Energy Resource, Economics and Environment
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Lecture 1 P2
Global Trends in Energy Used

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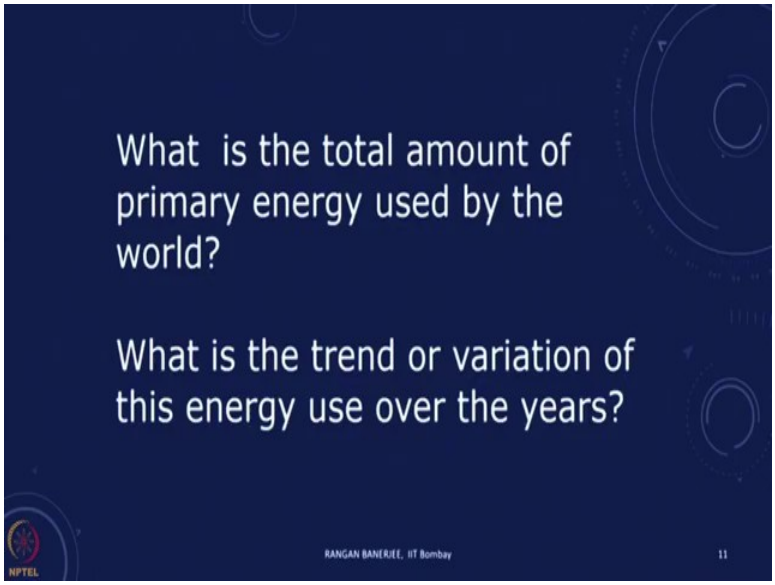

So, now let us look at the question what is the total amount of primary energy used by the world. And let us try and also see what is the trend or variation of this energy used over the years. We will look at the world we will also look at the energy used in India and we will see how to create and make these kinds of energy balances from the data that is available in the public domain. So, let us look at the global energy use.

So, we will talk in terms of, when we talk about energy use we are talking about the primary energy use by the world. Remember we talk about the energy that we have available in nature and then that goes into different sources, going to secondary and to the final energy use and giving the energy service. And then we would like to see how this energy use has been changing over the years, what factors affect the change of this energy use.

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Ok so, there are many different sources and couple of sources that I would I think you can look at is the international energy agency has details statistics for almost every country in the world and the US DOE also has statistics. Many of these companies like the British Petroleum provides the statistical review of all day energy.

For every country there are also energy statistics, so in India there is an energy statistics released by the ministry of statistics and program implementation and that is an annual kind of statistic. Each of our supply like the ministry of power provides statistics related to electricity, ministry of petroleum, natural gas and these are compiled and provided in these overall international statistics.

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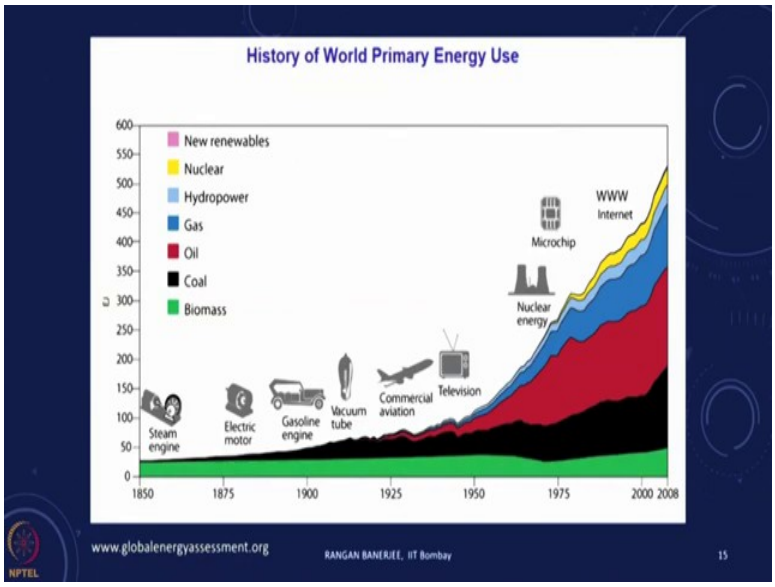

So, if we look at what is the history of the world primary energy use, you can see this is a figure which shows you that the, we had a very significant increase in the energy use. You can also see the different colours represent the different sources of energy. So, in the initial period it was all traditional energy.

If you look at the 1800 we are looking at biomass, wind, water and slowly then with the steam engine and with the use of coal we had the coal coming in and we had the electricity, we have the Edison's first grid and then we started using the next invention which changed the energy sector is the gasoline engine and the growth in the automobiles and then of course, we had aircraft and television and nuclear energy, the micro cheap and the internet.

And you can see it started off with mostly all renewables then went on to coal and then oil started coming in. You see the red which is the oil and oil became the predominant source of energy, then we had natural gas coming in and now again we are moving back. So, it has gone to a situation where it is become predominantly fossil, we are now moving back and we want to go with modern renewables. So, that is the transition that we are looking at in the future.

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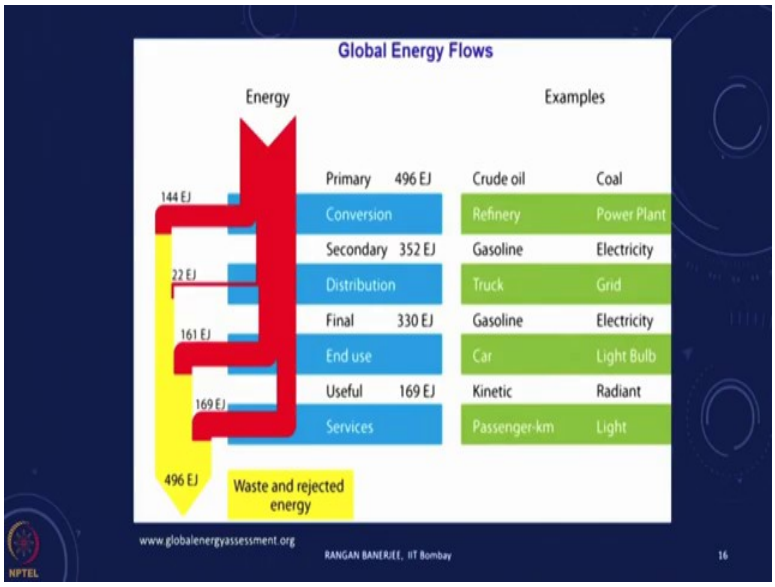

When we look at this, this is an example of the total energy use, I think this is for 2010 and you can see of the almost 500 Exa joules that is being used that gets converted to about 350 Exa joules of secondary, 330 Exa joules of final and the useful energy is only 169 Exa joules, out of this and then you have a significant amount of waste and rejected energy.

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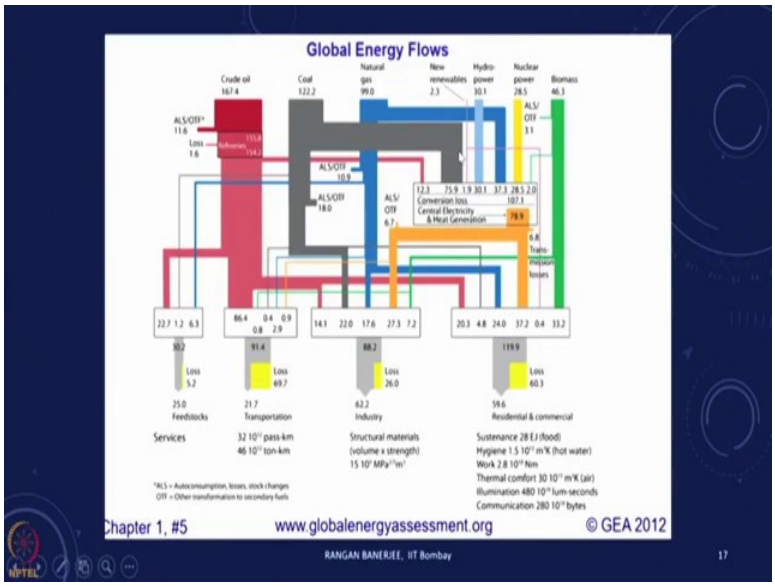

These are the, this is the balance, energy balance which is there and it shows you, this diagram is called the Sankey diagram on an energy balance diagram. Each of the block which is shown there is proportional to the energy use and it shows you the flows from crude oil, coal, natural gas and to the different sectors.

So, if you look at the transportation and you have industry, residential and commercial. It also shows you how much is going in to the electricity generation sector and this helps you get an overall picture of the energy use pattern in the worlds. Similarly, you, one can actually do the same thing for any country in the world.

And one of the things that I would like you to attempt on your own is take a particular country and use that data and create this kind of a diagram, then see what are the mixes in terms of, so we can do the mixes in terms of either primary, if you look at this segment or you can look at it in terms of the final energy or you can look at the secondary which is in between, and so this is a Sankey diagram or an energy balance diagram for the entire world as a whole.

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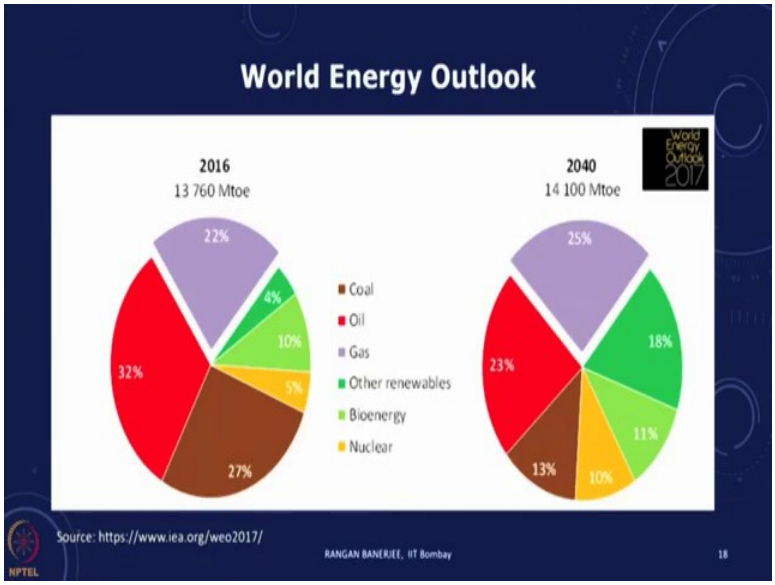

And if you look at 2016 you will find that predominantly we are looking at oil and followed by the natural gas and coal as the major chunks and there is a significant amount of bioenergy and some other renewables and nuclear and it is expected that in future we are going to the share of renewables is going to increase. This is from the world energy outlook, of course, these are all different scenarios. Whenever we talk of the future we know that there will be differences in the energy system and we are going to have more renewables in the future.

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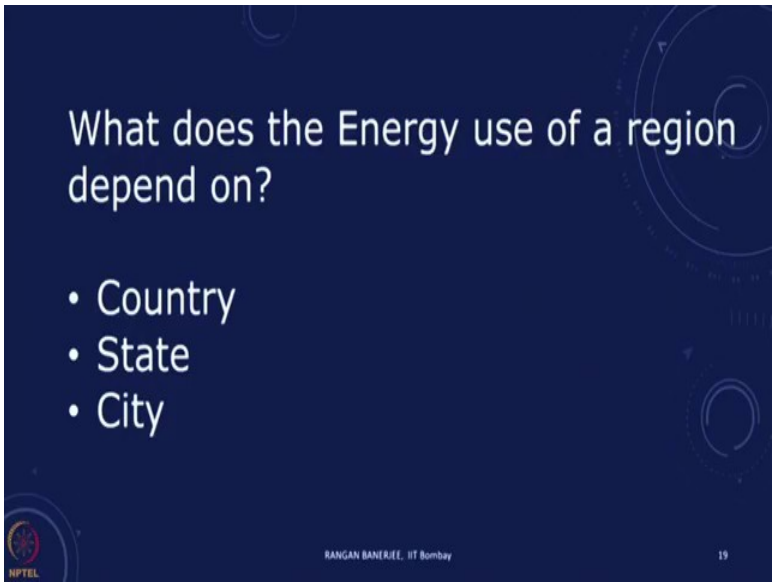

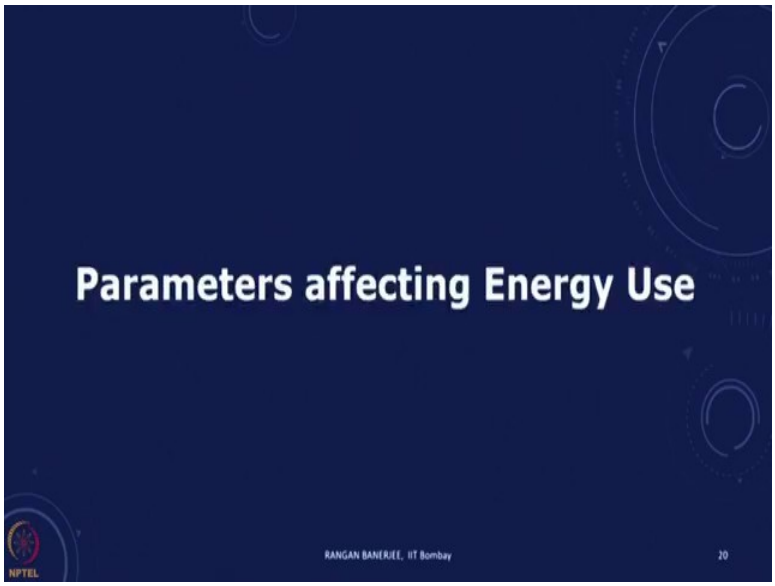

So, the question we need to ask is what does the energy use of a region depend on, wherever it is a country or a state or the city, what will it depend on? And to, what are the parameters affecting the energy use.

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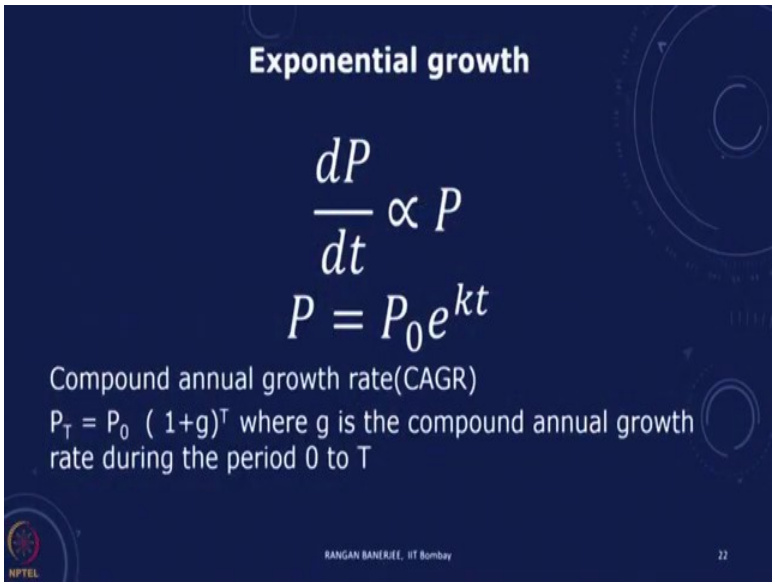

You see whenever we look at the population of a country that is one of the important parameters which will affect the energy use. So, if I have more people there will be a demands for more energy, the level of effluents or the level of industry, the level activity, level of services also will matter. When we talk about population by its very nature the rate of change of population or dP by t will be proportional to P and to the existing population.

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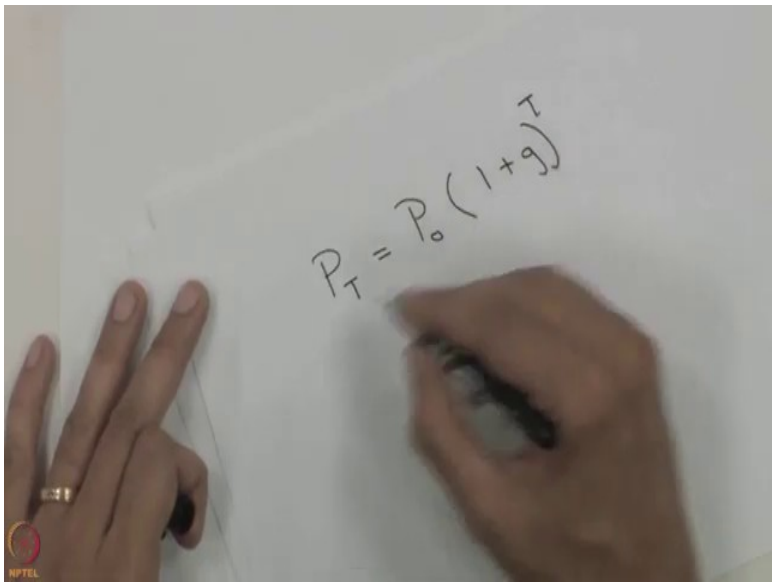

So, that there will be an overall exponential growth rate so that we call this is as a, we can call this as an compound annual growth rate and we can write, we can essentially write that

$$P^T = P_0(1+g)^T$$

If you take it in the P zero is in the initial years and this is the compound annual growth rate between this years. Now, we can compare this growth rates and we can see so this is like an exponential growth and when we talk about energy we can look at what is the energy used per person and then multiply that by the population and then you get the total energy use.

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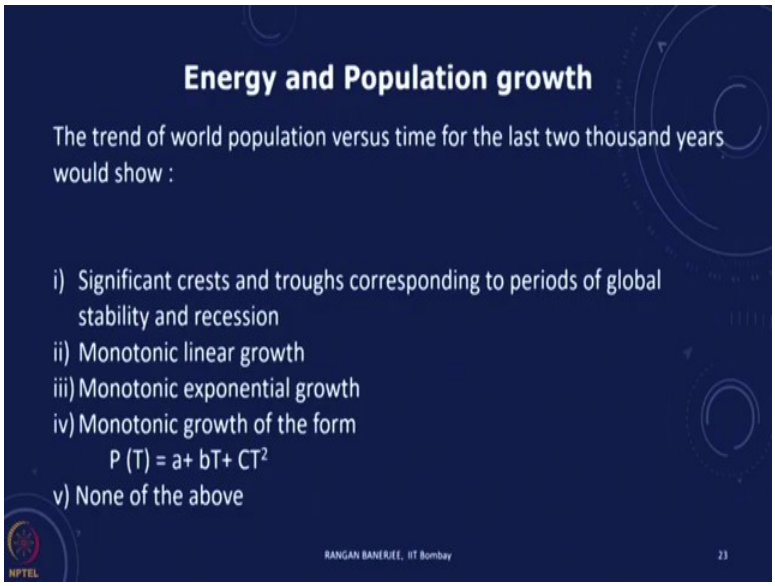

So, when you look at some of the trends, what would you think when we look at the trends of energy and population growth what do you think, think about it trend of world population versus time for the last 2000 year which show significant crest and troughs corresponding to period of global stability and recession, monotonic linear growth, monotonic exponential growth, monotonic growth of the form PT is equal to A plus BT plus CT square, none of the above.

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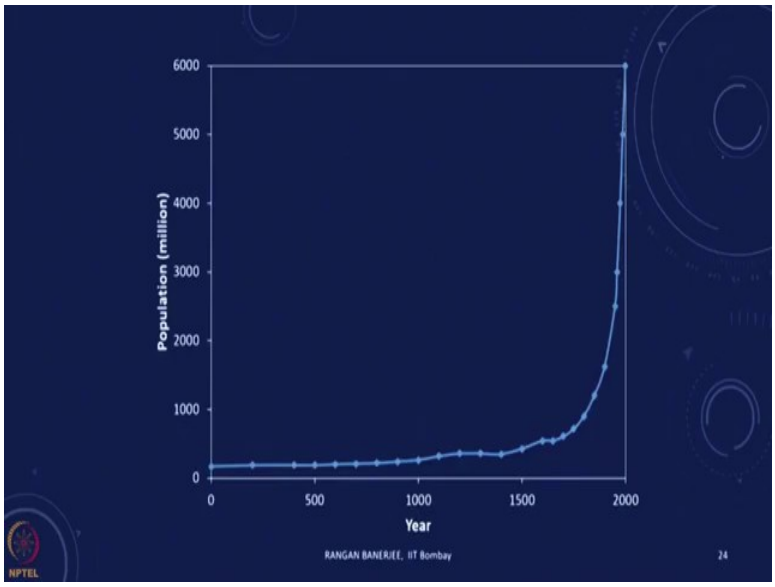

And you will that in general this has been monotonic exponential growth, and that is been the way in which this happen and you can see this, this is population statistics are all available in the public domain. You can take the data and plot it and you can see that this has been growing exponentially. And following this many of the things which are used by humans will also follow these kinds of exponential growth patterns.

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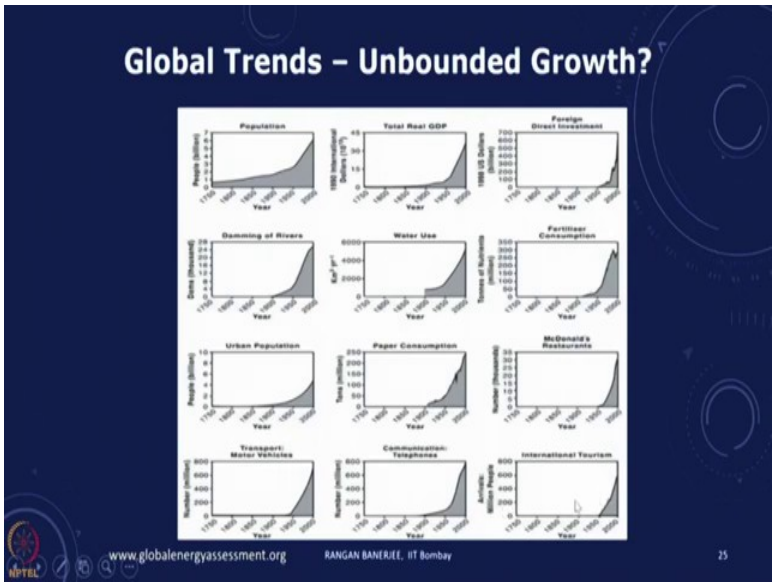

So, this is from the global energy assessment and you can see there are different things that we have project shown here. This is the population, this is the total real GDP which means this is the total sum of all the output of the world, and then you have the foreign direct

investment, damming of rivers, water use, fertilizer consumption, urban population, paper consumption, even Macdonald restaurants, you can see exponential growth patterns, transport motor vehicles, telephones, international tourism.

So, all of this follows the exponential growth of population and what does this mean is this something that is sustainable, this is basically unbounded growth, so if you look at now, take the area under the curve you will find that this going to be infinite. So, if we are talking of a finite resource and we will be talking about energy resources in another lecture.

You will see that if you are going for exponential growth the resource will get depleted, resource will get depleted, so it is not obvious that an exponential growth can be sustained indefinitely in to the future and that is point to keep in mind.

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And now let us think about we talked about the population growth we also talked about world energy growth. So, the world energy trend for the last 2000 years would show: do you think it will show an exponential growth similar to the population growth, exponential growth with a growth rate less than the population growth, monotonic growth that initially follows the population growth but a reversal of growth seen after seventies, exponential growth with the growth rate higher than the population growth, or none of the above.

And the answer to this is actually 4 which is exponential growth with a growth rate higher than the population growth. The energy use per person has been increasing over time and this is because we have use more and more of appliances to make our lives more comfortable and

so the history of human development is characterised by an increasing use energy per person, this of course may not be sustainable into the future and so there would plateauing out over all. But as of now this the kind of trend that you can see.

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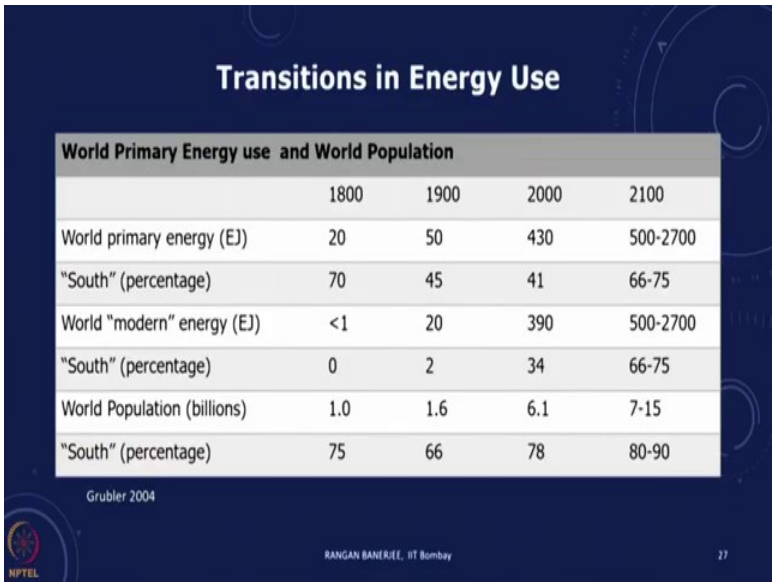

So, just to give you an idea. This is a paper from Grubler in 2004. He compares the north, the developed courtiers with the south which is the developing countries and you can see that the population share of the south is the developing countries is significant in the total, but the primary energy, if you look at this with south has 78 percent of the world's population but has only 34 percent of the modern energy used. So, obviously there is a disparity in terms of the energy use.

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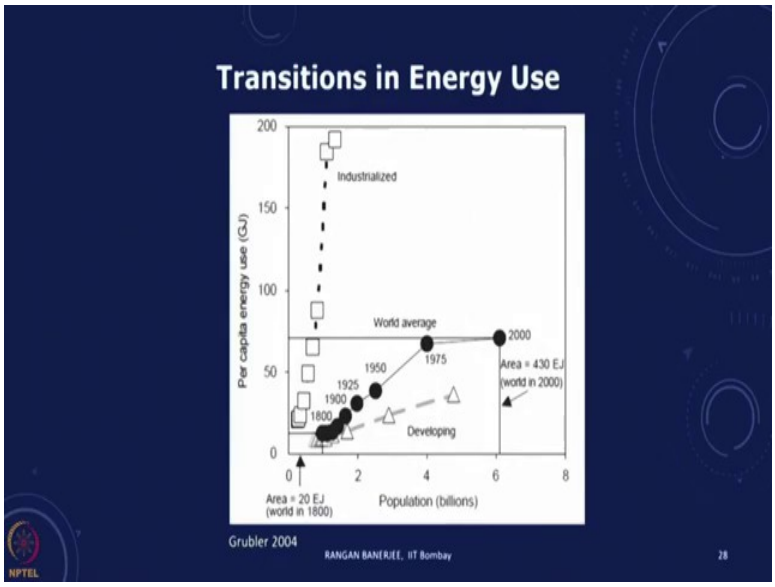

And this disparity is plotted by Grubler in the, there are two curves you can see this is the industrialised curve the per capita energy used for the industrialised nation, you can see how it is been growing and you can see for the developing nations this there are two completely different kinds of slopes or two different kinds of growth rate and this is how the average is going.

And so with the result that if everyone aspires to have the life of the industrialised countries, the energy demand of the world will grow at much much faster rates then our currently sustainable.