Energy Resources, Economics and Environment
Professor Rangan Banerjee
Department of Energy Science and Engineering
Indian Institute of Technology, Bombay
Lecture-1 P3
Energy Use in India: Some Calculations

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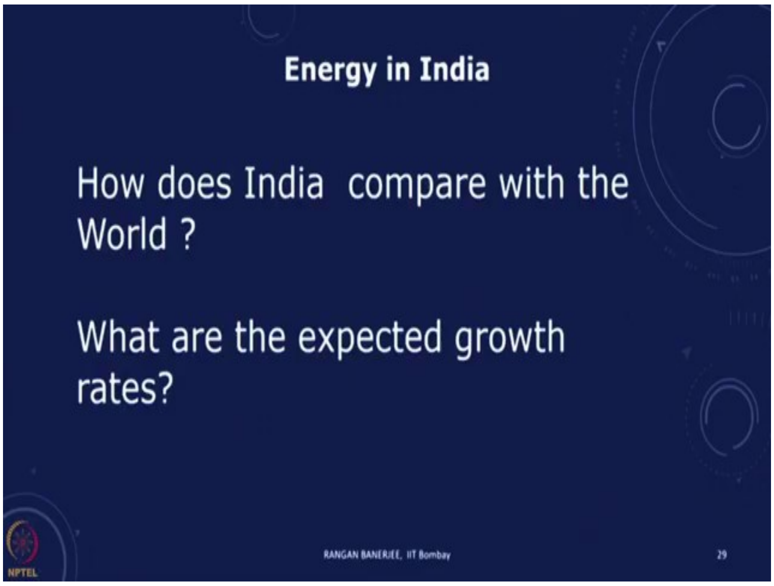

Now, we talked about the energy flow diagram and we talked about the overall global energy use. Now we would like to see how India compares with the world and what are the expected growth rates in the Indian context.

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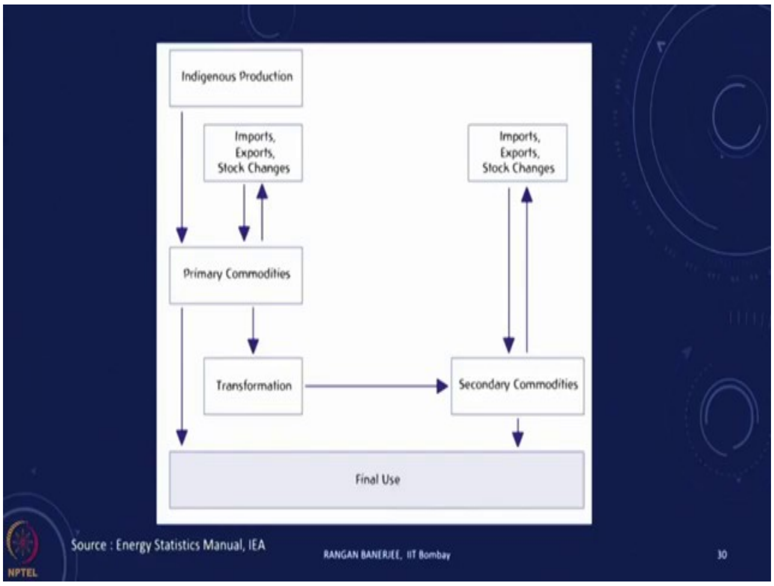

So, what I would I suggested to you that you should actually look at different countries and try to do the energy balance we can do the same thing for India, you we have a table which gives you the indigenous what is the amount of production of coal, oil, natural gas what kind of what are the imports, exports and the stock changes and then you can get the primary commodities.

Some of them are being transformed into secondary commodities for instance coal is being transformed to electricity and even in electricity we are importing and exporting, we are importing electricity from Nepal and we may be exporting again to some of our neighbours then may be stock changes and then there is a final use.

So, this is what is that there, there is a in the international energy agency there is a energy statistics manual and with that you can look at the data base and you can actually work out this for any country that you want and that will give you also a sense of the calculation a sense of these energy flow diagrams and a relatives sense of magnitudes is how important is hydro, how important is coal.

How much of the energy is imported for that country and I will encourage you to do this on your own so that you get a sense of the overall energy. So, when we talk about the energy balance you will find for instance if you are trying to do this for India we would like to see in a year how much coal are we using, how much oil, tons of oil, tons of coal or barrels of oils.

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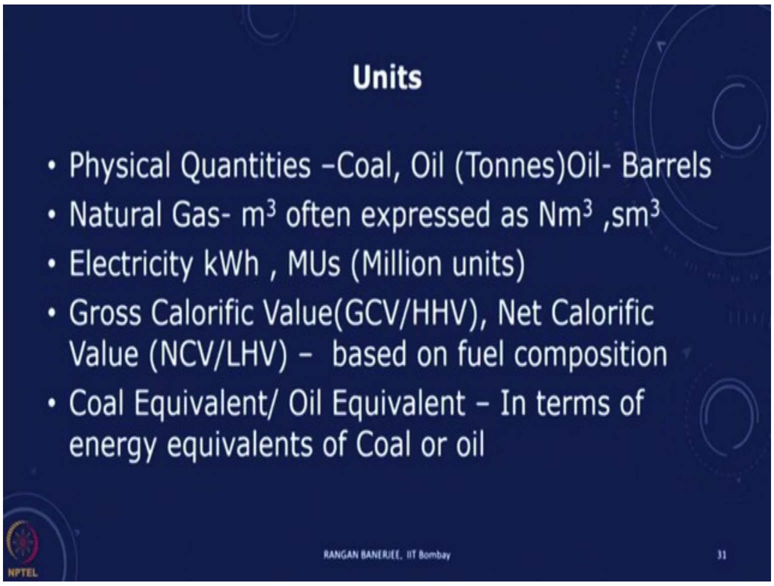

And then in the case of the natural gas its often expressed as normal meter cube, the standard meter cube, electricity will be in kilo watt hour or million units and then for a physical for a certain amount of coal will measure the energy content by either the gross calorific value or higher rating value or the net calorific value. Based on the fuel composition and then we can convert it also into coal equivalent, oil equivalent that kind of thing.

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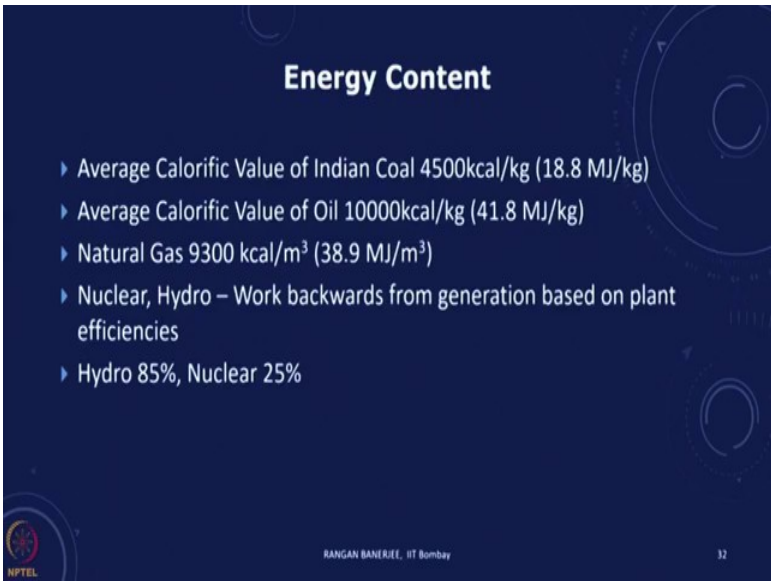

So, typically when you look at an Indian balance we take Indian coal has an average energy content which is lower than that of international South African or Australian coal and it is right now the average may be of the order of little less than 5000 kcal/kg, 4500 you multiply that by 4.18 kJ and you get 18.8 MJ/kg.

And oil it has a greater calorific value per kg so about 41.8 mega joules per kg and natural gas is of that same order of magnitude. In the case of nuclear and hydro it is very difficult to talk about the amount of flow of water but what we know is we know the generation from hydro plants and we work backwards using the efficiency. So, a hydro efficiency, plant efficiency is of the order of 85 % nuclear of 25 % and then you can get what is the energy content.

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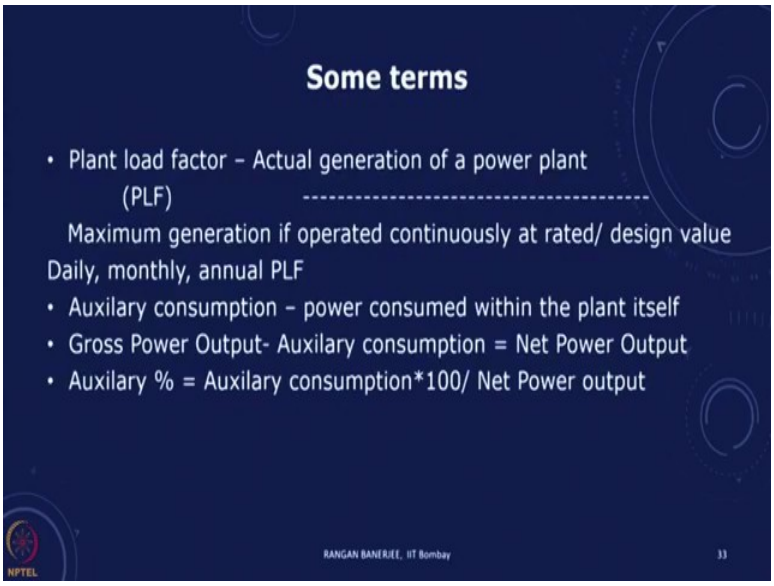

So, some of the terms that we may want to look at when we do this overall balances one is the plant load factor, plant load factor of a plant is the actual generation of a plant over a period which may be a day or a month or year divided by the maximum possible generation if it is operated continuously at the rated or the design value.

So, typically what happen in these plants is that the plant would like to operate at high plan load factor, why is that that is because whatever investment you have you would like to recover it over a larger number of units. So, your electricity would be cheaper if you have higher plant load factors but the plant load factor will be dictated by the fact that you know you cannot just supply electricity to regret.

There has to be a demand for that electricity. So, that supply demand matching is one of the factors when you look at the electricity system but so plant load factor is one of the things in every power plant there is an auxiliary consumption, that means in a coal base power plant you will find that there are fans and there are pumps and these consumes electricity.

So, off the electricity which is being generated some part is being used internally inside the plant itself that is the auxiliary consumption and so what we often do is we can specify the output of a power plant in terms of the gross power output or the net power output. In the Indian power system we specify it usually by the gross power output.

In the Europeans and US often talk about it in terms of net power output and then the gross power output minus whatever is being used internally becomes the net power. So, the auxiliary consumption percentage is the auxiliary consumption into 100 divided by the net power output.

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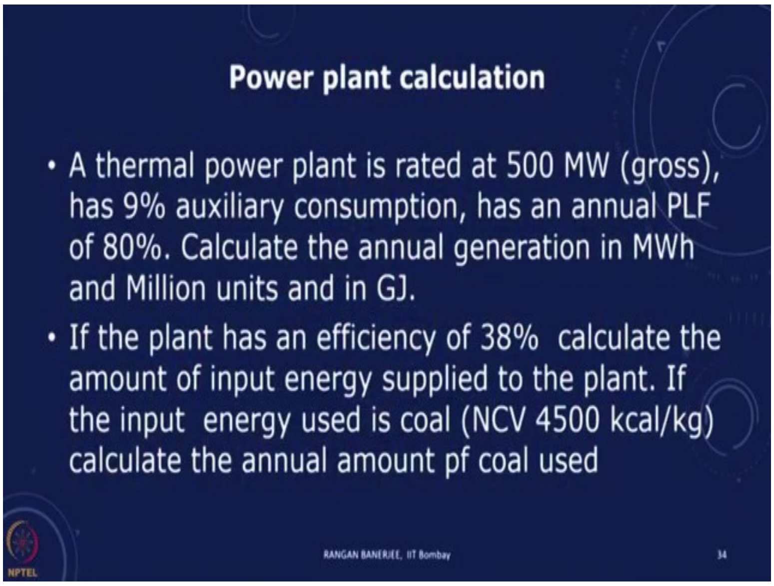

So, if you look at this term let us do a simple calculation. So, if we look at a thermal power plant which is rated at 500 MW gross it has 9% auxiliary consumption and has an annual PLF of 80 %. So, we want to calculate the annual generation in MWh and in MU and in GJ.

And the next part of the question is, if the plant has an efficiency of 38 percent calculate the input energy supplied to the plant we can do this in terms of mega joules, peta joules, tera joules in joules basically. And if the input energy used is coal calculate the amount of coal use.

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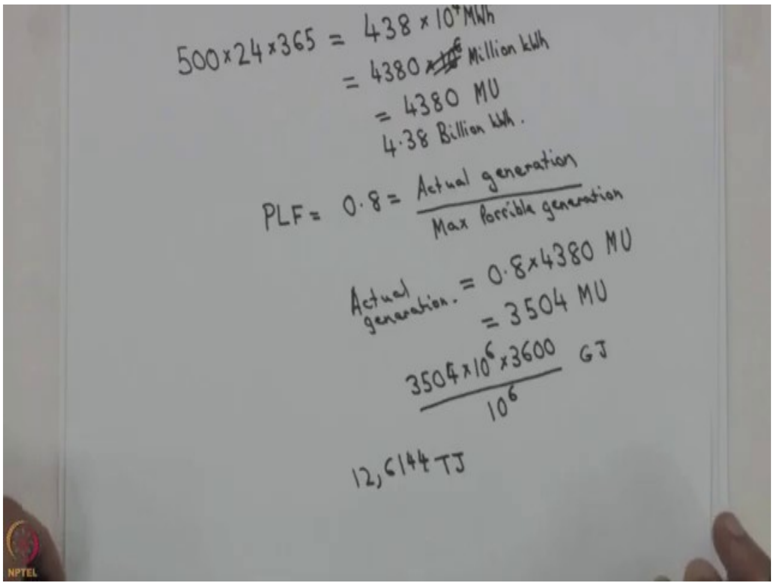

$$500\ x\ 24\ x\ 365 = 438\ x\ 10^4\ MWh$$

$$= \ 4380\ \ Million\ kWh\ \ or\ \ MU$$

$$= 4380\ MU$$

$$= \ 4.38\ Billion\ kWh$$

$$PLF\ \ = 0.8 = \frac{Acual\ generation}{maximum\ possible\ generation}$$

$$Acual\ generation\ \ = 0.8\ x\ 4380\ MU$$

$$= 3504\ MU$$

$$= \ \frac{3504\ x\ 10^6\ x\ 3600}{10^6}$$

$$= \ 126144\ \text{TJ}$$

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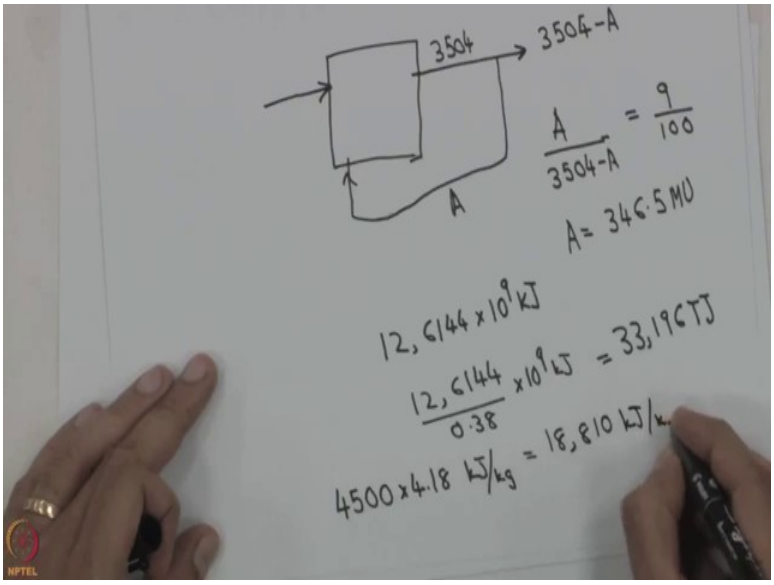

Now, let us look at this was the gross generation, we were talking in terms of the auxiliary consumption. So, if we look at a power plant we have an input and we have gross generation this gross generation is 3504 MUs out of which we have an auxiliary consumption ‘A’ being used and this net which we get is 3504 minus ‘A’. So, let us calculate, we are told that 9% is the auxiliary consumption, which means

$$\frac{A}{3504 - A} = \frac{9}{100}$$

$$A = 346.5\ MU$$

$$126144\ x\ 10^9\ kJ$$

$$\frac{126144}{0.38}\ x\ 10^9\ kJ$$

$$=\ 33196\ TJ$$

$$4500\ x\ 4.18\ kJ/kg$$

$$= 18810\ kJ/kg$$

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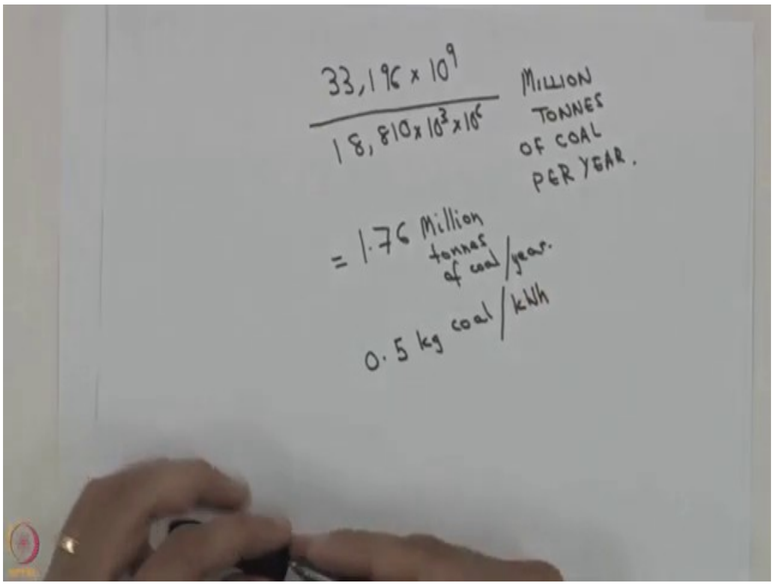

$$\frac{33196\ x\ 10^9}{18810\ x\ 10^3\ x\ 10^6}$$

$$= 1.76\ Million\ tonnes\ of\ coal/year$$

$$0.5\ kg\ coal/kWh$$

We will come back to this when we talk about the environment and others, other things but here this was to just show you one simple calculation when we think in terms of energy and power and we look at a power plant.

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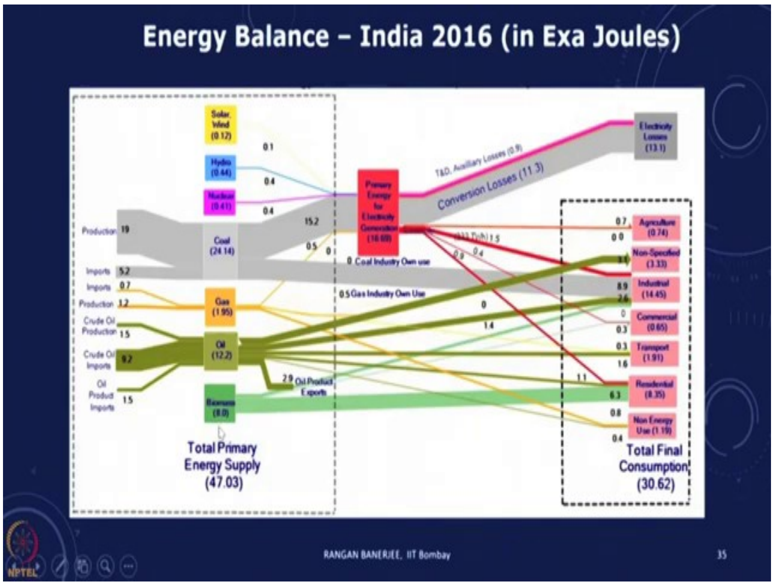

Let us go back to our main topic and we using this we can actually billed up a total the energy balance equation, do you remember we were talking in terms of for in EJ for the for India you will find that the largest chunk of our energy supply comes from coal and we get a reasonable amount of coal in terms of imports, in terms of oil also is a major chunk of our energy supply.

In the oil, the bulk of the oil is coming from imports. So, if you look at the total primary energy supply of 47 EJ you will find that this then goes and we can see a large chunk of the energy is going to the power sector and then in the power sector there are conversion loses and transmission and distribution and auxiliary loses.

And then you have the electricity which is going to different sectors, you know one of the major sectors is the industrial sector for electricity and then is the residential sector and then the commercial and we have a reasonable amount of biomass which is being used in our energy supply.

A most of it is being used in the traditionally in the residential sector for cooking with very low efficiency, so this is like a Sankey diagram which gives you an sort of overall idea of the energy situation in the country.

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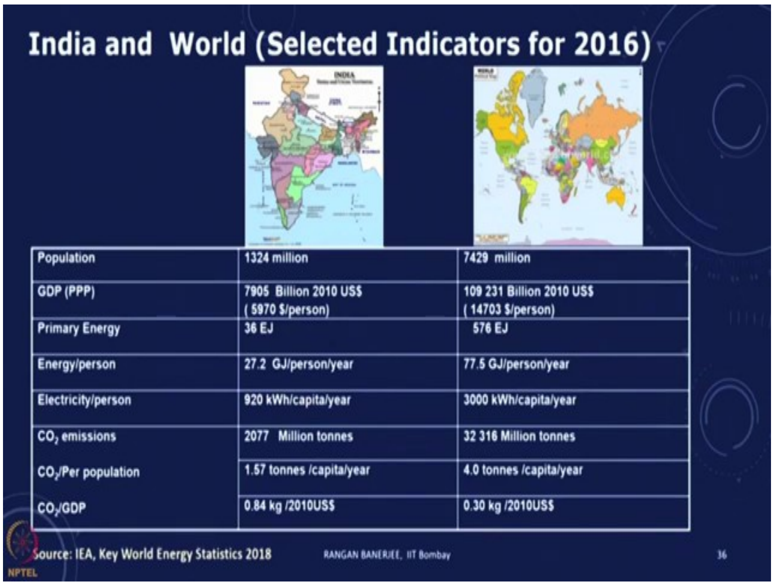

Let us also do a simple calculation of India verses the world. We are a population, we have a population of about 1.3 billion as compared to the worlds 7.4 billion and we are one of the largest countries in the world. You will see that on a per person basis the GDP is about little less than half of the world average and this is done on a purchasing power priority basis, later on in this course we will talk about marketing change rate and purchasing power priority.

If we look at the energy inputs, we can see the primary energy used is 36 EJ and for the world it is about 576 EJ. The energy use per person again we on an average the energy use per person is significantly lower than the world average.

May be about a third of the average and similarly if we look at the electricity use 920 kWh/per person/year as compared to 3000. This obviously means that on a per capita basis are CO^2 emissions are significantly lower than the world average. CO^2 per unit of GDP is of course slightly higher and we will come back to this when we talk about the Kaya identity and other factors.

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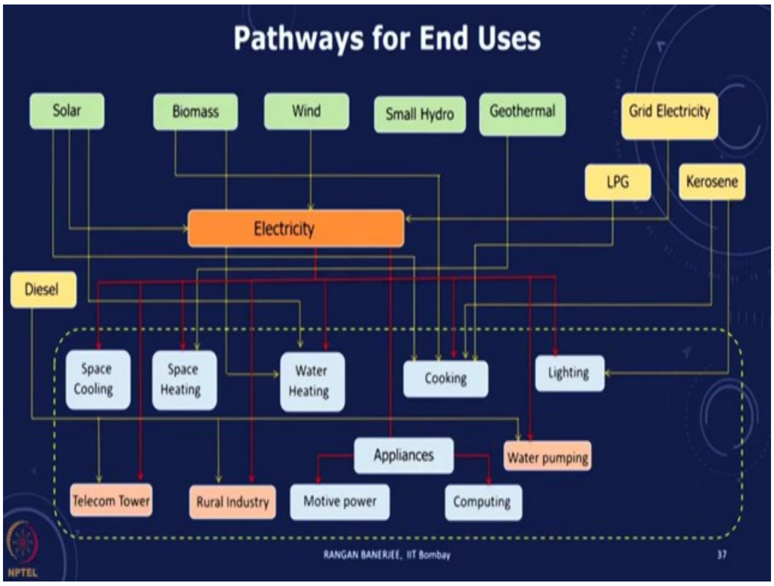

So, when we look at different energy systems there are many different pathways for end users. So, we, you can look at, we talked about the energy flow diagram and when we talk about the energy flow diagram we are looking at different primary energy sources whether it is solar, biomass, wind, small hydro, geothermal, grid electricity and this many of these can come into creating electricity and then that goes into the different kinds of end users like space cooling, space heating, water heating, cooking, lighting. And there are many different ways in which we can configure energy systems.

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So, with this if we look at the overall summing up of what we have discussed today we talked about an energy flow diagram and we saw how we move from primary to secondary and to the final energy to the energy end use, we then took that concept to create an energy balanced diagram for a region, we looked at what factors affect the overall energy use, we looked at different units of power and energy and their conversion, we talked about a 500 megawatt power plant and did a simple calculation.

If we use to look at the energy use pattern we are talking of exponential unbounded growth and that it may not be sustainable and that is the issue that we will talk about when we talk about energy and environment. There is a disparity between develop and developing countries and this again is something which we will touch up on in the course when we talk in terms of inequality, measures of inequality and see how to aggregate and look at inequality and their impacts. Both in terms of income as well in terms of energy.

Drawing up aggregate energy balances we talked about level of aggregation which is basically for the country as a whole or the world as a whole and you talking of physical and energy units. The goal with what we have done today and with the references you can develop an energy balance for a region and we would encourage you to look at one country and look at an energy balance and look at the trend of that energy balance in that country.

And this will help you get some insights on the energy systems for that country. So, the question that we that I leave you with is what are the drivers for energy systems. So, we saw that population is a driver, the income and the increase the effluents is a driver for energy systems. In addition to this there are other drivers and we will see that the environment is one of the major drivers for energy systems.

And that will be the next theme that we talk about. In this course we will look at the energy systems we will look at the resources for energy supply, we will look at how to allocate and them optimally and we will look at economics and we will look at environment. So, we will basically blend energy resources economics and environment to get a complete perspective and give you the tools and techniques for you to be able to analyse different decisions in the energy sector.

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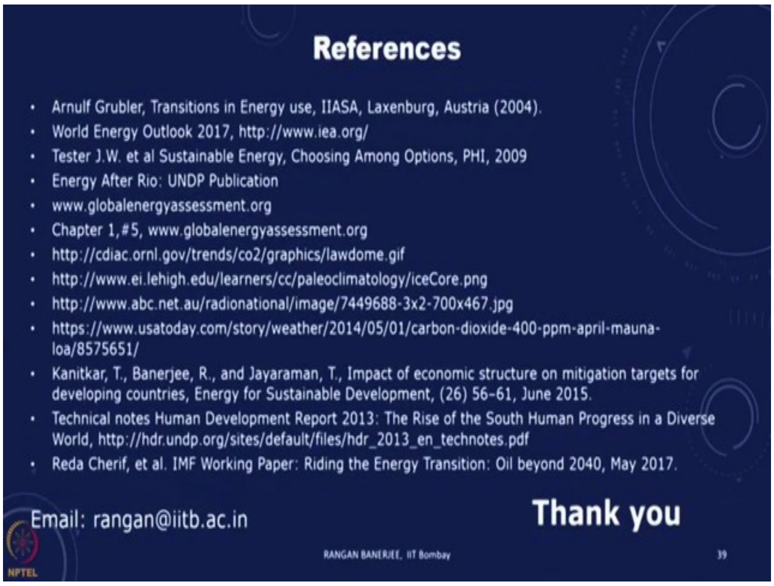

These are some of the references which we have used and I would encourage you to look at the global energy assessment. The first chapter provides the basics and that will be, those will give you a lot of the inputs that will be required later on in the course. There are also many different sources and that is the international energy agency and the world energy outlook where you will have a large number of numbers and scenarios. But we would like you to be able to go behind these numbers and to be able to do the analysis so that you can understand what is happening in the system. So, with this we will conclude this lecture.