Non-conventional Energy Resources

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Lecture – 04
Non-Conventional Sources of Energy: An overview

This is a course on Non-conventional Energy Resources. And in this class we will go through an overview of non-conventional sources of energy. And basically it will be some sort of a summary of the various technologies that we will kind of look through as we go through this course.

The term non-conventional source of energy is something that you see quite often in popular literature and so it means a variety of different things to different people. And in fact, if you make a list of all the technologies that come under this category of non-conventional energy resources, you will find actually the list is quite long and there are a lot of people trying various different technologies with the differing degrees of success, maybe they are still in the research stage, maybe they are still exploring some initial prototype and so on. So, there is a pretty large I would say a fairly significant list of such sources.

And what we will look at in this course are the more major you know versions of these sources where they have actually been deployed to some degree and actually are already in use at different locations. So, that's the basically what we will look at through this course and also in this class we will highlight some of those major non-conventional sources of energy.

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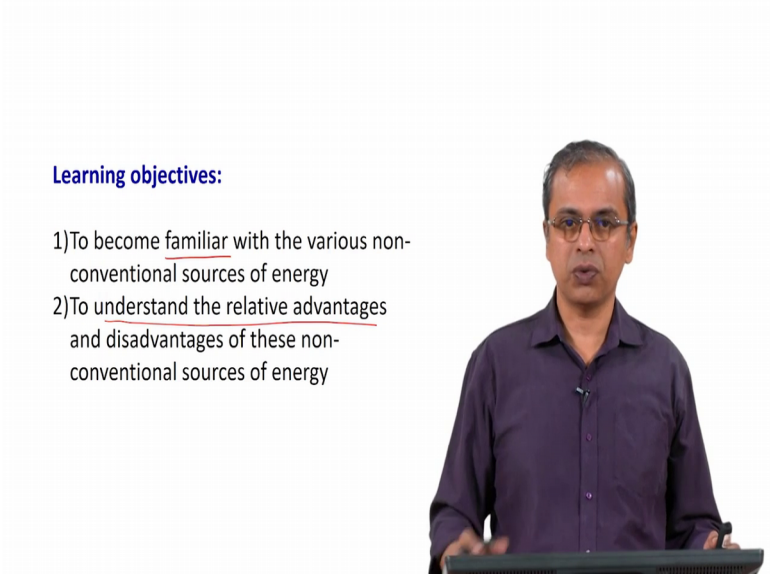

So, for the purpose of this class our learning objectives are to become familiar with the various non-conventional sources of energy. So, I just at least want you to get a sense of you know what are these names of these non-conventional sources of energy, some basic principles of you know what is the idea behind that source of energy, how does it actually function some basic idea of it because later in the class we may actually spend a fair bit of time on specific versions of these sources that we are discussing today and look at them in much much greater detail. This is to serve more as an overview so to speak.

And we would also like to understand the relative advantages and disadvantages of these non-conventional sources of energy. So, each of them is a package of you know pluses and minuses, and its sometimes bit difficult to find any one solution that actually meets all our requirements and is very clean, very good and something that you know people are investing on heavily. So, we will look at the pros and cons of each of these technologies as we go forward and we will see what is I will try to develop our own ideas of what we think is possibly something that we should focus on maybe look at some areas of concern for some of these technologies that are perhaps not that evident at first glance. So, we need to just do that, so we will as we go through this overview I will try to highlight those relative merits and demerits.

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I indicated this earlier and I want to highlight that again the GDP of various nations is often very closely related to energy consumption. So, this is a point that we have to keep in mind. And as we discuss all the material in this course, as we read popular articles, as we look at, as we look at the political position that is held by different countries at different points in time many times all of that is linked to this idea that GDP is linked to energy consumption. It is sort of in some ways a natural link and some ways an unfortunate link.

It is a natural link because basically this means I mean if the GDP is high it means you have a lot of you know activity commercial activity that is on industrial activity that is on and typically that means, there are more industries, there are more factories, there are more places where you know energy is being demanded and consumed in significant quantities because all of these factories need considerable amount of energy and so on. And therefore, naturally if GDP is high energy consumption is high. So, people in fact use the energy consumption as a track of the GDP and so that's how it has been I mean if you look at the data you see this link between the two of them.

But the issue is that the area of concern here is that when you link these two together it seems like we should find ways to increase our energy usage, and that's a little unfortunate way of linking them up because every time we increase our energy usage chances are we are also doing more you know damage to the environment which finally,

affects us it's not just you know it's not that the environment is some separate entity that out of you know out of goodwill that we are taking care of it that's not how it works, we live in the environment. So, if you affect the environment it affects us. So, that's the context in which we need to be concerned about the environment. I mean in an altruistic way you may want to take care of the environment regardless of what it does to us, but the truth is it does come back to us. So, it is not like you know you can do something to the environment set it aside and set it aside and then continue doing whatever you want to do. So, it doesn't work that way.

So, generally the energy usage which is typically drinked with lot of other aspects such as you know emissions and so on finally, affects the environment which finally, affects us again. So, therefore, this is a link that is a little unfortunate, but we have to you know handle we have to do something about.

So, it is very important therefore, to find cleaner sources of energy. So, cleaner sources of energy and particularly if nothing else motivates us, it is to save ourselves. So, that is the bottom line. If no other motivation is there at the end of the day if you use cleaner sources of energy it gives us a good quality of life at the same time we are not harming ourselves. So, therefore, this is something of interest to us.

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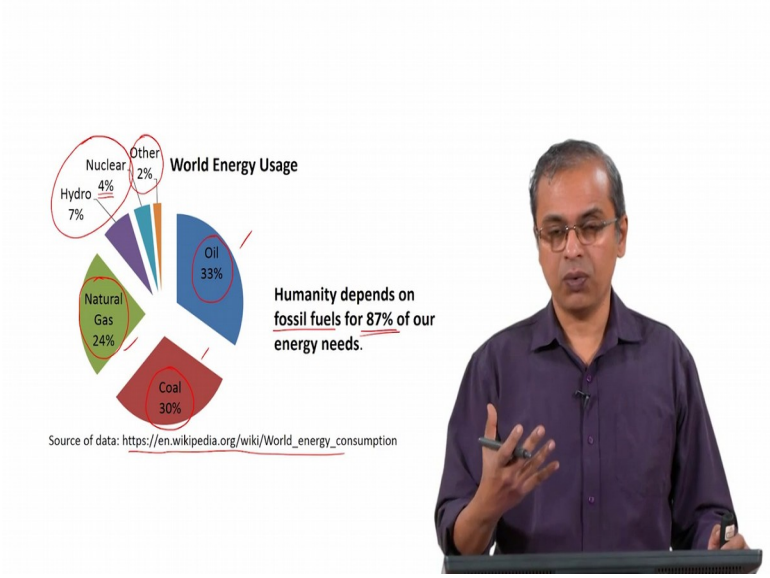

Okay so, we will look here in this slide the sources of energy that are presently being used around the world and I will highlight one aspect of it before I get into it and I will

point to this a little bit more as we look at more data in the subsequent slides as well and that is simply that the data if you see here will vary a little bit from source to source to source. So, if you look at, if you search for various you know scientific literature reports on you know how energy is used around the world you will find some variations in the percentage, in fact even in the few slides that I am going to show you there is going to be a variation. This does not necessarily mean that there is something wrong with that data it's just that when the data is put together there are certain aspects that people are focused on and therefore, it is presented in a certain way because sometimes some energies are clubbed together, sometimes they separated and some decision has to be made as to what category should one energy fall under what category should another energy fall under etcetera. And so it's a area for considerable debate.

We will that is one important point that I will emphasize to you as we go through this class that there are different terms that are being used they mean certain different things, sometimes we are using them interchangeably in fact in popular literature it is often used interchangeably some of the terms that we are going to discuss today. And because of that we have a general perception that a particular form of energy should fall under some category, but if you look at it a little bit more deeply maybe it should fall into some other form of category.

So, those issues are there and that's why you see some variation in the numbers as you look at different statistics from different sources. But nevertheless if you look at the statistic that we have we have here, if you look at the world energy usage you will see significant usage coming from oil, based on oil, significant usage based on coal and significant usage based on natural gas.

So, I think if you look at statistics from almost any source that you find, that is in any way you know scientifically reliable something which has gone through any kind of peer review and then you are looking at that data, invariably you will find that these three are the major used look I mean sources of energy of conventional energy.

So, this is I think generally this there is a broad agreement on it. So, for example, here I am using this data which is so, I mean open source available at the Wikipedia site. But basically similar data you can obtain from different places you will generally find that these three forms of energy are the largest used internationally. So, in that sense they

broadly agree it doesn't really matter which source of data you use. So, here for example, I am saying this totals to about 87 percent. So, that exact percentage may vary a little bit. So, in some cases you may see as low as 80, 78 some cases you may see higher, but generally you will find you know 80 plus percentage of energy that we consume seems to come from these sources which is oil, natural gas and coal. So, essentially it is fossil fuel of some nature right. And that comes that takes up significant amount of our usage that we do. So, that's what contributes significantly to the usage that we do.

If you look at the others you have hydro and nuclear acid two other major sources of energy and there again if you see you know hydel power stations are there internationally. So, many places and so that contributes to 7 percent we will see some aspects associated with it. For the most part in this course we will not really look at nuclear technology at all, but you should you have to be aware that you know it's about 4 percent of supply of our energy comes from nuclear power plants and so even though you here nuclear a lot that puts some sense of perspective on what it is doing. Almost all the other forms of energy that we use you know actually give us only about 2 percent of everything that we are doing and therefore, we have to look at that with some sense of perspective.

I will also point out that you know this is a world energy usage kind of a pie chart; if you actually go to each individual country you will find that there are differences. Although broadly you will see this kind of a trend you can see you know things like what we see as the two percent may actually be a larger chunk of the pie chart of their energy supply. So, that can vary actually quite significantly from country to country. Some nations have taken a lot of initiative to push their you know clean energy processes up significantly and so there you will see maybe even a drastically different pie chart from what you see here.

But this is approximately true and certainly if you consider the most major consumers of energy chances are you will see something very similar to this. So, this is overall world energy usage even this I will show you in a slightly different format in our very next slide, but we will take this and we will move this a little further in to get little bit more detail and to understand what else we can you know examine in this kind of pie chart.

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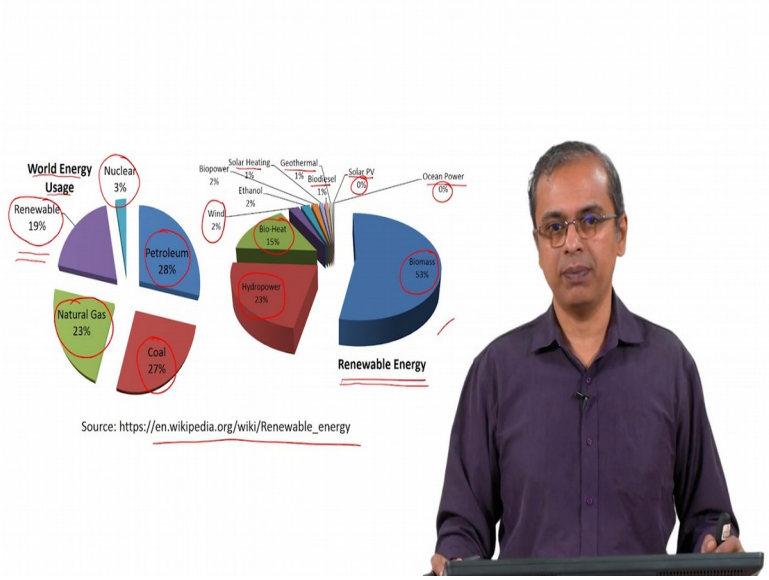

So, again on your left you see a world energy usage and you can broadly see here that for example, I see again the same kind of features here. This data you will see is not exact match of what we saw last in the in our previous slide and I will try to highlight what is different about it. So, on your left first of all you see the world and energy usage and on your right you see renewable energy okay. So, these are two different things this is world energy usage and this is renewable energy on your right hand side.

So, let me just quickly see what we are looking at from the world energy usage perspective and related to what we just saw in our previous slide. Again you see that three major contributors petroleum, you see coal and you see natural gas. So, here you are looking at a percentage total of these being very close to 80 percent not quite the exact 87 percent mark that I showed you in the previous slide this is around 80 percent 78 percent is what you are seeing here, but again predominantly it is these three. So, you we the exact number that you are seeing there is perhaps not as critical, but this general tendency that you know well over three quarters of all the energy that we use is coming from these three sources.

Now, there is a 19 percent that is listed here as renewable. So, the this source I am looking at which is also another source related from another site here which is also a Wikipedia site. But you can see slight variations here this is 19 percent renewable. If you compare against a previous slide you see hydro, hydro electric power listed there

separately. So, that is something that would also you can think of it as renewable. So, that these are the places where you know a lot of thought processes go into what is to be put under, what category I was just indicating to you that you know you have to think of what category you have to look at things. And so therefore, you can think of this 19 percent containing contributions like that which would then you know be the reason why you arrive at an 19 percent. And, so that includes that two percent of other that we had in the previous slide the nuclear remains there. So, even nuclear you see a slight variation it says 4 percent here, it says 3 percent here. So, some variations are going to be there in terms of the exact quantities that you see you also going to see some variations based on how those quantities are clubbed together.

So, that something you should just keep in mind. So, therefore, I will also alert you that you know you do not really have to remember these exact numbers. This is just to give you an idea of what is involved here, its sufficient that you keep in mind that you know over three quarters of the energy we use is sort of fossil fuel related and then we are looking at other aspects chipping into the energy supply which come from other sources including renewable nuclear and so on.

So, this renewable energy usage renewable energies supply is about 19 percent of the overall global supply and that again is split into this pie chart that you see on your right hand side. And you will see various names here some of which you may in fact may not even have heard of that much. So, suddenly you see if you look at renewable sources of energy you see this term here biomass and you see this bio heat. So, between them you are looking at 68 percent about, 70 percent of this renewable energy is coming from something that is bio related okay. So, we don't when we read popular articles on renewable energy we look at clean sources of energy etcetera is articles of that nature we tend to hear about solar, we here tend to hear about wind and those are maybe the two terms that we hear much more significantly we also tend to hear about batteries we here about fuel cells these are the kinds of terms that we here about fairly significantly.

But if you look at the statistics if you look at what you can actually pull together you see a pie chart like this where you know about 70 percent of this 19 percent. So, this is 19 percent is what is being split here into this pie chart on your right hand side. So, this 19 percent when you look at the distribution within that 90 percent you find that you know about almost 70 percent is coming from something that is bio related. So, what that is we

will see in a little bit, but we just keep in mind that there is such a thing and then we are not really often discussing it. So, we will keep that.

Hydropower is listed here 23 percent of the energy that we are getting in the form of renewable energy is hydropower which basically means typically means dams of different kinds, different you know sizes and capacities typically that is that is there. And then you have a lot of small contributors a huge number of small contributors. So, just to run you through them we have wind which is about 2 percent there's still something more bio, there is ethanol which can be used there is solar heating that you see here, there is solar PV which means photovoltaic which you see there, then there is something called biodiesel, then we see geothermal sources and then you see ocean power, right.

So, I am listing 0 percent here for ocean power and solar PV primarily because their contribution is so small that in the scale of this chart you almost cannot see them. So, that's how small the contribution of these two sources of energy is to the overall pie chart. But they do exist people are working on them, so you will see if you look around internationally you will find sites where you have power plants which are solar PV based or photovoltaic based or you know ocean power based.

So, the 0 is doesn't mean that there is no such plant it simply means it is very small to show in this in the scale of this figure and that's that's why it's simply being shown as 0 percent it, basically means its much much much much less than 1 percent. So, that's the situation we are dealing with. So, you see this range, you see this diversity in the sources of energy that are renewable that we are currently utilizing and making use of okay. So, we will keep this in mind if necessary we will revisit some of these ideas as we move forward.

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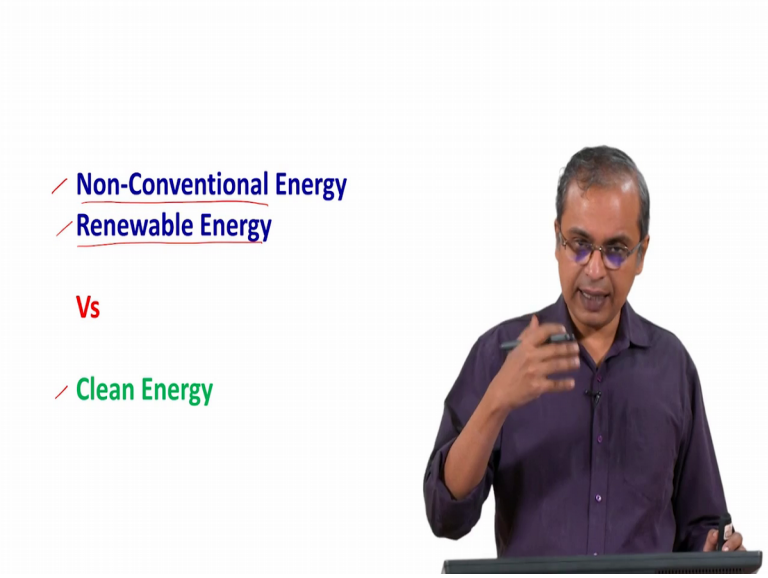

So, already in this class we have used some terms which are the terms that are also present in the popular literature and I think it is a good time for us to pause a moment and consider these you know terms a little bit more carefully to see what is it exactly we are trying to express when we use those terms. So, there are three terms here, one is non-conventional energy, the other is renewable energy and I will put in this third term here which says clean energy.

Often in popular literature you find these three terms being used interchangeably. Okay so, when somebody says non-conventional energy it somehow registers in your mind as something that is clean, that is you know something that is environmentally friendly. When somebody says renewable energy again that is the same idea that registers in our, my oh it is clean energy it is you know something positive that we should utilize and so on. So, that's the common you know; common usage situation that we tend to look at these three terms as you know being basically the same term and that you can use them interchangeably and quite possibly in many articles they are used interchangeably. However, you need to look at these terms a bit more carefully to understand what exactly are these terms referring to and also you know atleast put in our thought process into what these terms are referring to and really gauge for ourselves whether they really can be used interchangeably or if we need to be cautious about their usage in interchangeable manner.

So, first of all if you look at this term non-conventional that itself is a very difficult term to you know pin down accurately okay. So, when we say non-conventional it means different things. So, first thing is it simply means it's not the most common way in which we are doing something. So, that's basically what it means it's not the most common way in which we are doing something.

However, we have to remember that this is being used only in today's context. So, when you say non-conventional it is non-conventional from the perspective of what is happening today so in fact in some cases as you will see in some cases when you say non-conventional if you actually go back even 100 years ago, even 100 years ago that was conventional what it was the conventional way in which we were using on energy 100 years, 200 years ago and in fact for fair part of human history something that we were doing was conventional way of doing it. And only in the last say 100 years or so, we have drastically shifted the way in which we are doing things. So, what was conventional a white back may sometimes look non-conventional at this point or may get classified as non-conventional at this point simply because it is not the majority of what we are doing. So, that is the thing that we have to keep in mind. So, that is the point about non-conventional energy.

Then there is renewable energy renewable energy simply means you can renew this source of energy that's all it means. So, or at least in either we can renew the source of energy or nature automatically renews the source of energy. So, at a timescale and I know at a rate that that is something that is in line with how we are using that energy, right. So, in principle if you wait, if you stop using fossil fuels now and then you wait another you know 20 billion years you may get back fossil fuel that doesn't mean you know it is renewable energy, right. So, we want it in this time scale in the time scale that we are currently using it. So, we consume some energy over the next 5 years can that energy be replenished in the same 5 years, if we consume energy through the month can it be replenished through the month. Per day we are consuming some energy same day will it come back as you know source of energy for us. So, or the very next day it's available. So, if it is something that we can you know sort of regenerate or is available to us in an you know in inexhaustible form then that is something that we are considering is renewable, right. So, that is the second aspect of it.

The fact that it can be renewed at a time in a within a times timeframe or in a time scale that is in line with the rate at which we are using it. So, that is how we call renewable energy. So, that is a second term that we have used.

The third is the idea of clean energy. So, this is again something that has a specific connotation. When we say something is clean, at least in today's discussion of energy it means it is clean with respect to the environment which means you already have a certain environment around us which has a certain you know distribution of gases, a certain distribution of a temperatures and heat and so on. And as long as the process of you know generating energy and consuming energy is such that we are not disrupting what already exists in the environment in any manner which neither or we doing some spill somewhere we are not releasing some noxious gases into the atmosphere, we are not changing the composition of the atmosphere, if we take all that into account. And it still happens to function in a manner that is not impacting the environment in any manner. It stays kind of benign with respect to the environment or only releases things that are already there in the environment in the sort of the same composition that it's already there in the environment. If you sort of maintain all these kinds of things then you can call that energy as clean energy okay.

So, again I have gone through three terms and tried to highlight what they represent non - conventional energy, renewable energy and clean energy. And maybe now you have some sense of individually what they mean, but I still want to press home the point that they are slightly different and that's what we will do in our next slide.

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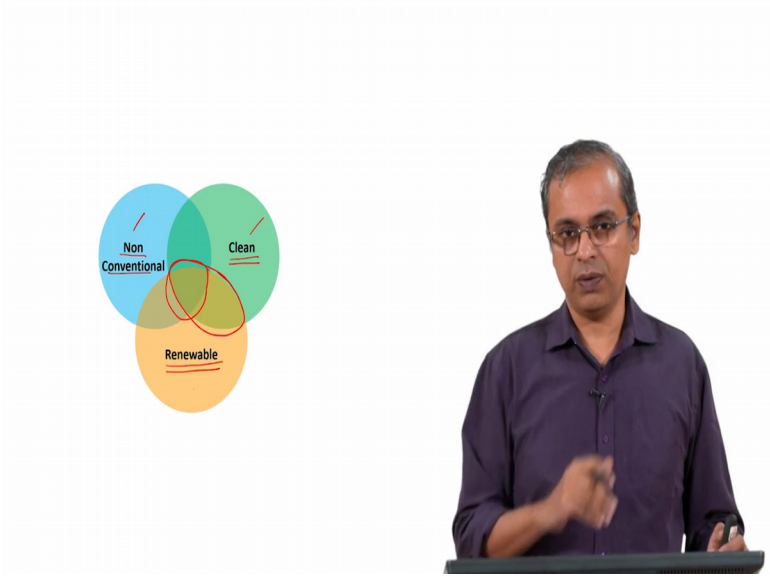

So, my basic point that I want to convey in this discussion in this part of our discussion is that we have three terms non-conventional energy, we have clean energy and we have renewable energy. So, if you look at all the technologies that are available to us to generate energy, all the possible technologies that are used in small scale or large scale etcetera and if we classify them if you set aside the so called conventional ones you set aside the direct fossil fuel ones for the moment and then you just look at what remains. We find that they can all be clubbed into three different categories some of them are non-conventional, some of them are clean and some of them are renewable. And if you draw this kind of a Venn diagram you find that actually you can make you know groupings which are not necessarily completely overlapping and that's the reason why we have to be careful when we see an article where these terms are being used in interchangeably. They are not exactly equal to each other that's the point that I wish to make.

You can easily have a source of energy that is renewable which means you consume it and it is available to you again, right. You can you can create such a source, but the process of using that energy can be very polluting we will see examples of that. So, just the fact that it is renewable just the fact that you can get it or you can get it back at a timescale or you can at least try to get it back in a timescale that is similar to the timescale in which you are using it. Does not necessarily mean that it is clean, right. So, you may be doing something which is quite damaging in the process. So, everything that is renewable is not necessarily clean. Everything that is non-conventional is again not

necessarily clean and as I said you know again the idea of non-conventional itself is questionable because some of these things where conventional just 100 or 150 years ago and certainly in that and you know if you look at more recent human history in this last 500 years or whatever.

Some of the sources of energy that we discussed today in courses like these are or were conventional at that point in time only in the last 50 years or 100 years they have become non-conventional so to speak, but they are not necessarily clean. So, just because they are non-conventional does not mean they are necessarily clean. So, you can have various combinations. And maybe when we look at each source of energy we will highlight this idea that you know you can have various combinations of them it may be non-conventional it may be clean, it may be renewable or some two of these and not one of them or just only one of them and not the other two and so on.

And so, there is one overlap in the middle which is always of interest to us because that is clean that is renewable and it is non-conventional. So, that is of interest to us. But really if you want to look at this from an environmental perspective truly environmental perspective if you want to look at, this is the first greatest priority that we have that it should be a clean source of energy. If it is clean and it is renewable then this this overlap that we see here, this entire overlap that we see here that is really what is most interesting to us. Whether or not it is conventional or non-conventional is really not that critical to us I mean I we don't really care, whether it is the most recent technology or old technology or ancient technology that is not as relevant to us except for you know curiosity sake from scientific curiosity perspective we can you know think about that.

But what is most important is, is it clean and if it is clean is it renewable if you have a combination of those two then we really have a good source of energy because it means it is something that we can keep on using we can keep on getting it, its continuous to get renewed as and when we use it, but at the same time it is clean. So, that combination is I think much more useful to us much more of interest to us than anything else and so that's what we need to look at.

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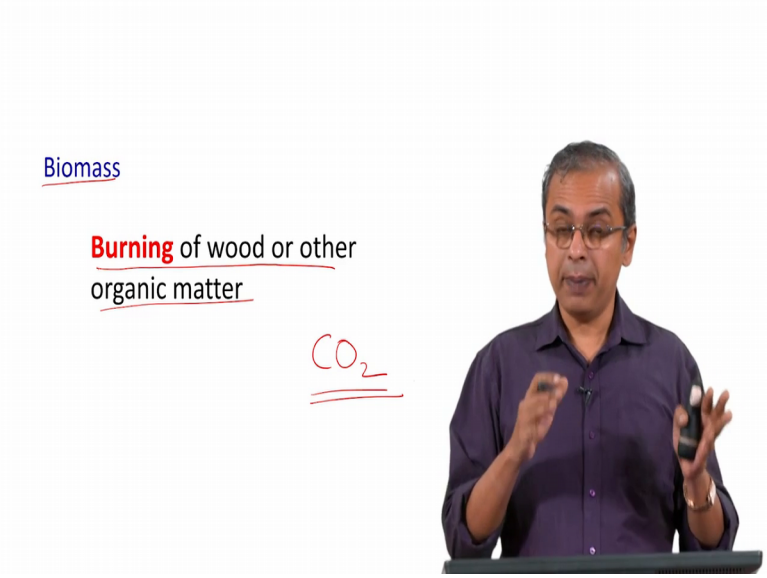

So, we will look at if you look at our previous pie chart that we had here we see that biomass something related to biomass is considered you know is basically taking about 70 percent of these renewable sources of energy. So, let's spend a few minutes looking at what is biomass and then see what we need to consider about it.

So, biomass is nothing, but burning of wood or other organic matter. So, you see here suddenly you have something renewable people say a non-conventional those kinds of terms are used, but what is it? It is simply burning of wood things that I mean for generations people have done, for thousands of years people have been doing in fact the first forms of energy that you know cavemen used was burning of wood okay. So, if you look back it is such an ancient technology you basically burn wood and the kind of thing that we actually try to discourage people from doing on the streets, people from doing in you know in various places in the city which is burning its exactly what this is this is just burning of wood and wood or other organic matter. It is considered renewable because if you actually set this up in a in some you know organized manner, you can set up some process by which you have a large area of land which is marked as a forest and you just you know stakes a half of it cut it down use it for energy then take the other half of it and while you are using the other half to create energy you regenerate the first half.

So, you might have to do this in a very planned and organized way to ensure that you are always using that same you know; same amount of organic material and you know

repeatedly cycling within that within the framework of that organic material that you have available to you. But in concept if you did this, this is indefinitely renewable you can keep on you know growing a forest burning, the forest growing the forest, burning the forest. So, this is something that you can do and therefore, it is renewable.

But the point that you have to remember and this is why I thought the classification that I just discussed with you is so important is that this can hardly be considered clean this is by any stretch of imagination this is not clean because you are burning wood if you burn wood you will release CO_2. So, CO_2 is being released. And this wood you got by cutting down half of a forest, right. So, that half forest is no longer available to absorb the CO_2. So, you removed that half the forest and you burned that half the forest and you got yourself energy. So, this cannot be considered as clean.

This is not in my opinion not a clean form of energy and even though in fact this is become an issue of contention actually internationally because in their attempt to meet global you know global standards of environmental cleanliness people have tried to go away from fossil fuels to biomass, saying that you know we have stopped using a non renewable source of energy which is fossil fuel and we have shifted to a renewable source of energy which is biomass. Yes from the description of non renewable to renewable this seems like a good shift, but at the end of the day you are releasing CO_2.

So, you are in that sense this is not really in any form really truly a clean form of energy. And in fact if anything else chances are this biomass may not be giving you the quality of heat that you want and you may end up actually having to burn lot more biomass to get a similar quality of heat quantity of heat and actually do something useful. So, its chances are you are releasing even more CO_2 because you are probably doing this in an inefficient manner and therefore, it is actually lot less clean then perhaps using certain forms of fossil fuel.

So, anyway biomass is that it simply relates to this idea that you use something that is organic that is available that can actually be created. So, it could be said you know trees or other organic matter that you use. So, as you see large fraction of renewable energy falls under this category or this consumes a large fraction of that renewable energy pie, but it’s not something that we can particularly aim to expand because it has aspects of it that are not particularly pleasant.

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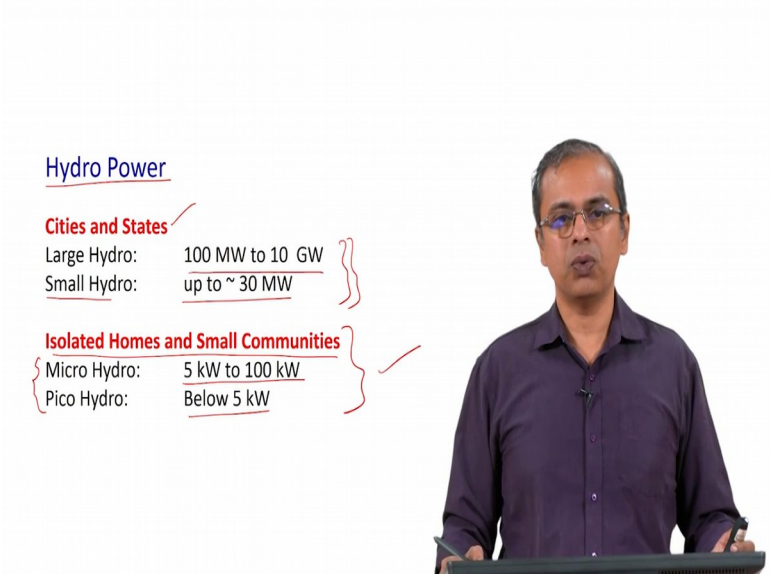

Hydropower, hydropower is again a significant part of that pie chart and actually has been there for generations I mean for you know at least few 100 years we see hydral power stations of different capacities that have been around. And in principle in concept it is clean power because you simply have water that is moving you are just making use of this natural process of you know water evaporates from the sea the water cycle it becomes clouds it becomes rain somewhere and then it flows down in rivers. As it flows down in rivers you construct dams, you convert that you know collect up the water, convert that potential energy into you know electrical energy that you can capture using turbines. So, in that sense it is considered very clean energy.

But even then there are some issues associated with it. So, for example, if you look at capacities you can think of some very large capacity dams which are you know in that 100 Megawatts to 10 Giga Watts kind of capacity or maybe even slightly more. So, for example, I think the three gorgeous dam in china which is considered the largest you know power plant in the world it goes to I think close to 20 Giga Watts of power is what it is generating. But there are only about a handful which are maybe over 4 or 5 which are in the which are in the 10 Giga Watts or higher internationally and then everything else is less than that.

But generally a large hydroelectric plant would be in this 100 Megawatt to 10 Giga Watt kind of power range smaller ones are more like up to about thirty megawatts of power

range and generally this kind of capacity is what you will use to power cities and states. So, that's the kind of capacity that you will use.

There are also these other versions which are called this micro and pico hydro dams, hydro I won't say dam hydro power generating units and they are very small 5 kilowatt to 100 kilowatt or even below 5 kilowatt and these are just using you know small flow of water across you know some height difference to get you this electricity generated. And if you see the number of 5 kilowatt you know that that's kind of the power that is required for house typical households which may have a television, in a washing machine refrigerator, a few air conditioners of different capacities you are all looking at about 5 kilowatts of usage roughly. So, this kind of a small installation can actually power your house and maybe a few neighboring houses if you set it up correctly.

And, so they are often used to power isolated homes and small communities especially if it is in some wilderness area where you have you know let's say you are on a hilly terrain and you do have some natural flow of water that is occurring there and you tap into that natural flow of water. So, these are know if you look at the hydropower scenario, the landscape of hydropower this is the sort of the range that you are looking at in this generally today's assumption and today's you know thought process is that the smaller capacity dams are actually good, the smaller capacity hydropower generating units are actually good in the sense that they are clean because primarily it is water that is flowing, they are also not that disruptive on the nearby localities right.

These large stations actually do a lot of disruption invariably when they are constructed even from a human perspective significant amount of human community settlements are affected because a lot of people have to be moved you are suddenly going to raise the level of water in some location in a in a very significant manner it impacts the local environment significantly often. You know of course, this may not seem like much, but often historic sites get submerged, but more than that often forests get submerged there are you know regions where because the water of the dam has gone up to some level and it is a freshly constructed dam. Some pre existing forest in that area or pre existing you know wilderness in that that area gets completely submerged by that water. So, there is significant you know destruction environmental destruction due to the construction of large dams.

And is people also argue that when you when you submerge a forest the kind of damage you do in terms of not just destroying that forest, but what gets released due to these you know you know drowned forests into the atmosphere is also considered kind of harmful. So, there is a lot of debate there is a lot of discussion and arguments in the international scenario about large dams.

So, invariably you will find that is the reason why anytime there is a large dam project there also seem to be a lot of environmental people you know objecting to it raising concerns about it and that's generally been true of any large you know hydroelectric power project that's been set up almost anywhere in the world. So, there are concerns about it, but you have to I mean also keep in mind that once it is set up and it is running it tends to be a clean form of energy you are not really doing any you know nothing is being burnt you are just using the general flow of nature to generate the electricity.

But increasingly the thought processes is that if you have a large you know if you have a river that is flowing it's much better to have several smaller you know hydroelectric generating units along the path of the river rather than to put one massive dam and create this one massive project. And I think a lot of sense there is there because it also means your transmission costs are low you can keep generating at various locations and you transmit very locally, if you see internationally and look at the electricity that is generated and transmitted significant losses are associated with the transmission of the electricity. And so a lot of effort is put in to try and cut that transmission loss down. And the best way to cut down this transmission loss is to actually generate the electricity locally or as close to the site of usage as possible. So, having several my you know micro dams or a pico dams along the flow of a river is actually in that sense much more useful and you know you know clean way of using this energy then putting one massive dam.

Even infrastructure wise it is much easier to do you can probably set it up much much much sooner than you know block up the whole place for a few years to construct the dam. And it does not disrupt the local environment that much it's all small small constructions and then it keeps running smoothly. So, s this is something that is of interest. So, therefore, people I think generally feel that this is a better route to take than the larger projects.

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Okay Wind energy is the next major form of energy that we look at when we you know try to get ourselves clean energy. So, in the last several years maybe last say 20 years or so, lot of interest has been there in wind energy it has been there traditionally for a long time, but to sort of harness it in a systematic way in a very large scale manner has really happened in the last say 15-20 years and there are big wind farms around the world which capture this wind energy capture it and convert it to electricity I think the largest one is in China. So, the largest wind form wind farm happens to be in China. There is one large offshore version of it, which is a setup such that it's not you know a taking up land on the in the you know habited way habitable places and that is there in London it's called the London array.

So, that is offshore and in India we have a one large project in Jaisalmer in Rajasthan which is the largest such wind power generating unit within India. So, in fact this image you see here is also very much from India, it's from the southern state of Kerala, it's actually in I actually got this from the temporary campus of IIT Palakkad and you can actually see this, these you know windmills if you happen to visit this location. And very very appropriately you also see all these wires which are transmitting this electricity somewhere.

So, this is a very common now it is available in many places a lot of people there are specific companies that has specialized in it and many countries are actually trying to

install such wind farms across the their you know geography. There are various issues associated with it because first thing is it is not consistent, it depends really on the wind flow wind, flow pattern, so not every location you can set this up you can set this up in some locations, but not in every location. So, you have to look at that you have to see how seasonal variation affects it and so lot of other parameters are involved here.

But you do see some interesting variations on this interesting you know ways in which people have tried to extrapolate this process there are buildings where they you know try to set up a windmill or a windmill based power generating unit at the topmost floor of that building. Usually there is fairly good breeze at the top floor and they try to see if they can at least power that building. That's a very interesting way to go about it because if you and set something up at the top of the building using you know wind or you know some other form of you know we are going to see solar energy too. So, you solve that and capture energy for the building then you are done you don't really have to you know look at transmission losses you don't have to look at you know pollution all that is done within that building. So, if you keep, you know stick to these kinds of clean sources of energy.

This is quite clean because you are really doing nothing you are just you know taking wind which is already blowing and converting that to electricity. Maybe the only negative aspect of this is that you and again it will depend on when I say it's only negative aspect for some that may be a significant negative aspect is that this can affect flying birds. So, you have to be a little cautious about it, but other than that thing it's considered a clean form of energy.

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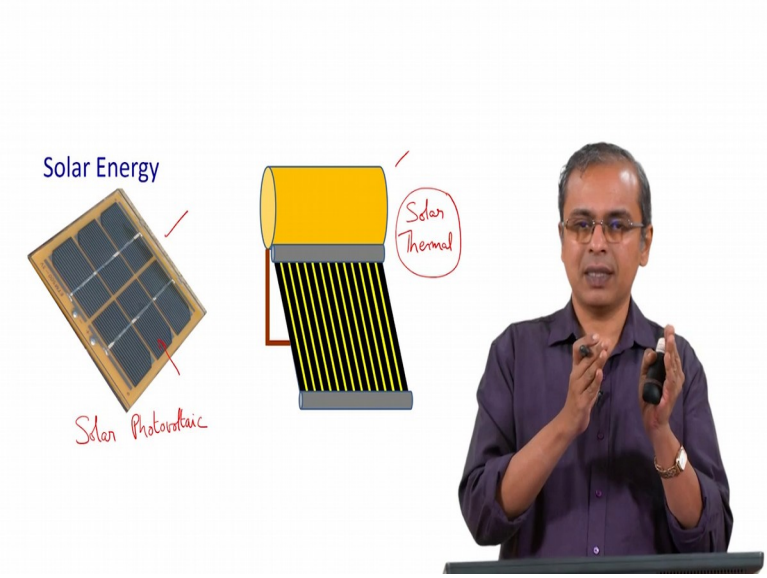

Solar energy, so this is something that we are all most familiar with. I think of the non-conventional forms of energy that we see renewable forms of energy that we see. I think maybe wind and solar energy is what we are most you know familiar with at least from our popular reading you keep on hearing about solar energy all the time and actually broadly in fact solar energy can be tapped in multiple ways. And what I am showing you on the slide is we may be the two more prominent ways in which it is stopped tapped and one is the idea of using a solar panel which is also called solar photovoltaic. So, solar photovoltaic and this is solar thermal.

So, you will actually find that you know these solar thermal units are now in fact available in many households install it on the rooftop maybe in your own house, you have this install or in your hostels you have it installed dorms you have it installed. So, this is there in some cities actually it is compulsory that for example, I think in Bangalore in India it is I think that is one of the cities where this seems to be necessary I think it is legislated that it is necessary if I am not mistaken and so almost all the buildings have it, have this solar thermal unit which takes care of hot water requirements for that building.

And it's basically, this is just capturing heat energy from the sun and solar thermal itself has a wide variation in how it is captured, what is accomplished with it and so on. So, when we get to the solar power we will look at that in greater detail. This is just one implementation of it and maybe the most common implementation of it that I am

showing you right now. And solar PV is again something that is common place relatively speaking in many cities we find now the you know street lamps street lights have a solar panel attached to it. So, they it comes as integrated unit you have a solar panel you have a small battery associated with it and then the solar energy is converted to electricity, stored in the battery and then it runs the street light in the night.

So, we have all sorts of interesting products that have come up based on the solar panel this actually is more you know you have some special semiconducting materials that are used in this panel. So, when we get to this solar energy discussion we will look at that in greater detail and that is used to capture sunlight and convert that to electricity. So, there is a process involved in it we will look at the science behind that process when we get to it.

Generally speaking these are very clean forms of energy except again here you have to keep in mind that the method that you may use to generate the solar panel should also be harmless. If you finally, you know if you have to fill the world with solar panels photovoltaic panels and you use a extremely toxic process to create those solar panels then that defeats the purpose. So, that's another aspect of it that you have to look at. So, they sort of talk of this, you know there is always this phrase that is used cradle to grave which means from the time, you start that technology start the first step towards creating the technology till you finally, you know you make it you use it and then finally, it becomes bad after several years of usage you finally, have to dispose it off and you find a way to dispose it off.

So, from the time you start till you dispose it off all steps should be clean. So, only then it is truly clean. I mean if you want to really make an impact at an international level, you know at a global scale and you want to want it to be clean then this is something that you have to keep in mind, is it clean from cradle to grave. So, that's the idea that you would keep in mind. So, in that context you have to look at these technologies a bit more closely. But that aside generally speaking solar energy is very clean we are really doing nothing it is already arriving on our planet we simply are tapping it that's it. So, that is the other form of energy that we look at.

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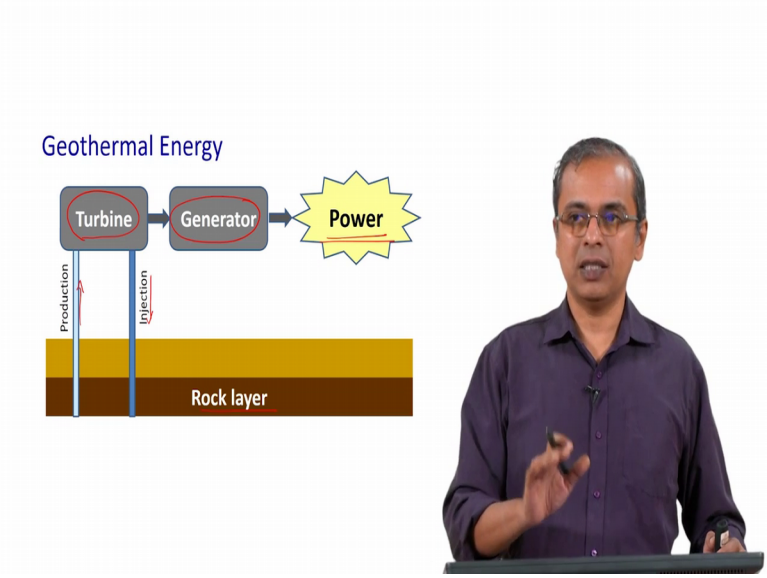

Geothermal energy, this is energy that is already there inside the earth. So, if you go deep inside the earth maybe even you know say one and half, 1- 2; say to 1, 2 or 3 kilo meters deep into the earth you see temperatures that are extremely hot right. And in fact the I mean some representation of this is what we end up seeing in the form of volcanoes where you know it has eventually broken through and you have this fissure through which lava is coming out and you see this volcanic eruptions.

So, that is anyway happening independently, but this is tapping that energy in a controlled manner. So, this energy is already there under the ground. So, what we basically need is a system by which you inject water through a pipe which goes deep underground and then goes to a place where the temperature is say a couple of 100 degree centigrade of that order and there it just gets converted to steam and then the steam comes out in another pipe and so the steam is used to run a turbine. And once it comes runs the turbine the steam cools down becomes water is again injected back underground to heat up and come back. This turbine then runs a generator and you finally, get electricity.

So, this concept is very simple in that sense of course, you have to install it carefully you have to send this set of the pipes so that it goes somewhere deep and picks up the heat and comes back. You don't want to accidentally start some you know uncontrolled process. So, you have to look at it, but it's a very clean form of energy it's already there

underground. There is a small element that you are releasing gases which are trapped under the rock layer that is there underground you are releasing it, but in this process, but that is generally considered an extremely small amount that you are releasing you can set this up in a relatively clean manner. So, it's a very interesting way in which you tap energy that is already there in the earth there is no, so it looks you know vaguely like you know thermal power plant except that the there is no coal being burned to generate the heat, you simply have underground heat from the earth that is being tapped. So, that is the geothermal energy process it's pretty clean and therefore, it is very interesting to utilize.

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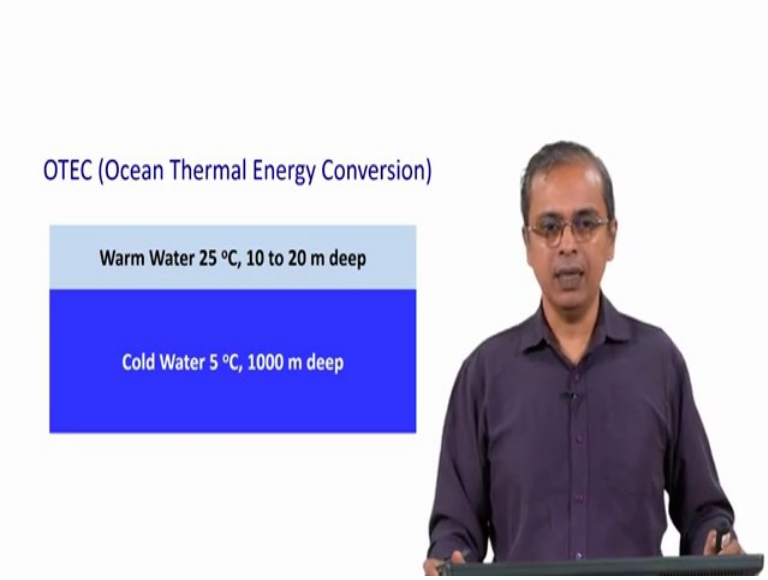

Then there are couple of ways in which we can tap ocean energy there is still energy available in the ocean and one of them is this OTEC process, Ocean Thermal Energy Conversion. So, this is based on the idea that if you actually look at the temperature of the ocean from the surface down deeper you will find that there is warm water at the top and it is about 25 degrees centigrade is the temperature in there it is there in about you know the top layer which is about 10-20 meters deep and then when you go much deeper you can get cold water which may only be about 5 degrees C in temperature.

So, you have about 20 degree C difference of temperature that is readily available to you in large quantities, the massive quantity of water available at 5 degree centigrade massive quantity of water available to you at 25 degree centigrade. So, if you take these two and

you run a heat engine based on this temperature difference you can generate electricity. So, that's basically the idea here. So, they will typically pull out water from which is from deep below and pull in water also from the top and then they run this heat engine and then the averaged out temperature which will be around you know 16 degree C or something is then pushed back at the ocean. So, this is the general idea we can maybe look at it in little greater detail at a later point in time, but this is one way in which you can tap energy that is available at the ocean.

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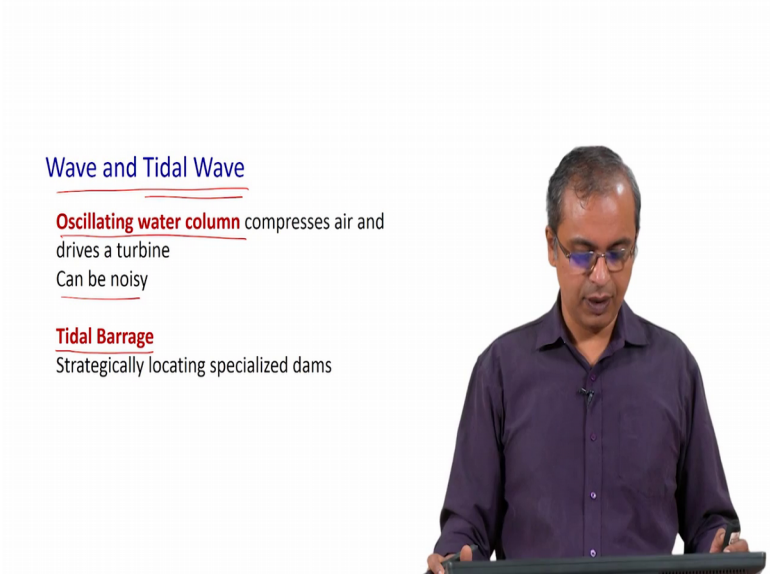

The other way you can tap it is the idea that you already have a lot of movement of water in the ocean, either in the form of waves which are you know happening in every minute or every few seconds you see waves or you have the tidal process which is going to happen over several hours. So, both of them are happening and you can tap them.

Of course, this has got the tidal process also has got a little bit to do with your geography first of all you should have access to the water you should have access to the seas only then you can pull this off and, but basically the idea is quite straightforward if you are looking at wave you can have an oscillating water column. So, there is a water column and that is oscillating up and down up and down based on the wave that is coming in and going out, every few seconds water is going up and down. And then you can use this process of I mean moving water to compress the air that is above it. So, you compress the air expand the air compress the air expand the air and so on.

So, you have all these things going on you can use that to run a turbine. So, this moving air you convert the moving water to moving air and that runs a turbine and then you generate electricity. Maybe the only thing that is a little bit an issue with this oscillating water column is that it can be noisy it can affect the marine environment and marine animals and birds in a very local area. So, if you are doing large scale installation of this you know wave based power generation units then that is something that you have to be a little bit concerned about.

You can also look at tidal barrage so that is the other way in which you can generate electricity this uses the tidal wave activity. So, it is actually a very interesting way in which you capture it, but again its limited a little bit by geography and the fact that you need some specialized locations for this you just capture the fact that you know during high tide the water level rises up and so, you allow the water level to rise up and then you have these small dams which actually get closed and then they hold that water.

Now, at a higher level and then as the low tide happens. So, the water level recedes you now have this potential energy that has now been stored. You release it in a controlled way back into the sea, but you are generating power in the same in during the process. So, this is a very clean way in which you do it this is relatively smaller dams you can put up at some strategic locations and you can keep generating current, but because of the limitation in the location you cannot have a significant amount of you know energy generation through this process. You may have some limitation on upper limit on how much you can pull this off even at an international level, but still there's considerable room for you to do these two processes. So, these are this is another way in which you can generate energy from you know natural processes.

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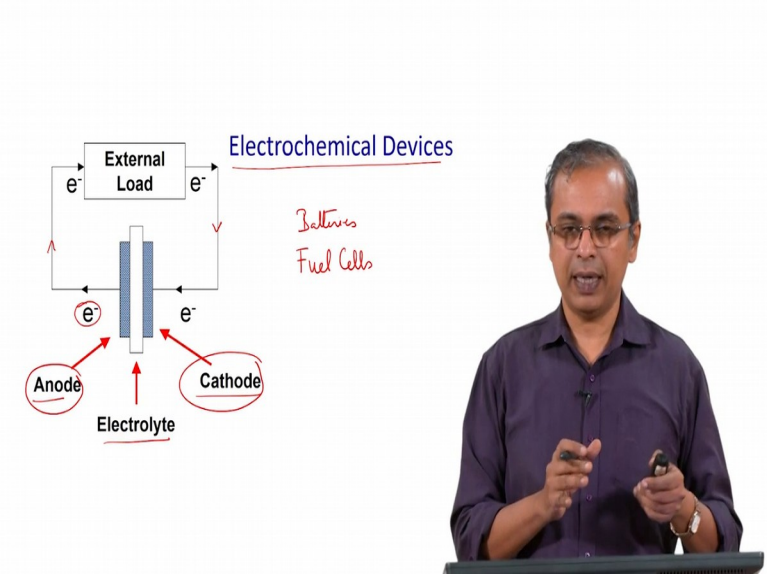

I will finally, finish with this we in all these sources of energy invariably we find that you know and the end use you also need to have some kind of storage of this energy because be it you know thermal energy, wave energy, tidal energy, etcetera wind energy.

It turns out that they are never likely to be you know uniform and continuous through the day you are going to see fluctuations because that's the nature of how nature behaves. And therefore, you need to augment such power or energy generating processes with some energy storage processes so that from the end user perspective there is a relatively undisturbed and predictable supply of energy. And the most common ones that are used for such activities are electrochemical devices and mostly batteries and fuel cells.

So, a batteries and fuel cells are extensively used in this context and they are quite simply what you see here as an arrangement consisting of an anode, a cathode and an electrolyte, and you have oxidation reaction occurring at the anode, you have a reduction reaction occurring at the cathode and this causes electrons to go through the external circuit run your load which is running powering a household and then it comes back to the cathode and completes the reaction. So, this is a typical battery. There is a lot of electrochemical science behind it and engineering behind it and when we discuss these batteries we will look at that in greater detail.

But this is typically there, as part of almost any of the other technologies that we have discussed through this class as an overview of non-conventional sources of energy and

therefore, we will spend actually a reasonable bit of time trying to understand these devices.

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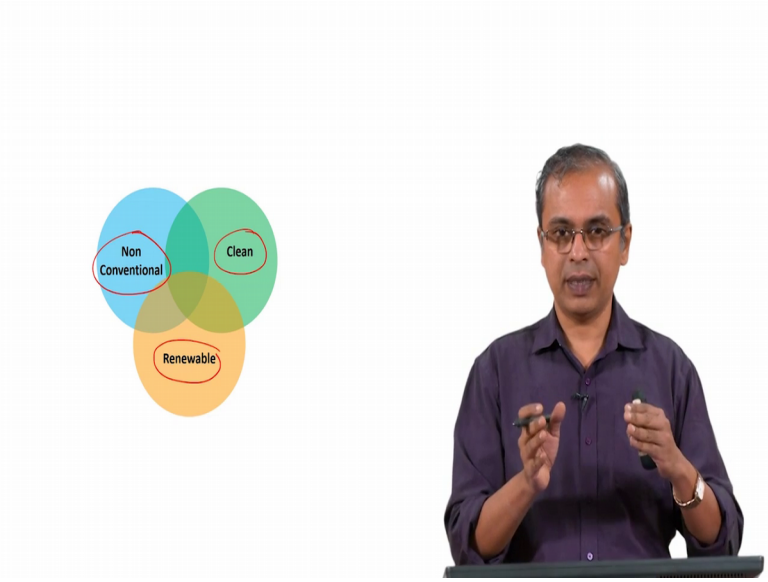

So, I will finally, close with this slide which we saw right at the beginning. I think through this class we have seen various forms of non-conventional sources of energy and we have also tried to look at what are the positive aspects of those sources and some you know drawbacks or limitations of those sources. And again I will alert you to this point that I made in path way into the class that there are some that are non-conventional, there are some that are renewable and then there are some that are clean. So, for us actually it is the clean part is what is most interesting to us and therefore, when we look at all these other technologies doesn't matter what their classification is I think our we should lean towards the clean aspect of it and then stay focused on you know how clean are we actually accomplishing in the technology, how clean a run it is, how clean a technology it is something that will be of interest to us. So, I will always keep emphasizing that through the different discussions that we have in this course.

So, with that I will close this class.

Thank you.

KEYWORDS:

Non-Conventional Sources of Energy; Biomass; Bioheat; Solar Energy; Wind Energy; Battery; Fuel Cells; Hydropower; Photovoltaic; Biodiesel; Geothermal Energy; Ocean Energy; Renewable Energy; Clean Energy; OTEC; Oscillating Water Column; Tidal Barrage; Batteries; Fuel Cells;

LECTURE:

Difference between non-conventional energy, renewable energy and clean energy is enunciated. A bird's-eye view of a list of above mentioned types of non-conventional energy, renewable energy and clean energy and it's crux is discussed in brief.