Energy Resources, Economics and Environment
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Lecture 05
The Kaya Identity

We would like to now look at the, we will focus on the CO2 in more detail. So a Japanese scientist Kaya proposed a simple identity to try and see what are options are with respect to CO2.

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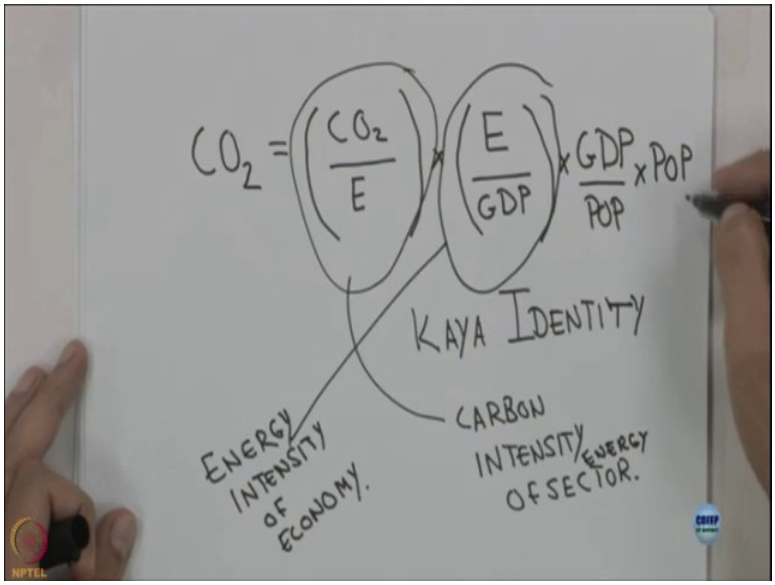

The way this is done is you take the total amount of CO2 either in the world or depending on the, if you are talking about a country, let us look at either a country or the world as a whole. If you look at the total amount of CO2 emitted in the year we can write this as CO2 per unit of energy into energy per unit of GDP into GDP per population into population, this is called the Kaya identity based on the Japanese scientist who proposed it.

$$CO^2 = \left(\frac{CO_2}{E}\right) x \left(\frac{E}{GDP}\right) x \frac{GDP}{POP} x POP$$

Energy intensity of Economy — KAYA IDENTITY — Carbon intensity of the energy

Now the advantage of this is if you look at this, this is called, this is the carbon dioxide per unit of energy is the carbon intensity, intensity of the energy sector. So, for instance, if I have a state like Karnataka or Kerala which has a large part of its electricity coming from hydro, the carbon intensity of electricity for that state would be lower than that of let us say Maharashtra which is predominantly having a large part of its electricity from coal.

So this is the carbon intensity of the energy sector and the other factor this energy per unit GDP is called the energy intensity of the economy. So the question we need to see is that when we want to, if we want to stabilize the CO2 emissions. Now we have limited amount of things that we can do in terms of population stabilization. GDP per population is usually a measure of how we would like the affluence we would like the services and the goods the quality of life typically increases with GDP, so we do not want to reduce GDP population.

So if you look at this and this, these two are things which are sort of outside our control we basically will focus on reducing the energy intensity of the economy or reducing the carbon intensity of the energy sector and these are the two things that we can focus on as we go ahead. So as we said this is the CO2 carbon intensity and the energy intensity.

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Now the question we can ask ourselves is does a country that has a lower energy intensity per unit GDP implied that it is more efficient? Think about it, the two countries, let us say India and Singapore and India's energy use per unit of GDP is higher than the energy use in Singapore, does that mean that India is more inefficient in terms of energy used than Singapore.

So the answer to this is that it is not necessary, energy intensity depends on if you look at GDP, GDP is the total value add of the goods and services produced by the economy. So, if you look at the economy, different economies have different kinds of output, so we look at and in economy which has a large amount of agriculture, economy may have a large amount industry and economy may have large amount of services.

Now industry by its very nature and if you look at heavy industry is energy intensive, so if you want to produce steel, you want to produce cement you will need a minimum amount of energy to do that, white if there is a country which is only importing steel and cement and is mainly focusing only on the service sector it will have a lower energy intensity.

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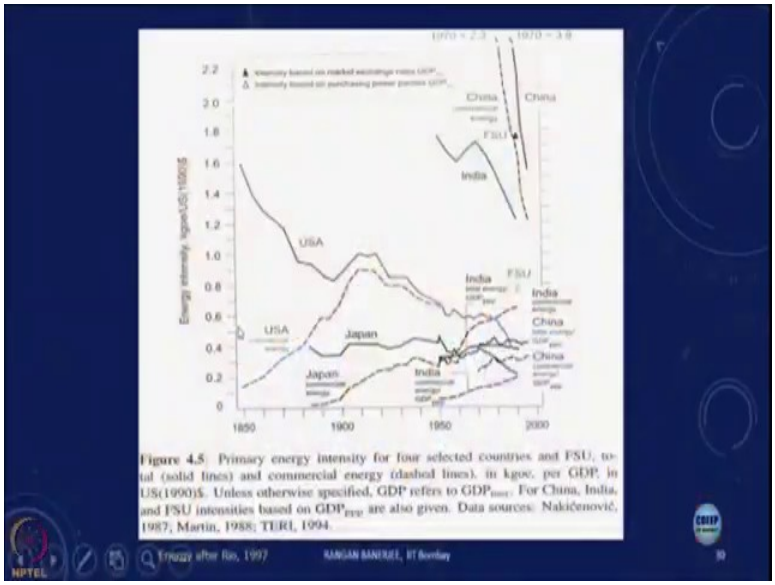

So if we look at this graph this is a graph from the energy after Rio in the 80. You will see that as overtime if you look at the energy intensity of GDP, if you look at US, initially there is been a rapid decline and this is because the country develops from traditional energy use sources which were very-very inefficient to modern energy use and then it again keeps on declining. A lot of this some of this decline is because over a period of time it does not require money of the energy intensive material, so steel, cement it saturates.

The demand for steel, cement and energy intensive material saturate and most of the growth and the GDP then starts coming from the service sector which requires much less energy. And of course, there is another trend where basically industry has moved out from US and Europe and it is predominantly now in China, little bit in India, little bit in Brazil and other developing countries but China has taken the brunt of all of this.

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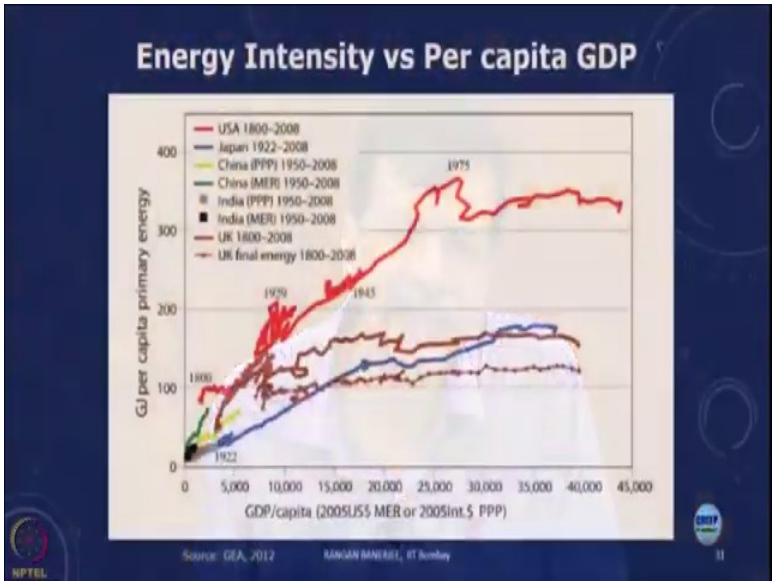

So if you look at the energy intensity, Giga joules instead of the energy intensity if we look the energy used per percent and we look at the GDP per percent you will see that beyond a point with increasing GDP per percent the energy use per percent stabilizes because beyond a point there is no additional amount of energy that you need and so this kind of there is a growth and there is a stabilization.

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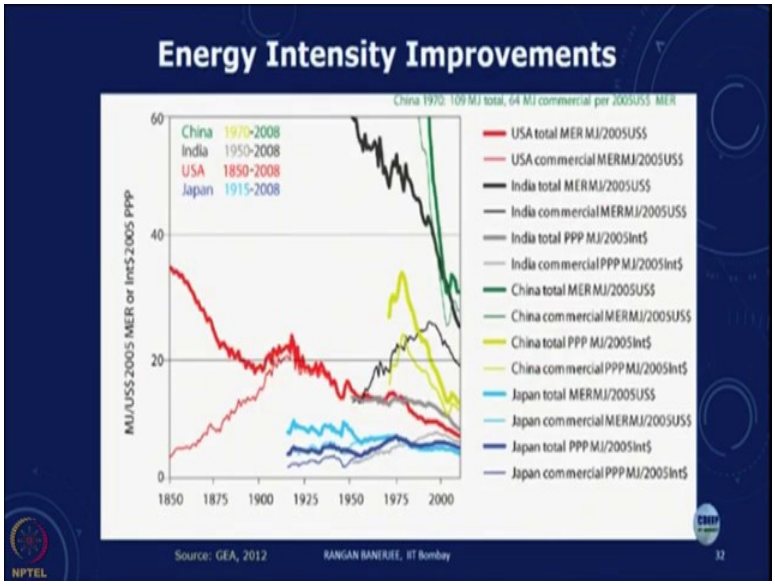

And this trend also if you look at energy improvements this is a more recent graph, you can see that all countries are going through reasonably rapid improvements in energy intensity and energy intensity per capita also going in that fashion. But just to reemphasize the

question the reduction in energy intensity has two components, one is because of efficiency and second is because of the structure of the economic.

So, if the economy changes where more of the GDP starts coming from the services sector this will result in a energy intensity deduction, there are methods by which using decomposition analysis we can see the effect of both these parameters.

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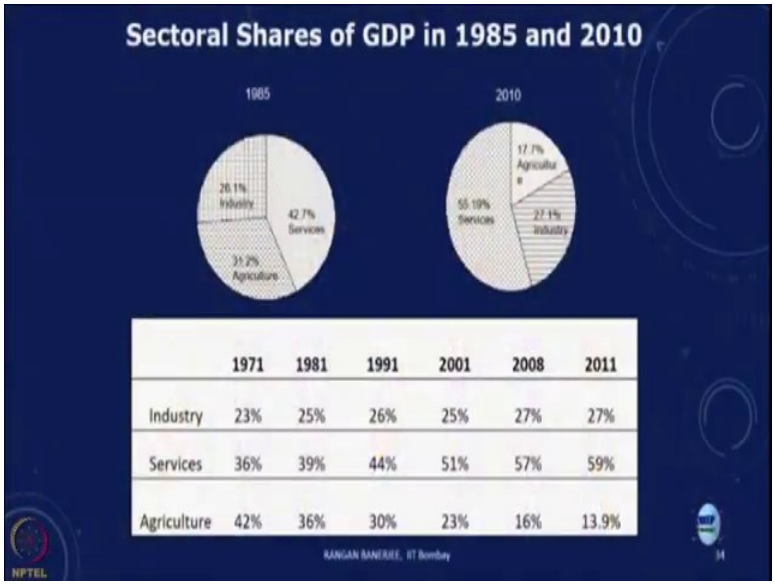

So just to give you a snapshot in time 1985 and 2010 we can see over the 70's and 2000 you can see that agricultural share in our GDP have been declining rapidly service share has been increasing and industry share more or less is being remaining sort of constant and so this services with the result that we have had a significant decrease in the energy intensity we have also had significant improvements in efficiency.

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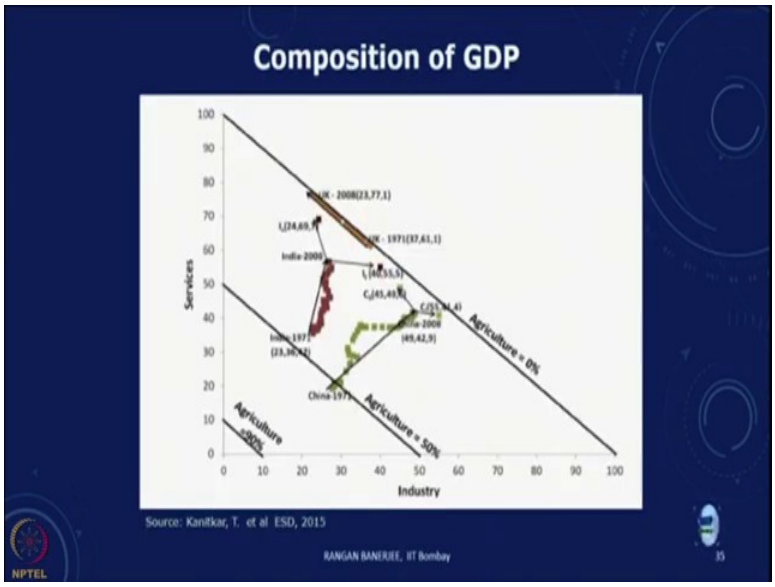

So if you see this, this is a tri plot which shows agriculture is 0 here and agriculture 0 to 100 is on this side, industry 0 to 100 is on this side and services 0 to 100 is on this side. So, if you see different countries you will see that China has grown where its increase its industry share and in Indian context the industries share has been more or less constant but we have actually we have the option of wither going high services or a high industrial growth and this will have an impact in terms of the kind of energy used that is there.