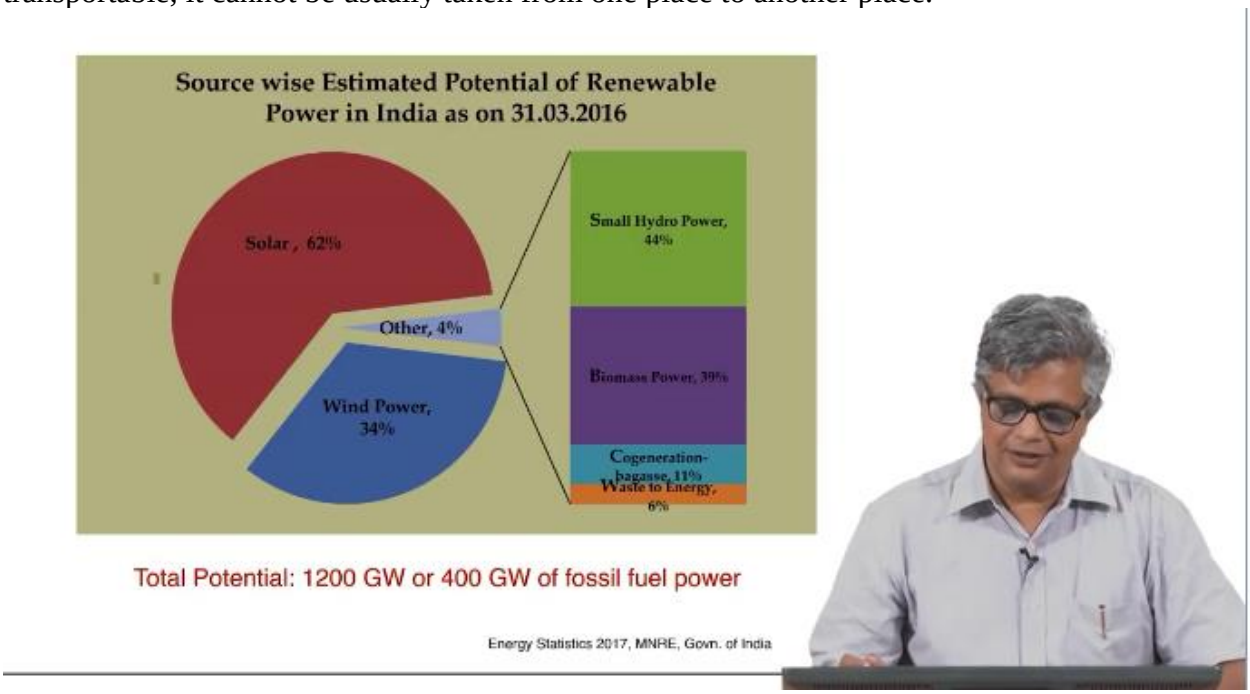


And we would also like to make a distinction between the installed energy capacity, power generation capacity in terms of megawatts, and the extracted generated electrical energy in terms of megawatt hours or kilowatt hours or units of electricity. And here as of 2016-17 we have a distinction between the source from which the energy has been received at delivery point, that is at the consumer site, and at source point, so that which is where fuel or the energy generation mechanism is put into place, and it has consumed so much of energy, and it has given so much of lesser energy at the delivery point because of transmission losses and generation losses and all that. And when you look at, at delivery we can see that a significant amount of 43% is coming from coal, natural gas accounts for 7, accounted for 7 in the year 2016-17. So, that is about 50%. And lignite is a form of coal and accounted for another 2, and as we will see this is a major source that is available in India. Electricity from nuclear hydro and other renewable sources together accounted for 13%, and crude petroleum which essentially for transport applications and other kind of applications has been contributing for 35%.

And at source we can see that coal has accounted for 64%, crude oil for 31%, natural gas for 5.7%, nuclear only 1.2%, hydro only 1.3%, wind 0.3% in terms of electricity generated, and obviously solar is much less than this. So, the amount of energy generated from wind and solar in India has been was very small in the year 2016-17, and even today it is hardly a few percent, So, this is the situation.

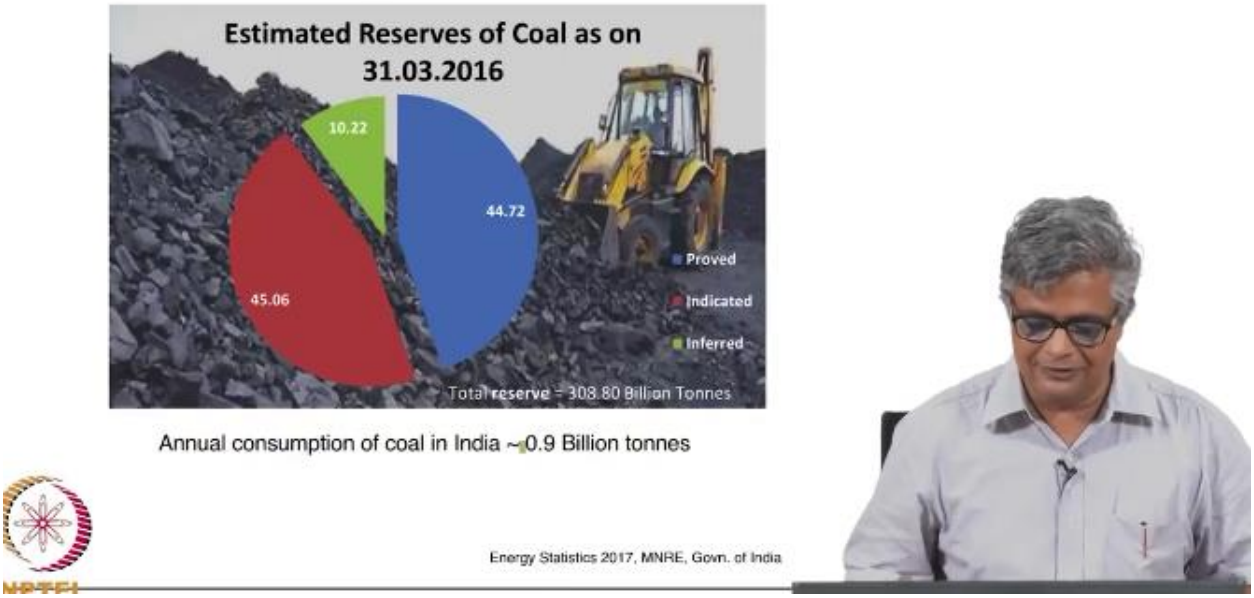


In terms of potential, that is how much more we can extract, there is a lot of potential for wind power and this is at a height of 100 meters above ground level and you can see that wind power is not uniformly distributed. It is available in good quantities in certain parts of Tamil Nadu - Kerala border, in certain parts of Gujarat Coastal areas, and up there in Jammu Kashmir. And in fairly significant quantities in Rajasthan and Gujarat, some parts of Andhra Pradesh, Karnataka and a bit of Madhya Pradesh, Maharashtra like this. But there are many other areas in India where you do not have a lot of wind power. And wind power is something that can be generated only in small quantities compared to thermal power stations. And so, in that sense it is not easily transportable, it cannot be usually taken from one place to another place.



And if that that is the wind power, this is a total of potential renewable sources, we can see that wind power accounts for a third of potential, third of, around twelve hundred gigawatts of installable extractable power, okay. How does this 1200 gigawatts compare in real terms? Currently this year we have about 250 gigawatts of installed capacity, 250 to maybe 300 if you include all the other captive power generation for industrial purposes, okay. So, it is 250 to 300, and this 1200 gigawatts of installed solar or wind power is equivalent to only about one-third of the equivalent capacity of fossil fuel power plant. So, that means that we have 400 gigawatts of electrical generating power capability from solar and wind and everything, every other renewable sources included, others contribute very little, this is a potential.

And how does these 400 gigawatts compare? It is about 50% more than what it is currently, okay. That looks like lot, but in practice, in reality, we know that we are consuming only one-third of the world average in terms of energy, energy consumption for our daily use. So, if we have to bring it up to the world average, we have to increase it by a factor of 3. And if we want to get up to that level of energy consumption by which time the world average will also increase, but we can see that only part of that can be contributed by renewable sources. So, that means that we are still lacking a significant amount of energy that is required to raise our energy consumption level and thereby economic prosperity and standard of comfortable living to the world level. So, if you want to do that across the entire population then renewable sources can contribute only a part of it, we cannot go completely carbon neutral, we have to depend on fossil fuels, and that is a scenario in India.



So, what about fossil fuels for us? We will deal with that in a very short, in part B of this lecture.

Thank you