Indian Institute of Technology Kanpur
National Programme on Technology Enhanced Learning (NPTEL)

Course Title
Bioenergy

Lecture-03
Unit of Energy & Introduction of Bioenergy

by
Prof. Mainak Das
Biological Sciences & Bioengineering &
Design Programme
IIT Kanpur

Welcome back for the lecture series on bioenergy so today we are in the third lecture so in the first two lecture I gave a overview about the significance of energy in our in the global economy, we talked about the different forms of energy which are available and the energy economics how it governs the per capita consumption and the standard of living and how that rules the economic status of a country whether we are underdeveloped nation or we are developed nation or we are developing nation like in science and so forth.

Then we have enumerated about the different forms of energy consumption where we talked about the commercial industrial residential and the transportation where all the energies being consumed and apart from it we have talked about how Indian economy can be more energy independent economy if we could exploit our bioenergy well. So today in the third lecture we will leap forward and there will be two segments what I will be covering the very first segment we will talk about the different units of energy.

In a sense whenever we talk about energy as we have already talked about we talked about electrical energy, we talked about heat energy we talked about nuclear energy and so on and so forth. But each one of these has to have a quantification how I say this much energy is needed say for example I say from here to go to some x place you need to consume this much petroleum or this much gas or this much a diesel or this much coal or something. Now there has to be an equivalent unit say for example, I say in the heat energy so what will be the equivalent energy in

terms of say thermal or electrical or if I consume something in electricity I should be able to convert it into how much thermal equivalent it will be there, like so on and so forth. So today what we will do in the first segment we will talk about the units of energy consumption.

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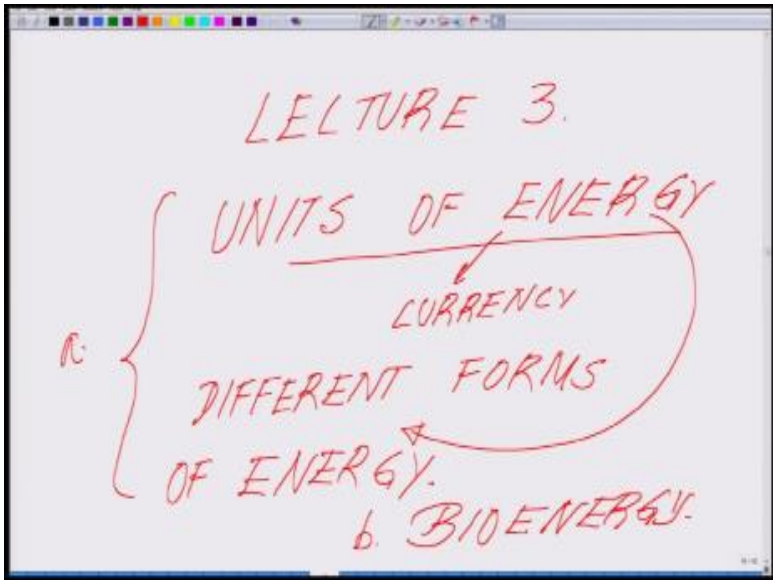

So let us get back into that slide today unit two lecture 3 so part one will be unit of energy, so in other words we will be dealing with the energy currency how we equate energy currency of different forms of energy, okay so and in the second segment what we will be doing we will be talking about the basic fundamental concept of bioenergy. So if this is part one today we will be dealing with a so they will be our d which will have a formal introduction of bioenergy, okay.

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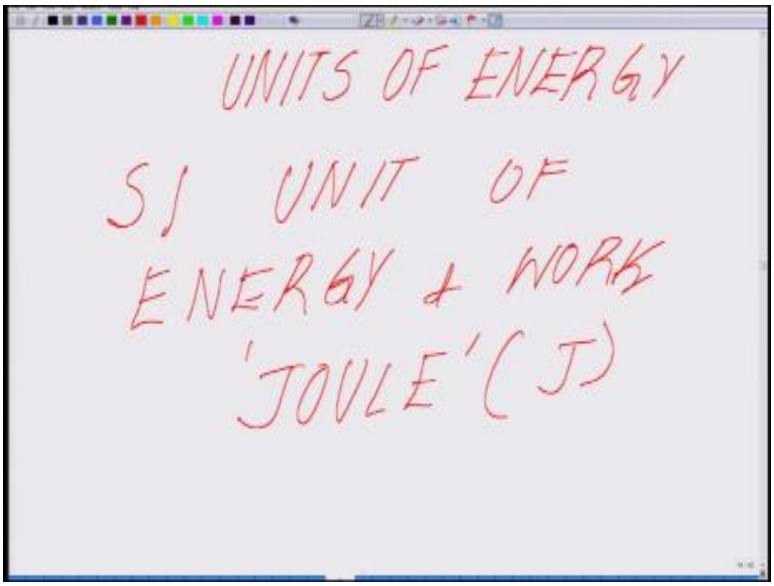

So let us move on to talk about the units of energy part 1 and the major units of energy which is called the SI unit of energy a sign it a standard international a sign it of energy and work is joule okay, in the name of James joule this is and it is represented as J.

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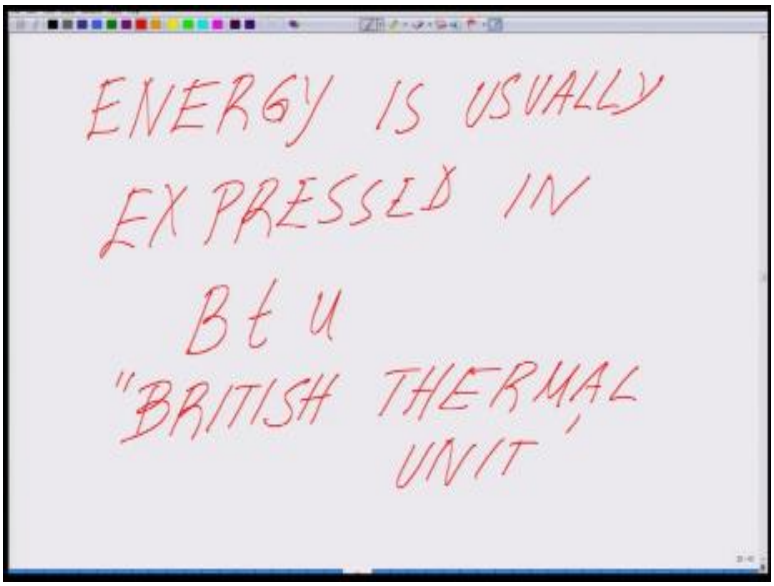

Now there is another unit which is very commonly used which is also called British thermal unit or BTU energy is usually expressed in B TU which is also called British Thermal Unit, now having said this that energy is expressed in terms of British thermal unit or in terms of joules we have to have different equivalency how much joules make one BTW or how much BTU makes one joule or how much kilowatt-hour make say for example we talk about electricity just I was explaining.

So what is needed is the next slide I will just kind of give you a feel what we are looking forward to is.

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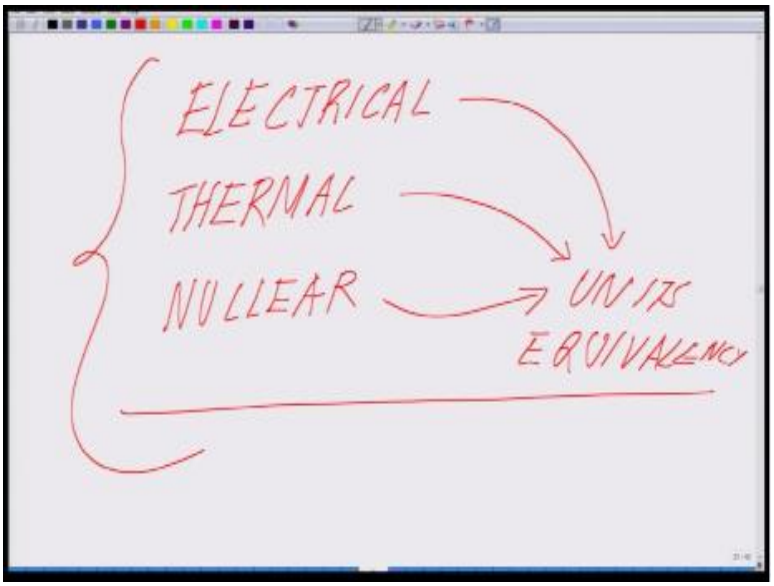

Something like this, say for example you have different forms of energy say electrical, thermal, nuclear so these different kind of energy has to have different units, units equivalency that is very critical in terms of whenever we are explaining any form of energy production or energy consumption whether we are consuming electrical energy we are consuming nuclear energy we have to equivalency.

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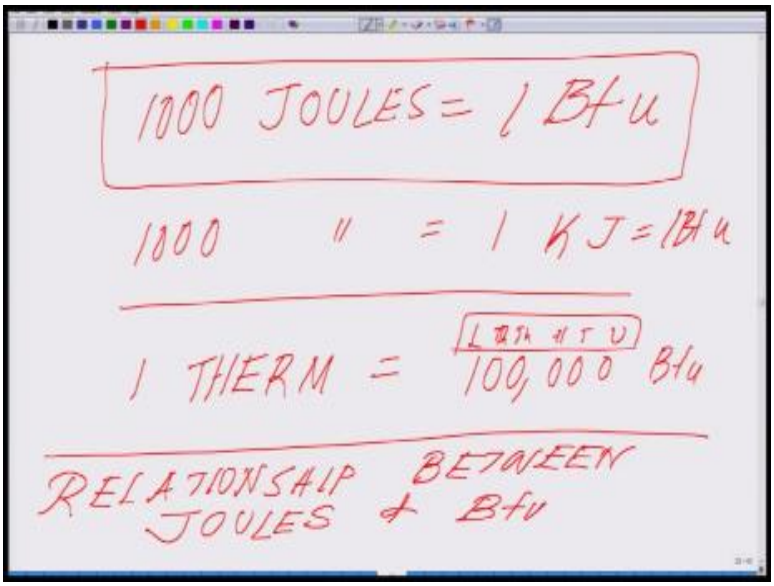

So let us talk about the equivalence is now okay, so talking about the equivalencies now so 1000 joules is equal to 1 BTU British thermal unit and these few tables are very essential for you people to kind of remember that will help you to understand many things 1000 jouleswhich is also equal to 1 kilo Joule because thousand joules is equal to 1 kilo Joule okay, which is equal to 1 BTU fine. Similarly there is another unit called oneTHERM one therm is equal to 100, 000 BTU unit 10 ,100 1000, 10,000 lack so one lack BTU is equal to one term. So that is the relationship between joules and BTU.

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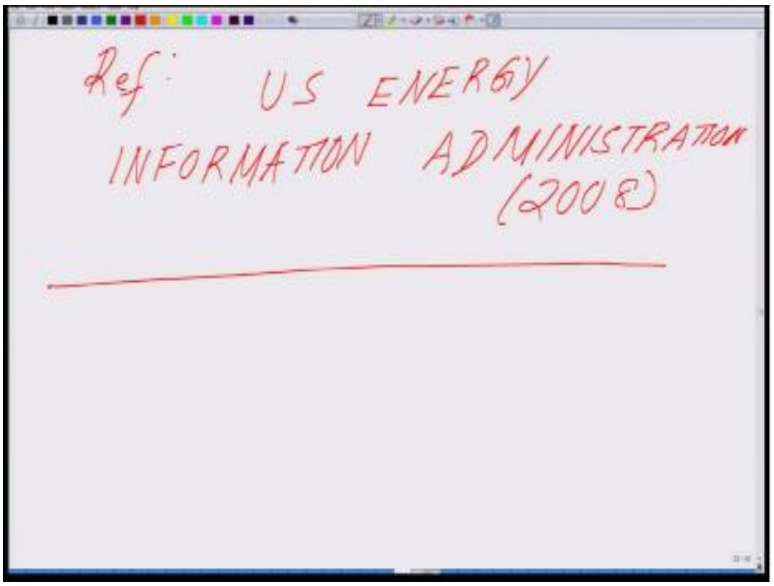

Next from here we will move on to and for you the reference what you can use to know a little bit more about it, it will be the US energy information administration of the year 2008. Information administration of 2008 so this is the reference for from where am I am quoting all these things, okay.

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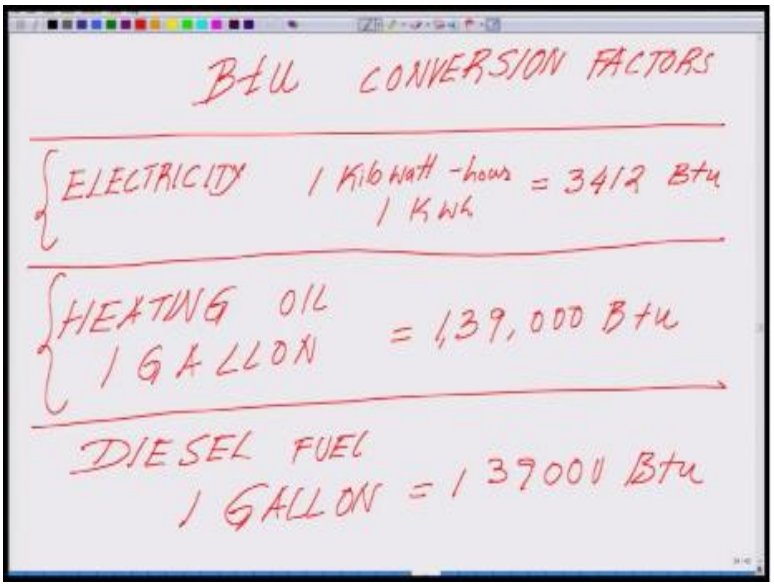

Now let us go for the other BTU okay, BTU conversion factors now BTU conversion factors say for example, we talked about electricity general electricity is expressed in terms of watt okay, so in terms of electricity one kilowatt hour or 1 KWh is equal to 3412 BTU so you see this is the first instance where we are showing that how you can convert the amount of kilo watt hour in terms of British thermal unit so these conversions are very, very essential and it will come very handy.

So let us move on to the next conversion after we have done this first conversion let us talk about heating oil okay, because we heat oil for several purpose in their cars in the aero planes and wherever okay say one gallon of heating oil is equal to 1,39,000 BTU so this is where the oil energy is converted into British thermal unit okay. Now within that if we talk about the diesel fuel what is used in the diesel engine so one gallon of diesel is equal to 139000 BTU, okay.

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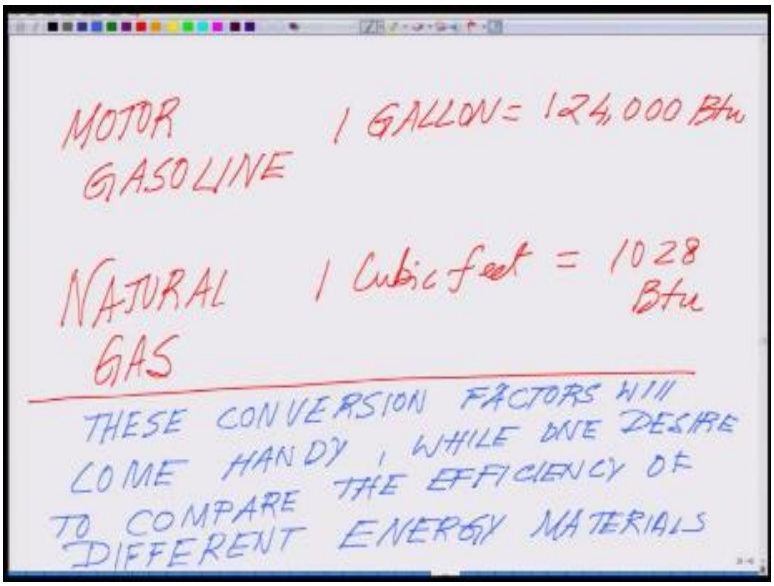

Now you we talk about motor gasoline which is used in most of the cars so one gallon will be equal to 124000 BTU and similarly for natural gas which is use for cooking one cubic feet natural gas is equal to 1028 BTU okay, so what is most important out here the take-home message out here is these conversion factors will come handy while one desire to compare the efficiency of different energy materials, so this will come very, very handy when we will be talking about how we really an you know compare different forms of energies which are available to us.

You might wonder why I have drawn this table for you because the one has to realize when we talk about bioenergy we are burning bio-fuels or different form of bioenergy as we are going through, so one needs to equate that by burning say one liter or one gallon of bio-fuel or this much amount of it how much thermal unit you are gaining and one has to have a comparative when you say for example.

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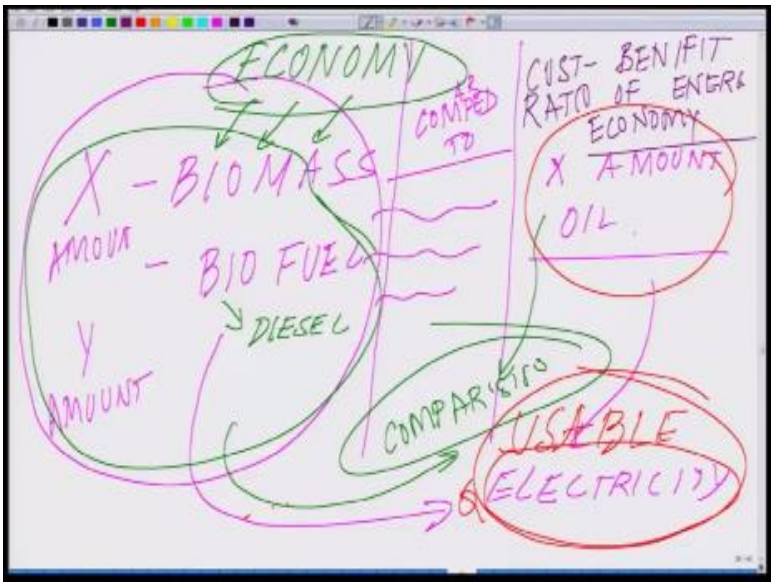

If X amount of a biomass okay, X amount or say Y amount of bio-fuel and what is their equivalency with respect to so there is a compared to come one second compared to say X amount of oil or how much electricity could be generated from these two sources say for example okay, so the economy works like this if you need lesser amount of this to generate say Q amount of electricity at a cheaper price as compared to this one then this one will be much more economical.

So it is all about how much conversion of how much would lead to usable power or you can put it like this something like a usable electricity out here what so ever will be usable electricity or usable power will dictate how much it takes to form that much of biomass or that much of bio-fuel or that much of the biodiesel or whatever you know we talk about, so for everything there is an economic components which I am adding because in the last part of the course this thing will come very handy what is the economy of producing this much biomass or this much bio-fuel or this much say biodiesel, okay or whatever you know.

This economy will be compared with the X amount of oil which we are consuming currently for all the things so once this comparison is in favor of all sorts of biological origin fossils s or

biomass and something the economy will try to take a different kind of shift, so that is why the conversion factor I insist you people to kind of have at least try to remember few numbers very clearly that this much oil this many gallon of oil this much will be produced equivalent to this much thermal energy this much kilowatt hour who is equivalent to this much British thermal unit like and so forth.

It will be really helpful for any kind of whenever you sit in a public forum or you talk to people or you listen to something it should you should be able to calculate it immediately in your mind okay if I use this, this is the benefit I have and this is the cost-benefit ratio so there is this thing which will come very handy as long as if you know these values then you can build up what we call as the cost-benefit ratio of energy economy so this will come very, very handy if you can instantaneously do that kind of convection.

So having introduced you to all the different conversion tools or conversion factors from here we will move on to the very, very core of this lecture series which is the bioenergy and how everything falls in one spectrum, okay.

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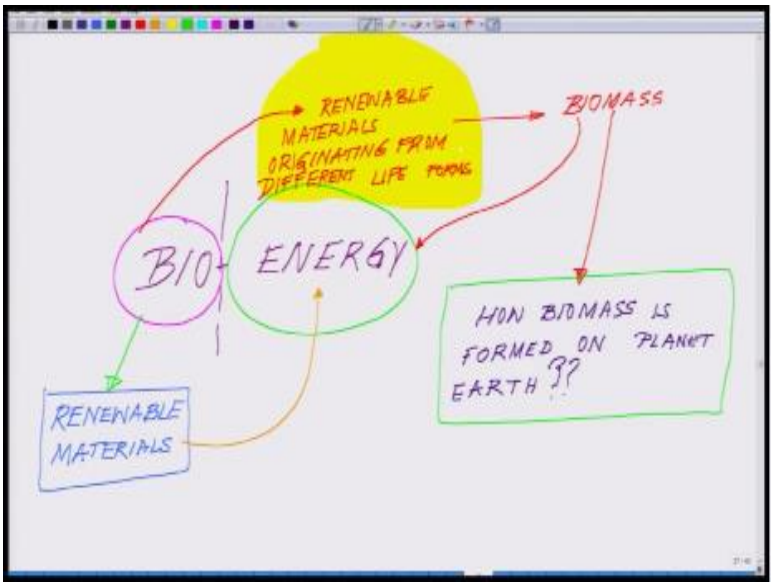

So let us move on to the part 2 of it of today's lecture which is, so let us put the two words together we call us bio-energy so if you look at these two words so there are two different words here one which is bio if I split this word colors this is the bio the other part is the energy, whenever we talk anything about bio we talk about something like some form of a renewable material, what does that mean the plant grows, grasses grows algal population grows, bacterial population grows these are all or biological origin.

Any life-form which persists on earth it goes it grows because there is a perennial source of energy called the Sun we will talk about that as well move through so when these renewable sources so let us get the concept right, when these renewable sources are used to generate energy we call that as a form of bioenergy, so now what we are talking about is what are the different first of all let us classify the different kind of materials of biological origin, okay.

So those could be classified as renewable materials so something like this get this concept in your brain renewable materials originating from different life forms, okay and those are called biomass and this biomass is used to harvest energy. Now when you talk about this biomass this biomass the one of the critical question which comes is out here how biomass is formed on planet earth will deal with this question just after this, so this is a key question and will be devoting lectures on this how this biomass formation takes place just before that let us take a look at so let us talk about this part okay.

So let us talk about what are those renewable materials in the next slide we will go on and talk about.

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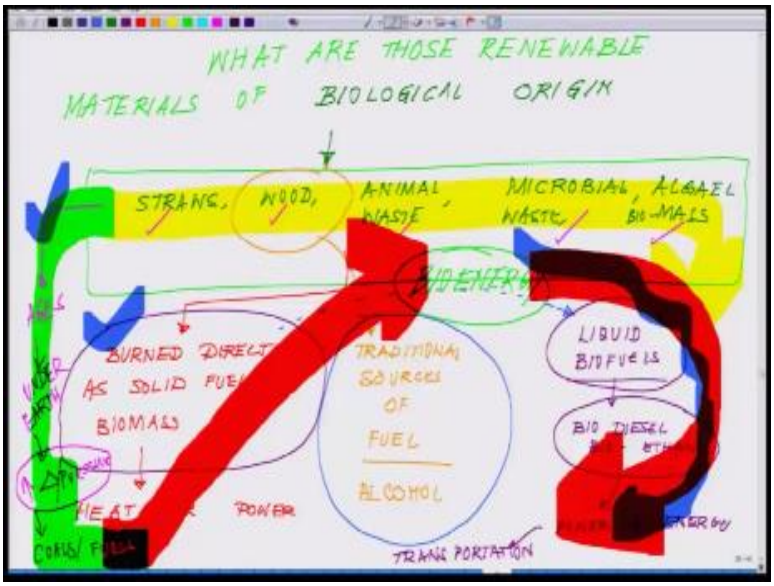

What are those renewable materials of biological origin, so that includes straws plant straws wood, animal waste, microbial waste, algael mark or algal biomass bike was not so and so forth there are seen this list can go on and on but these are some of them what we talked about. Now next thing is that now these could be there are two ways two methodologies which could be followed either these could be how we can process them they could be burned directly as solid biomass okay, this is one route you all must have seen this burn directly as solid fuel or biomass and which leads to generation of heat or power.

So having said this, this part when we are talking about you can burn them directly so this is the age-old process if you look at it people have burned wood for energy for cooking for hitting the room and so and so forth wood similarly we look at it there is some very interesting thing about wood, so wood has been used earlier on the much earlier time the wood has been used for traditional sources of not only traditional sources of fuel but also of alcohol we know that we can convert wood into alcohol so wood remain for a long till this date is one of the very, very traditional sources of alcohol and other things, so this is one way or you have seen the animal waste or the cow waste you make these applause and everything which is kind of you know used

for preparing food like no burning them dry them up and you can use the cow feces and buffalo feces and everything which could be used to develop the cakes which are used for burning.

So these are the direct conversion where a biomass is being converted directly for generation of heat energy which is used for cooking and other applications okay, so this is a very age-old process apart from it these biomass are being used for producing alcohol and several other product this is one route, okay. Now we will come to a second route okay, the second out talking about the second route coming back what will be telling so from here what we can do you can convert these ones all these what you see out here this whole thing could follow a different path and I am coming to that path now.

The second part is that you can generate liquid bio-fuels from all these and there are different kind of conversion processes which are being followed like pyrolysis and several other processes biodiesel, bio-ethanol where you are not directly using them but you are converting them to much more energy efficient product which will generate more energy, again the same thing power and energy and which could be used for one of the major things like transportation and all. Now if you see it is not that the bioenergy is something very new, the concept of by energy is as old as the evolving human race human being has been using different kind of since the discovery of fire human being has been burning biomass since ages for its most fundamental to the most complex requirements.

But what is important to note here is that what is the current role instead of direct burning as I have shown you how tear if you look through in the slide if you look it through this is where this is the traditional route so what we are telling is from this route this is what is the dream why is it so this dotted line what you see, why when we wanted to convert them more efficiently because the amount of energy which is generated by burning a log of wood as compared to buy certain chemical process if you could convert it in such a way that we generate sufficient amount of biodiesel or other product then they are combustible their energy efficiency is much more higher this is where the whole role of coming back this is where the whole thrust area of bioenergy stands, how we can convert these naturally available biomass into products of high combust

ability product of high utility and much more cleaner form of energy, so keep this exclusively in mind.

And now I will add one more dimension to this if you think of it what has happened through the ages now these biomass what we talked about all these say for example we talked about the straws we talked about woods we talked about animal waste we talked about microbial waste we talked about algal waves like and so forth through the ages under the earth in high pressure through ages billions of years under the earth high heat, high heat and just showing the triangle pressure we have converted to the product like coals and fuels.

So actually the nature has done this process over billions of years the one which I showed you even think now what we really wanted to do if nature has done it and nature has done it at high pressure lack of oxygen deep inside that, now if we know this process say for example now let us again let us concentrate on the slide if we know this process of conversion some way or other if we know this whole process how nature have done it okay, now could we now here it is the critical point to realize if we know exactly this whole reaction has taken say one billionaire or one millionaire or whatever if you know the time and if you know the reaction could we learn from nature and do those reactions in a controlled environment which instead of taking billions of years could happen in few days.

So in other word the other area of bioenergy is to learn those processes which nature does or nature has done over billions of years nature has learned through it so the inspiration for the conversion of biomass while it is coming back to the slide so the inspiration for all this conversion of biomass has to be drawn from here so we fit in here and there where we believed will be able to make a difference like what, so see for example.

Now there are three things let me because this is a very critical slide for you guys to understand let us again I regurgitate it what we talked about, so we talked about the word called bioenergy a biological component I-energy component so that means any biological material could be a straw could be cow dung could be algal biomass could be microbial biomass could be plants could be woods so what is ever if we could convert them or if we could use them for energy so the age-old

tradition remain these have been burned directly using fire to generate energy which is a direct conversion. There is another conversion which nature of followed through thousands and thousands and millions of years.

What has happened these things have gone down under the earth crust at our in a high-pressure high-temperature lack of oxygen they have got converted into what we today use or have been using for lost on areas as cold patrol like so and so forth now then what is the need nature has already done all these things why we need it to a study bioenergy so here is the catch, catches this if nature could convert by it is high-pressure high-temperature these products into something far more combustible so you can compare but by burning our wood driving a vehicle as compared to burning petrols will be much more easy using petrol why is it so the product they have all originated from the same biomass, right.

So that is something very important to understand it means nature has already discovered certain things through billions of your topics of elution how to convert this biomass, what we are trying to learn is we are getting inspiration of converting these biomass in a way so that we get more combustible product. Now let us look at the slide that is exactly what I was trying to highlight to people so there were three parts what we can look at is this is once again so this is your this is your direct conversion route for traditional fuel usage this is what nature has done and this is where your generation will be getting, okay.

So this is the basic concept of biology which I wish that you people understand very clearly let me go back to the slide again.

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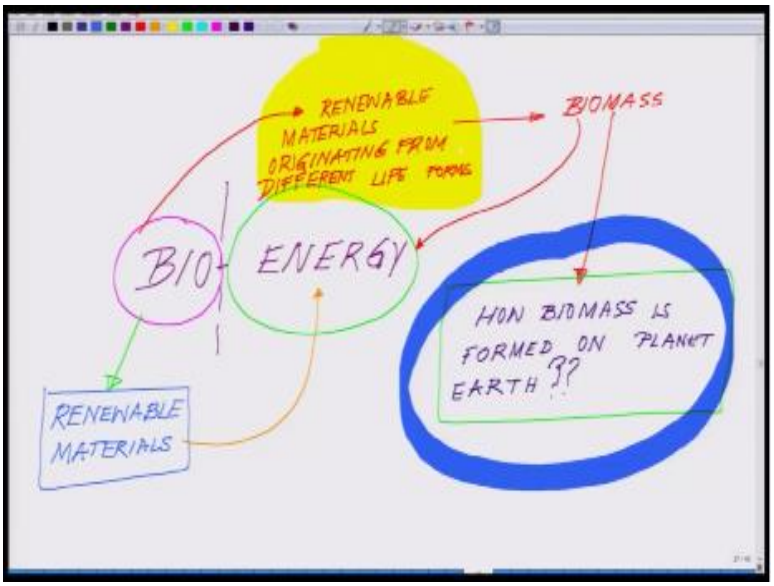

Here I told you that how biomass is formed on earth because that is your raw material, so if you do not know how the biomass is found on earth you will not be able to address this question what we are dealing that how to deal with this kind of situation so for that now in our next slide we will talk about how the biomass formation takes place takes place on the floor of earth, so let us concentrate on it.

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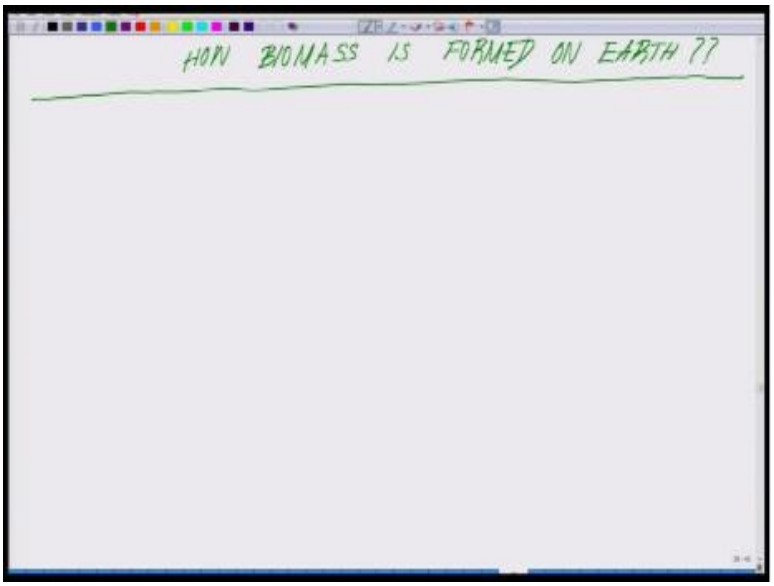

Now so let us address the question, how biomass is formed on earth this is the question will be end which we will be answering now okay, now before answering this question let us summarize what we have done as of now we talked about just I am keeping you on the loop we talked about first of all the significance of energy we talked about the different forms of energy we talked about how the energy economy rules our planet and our livelihood and our standard of living then we talked about the different how a evolving concept of bioenergy could change the Indian economy then we talked about the different currencies how energy can be calculated or how energy could be equated with its electrical energy whether it is a thermal energy like so on and so forth.

And then we talked about the fundamental concept of bioenergy in terms of what are the biomass which are formed how in nature they form over billions of years has goal and other products how we directly burn them and how we could get inspiration from the formation of coal and everything to convert them into much more combustible product and which is the core of our it and now we came to the question how biomass is formed on earth so this question will be addressing in our next lecture what are we talking about the biomass formation the fluorophore

so I will close in here and we will continue in our fourth lecture on how biomass is found on, thank you.

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Prof. Satyaki Roy

Co-ordinator, NPTEL IIT Kanpur

NPTEL Team

Sanjay Pal

Ashish Singh

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Ram Chandra

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Sanjay Mishra

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