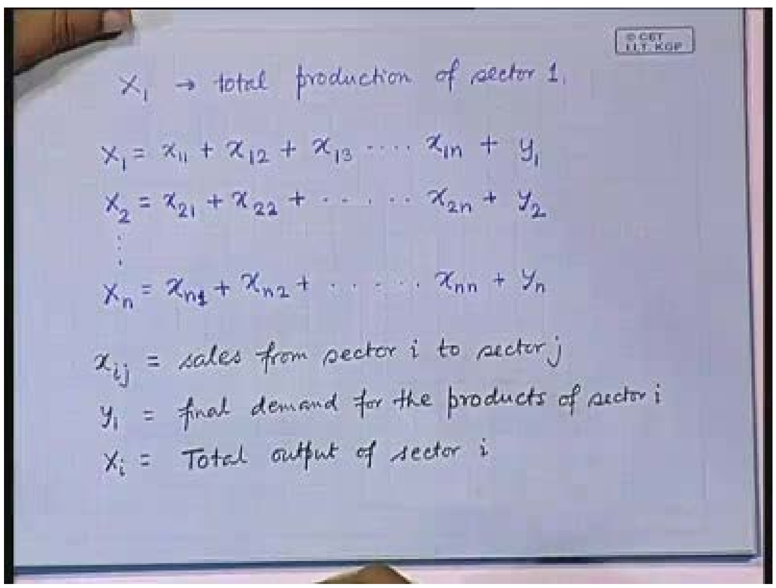
Energy Resource and Technology
Prof. S. Banerjee
Department of Electrical Engineering
Indian Institute of Technology – Kharagpur

Lecture - 7
Energy Economics: Input-Output Analysis (Contd.)

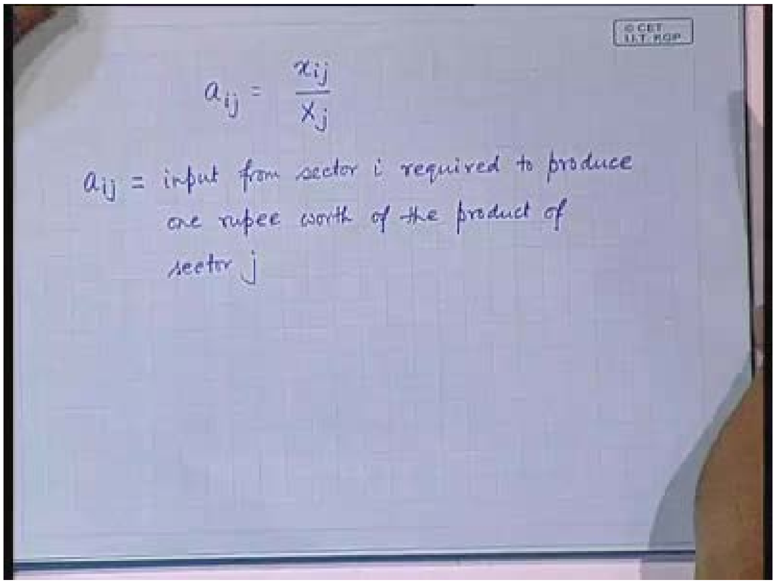
First, let us recapitulate what we said in the last class. We said that any economy can be divided into a few sectors and then, we can study the intersectoral transactions between the sectors and for that we had, I will just show the papers that we used in the last class. Please be seated first.

(Refer Slide Time: 1:22)



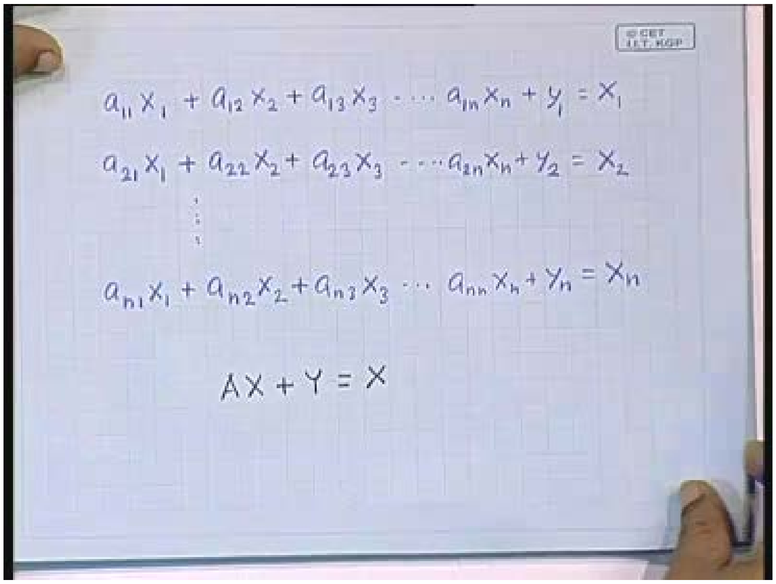
X 1 here is a total production of sector 1, X 2 is a total production of sector 2 and so on and so forth and that would be composed of the intersectoral transactions which are the small x. x 11 is the production of sector 1 that is consumed within sector 1, x 12 is the transfer from sector 1 to sector 2 and so on and so forth and finally, we have the y's, the y representing the final demand, the ones that are finally consumed by the user and so we had composed this kind of a set of equations and from there, we had defined the terms a ij which are the x ij divided by x j, which means that the transfer from sector i to sector j divided by the total output of sector j.

(Refer Slide Time: 2:12)



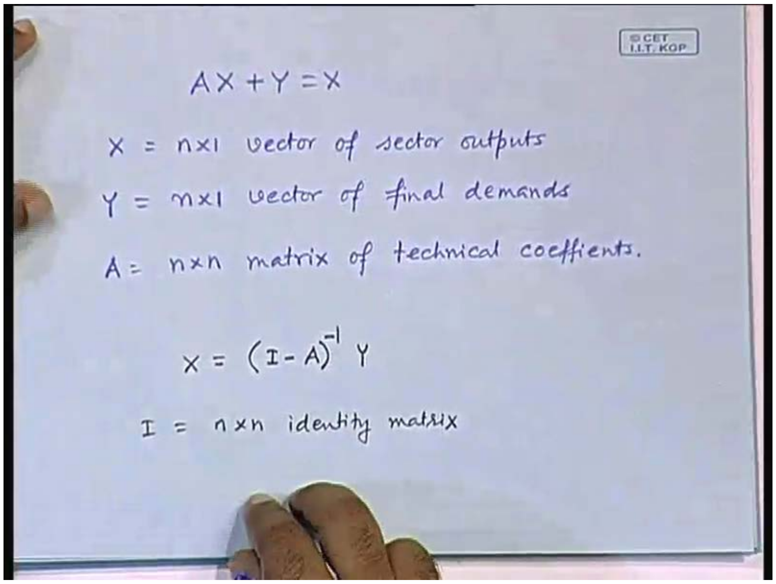
What does it mean? It means the amount of the product of sector i that is necessary in order to produce a rupee worth of product of sector j. If you say verbally, it will be that.

(Refer Slide Time: 2:50)



Once we have defined this, we said that we can then represent it as a set of equations like this a 11 X 1 plus a 12 X 2 plus a 13 X 3 and so on and so forth plus Y 1 is equal to X 1 and similarly, you write the other equations. It clearly has the shape of a matrix AX plus Y.

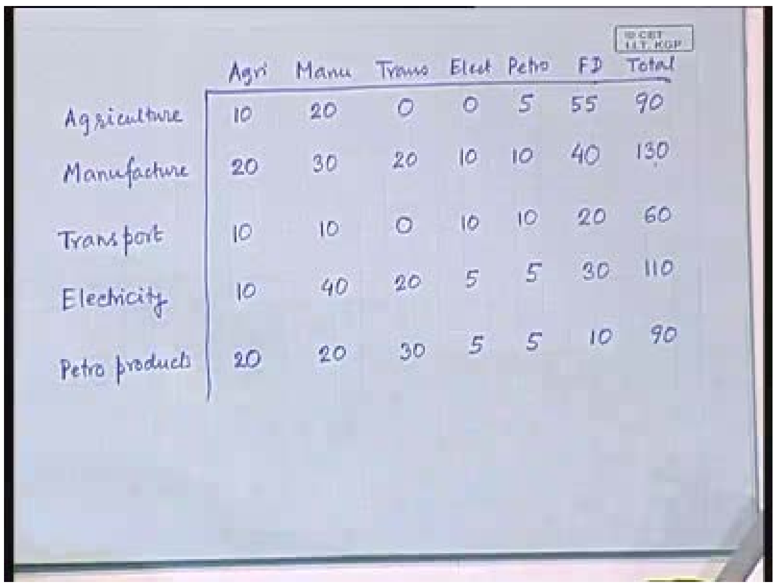
(Refer Slide Time: 3:17)



So, we had written as this matrix and finally, when we write it as the matrix AX plus Y is equal to X, in this, you have to remember that X vector is the vector of sector outputs, Y is the vector of final demands and A is the n cross n matrix of the technical coefficients. So, we had decided that from this we had, we can write X is equal to I minus A inverse times Y. So, what was the conclusion? That the whole crux of the economy is contained in this matrix I minus A inverse, so that this matrix when multiplied with the final demand that goes into the users use, if you multiply this, you get the total outputs of different sectors and this we said should be used, can be used for prediction, for planning, in the sense that supposing a country wants to increase say the agricultural output by say, 10%, then what will be the increase?

What will be the necessary increase in say, the manufactured goods like you need increased amounts of tractors, increased amounts of fertilizers, which are the products of the manufacturing sector and so on and so forth, so there will be a multiplying effect; you will need more amount of petroleum products, you will need more amount of coal. So, because production of tractors will need production of steel, production of steel will need production of coal, so it will have a multiplying effect and you need to understand quantitatively, how much is the necessary increase in the production of each sector? That can be obtained from here and in order to illustrate this we had cooked up an imaginary economy, in which the sectors had these outputs.

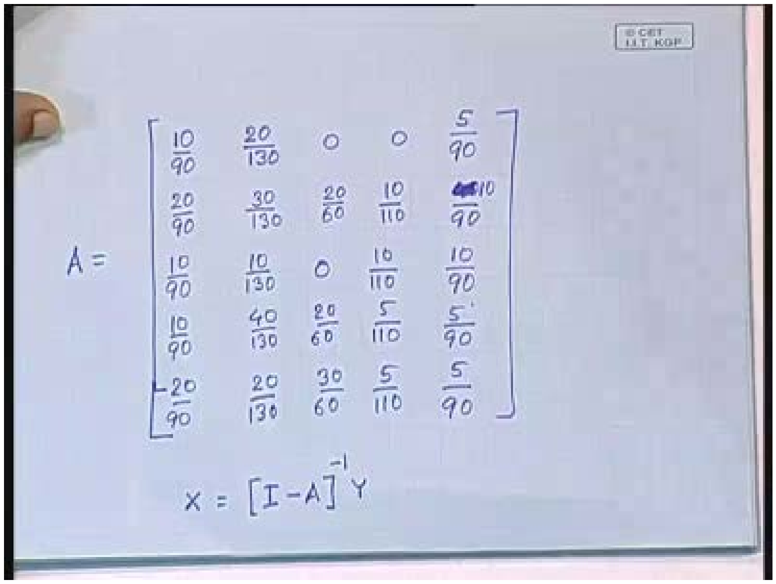
(Refer Slide Time: 5:20)



	Agri	Manu	Trans	Elect	Petro	FD	Total
Agriculture	10	20	0	0	5	55	90
Manufacture	20	30	20	10	10	40	130
Transport	10	10	0	10	10	20	60
Electricity	10	40	20	5	5	30	110
Petro products	20	20	30	5	5	10	90

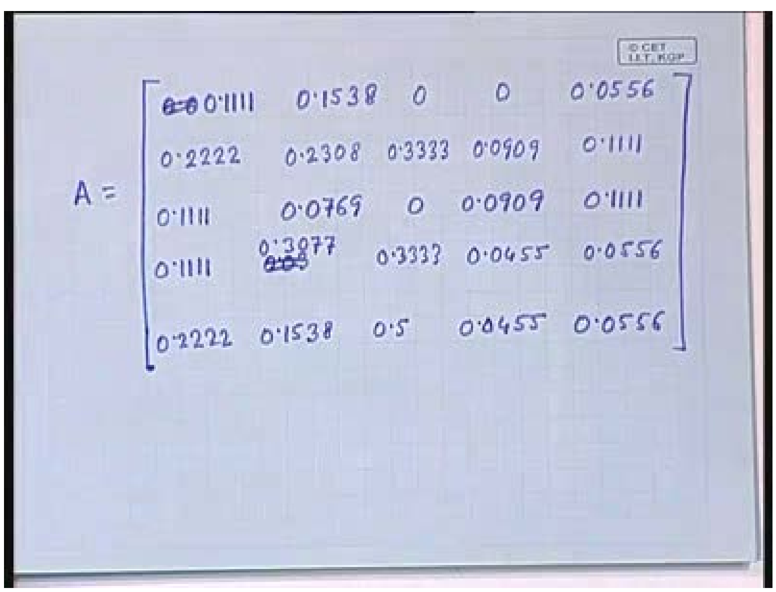
You remember that, right, the last day we had done this. So, for example, just to show you one, the manufacturing sector, 20 rupee worth, it is not only 20, but it should be 20 million or something that means everything is multiplied by a million factor, whatever it is, 20 unit worth goes to agriculture, 30 unit goes to manufacture that means manufactured product consumed within the manufacturing industry, manufacture to transport, manufacture to electricity, manufacture to petroleum products and finally manufactured products that finally the users consume, 40. These added up gives the total, which is 130. Similarly, you constructed the whole thing. So, we had also constructed the A matrix, which means we will take these, these are the X ij divided by X j would give you the A matrix, so that to the shape like this.

(Refer Slide Time: 6:29)



We had probably done up to this point in the last class. So, the first one is 10 by 90, because 90 was the product total production of sector 1. Like, can you tell me why is this here 40 by 130? The 40 units of production of sector 4 was going to sector 2 and the total output of sector 2 was 130, so 40 by 130, so on and so forth. Now, in the mean time, I had simply sat on a computer and just computed those.

(Refer Slide Time: 7:18)



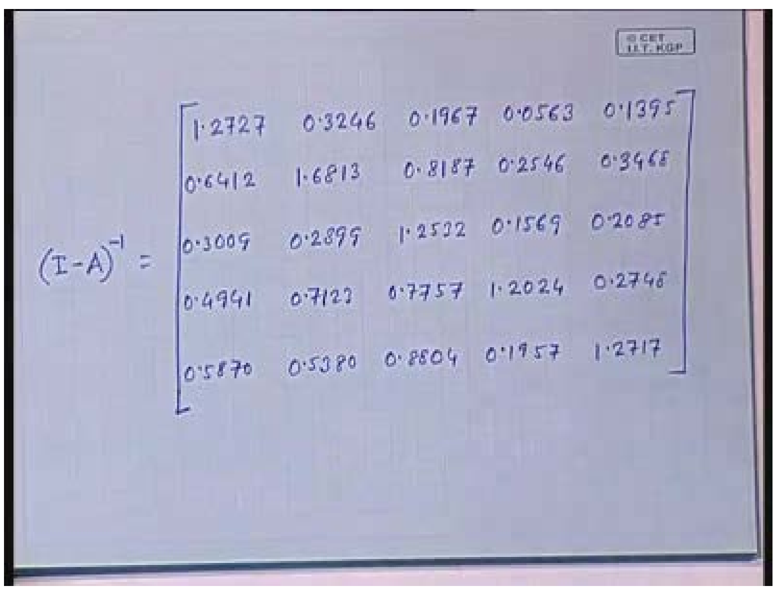
So, let me write down the matrices for your convenience, sorry; write them down because we will use them in further calculations 0.0769 0 0.0909 0.1111; again, 0.1111 0.03 sorry, 3077 0.3333 0.0455 0.0556 and 0.2222 0.1538 0.5 0.0455 and 0.0556. So, that was the A matrix which we say that it contains all the necessary information of the technical coefficients.

What was the next step?

Student: I minus A

I minus A inverse; so, you can easily put this matrix into any program like MATLAB and get I minus A and then invert it.

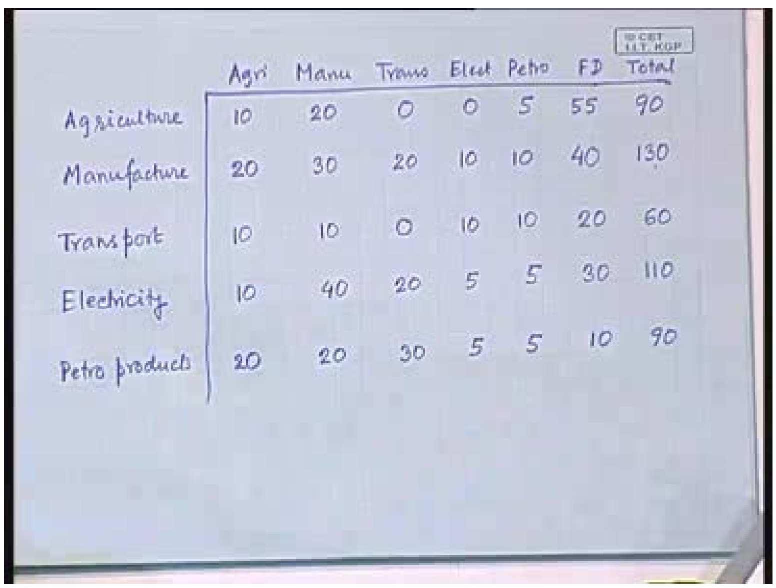
(Refer Slide Time: 9:44)



So, if you do that you get, I minus A inverse. I is the identity matrix; 1.2727 0.3246 0.1967 0.0563 0.1395, 0.6412 1.6813 0.8187 0.2546 0.3468, 0.3009 0.2899 1.2532 and 0.1569 0.2085, 0.4941 0.7123 0.7757 1.2024 0.2748, 0.5870 0.5380 0.8804 0.1957 and 1.2717. So, that is the I minus A inverse matrix. Now, obviously if you multiply this with the Y vector, what do you get? The X; so, you can easily check that. That is one of the checks. You already know the total A's vector. So, if you multiply this, pre multiply this to I, to Y you get X. Now, what is the use of this?

Use of this is that in planning, we essentially plan; if we change, if you plan a change in the things that the users consume, for example if you want to increase the education sector, if you want to make more food available to people, if you want to increase the production of various things in industry, here we have clubbed together the whole of the manufacturing sector. But, in general, when an economy's data sheets are published it has far more number of sectors. So, you might say that this particular sector I want to increase, what is the result of the economy? So, if we do that, for example, for our model economy, if you say that, what was the agricultural output? Let us see.

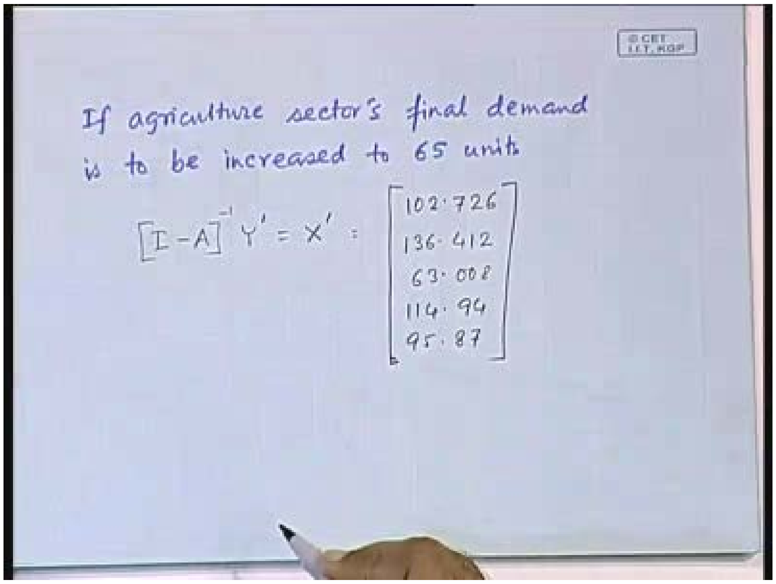
(Refer Slide Time: 13:09)



	Agri	Manu	Trans	Elect	Petro	FD	Total
Agriculture	10	20	0	0	5	55	90
Manufacture	20	30	20	10	10	40	130
Transport	10	10	0	10	10	20	60
Electricity	10	40	20	5	5	30	110
Petro products	20	20	30	5	5	10	90

Agricultures output going to the people was 55 units. Suppose we want to increase it to 65 units; a good plan, you would like to do that. The question then is how much would be the necessary increase in the output of the manufacturing sector, how much would be the necessary increase in the output of the transport sector and so on and so forth. What will you do in order to obtain that? We will simply multiply this matrix to the Y vector, where in place of 55, you substitute 65.

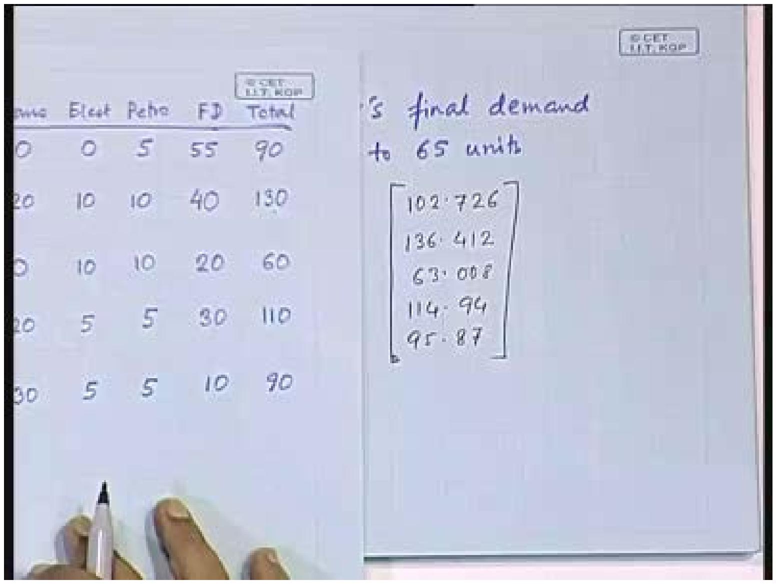
(Refer Slide Time: 13:50)



Now, if you do that, then that means if ……., then what will you do? You will multiply I minus A inverse times Y prime, where Y prime is the chased Y. Now, if you do that, you get the X prime. Now, right now I do not have MATLAB installed in this computer that we are using. So, I, just before coming, I calculated this. So, this comes to 102.726. Do any one of you have the calculators that can do this calculations? Now, nowadays, some of the scientific calculators can do that; 136 point, but I suppose you know how to do that by MATLAB or some, something, some program like that. You don't, okay.

The problem is that if I use MATLAB on this computer, the fonts are too small to be seen on the screen that is why. Presently you can see, because I am writing big. Similarly, if I have to show on a computer, the fonts have to be big and MATLAB cannot do that. So, if you know how to use MATLAB, to enter matrices or invert matrices or manipulate matrices, better use the help screen and get used to it. MATLAB is available in most of the computers in the computer center; just come and get used to it. This will be necessary. So, you have 63.008, 114.94, 95.87. What does it mean?

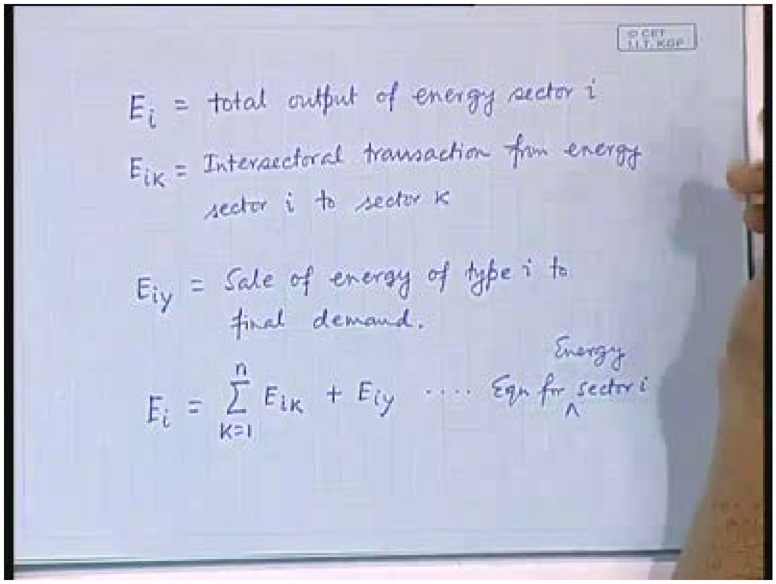
(Refer Slide Time: 16:35)



It means see, earlier the agricultural sectors total output was 90, manufacturing sectors total output was 130 and so on and so forth. So, the X vector was this. So, I will put them side by side. You see, something that was 90, now has to be increased to 102, something that was 130 in manufacturing sector that has to be increased to 136.412. So, there has to be this particular quantity of increase, 6.412. Similarly, transport sector was 60; it has increased to 63.0, some 3 units. So, you can see, easily we can calculate the resulting necessary increase in the production of the other sectors.

Most important are these increases. These are energy, right. So, electricity sector has to increase its production by say almost 5 units and the petroleum products again almost 6 units. So, there you can calculate that if I want to do this planning, I have to make provision for this additional amount of electricity and additional amount of petroleum products, quantitatively. So, we are not talking about fussy ideas; here we are, everything will be complete, clear.

(Refer Slide Time: 18:13)

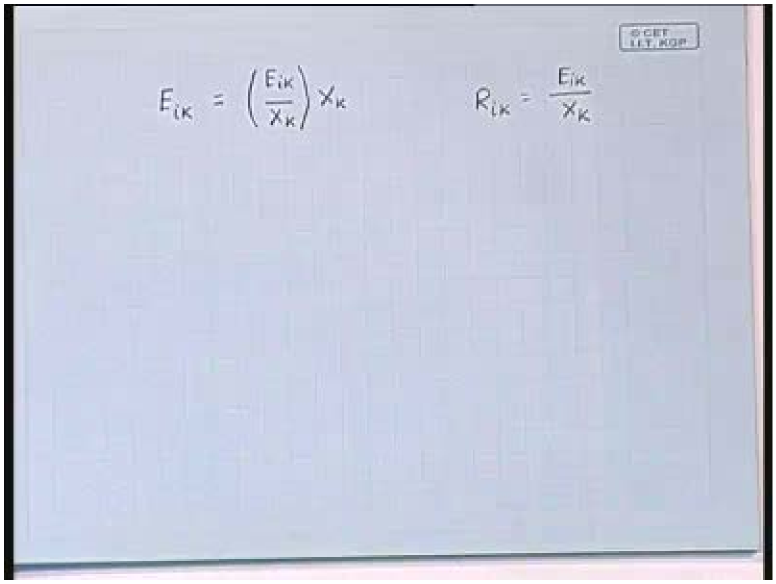


From here, in the end of the last class, we had started the next step which was, we said that the total output of the, now we are talking about the energy sectors, specifically. We are trying to extract the information about the energy sectors from these matrices that we have constructed. So, we are specifically asking the question which is with respect to energy sectors. When we did this so far, we are also asking how much would be the necessary increase in the transport, what is the necessary increase in the manufacturing, but now, we are specifically asking about the energy sectors, because that is what our concern is.

So, the total output of the energy sector I, switch it off, everybody; there should be no mobile phone ON in the class. E ik is the intersectoral transactions from energy sector i to another sector, any sector k and E iy are the sale of energy of type i to final demand. So, specifically with respect to energy, we have this equation. Now, let us see. We also say that these could either be in terms of the energy units like the British thermal unit or say kilo watt hours, so something like that, kilowatt, KLOE, so kiloliters of oil equivalent that is another unit in which sometime this is expressed. But, for us it is convenient to express it in rupee terms, monitory terms, because these data would be then directly obtainable from the published tables. So, we have this.

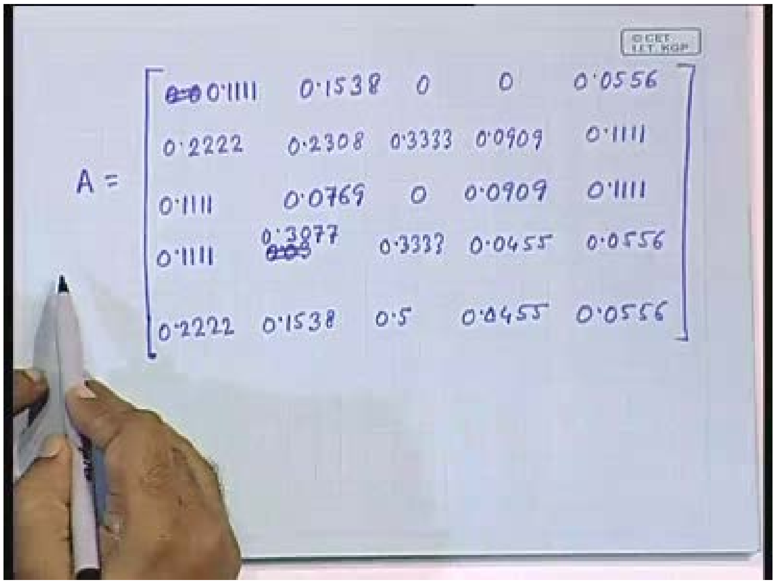
Now you have, let us pay special attention to this particular term. What is E ik? Energy of sector i going to sector k.

(Refer Slide Time: 20:27)



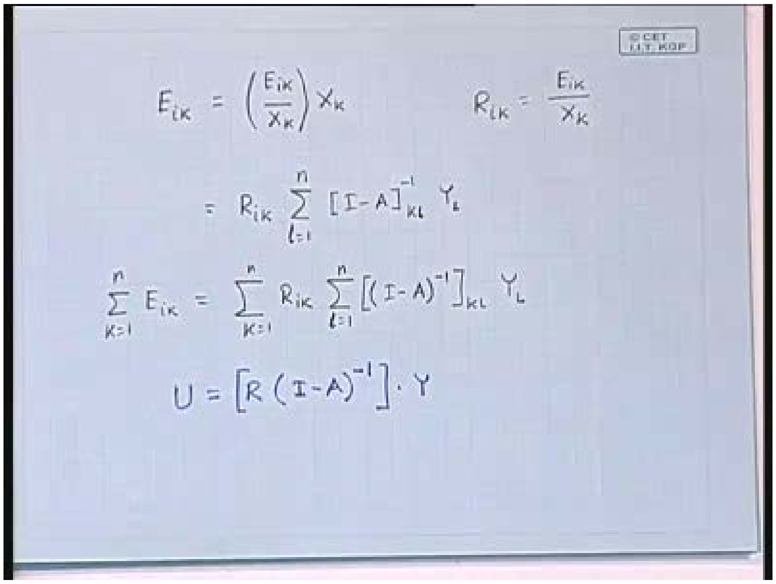
So, we have, we can write, E ik is, we express in the terms that we already know like, E ik by X k times X k. Now, E ik by X k are the things that we know. These are, what are these? These are the specific terms in the A matrix in the energy rows; particular rows will correspond to energy and these are the particular terms from the energy rows. So, we will call them R ik is E ik by X k. So, these are the energy rows. For example we have, where was the data? Here.

(Refer Slide Time: 21:45)



In the A matrix, the last two lines corresponded to energy and if you pick up say this, it is R 42. R 42 is this particular term, so we can pick up from the A matrix itself.

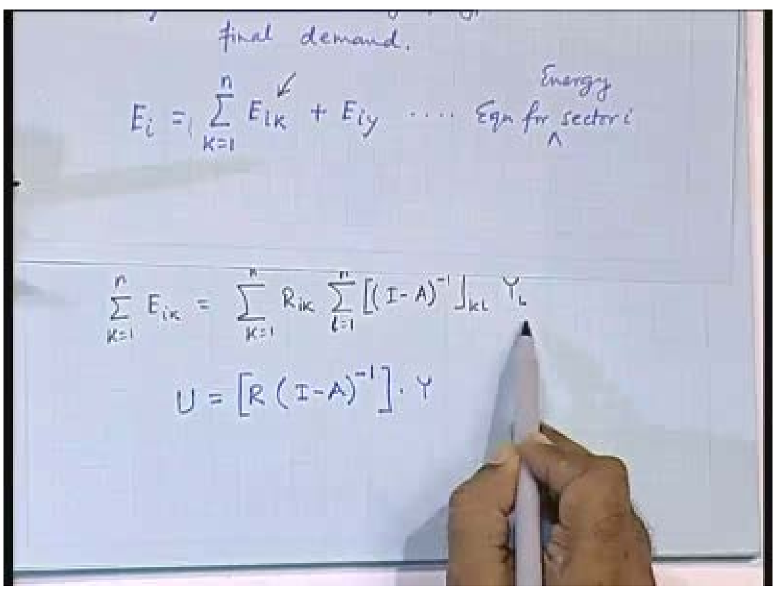
(Refer Slide Time: 22:11)



So, this is known. What is X k? X k can again be expanded as, so we will write as R ik times X k is nothing but, i is equal to 1 to n; X k is obtained from I minus A inverse times Y. So, kth term would be I minus A inverse its KL element times Y L element, right. So, we extracted that information from I minus A inverse times Y. So, now if we put all of these terms together, then we have sigma of k is equal to 1 to n E ik is k is equal to 1 to n R ik times i is equal to 1 to, I suppose it is l know, l; so, this should be l is equal to 1 to n, l is equal 1 to n, it is I minus A inverse, you have to take the KL term times Y L. This essentially embodies the indirect use of energy, energy that goes from the energy sectors to the other sectors of the economy and then this can be written as, I will write with another pen; U is equal to R, now I am writing in the matrix form, these are all matrices, I minus A inverse. Now take the whole times Y; is it not. If you have these matrices, then you can manipulate this way to obtain the indirect use of energy vector.

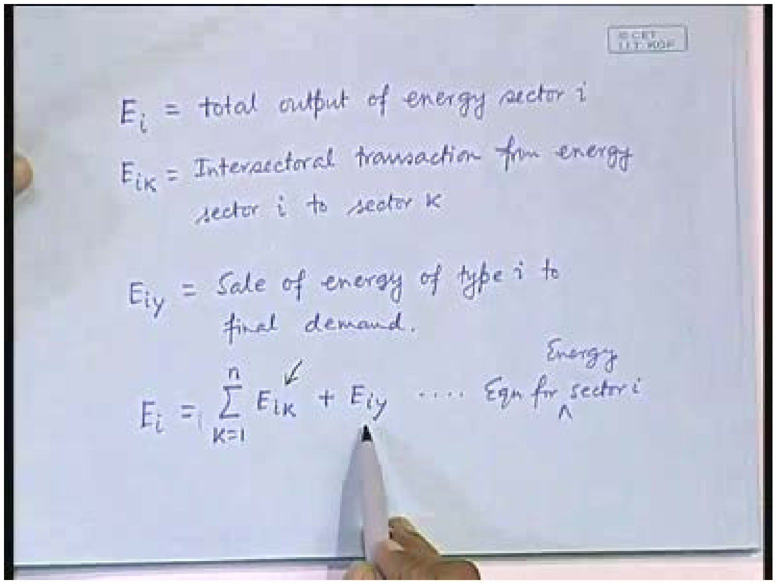
So, you have this equation. All these remember are the R matrices and this matrix is known, this matrix is known, this matrix is known and therefore, this can be determined. Now, this is only the indirect use of energy. There is also a direct use of energy because, where did we write that?

(Refer Slide Time: 25:36)



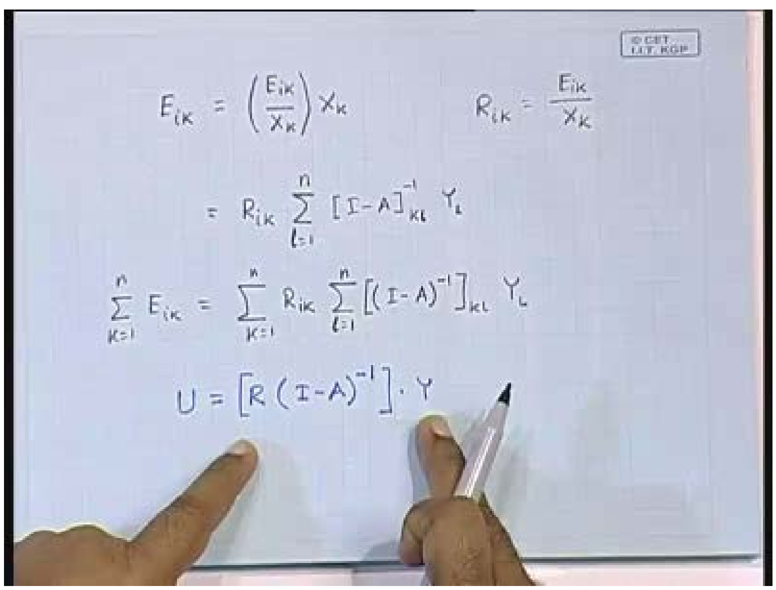
This is the indirect use of energy component, which we have written in the expanded form.

(Refer Slide Time: 25:43)



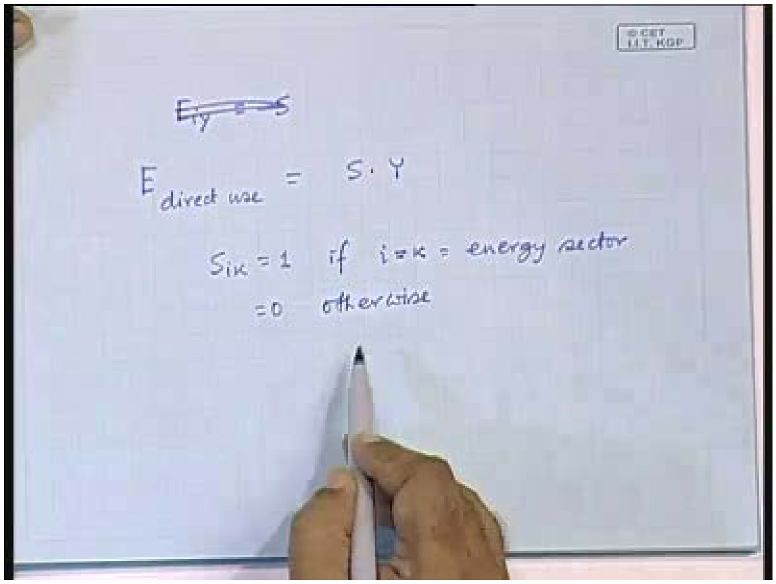
In addition to that there was the direct use of energy.

(Refer Slide Time: 25:48)



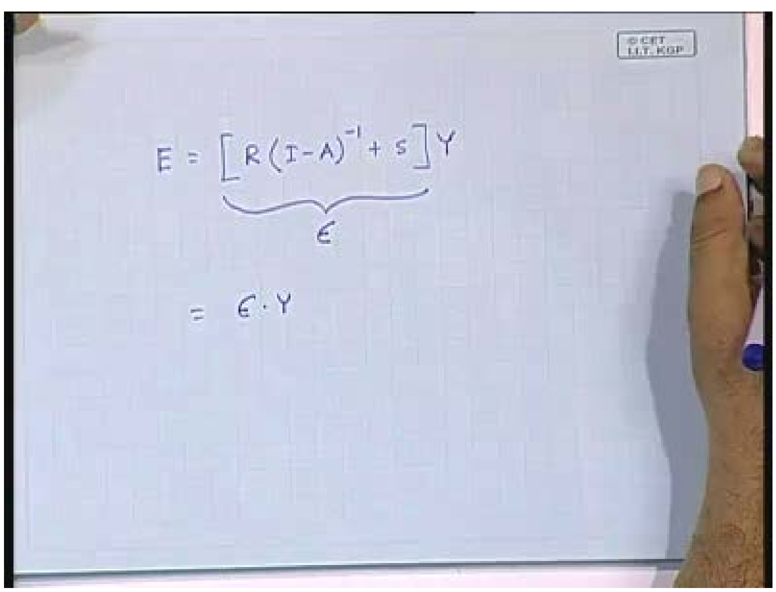
Now, you see, here we have something. If we have plus something and if you can express that as something times Y, then we can club that together and make it as something times Y. So, what is it that needs to be multiplied with the Y vector to extract the information about the direct use of energy? So, now we are trying to do something like this.

(Refer Slide Time: 26:21)



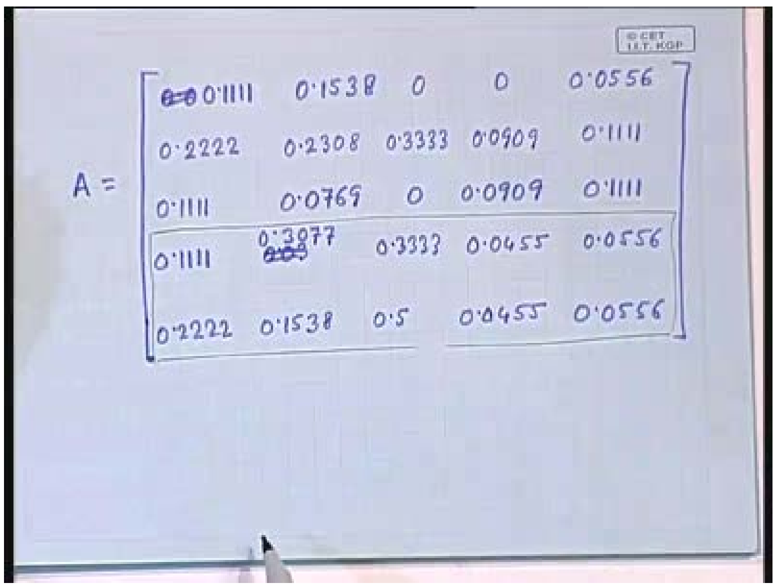
Here we have, E iy, this component we are trying to write. We want to write it as S, okay, let me write it this one. E of direct use is we want to write it as S times Y, where we are asking what this S should be. Now, this S obviously should be a matrix with only components that are 0 or 1. 1, where, so S ik is 1 if i is equal to k is equal to energy sector and is equal to 0, otherwise. Then, if we multiply this matrix with Y, we extract the information about only the final demand of the energy sectors, clear?

(Refer Slide Time: 27:51)



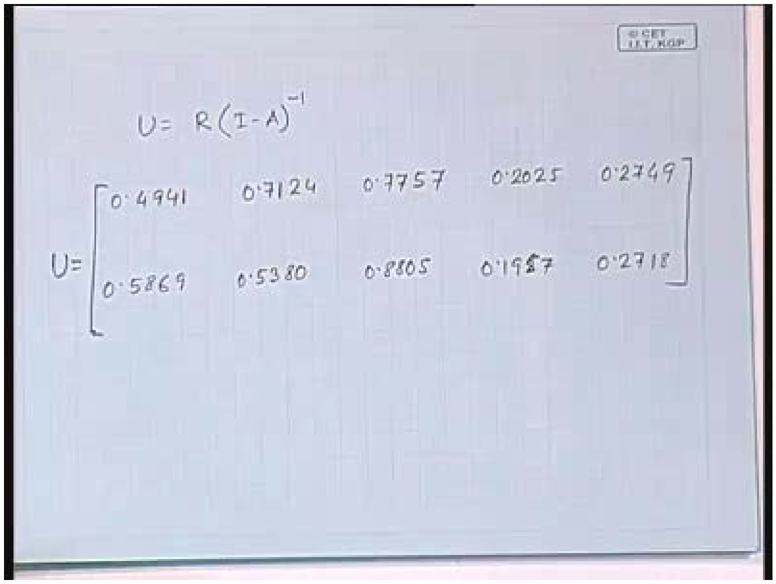
Well, once we have done so, once we have done so, we can then write the total energy, E is equal to R I minus A inverse plus S times Y. We can write it this way. So, here we have a matrix. This is normally called the epsilon matrix, so this is equal to epsilon times Y. So, before explaining what this mean that means this matrix manipulations are all fine, but finally you have to understand what they mean. What is the physical meaning of the terms appearing in these matrices, we will come to that; first, let us see how these matrices look actually for this particular example problem at hand. The first issue is I minus A inverse, we have already written. R matrix should be, where is it? Here.

(Refer Slide Time: 29:18)



The R matrix should be this particular component. Therefore, the R matrix is a 2 by 5 matrix; R matrix is a 2 by 5 matrix.

(Refer Slide Time: 29:39)



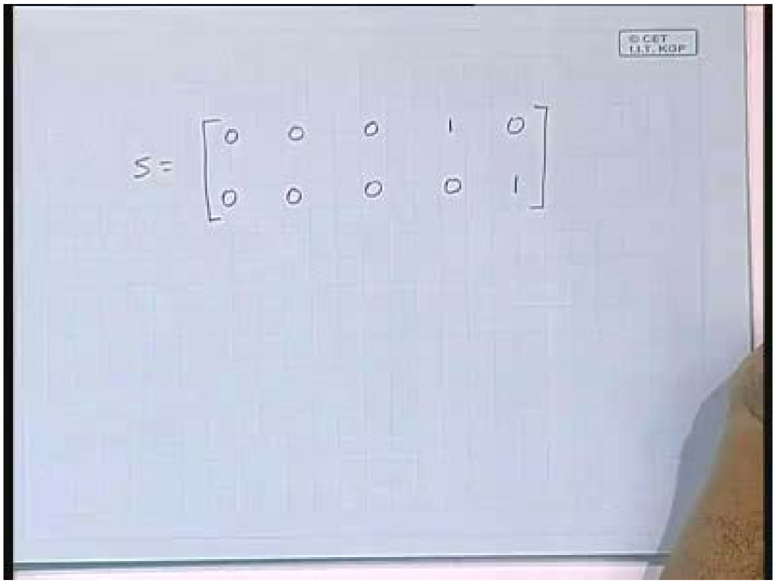
So, if we then write U is equal to R I minus A inverse, then what will be the form of this matrix? I minus A inverse was a 5 by 5 matrix.

Student: 2 by 5.

2 by 5; so, we can, we can obtain that. If you obtain that that takes the shape - 0.4941 0.7124 0.7757 0.2025 0.2749, 0.5869 0.5380 0.8805 0.192 sorry 57, 0.2718; so, this is what U is. So, what I have done is I have taken this matrix from the A, some particular rows from the A matrix and multiplied by the I minus A inverse. What does it imply? It implies that these when multiplied with Y will give the total amount of indirect use of energy.

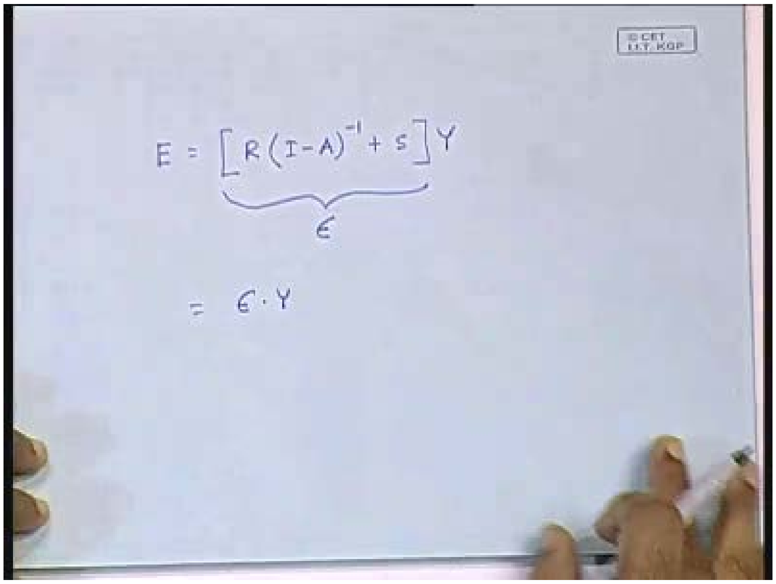
Now, what is the S matrix for this particular case?

(Refer Slide Time: 31:28)



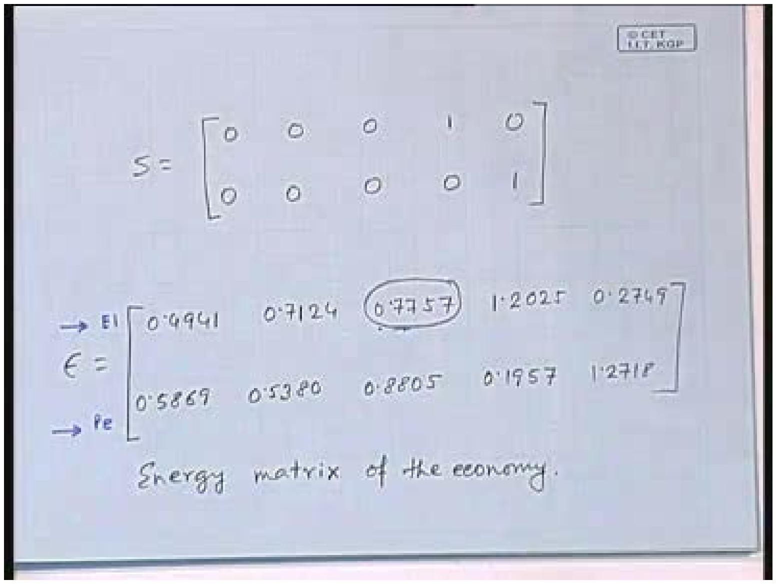
S is a collection of 0's and 1's arranged in such a way that this when multiplied with Y will extract the direct use of energies. So, what should be S? It is 0 0 0 1 0 and 0 0 0 0 1. Is that understood or things are going above your head?

(Refer Slide Time: 32:14)



So, if this is S, then we have already written that we can, we have then everything. We have this, we have this, we can add and we can obtain the epsilon matrix.

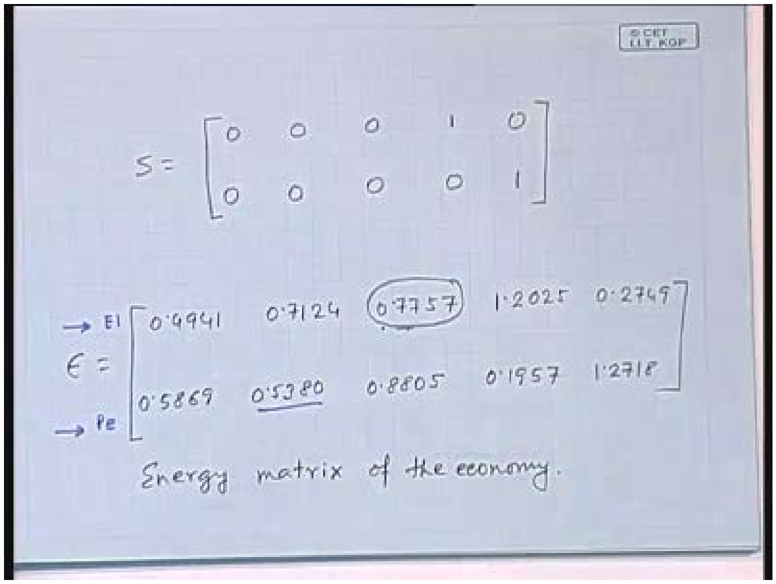
(Refer Slide Time: 32:27)



So, epsilon matrix is then, epsilon is 0.4941 0.7124 0.7757 1.2025 0.2749, 0.5869 0.5380 0.8805 0.1957 and 1.2718. So, we have this epsilon matrix and we are now trying to understand what physically it means. This is called the energy matrix, energy matrix of that economy; energy matrix of that economy. So, what does say this term mean? There are two energy rows. This row corresponds to what was it, electricity and this row corresponds to petrol. So, this is E and this is …. So, this row is electricity and this row is petroleum. So, it means that electricity needed to produce 1 rupee worth of the product of this sector, one rupee worth of the product of this sector means, what was this sector? Transport; so, now this electricity is not the electricity that really runs the trains.

The electricity that really run the trains and metro rails and stuff like that these are only a component of that. But, in order to manufacture the trains it needed electricity, in order to print the tickets it needed electricity; so, everywhere it needed the electricity. All that put together, how much is the electricity needed in order to produce 1 rupee worth of the product of this particular sector? Obviously, transport sector does not produce a product that you can use. It is a service sector, but nevertheless you can easily identify 1 rupee worth of the service and that requires this much of electricity, clear.
So, similarly what does this mean, what does say, this mean?

(Refer Slide Time: 35:40)



Tell me. What is the physical meaning of that? The amount of petroleum products needed to produce 1 rupee worth of manufactured goods, clear. So, have you now understood? Which means that when I talk about this pen, I can identify number; how much energy is inside this pen, by doing this procedure? How much energy has gone into this particular pen? If the economy is divided into that many sectors, so that the pen production is a sector, then only we can do that, else it will be clubbed together with many other sectors and it will be difficult to identify separately. But, if we can divide the sectors into sufficient detail, then of course we can do that and that is important. That is important, because this is what tells us how efficiently the economy is functioning in producing each and every of this produced goods, including the services like the transport and the improvement in the technology, in the economy, overall. One fellow is doing some improvement, does not, one fellow is doing something that is an indicator of things that will happen later may be, but the actual state of the economy is the average and that is ingrained in these numbers, clear.

So, how much is the energy necessary in order to produce all these? So, this is the energy content. These are the energy contents of specific products, energy content of specific products. When initially we said that in order to produce anything in the economy, doing anything in the economy, you need energy, which means that all these in the economy, all these terms will be filled up; there will be no null term. The laws of thermodynamic says that in order to do anything, any economic activity, even teaching, education, you need energy and that is why none of these sectors will be really empty.

Now, on the basis of this knowledge, this method, I would request you to look in the net and try to find out, I am not giving these data, because I want you to look at various different data. Some of the earlier data sets for both India and other countries are available on the net. In general, you will find that these are something like 100 by 100 matrices, handleable, highly handleable, remember. These are highly handleable things, if you, if you just put it into your program in MATLAB or some of the standard windows programs like the XL work sheet can also do that. You enter these and then inverting can also be handled in that.

Even, when it was the days, so I do not know whether you were born at that time; there was times when we had the PC XT's 8085 8088 based machines. Then there was no windows, there was only DOS and there was those LOTUS programs that could handle that. Then also inverting was something like, a 100 by 100 matrix was something like 3-4 minutes job. So, it was not that difficult a thing and nowadays, it will be click. So, what I am asking you to do is rather simple job, but what I am asking is this. Get this data for some countries for some year, from the net. I am asking you this, because you should develop the habit of locating these information on the net; everything should not be spoon fed. But, if you do look, you will find may be not this years, but some other earlier years data for many countries.

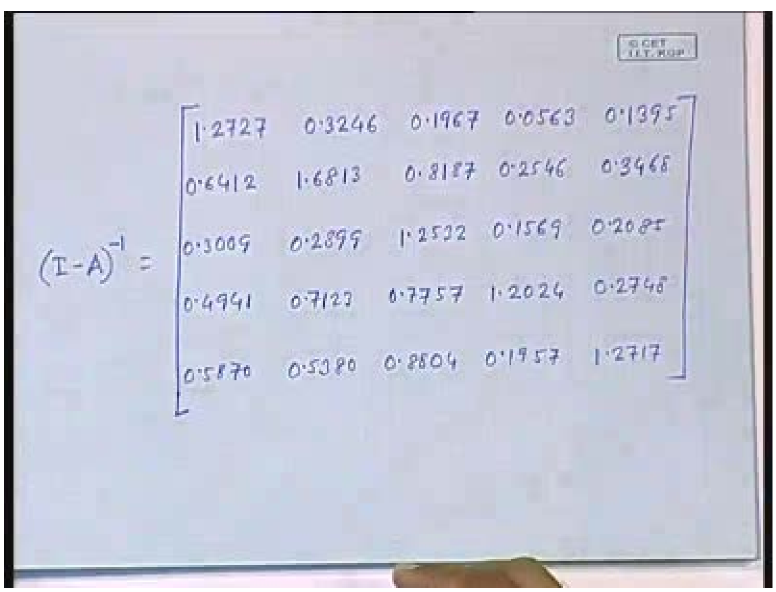
For example, the other day, I was surfing; I could find 3-4 countries data available on the net. For India also, the earlier data are available, but not today's data; today's data would be a classified information, you can buy it for something like 20,000 rupees. So, yes, you can do, do the planning sector in India's economy also; but, for those who need the information, you will have to find the money. Is that clear? What is the information used for? What is this information used for? Actually it is used for the planning commission;

planning commission does use this. So, what do you think that the people sitting in the planning commission are simply cracking their heads and trying to figure out. No; there are standard methodologies of doing that and they do use. That is why the input output tables are published for every country.

So, we do plan and accordingly we have to make provision for the other necessary things. We need to quantitatively estimate those and the most important in that is estimating the future requirement of energy. Sometimes we will find that people say that 10 years later the electricity requirement will increase by so many mega Watts. What do you think is the basis of that? What do you think is the basis of that? On what basis are new power stations installed? How many, how big? All these need to be decided on this basis and the increase in the petroleum sector that also leads to be assessed on that basis. That means you need to make provision for that much of increase in the amount of petroleum products in order to see some change.

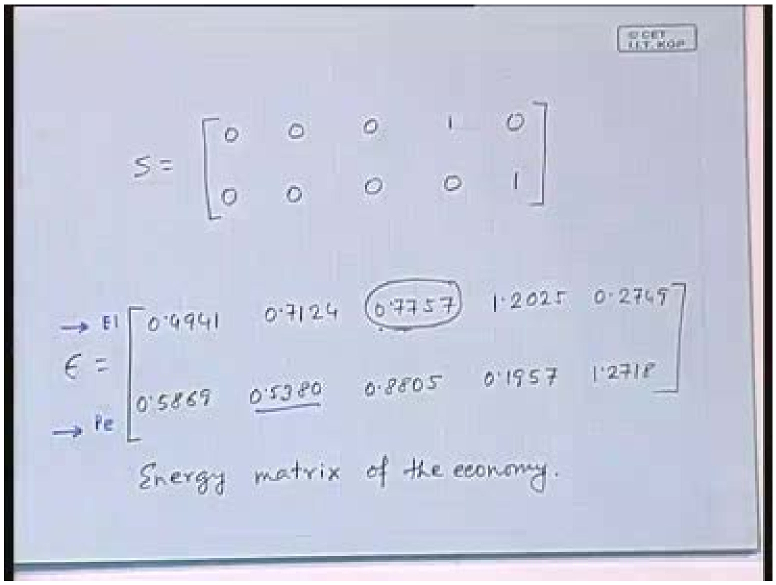
Now, notice one thing that when we talk about this, we essentially assume the technology of a country static. Have you noticed that?

(Refer Slide Time: 42:12)



When we construct these matrices, this essentially is a technological status in numbers, but the technological status as static. In a particular year, this much of electricity was needed in order to produce steel. All these are ingrained here, but in a particular status of technology.

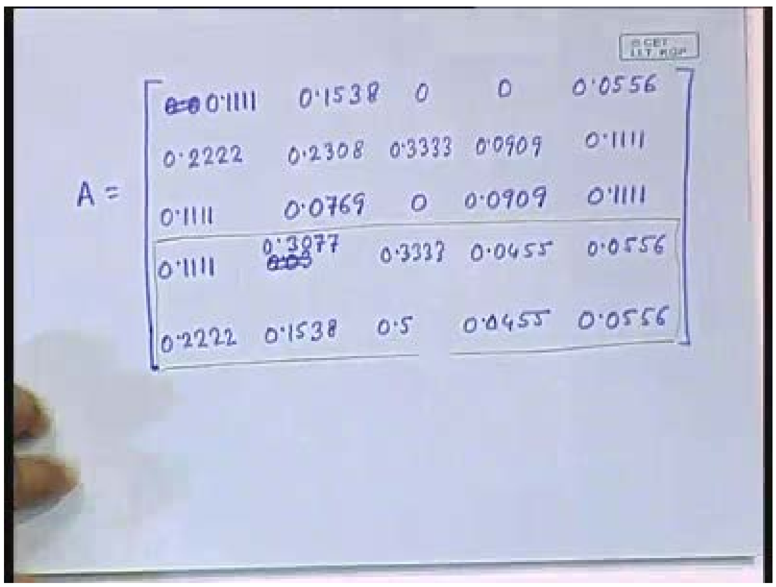
(Refer Slide Time: 42:39)



Now, when we see that in order to make a particular planning, we need to have a larger input of the petroleum products and we do not have that input of petroleum products, as you have just done before this, what do you do? Obviously, we need to change the technologies. The moment we change the technologies, these numbers will change, remember. So, there is a quasi-static assumption in these, you know, input output matrix analysis. In the present state of technology, it is this. When we project it for 20 years and say that I want to increase this, I want to increase that, this is as if you are assuming that the technology remains as of today. Is that right? This is today’s technologies, on the basis of that; so, remember that when we do the projection on the basis of this, essentially we do not assume, do not take into account the technological improvement that will happened in the intervening years.

When we take that into account we need to have some change in this. How do you do that? How do you do that? Normally it is not done though. Remember, normally that is why it is only 5 year planning. The reason for having a 5 year planning and not 20 years planning is this that we do not really have a estimate of these numbers, as it will happen 10 years later or 20 years later. But, in order to rationally estimate that for example, the country decides to go all the way for gas based transport, suppose; we change all our cars to CNG based cars and no longer we use petroleum based cars, obviously the matrices will change. Where exactly will the change be reflected?

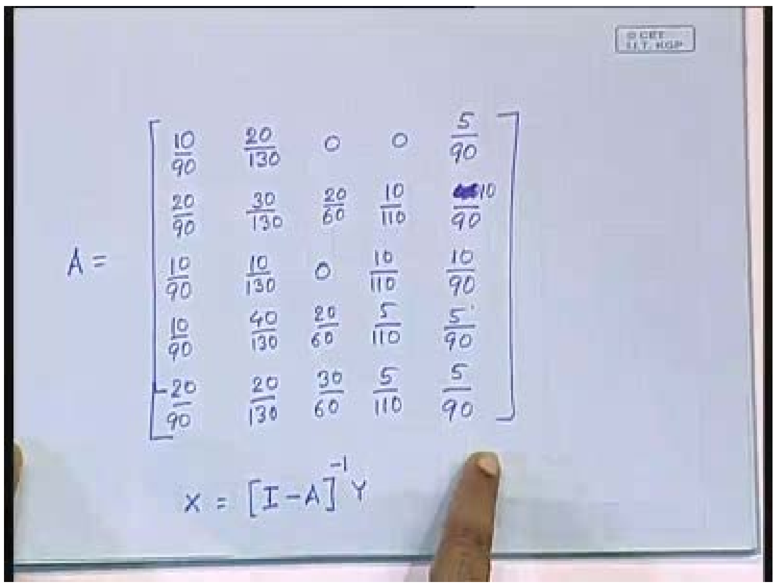
(Refer Slide Time: 44:30)



Can you tell me looking at this? Where will the change be reflected? The petroleum needed to produce one rupee worth of electricity that is where it will be needed or now here in this, the petroleum and natural gas have been put together. So, if you shift from petroleum to natural gas you will not see much of change here, but in the normal economical table you have these as separate sectors and therefore, there will be change from one sector to another, shift from one sector to another. Suppose we go, we decide to go, the city transport we change to make it either CNG based or electricity based that means we increase the dependence of the electricity based transportation.

What will be the result? It will be a shift from this line to this line. So, those changes you should be able to visualize, looking at these tables. These are numbers; often students have a tendency of getting lost at the number. What do you mean? They physically mean this that if in future there is a, there is a change in the transport sector from petroleum based transport to electricity based transport, all that will happen is, here is the A matrix that we have constructed.

(Refer Slide Time: 45:52)



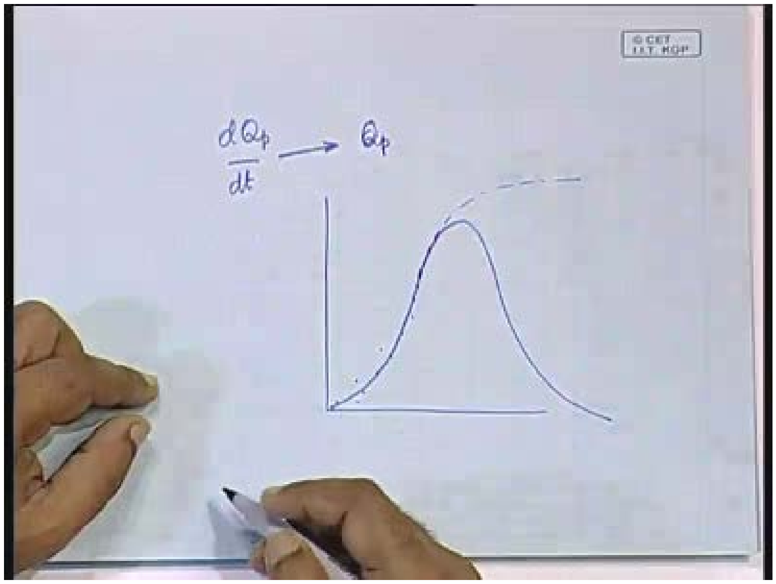
Which one will change, which one will change? No; this is the petroleum products row, this is the electricity's row. This is the electricity necessary in order to produce one rupee worth of transportation; this is the petroleum necessary. So, from 30 to 20, this will move, the numerator will move; numerator will move from here to here and also as a result of the movement, the total demand for the petroleum sector will reduce, the total demand for the electricity sector will increase. So, the X vectors there will change and therefore, the numerator and denominator will both change, but this number will be larger and this number will be smaller.

As a result of this change then, when you do the production based on the technological changes, you need to see where exactly the change will be reflected. That means planning; one thing as I said that planning on the basis of today's technology and then, we are also planning a change of technology. Then, either you simply through up your hands and say that we do not know or we do have some idea about where the change will be reflected like here; make those changes, some estimated change, recalculate the matrices and then plan on that basis. So, that is also another option; that is also a more, you know, intelligent option of doing so, clear. So, you have understood the meaning of the energy matrix and you are able to calculate the energy content in the pen. Are you? Given the data of the economy, you are able to calculate the energy content of say 1 kilogram worth of steel.

So, the assignment that I am giving today is get the data for any particular economy and do this. That means find out the energy content in a particular, no, not kilogram of steel, a rupee worth of steel; a rupee worth of steel, you find out the energy content in that. Energy would be then both the types of energy or all the types of energy put together. That is the assignment then. I am not giving you any particular data set. You download the data set, use that and then, also when you say that I have, I have found it, you say from which country and for what kind of data sector …., clear.

I suppose that will be all for today. Only thing is that in the last days assignment, some of you have shown me the assignment in which there was the mistake. Let me again clarify that.

(Refer Slide Time: 49:13)

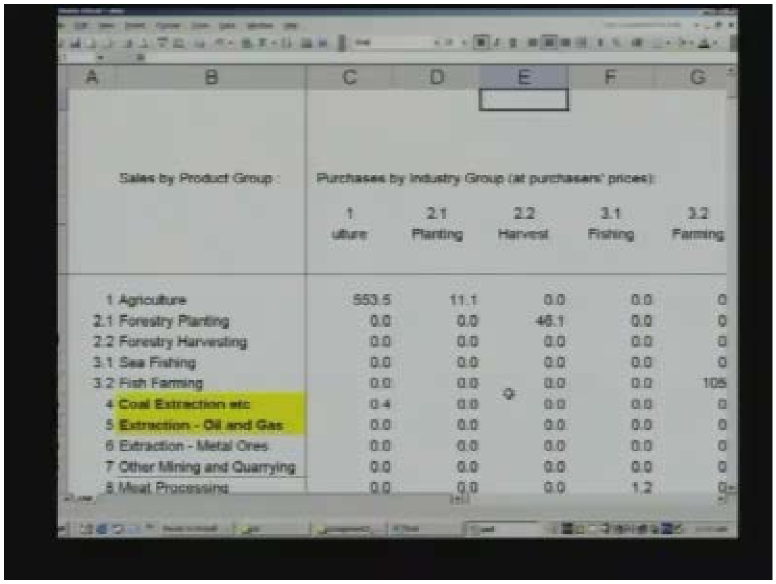


We had given you the data for dQ p dt. So, the data are something like this. If you draw, it goes like this and then some of you have approximated it with some kind of graph like this. Remember, dQ p dt graph is not like that. Yes, dQ p dt graph is like, so and this graph is for Q. So, this graph, this data will have to be changed to Q p data and this Q p data is the cumulative production. That means how much has been produced to date? So, these data are given in the unit of …

Students: Kilo barrels.

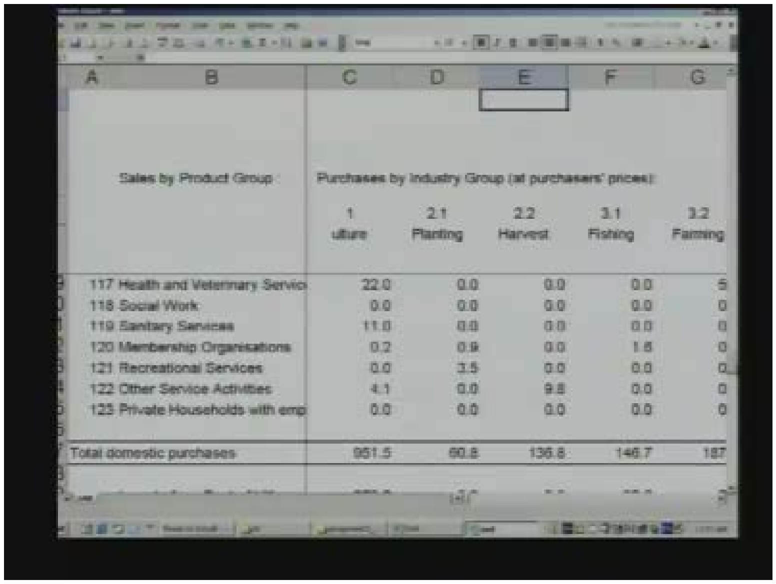
Kilo barrels per day; so, up to today you have to indicate all that history to obtain the Q p data and that is what you estimate, clear? Some of you have made the mistake of using the original data and trying to do that. That is wrong.

(Refer Slide Time: 50:29)



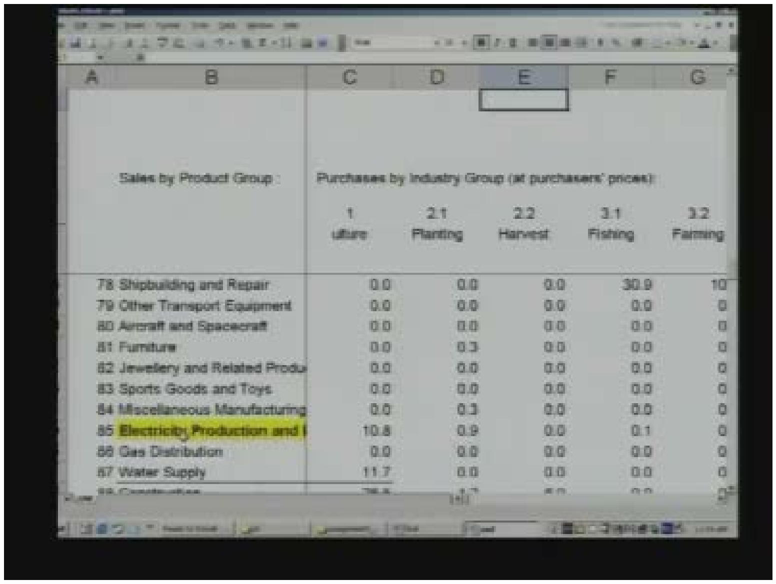
The file that you can see on the computer screen is the input output data for Scotland in the year 2002, which is readily available on the net. For many countries, as I told you in the class, these data are available readily on the net and Scotland has a very well organized data, so that is what I am showing here. Now, as you can see here, we have the various sectors – agriculture, forestry, sea farming, then extraction of metals and then there are some areas. I will just scroll down and you can see the various areas that are available. Some areas are the energy sectors; some sectors are energy sectors. So, a country reproduces tobacco, country produces textile fibers, then carpets and rugs and stuff like that.

(Refer Slide Time: 51:36)



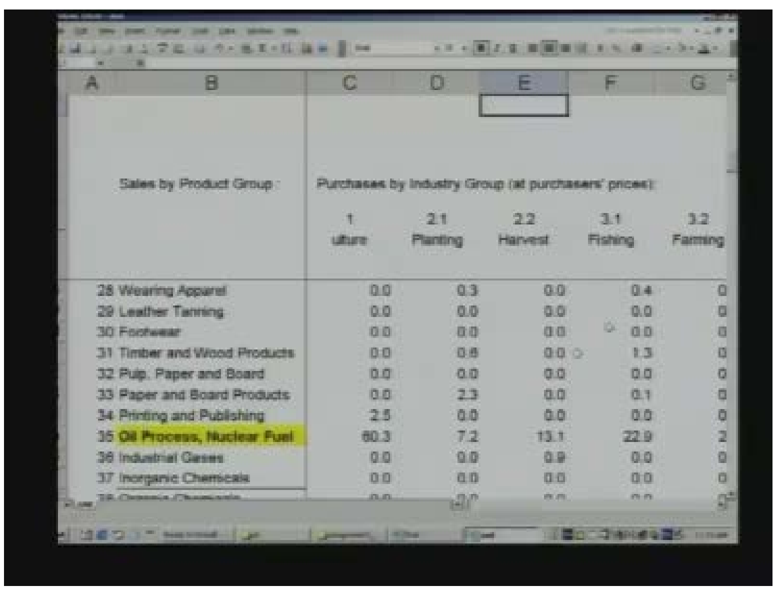
Total number of the sectors in this particular economy as they have identified would be something like 123. Out of that, there are some sectors which are not productive. That means from those sectors, things do not go to the other sectors. As a result, the elements in these rows might be completely zero. While depending on the character of the other sectors, there would be some zero elements and some non-zero elements, so in order to do the further analysis we need to eliminate or delete those sectors that have completely zero elements.

(Refer Slide Time: 52:09)



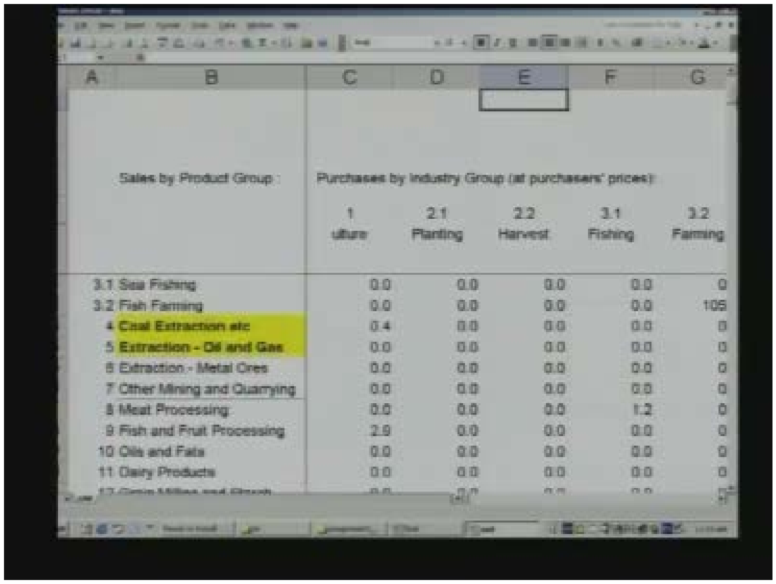
Ultimately we do identify some areas which are the energy sectors. For example, the electricity production is energy sector. We have highlighted those specific sectors.

(Refer Slide Time: 52:22)



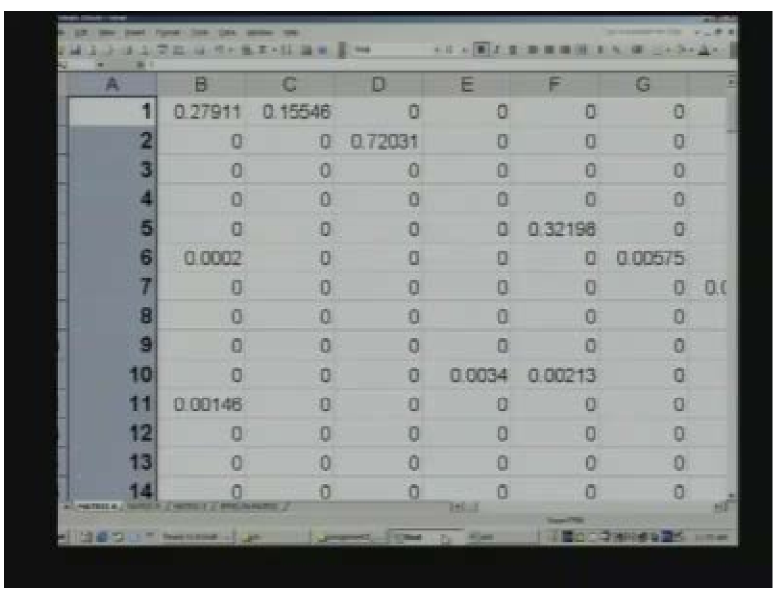
Oil process and nuclear fuel is an energy sector and here coal extraction and oil and gas extraction, these two are also energy sectors.

(Refer Slide Time: 52:29)



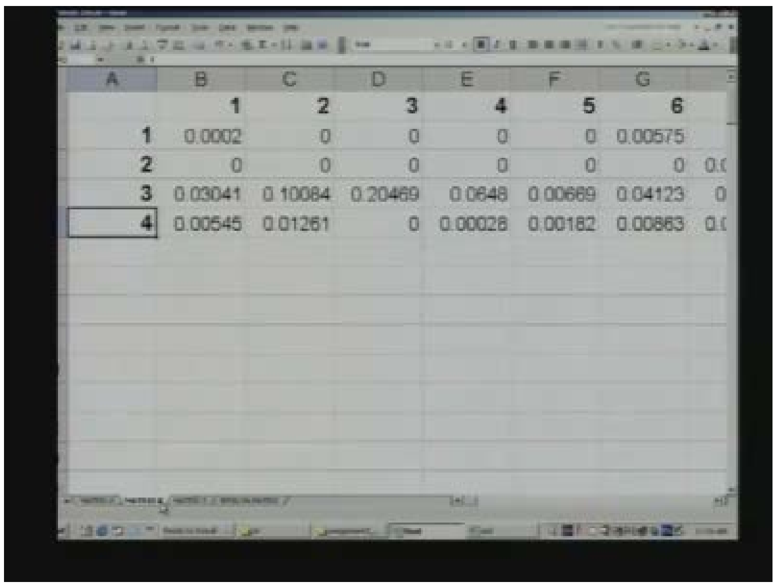
So, in this particular economy, they have compiled the data. They have categorized four energy sectors which are thus identifiable and then, when we do the analysis, then these numbers they have to be copied and pasted to a separate file which can be called into MATLAB and then the further analysis can easily be done in MATLAB and what I am showing you are the results of the analysis that has already been done using MATLAB.

(Refer Slide Time: 53:10)



For example, the next step would be to compile the A matrix and in this case, the total economy has 124 sectors and therefore, it will be a 124 by 124 matrix and this can easily be done by simple matrix manipulation. So, these are the numbers that yields. There would be more number of elements with zero value, obviously because from most sectors nothing goes to the many of the other sectors; only things go to specific, particular sectors and that is why there would many of the zero elements, say somewhat sparse matrix.

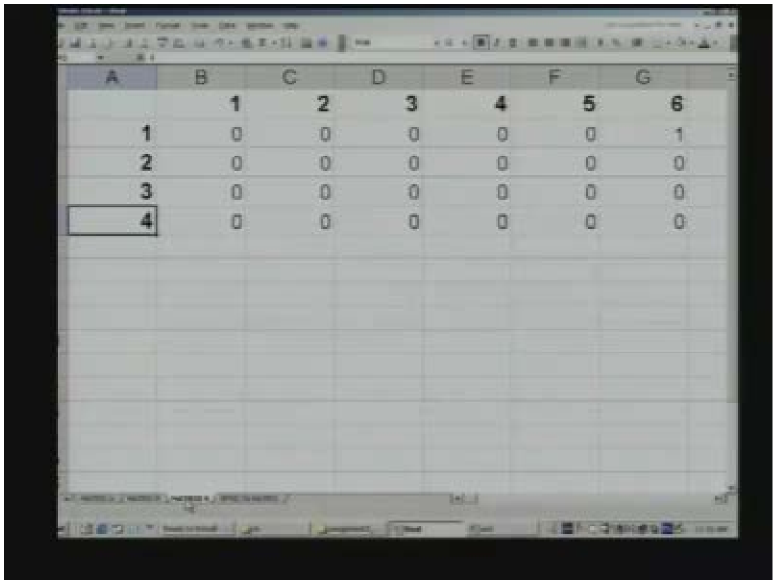
(Refer Slide Time: 54:00)



A	B	C	D	E	F	G	
	1	2	3	4	5	6	
1	0.0002	0	0	0	0	0.00575	
2	0	0	0	0	0	0	0.(
3	0.03041	0.10084	0.20469	0.0648	0.00669	0.04123	0
4	0.00545	0.01261	0	0.00028	0.00182	0.00863	0.(

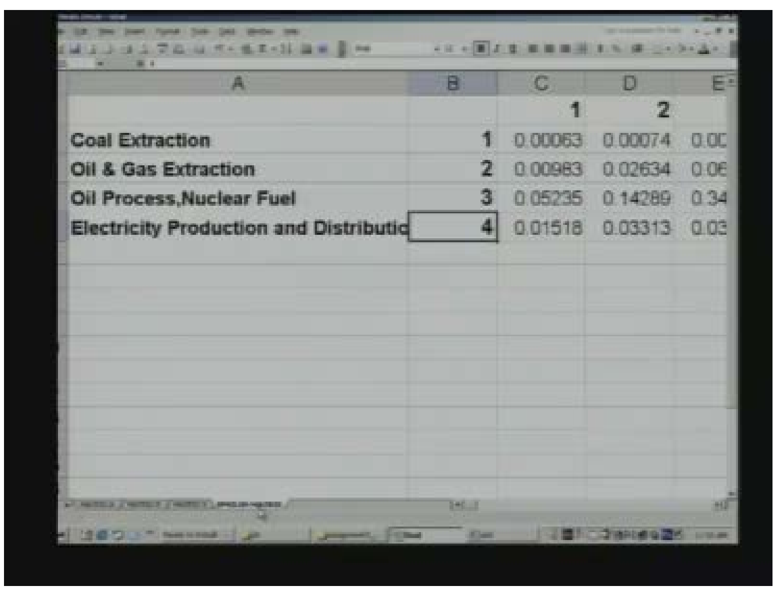
From there, we need to obtain the matrix R which has this shape. Here also you can find, I told in the class how to obtain this matrix R. Then we have to obtain the matrix S.

(Refer Slide Time: 54:14)



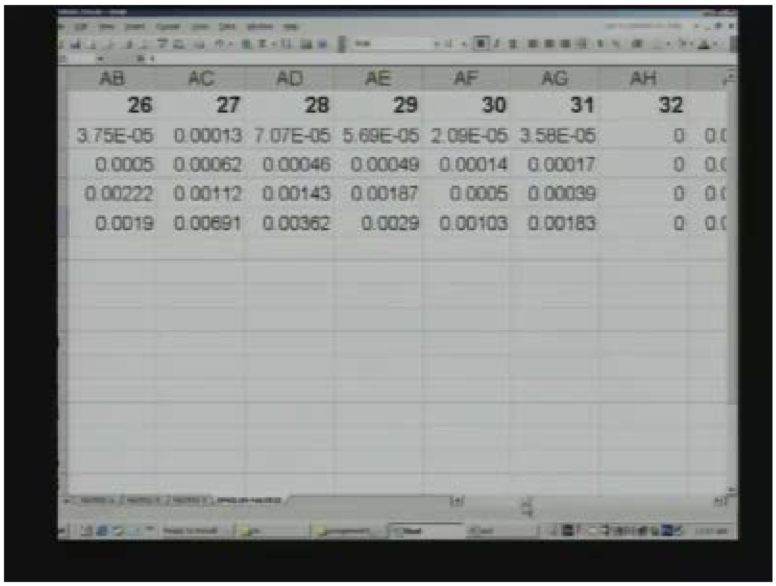
Now, this matrix of course is composed of only zeros and ones. There are only a few specific places where you will find ones, all the rest are zeros depending on the character of that particular economy.

(Refer Slide Time: 54:31)



Then, we finally obtain the epsilon matrix or the energy matrix for that system. So, here we have this four sectors and this would be 4 by 124 matrix and the columns, the specific elements of this matrix would mean how much is the energy intensity of specific processes, energy of a specific character, specific sector, intensity of the various processes and as we explained in the class, these matrix actually talks about the energy efficiency of a specific economy. How efficiently is that economy producing things, how energy efficiently it is producing the things.

(Refer Slide Time: 55:25)



AB	AC	AD	AE	AF	AG	AH
26	27	28	29	30	31	32
3.75E-05	0.00013	7.07E-05	5.69E-05	2.09E-05	3.58E-05	0
0.0005	0.00062	0.00046	0.00049	0.00014	0.00017	0
0.00222	0.00112	0.00143	0.00187	0.0005	0.00039	0
0.0019	0.00691	0.00362	0.0029	0.00103	0.00183	0

So, this matrix is the most important one as far as the energy analysis is concerned. Thank you.