INDIAN INSTITUTE OF TECHNOLOGY MADRAS

NPTEL
NPTEL ONLINE CERTIFICATION COURSES

ECOLOGY AND ENVIRONMENT

Module on

Energy & Environment

Lecture 6

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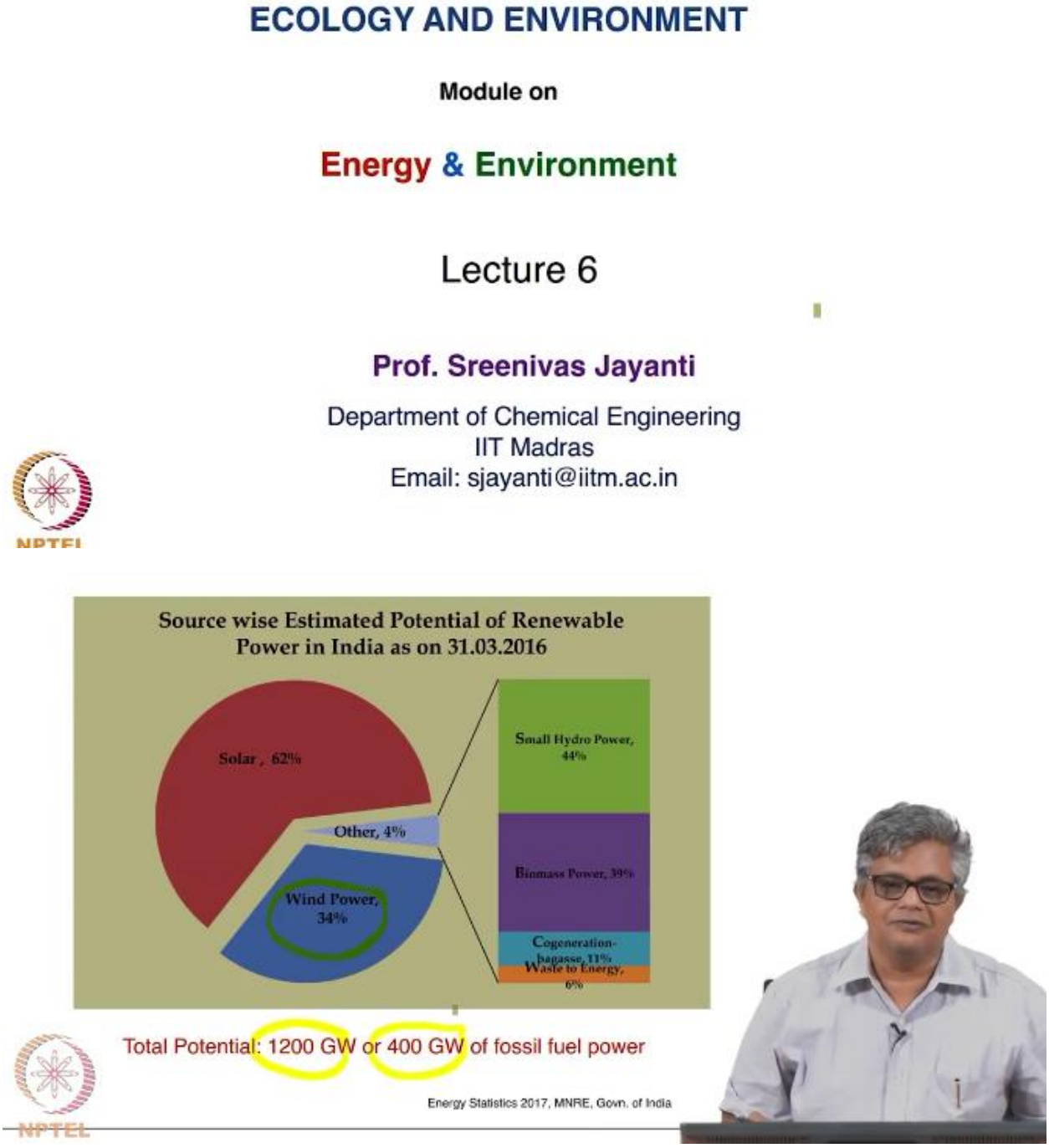
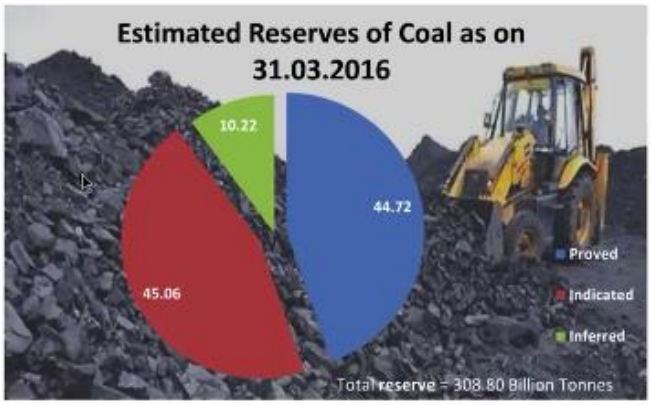


In part A of this, we have seen that we have renewable energy has significant potential compared to our current generation. We have currently 250 to 300 gigawatts of installed power generation capacity, and the potential realizable as of now in India for solar and wind put together is equivalent of 400 gigawatts of power generation capacity. It is actually 1200 but if you factor in the availability, realizability factor it is about 400 which is 130% of what, more than what is current feasible. So, what we are currently generating and but we say that this is okay for the next 10 to 15 years, but after that if you want to, as our economic policy planners are contemplating, if you want to reach up to world average by 2035, 2040 or 2050, then our energy

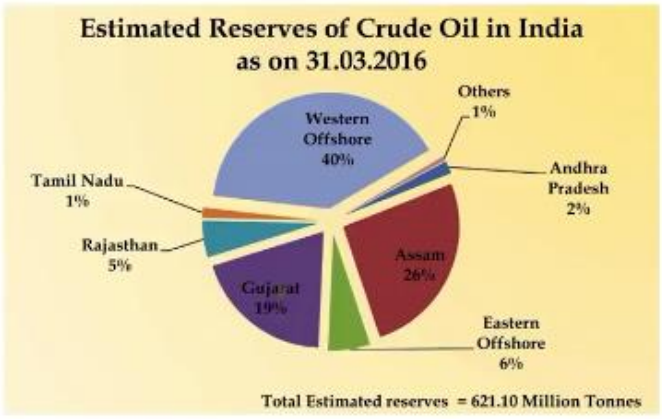
consumption would go by factor of 3. And renewable energies can give only a factor of 1.3 in that. So, that means that at that time we may be generating only additional 1.3 from renewable sources, and one from current sources. So, which means that we will still have 40% of energy coming from conventional fossil fuels.



Annual consumption of coal in India ~ 0.9 Billion tonnes

Energy Statistics 2017, MNRE, Govn. of India

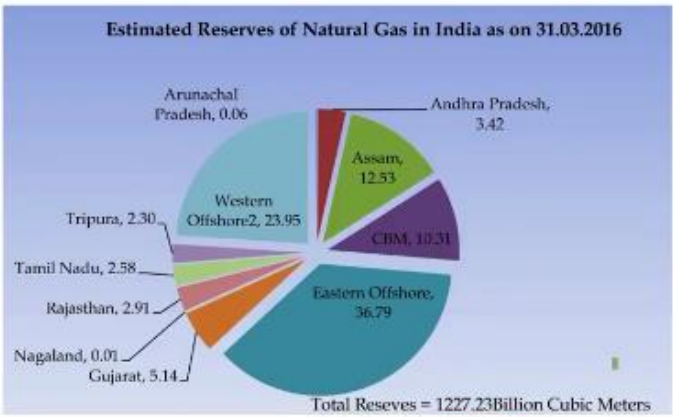
And we still will not be reaching 3 times what we are currently consuming. So, what kind of energy security we have in terms of other sources? If you look at our estimated reserves of coal as on 31st March 2016 these are revised annually, these are part of statistics, energy statistics produced by MoSPI, government of India, this is one of the ministries which prepares all the statistics, including the energy statistics and as of 31st March as per 2018 report, we have a total of 308 billion tons of coal. And how big is this 308 billion tons? Our annual consumption of coal for electricity generation and for industrial consumption put together is about 0.9 billion tons. So, that means that if you are continuing to use coal as of now at the same rate as what we are using, then it will last at least for another 300 years. So, we have 300 years of coal that is available with us including proven, indicated, inferred. These things depend on the classification, but definitely we have significantly, significant amount of coal which can power at the rate of 3 times of current capacity for about 50 years.



Annual production of crude oil ~ 35 MT
Annual consumption of crude oil ~ 240 MT

Energy Statistics 2017, MoSPI, Govt. of India

What about crude oil? That is another fossil fuels very convenient, very necessary for our transport sector as of now. We have Assam, Gujarat and Western offshore these places producing most of it, and this amounts to estimated reserve of 621 million tons. And how large is 621 million tons? Our annual consumption of crude oil is about 240 million tons. So, that means that we have only about two and a half years, only two and a half years of crude oil, that is why we import more than 80%, 90% of our crude is coming from outside. And we do not have so much reserves of crude, compared to our annual consumption.

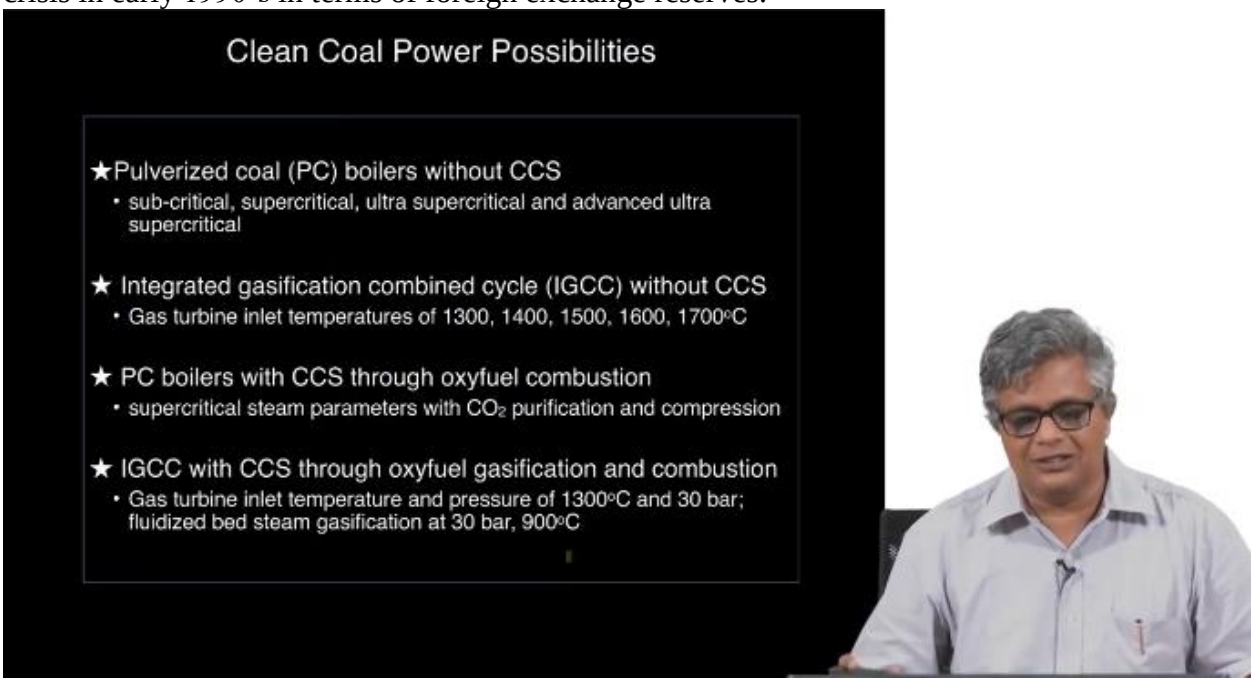


Availability of natural gas far outstrips the demand and potential for consumption

Energy Statistics 2017, MNRE, Govn. of India

Natural gas is a very desirable fuel, it can be used for lot of chemical productions, and it is also much cleaner than coal, but unfortunately, our amount of reserves of natural gas is 1200 billion

cubic meters or which is equivalent to about 3700 million tons of oil equivalent. And that is about the annual generation of natural gas all over the world. And it is not much because everybody would like to use more of natural gas and availability of natural gas far outstrips the demand and potential for consumption in India. So, what does this mean for us? It means that we only have coal, we do not have crude oil, we do not have natural gas. And this means that we have to continue to import crude oil for our motoring needs, transport sector and we have to play all kinds of geopolitics in order to get natural gas. And both of this, once we start importing fuel from other countries, we have to pay them in foreign exchange, in dollars or euros, or maybe Chinese Yuan things. And that make that puts a lot of strain on our finances. We had a big major crisis in early 1990's in terms of foreign exchange reserves.

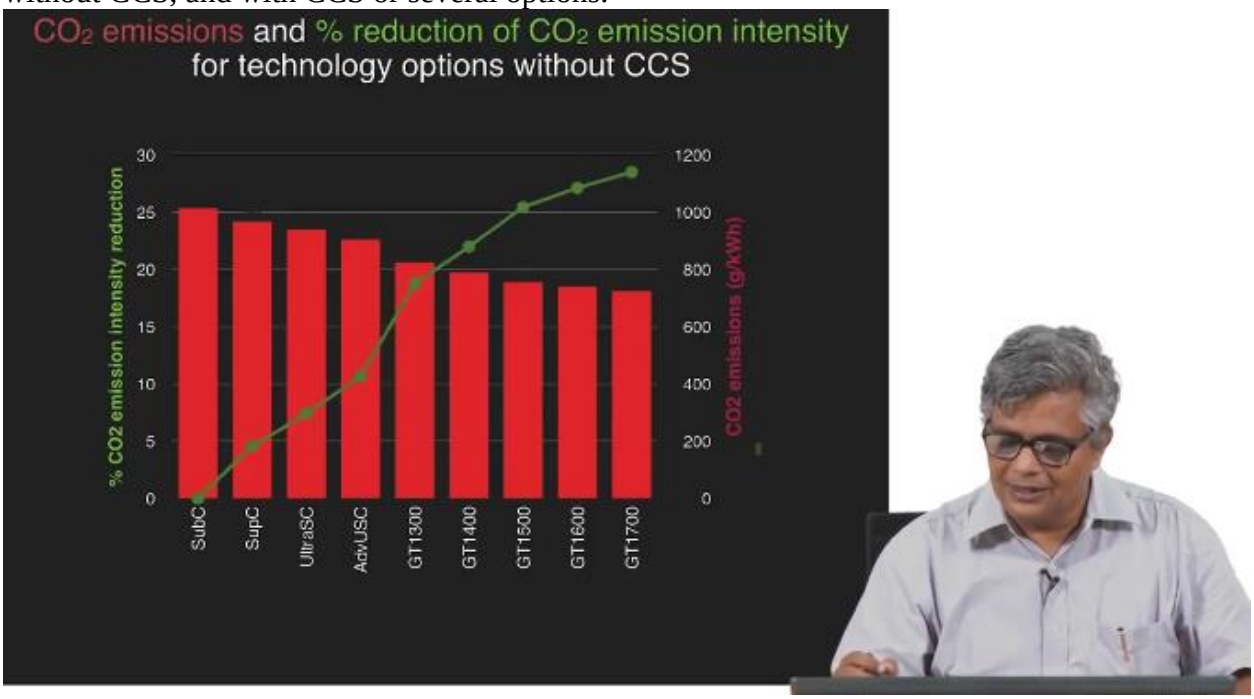


Right now, we do not have it, but if the situation gets out of hand, then we have difficulty in importing this fossil fuels. Coal is a natural ally in terms of power generation for the next 100, 200 years. And that is what we have, and we know that it is not a good source from the environment point of view. So, there have been a lot of studies, a lot of technology developments and all this with respect to clean coal power. So, that is power generation from in a clean way because we are aware of consequences on the environment of coal usage which we have listed as generation of sulphur dioxide and NO_X gases, mercury emissions, arsenic emissions, radioactive elements, and ash, in addition to carbon dioxide which is much more than what it would be emitted if we were to use natural gas. So, all those ills are there, but unfortunately when we look at where we can get energy from in order of fulfill our economic prosperity aspirations, then coal is what we have.

In entirely simple world where you can buy things at a prevailing rate with complete access, we could be importing lot of natural gas but even though for the past 10, 15 years in a sustained way we have not been successful in getting natural gas due to geopolitical considerations. Similarly, for nuclear power. So, things may improve in another 50 years with respect to nuclear power once we get into that third stage of nuclear power generation cycle. But as of now, coal is our only thing and how we can generate coal is something that, how we can generate clean electricity

from coal is pressing matter both to fulfill our energy requirements and also environmental constraints.

So, when we look at coal, we know that one of the consequences or the short-term pollutants, short-term short-range pollutants those which affect the immediate locals, like this ash, particulate emissions and then mercury emissions, and sulphur dioxide and all that. For all of which we have conventional technologies that are already been developed and that are currently available, commercially available the world over, but in India due to financial and other constraints, because they they reduce the efficiency somewhat, we have not installed many of those measures. And so, all those measures will not do much about global warming. So, when we look at the environmental problems as short-term short-range pollutants like conventional pollutants and the long-range, long-term problem like the global warming arising from CO_2 emissions. We can consider the conventional technology of Pulverized coal boilers without CCS, carbon capture and sequestration. And a more advanced Integrated gasification combined cycle without CCS, and with CCS or several options.



When you look at this, you can see the emissions of carbon dioxide which is known as this carbon emission intensity reduction. If you have the conventional coal producing this much of carbon dioxide, grams of carbon- dioxide per kilowatt hour of electricity generation, if it is 1000 for this, using this advanced technologies, we can continue to emit lesser and lesser amount of carbon dioxide which is about 25% gain in carbon dioxide emissions, is possible using measures which do not involve carbon dioxide capture.

So, that is not enough for us because we are still continuing to look for usage of coal and if we are trebling or if we are doubling the amount of carbon dioxide coal usage then we are going to double the amount of carbon dioxide emissions. And we are looking at going towards a situation where we are emitting as a whole 10% of what our CO_2 emissions are. And as it is India is the third largest carbon dioxide emitter, and with this kind of continued dependence on coal with

marginal gains of about 10 to 25% of carbon dioxide emissions is not enough for us to meet with the global warming requirements, okay.

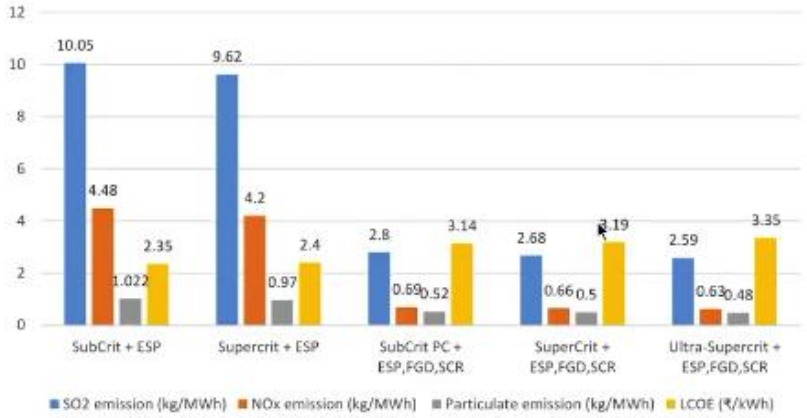
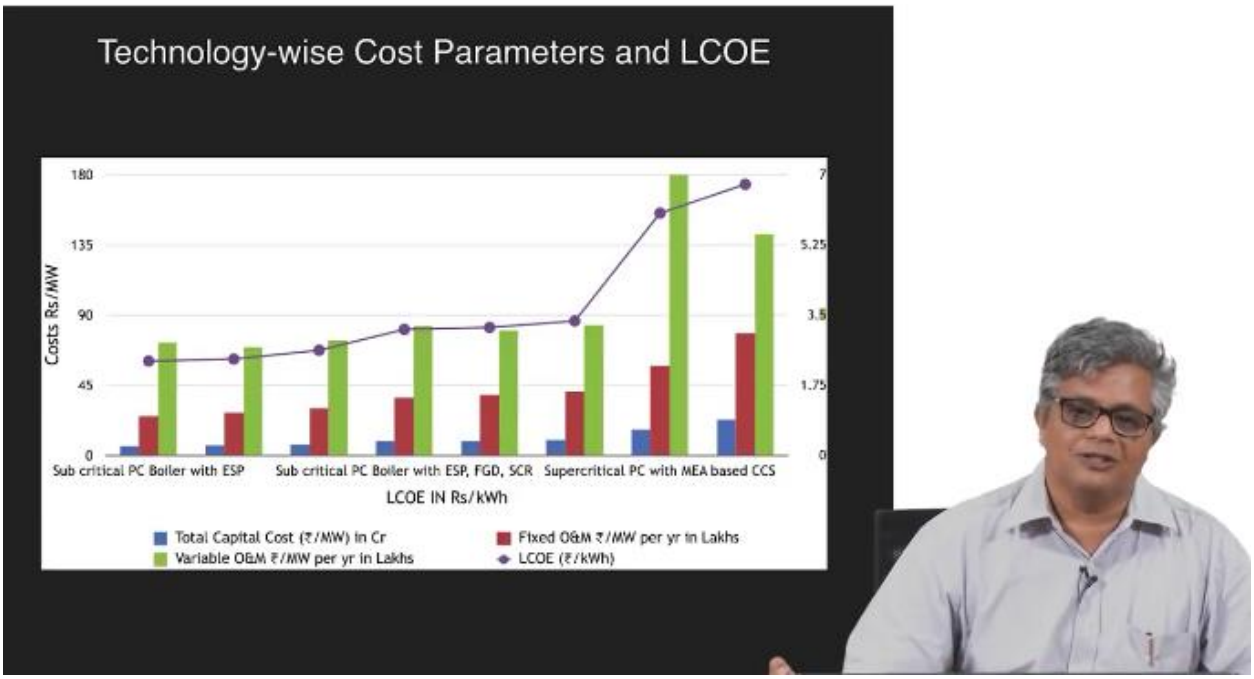


Figure 6.6 Emissions of conventional pollutants and LCOE for power plants without CCS.

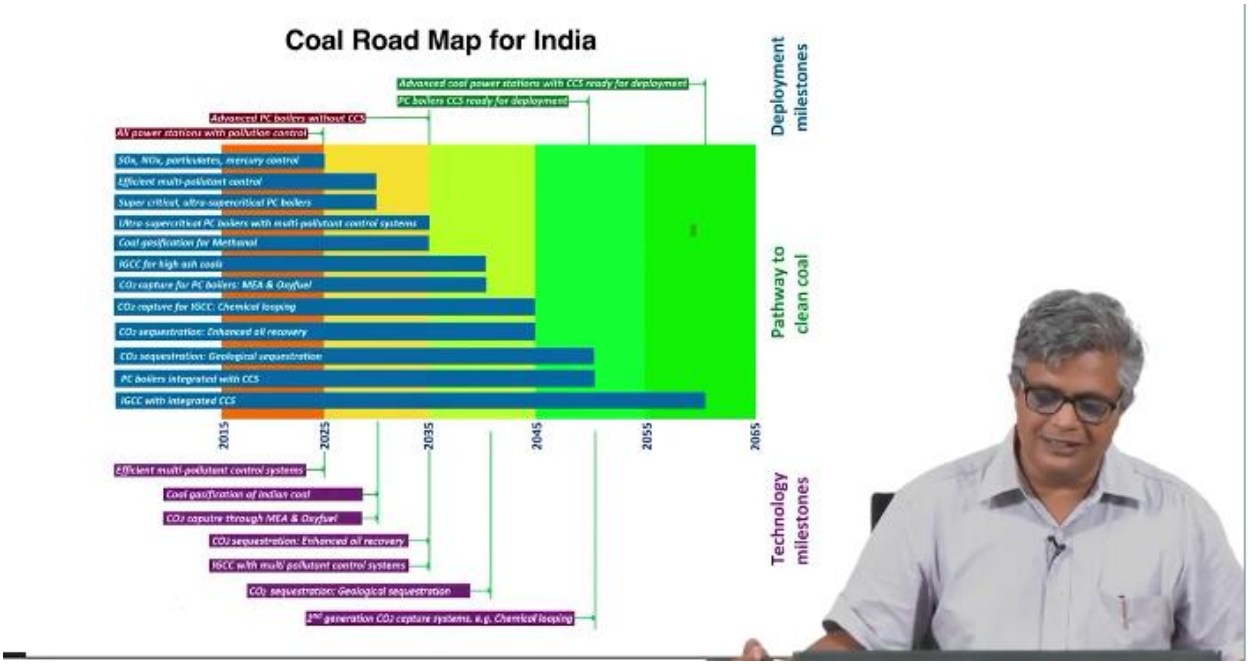
Jayanti et al. (2018) GTWG-ACT Report

So, another factor with respect to coal usage is the emission of this short-term pollutants like sulphur dioxide, NO_X emissions, and particulate emissions. And we can use technologies that are currently available to reduce this sulphur dioxide emissions for example given in blue color here and NO_X emissions given in orange color, and particulate emissions given in this grey color here with current levels of pollutants here, to a significantly reduced amounts here using technologies which are on the anvil. But there is a cost factor to this, what we have in this slightly yellow-orange color is the cost of levelized cost of electricity in terms of rupees for kilowatt hour at generation stage. You can see currently it is 2.35 and if you use these conventional technologies to deal with short-term pollutants and all that, the cost will go by about 30% to 3.35. So, we are paying about 30% more in order to get about 10 to 15% reduction in carbon dioxide emissions and in maybe 80% reduction or so in terms of SO_Xs and NO_Xs, okay. So, this 30% increase in the cost of electricity itself is large, but when we want to bring in carbon dioxide capture and sequestration which gives us a possibility of using coal for our to meet our energy needs in energy self-sufficient way, okay.



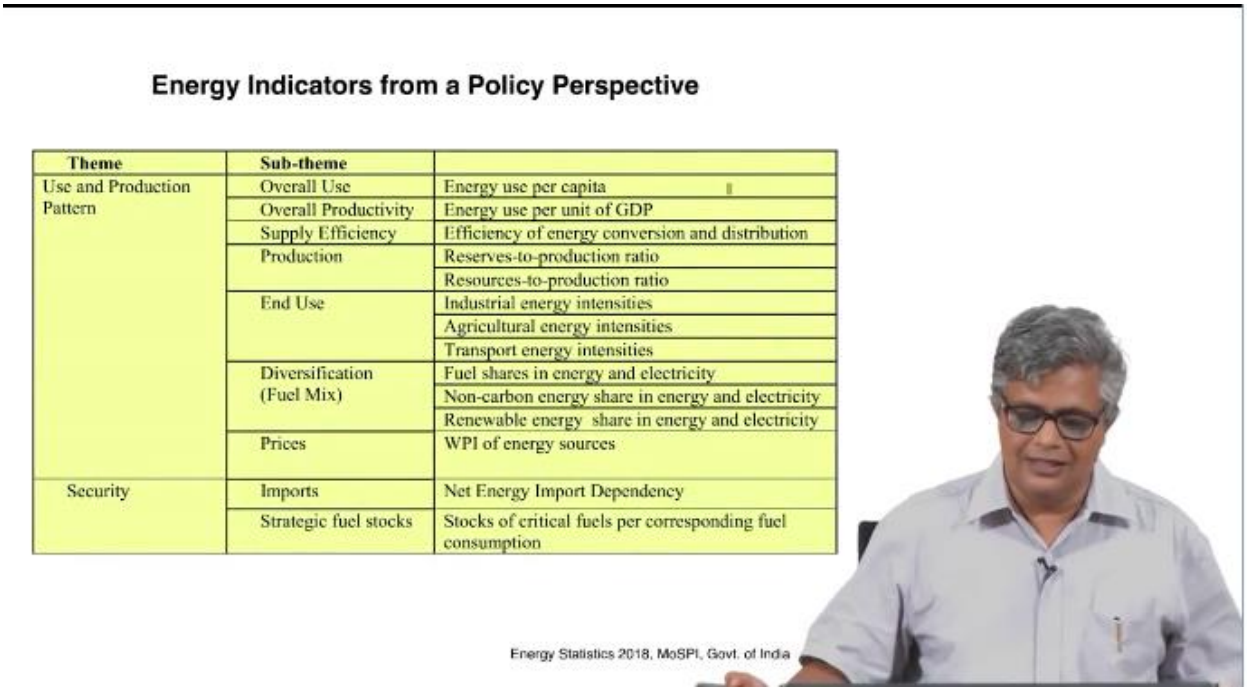
Where our security is not comprised in terms of energy, okay. So, if that is our desirable way of looking at it we can see that once we bring in CCS into play the cost of power generation doubles, and it goes up significantly here.

And so, you can see that currently, it is this, and conventional things are increasing up to this, but you bring in CCS it is going up this much, by using these kind of technologies which are currently being used in the oil sector, petrochemical sector. The hope is that this can be brought down somewhat by improved technology and also by economies of scale, but the fact remains that once we want to bring in carbon dioxide capture sequestration mechanisms into play then cost of electricity will go up substantially. And this is something that we have to really worry about as a developing nation because as a developing nation and as a nation with very young people we need to promote industry and create jobs and all of that requires a lot of capital, now that capital is being sunk into this into this pollution reduction measures. So, is that necessary when we are trying to promote industry, can we afford to increase the cost of electricity which is needed so much by industry and everybody else. So, that is a policy decision that one has to take.



And so in this sense, when we look at the Indian situation and what is really necessary, possible for us, looking at what we have in India in terms of energy resource and given that we have increasing needs of energy in a large measure, we have to continue to depend on coal and we need to harness as much of the large potential for renewable energy source, clean, renewable energy sources like solar and wind that are available to us and that are coming on to us. But in addition to that, we have to continue to depend on coal and given that coal is an obnoxious term from environment point of view for large-scale power generation, we have to clean up coal based power generation. And for this, we need to make technological strides, and we need to implement certain short-range pollutant combating measures like SO_X, NO_X particulate emission, and mercury control measures, maybe within the next 5 to 10 years. Because this is one of the major concerns for us when we look at the quality of air, and quality of life and health hazards that are coming from this. But we need to make them more efficient, and we need to go for more efficient power plants, and all this is being practiced in India, but ultimately, we need to be prepared to implement carbon dioxide capture and sequestration maybe in another 20, 30 years. Because that is an only hope for us towards the pathway to clean coal which will assure our energy needs for the next 50 to 100 years, in an environmentally sensitive way.

So, there is a lot of technology development that needs to be done by us, and we have to invest more into our R&D and qualifications and all that. So, technology milestones need to be achieved, and also technology developed is not sufficient. Deployment requires another major effort, and once these, both these issues are addressed then it is possible for us to continue to use coal for to meet a large part of our energy demand well into the 21st century and even beyond. But without this, it is really impossible for us to see how we can continue to use coal and pollute the environment in a big way, okay.



So, as a final word we would like to say that, from a policy point of view when as a nation we want to empower our citizens to towards a more prosperous life and a life which has quality of environment, we need a lot of energy. And so it is understood that energy requirement is a strong motivating factor for us and so there are a number of indicators that are currently being used to gauge our energy dependence and energy sufficiency. So, when we look at energy indicators, we have use and production pattern and also security pattern because energy is such a critical parameter in the strength of a nation that we have to look at where our energy is coming from. If we depend on outside sources for our energy then we may be taken hostage with a threat of cutting off those supplies, and this is something that is been happening in recent geopolitical world, and it has happened on a number of instances. And so for us as a developing nation and as an independent nation with its own foreign policy for the general good of us, and also in the larger context for the entire world, we have been following an independent foreign policy and our relations with our people and our neighbors and all the others are guided by rather utopian principles. We need not go into those things, but given that we have an independent kind of thing, we need to look at energy security.

So, energy security and use and production pattern are the two things within this we are looking at energy use per capita, this is an important indicator in terms of our GDP. Energy usage per unit of GDP, how much energy do we use in order to increase our gross domestic product which is an indicator of economic prosperity. So, if it is less we are quite happy, if GDP per kilowatt hour is large, we are very happy because then we can cut down on the greenhouse gas emissions associated with energy usage. And efficiency of conversion and energy conversion distribution, reserves to production ratio, how much of reserves do we have? What is the rate of production? And how many years can we sustain our reserves? So, and end use, where our energy is going in terms of industry, energy, agriculture, and diversification in terms of fuel mix, non-carbon share renewable energy share and fuel share, so and prices obviously. So, all these things are important, indicators in energy policy.

And strategic fuel stocks and imports are also concern for us. So, these are major drivers of policy in terms of energy generation and distribution. And given the sensitivity of GDP on environment based on these lectures, we should also say strongly that we need to include environment and sustainability, have to be two additional strong themes that need to be included in the energy debate and policy. Because energy is needed but so as environment and so is sustainability for 100 years, and only then we cannot take short-term measures which lead to chaotic problems at a later stage. When given that we have to develop our energy usage and increase it by a factor of 2, 3, 4, over the next 20 to 50 years, given that so much development still needs to be taken, we need to look at the sustainability of measures that we need to consider. And the sustainability has a strong component, not only coming from this use and energy and security, but also from environment, and that is a strong point that we would like to make. So, we should be looking towards energy and environment, and we should not be looking for energy or environment. And something like that is a necessary in our national interest.

So, I hope we have been able to get across to you, a sense of, the dynamics between energy and environment both of which are necessary for us in our modern-day life. And I hope you will be able to understand the issues better as a result of these lectures.

Thank you very much.