**Course on Integrated Waste Management for a Smart City**
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**Module No 08**
**Lecture 37: Thermal Treatment (Contd.)**

Okay, welcome back. So we will get started where we left in the previous video. So towards the end of the previous video, if you remember we were talking about in general about the combustion facility. So we will continue that discussion, we will continue the discussion on the thermal treatment in this video as well.

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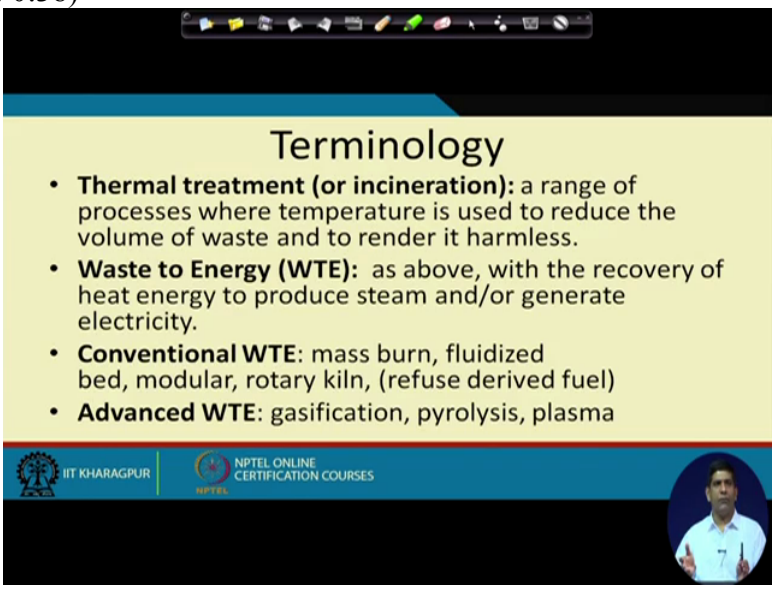


And here we will 1st as I said we will try to look at some of the these terminology before we go into like we will try to look at different types of, so far are we focused mostly just on the combustion, mass burn or RDF. So that is that is the most common one, that is the most common waste to energy system, specially when we say waste to energy from its formal point of view, that is the most common one used. But there are other technologies out there so let us look at some of those terminology.

Thermal treatment which is thermal treatment or the incineration, this is one part of the like it is used as a range of process where essentially what you are doing, you are using temperature to reduce the volume of waste and make it harmless. So what you are trying to do is, your

temperature is used, you are using the temperature to reduce the volume of waste and to render it harmless. So many times, if you look at a hazardous waste sector or even biomedical waste, we are essentially doing a thermal treatment of that.

We are not that much interested from recovering energy or recovering heat from those thermal treatment. Our goal there is essentially to do the, to make it less harm, make it harmless essentially. So we do not want that biomedical waste or hazardous waste to be a problem for like a human health impact, environmental impact, when we are managing it in the environment. So to make it harmless, you make it, you do a thermal treatment.

If you have worked in a microbiology lab or any biology lab or if you have been to a biology lab or if you are aware of the biology lab, you may have seen the they many of these labs carry an autoclave. Autoclave essentially basically to kills all the bacteria, pathogens and other stuff. So all the glasswares or other things that we use for doing day-to-day testing of like a biological related testing, at the end of the day, we will put it in an autoclave, we will clean it up, we will sterilise it so that it is a it is we do not get exposed to some of those bacteria and other stuff.

So basically we are killing them. So that is the thermal treatment part of that. So there, the energy is capturing energy is not our motto. Our motto is to just make things harmless from a biological perspective, from a chemical perspective, to make it safe to handle. So that is the basically the goal in terms of when we say just the thermal treatment. And yes, you hear more about that in hazardous waste class or in a biomedical waste and those areas.

When we say waste to energy which have been, we have been trying to talk about in this particular lecture, in this particular like in the previous few few few modules, when we say waste to energy, we are actually looking at means we are not only making the things harmless, but we want to recover heat energy to produce steam or to generate electricity. So our here the goal is to produce heat. We can use that heat as an energy source.

Heat could be used directly as I think I mentioned earlier, many of these western European countries, they have this district heating system. What does that mean is, they capture the heat many times from this waste to energy plants as well and use it directly for the home heating or office heating and those kind of scenarios. So that that is also one use of the heat and that is why

you hear that many times in the news article that Sweden is trying to import garbage from other countries, other European countries so that it can have its taste in simulators running because if the waste incinerator is not running, they will not have enough heat and then they cannot heat their homes or offices.

But heat can also be used to generate steam and then the steam can be used to generate electricity. So that is the other, either use the heat directly or you generate the electricity. So both are possible. So that is what we say in terms of waste to energy. Waste to energy term is much broader as well. Many times even the biogas to energy is also waste to energy. When we try to produce biogas using anaerobic digester or even in a landfill setting, that is also is a waste to energy system.

Now there are conventional waste to energy which we just talked about in the previous video. We have the mass burn where you basically take everything together, I will I will show you some sketches of that where basically waste comes in, whatever is you just pick the stuff which is harmful. Harmful from the sense that if you have a small cylinder, something which will either damage the grates when the grates is where the waste is burnt or it can create the explosion.

So you just take those materials out, your other things, you just let it burn. You produce heat, you use that for steam and electricity and so for and like can keep moving with that. Or you can have a fluidised bed. That is another thing. You can have a fluidised bed, you can have a modular, you can have a rotary kiln, you can use as a refuse derived fuel, so all those things are our conventional waste to energy plant.

Then there are some advanced technologies out there which you do not see that much is for municipal solid waste in general. Maybe part of the municipal solid waste where you have one particular waste stream and you want to do a gasification of that, you want to, you can do a pyrolysis of that or you can do even the plasma. Plasma usually is used for very high and for some like a something which is very harmful and you have to get rid of that, like a hazardous waste or so there you try to use this plasma because plasma, it typically burns at 5000 to 10,000 degrees centigrade.

So it is a highly energy intensive. So the amount of energy that is needed to have this plasma system going on, it is, it is quite enormous. So we want to make sure that it is not, it does not create like if it does not become energy negative. When I say energy negative, means the amount of energy that is produced either with, it is from the plant, is not less than but you have to supply to the plant to run this plant.

So because even waste to energy plans to require energy to run it. So it is it should not become energy negative. And that is the like the thing in terms of plasma. So that is why we do not see that much of a municipal solid waste plasma system in many countries where the waste to energy is very popular, incineration and thermal treatment is popular because it is highly energy intensive.

It is costly, but it does have the advantage that it makes things very vitrified, slack and so slack, it is claimed that it will not it will not leach out heavy metals and other stuff, and it is a cleaner material. But the research, even research done by our group has also shown that it does have some sort of like leaching going does happen. Not at a very high-level but does happen to certain extent.

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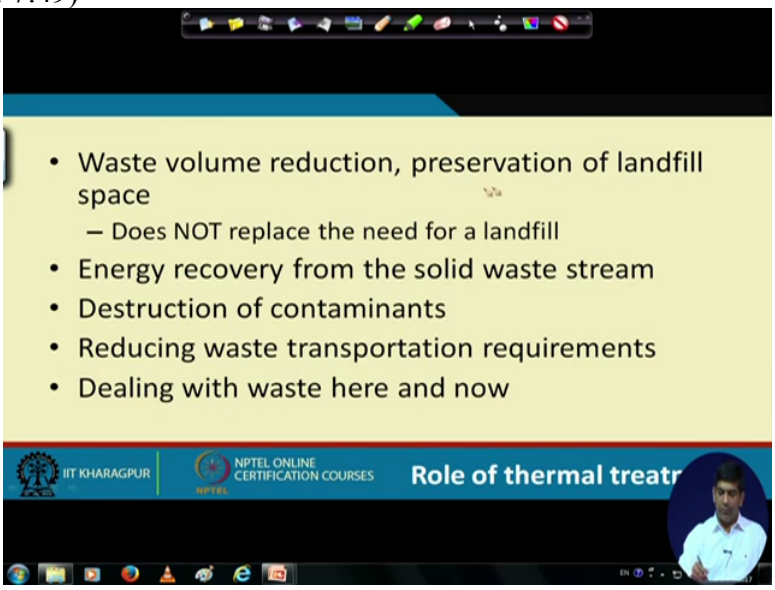


So next one so it is what we do it is it is a waste volume is waste volume is reduced. We are preserving the landfill space. So that good thing about waste-to-energy plants is it helps in

preserving of the landfill space, does not replace landfill actually but there is a need for landfill specially if you when the ash that is produced that has to go somewhere. So there is a need for the landfill. But does extends the life of the landfill and then it does help in energy recovery from the solid waste stream.

If any bad like a contaminant is there, it does help in destruction of the contaminants, reduces the waste transportation requirement because now you have as I said earlier, if you have 100 tonnes of garbage and if you pass it to a waste to energy treatment system, you have your left with around 10 tonnes. So if from 100 tonnes to 10 tonnes, so in terms of the transport requirements, the transport requirement is also gone down for this waste stream now. And you are dealing the waste here and now.

That is another big area where people make a lot of discussion these days is because landfill is you are leaving the problem for our grandchildren to take care of because when you put things in the landfill, 1st of all if they are, if it is a typical dry tomb landfill, waste takes a long time to degrade. And then the next chapter, next chapter we will talk about the landfill. And we did talk about landfill a little bit in the very beginning but we will kind of go in more detail.

So we deal, we are basically putting things in a big polythene bag and the waste, hoping that the waste will degrade over time, some do degrade, some does not degrade, depending on whether in the dry pockets or in the wet pockets and it takes a longer time, 30, 35 years to degrade. And then after that also, we are not 100 percent sure because little bit of gas is still being produced in some of those landfill which is more than 30 years old now.

And then we have to kind of manage, we have to babysit that landfill for a long period of time. So it is it is a it is not a like a many many many people call it more like a Band-Aid solution where you are just it is a temporary fix. It is not a permanent fix. A waste-to-energy plant is at least you are treating the waste, you are making it less harmful, you are making it mostly inert kind of material.

Still some of the leaching and other things could be of a question because you have now high concentrated amount of because everything about from 100 tonnes, if you had some lead over here, and essentially lead is nonvolatile, so now that same lead is in the 10 tonnes. So effective

concentration of lead has gone up because if you look at the mass per kg, earlier say you had X amount of lead per 100 kg, now you have the same X amount of lead in 10 kg. so your concentration has gone up.

Concentration gone up means it has a, from environmental risk perspective, it could be more harmful. But at the same time it is its inert kind of system. So we can probably control that is me know, so we do have to do some sort of environmental risk assessment if it is we are trying to beneficial reuse this ash outside of the landfill. If it goes the landfill, again, over time things may leach out, landfill typical is anaerobic system and anaerobic system, most of the metals, tends to precipitate, stays as a hydroxide or sulphide or those things in anaerobic systems.

You do not see that much of a heavy metals coming into the Leachant. Little bit traces you will find but not in an enormous amount. But in future, yes if something happens to the landfill, it gets exposed to air, things may become available and we may see some of the leaching taking place as well from this ash in a landfill. But it does, but in terms of the waste-to-energy system, we have we are basically looking at something in a waste is being managed here and now. So you are treating the waste and rather than putting it for a longer period of time as would probably happen with the landfill.

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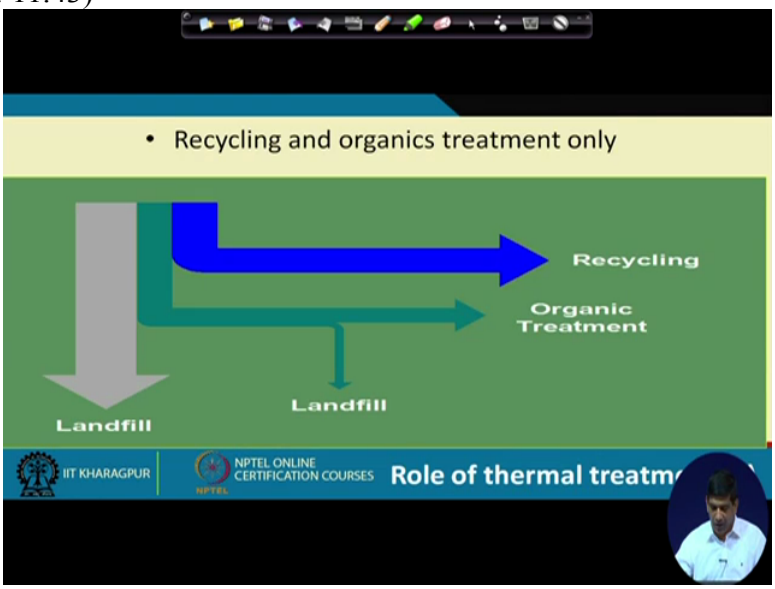

So there are different scenarios you can go for. So in the role of thermal treatment plant, in this you say few slides, we will try to explain how this thermal treatment plant can fit in as a part of integrated waste management plant. If you remember, few videos back, we looked at the nice diagram which was originally from USEPA which explains the different components of a integrated waste management plant.

So if you are here, we are trying to explain few of these scenarios which can potentially happen. But for example, if you have a waste to energy integrated waste system, where you have some part of the waste going to the landfill. Your landfill is one of the options. And then we have part of the waste going for organic treatment. So this organic treatment could be your compost or AD. So you have part of this going to either a compost or a AD plant or it could be something similar and then we have a good recycling system going gone.

But in terms of the organic treatment, there will be some residual coming out. There will be some residual which you cannot do anything for that. So you send that to the landfill. So that is much scenario where you have the recycling, you have the organic treatment and then you use and part of the waste from there to the landfill for disposal. Then in terms of the other options, it could be that you have recycling. You have recycling going on, you have organics treatment going on.

Then also, you do some sort of thermal treatment, you do some thermal treatment and then the waste from the thermal treatment goes to the landfill. And you have part of the waste which could not be either recycled or organically treated or thermally treated, that goes to the landfill anyways. So but the volume of waste and here these individual in this diagram, the different width of this different options kind of giving you some idea about proportionally how they are, like it is not to scale but kind of gives you some idea.

So here, the amount going to landfill is much less and then little bit of amount is also coming from here. But then most of the waste which is either there is it is recycled or thermally treated or organically treated. Of course for each of those process, you will have some of the things go into the landfill. So that is another a way out. So here, this is a good actually this is what is most of the ULBs in our Indian scenario what that is what we need.

We need a good recycling system because recycling, there are certain materials in the recycling which we can use. Of course, there are like a recyclables needs to have market. In terms of the Indian context, we are not that much worried even today. Recently if you remember, China is thinking of banning import of all the any mixed plastics or mixed paper. So that that means the market recyclables from say US or Canada or those countries which tends which is bigger market for them to sell these recyclables as a material, secondary material to the Chinese market, that may not be available.

So that mainly to some problems in terms of the economics and how things will move around for this recycling system. So recycling again needs to have a stable market. That is I have been saying, I said that several times. So it needs to have a stable market. If we do not have a stable market, then it is a problem. And then organic treatment, we if we can, as per this is basically if you look at the municipal solid waste 2016 rules, that essentially they also talk about.

They do talk about that we should do some recycling, they should we should try to do organic treatment because organic treatment is your where you try to go for composting or go for anaerobic digester. And then whatever cannot be recycled, cannot be organically treated, if it has a good calorific value, you can go for thermal treatment and then whatever cannot be done with anything about it, that needs to find a place in a landfill.

So we need to have all these 4 systems in place for a good integrated waste management for any ULB and specially for the smart cities, this will be like a must. We need to make these those 20 or 100 smart cities like a showcase for the entire country. So we need to have this kind of system in place there. And it it can be done because people have done it in the Western world. So it is not that it cannot be done. Just to we need to kind of work on it to make it happen.

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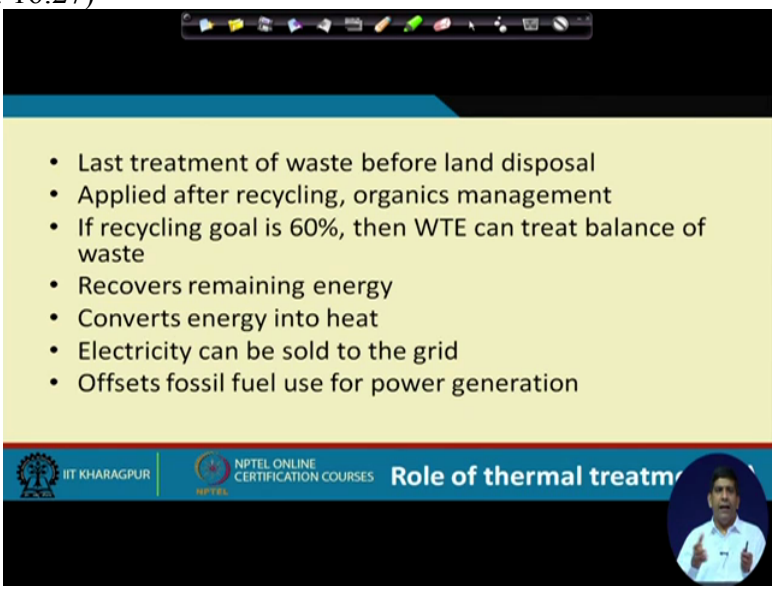


So it is a last thermal treatment usually is considered as a last treatment of waste before landfill disposal or land disposal. We usually put that in terms of the hierarchy, we put it after recycling. It goes after recycling. It is kind of points it is placed after recycling and organic treatment. So we try to do recycling 1st and then organic treatment is done. And if the recycling goal is 60 percent, then waste to energy can treat balance of the waste.

So if you are recycling where that does include the organic management as 2. So that is if you do 60 percent waste 40 percent, we can send it to a waste to energy plant and the residual, there will always be little bit of residual which goes to the landfill directly but then the residual from all these facilities will also end up in a landfill environment. So it does recover remaining energy, it can convert energy into heat. Energy can be converted to heat.

Electricity can be sold to the grid. We can sell the electricity for and then we can have offset fossil fuel use for power generation. So it also impacts kind of reduces the impact of CO2 emissions. So it is a there is a positive impact in terms of climate change and all those stuff that is happening with our environmental parameters as of today. So there are a lot of.

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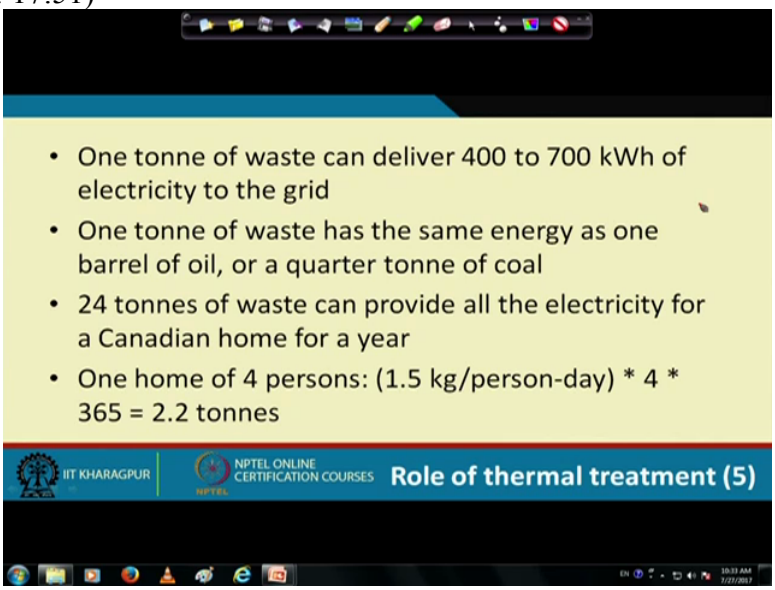


So one tonne of waste just for some example, if you have one tonne of waste, that can deliver 400 to 700 kilowatt-hour of electricity to the grid. So here we are talking about a typical Western-based. So it is around 4500 to 5000 kilocalories per kilogram. But in Indian scenario, our calorific value will be nearly half of that. So even if it is half of that, so even if you go for 200 to 350, so that is not bad.

200 and 350 kilowatt-hour of electricity to the grid. So one tonne of waste. So that is not a bad number. And it has a, so again a 1 tonne of waste has a same energy as one barrel of oil. So again if it is for the Western situation, we can say half a barrel of oil. That is also not in Indian scenario because our calorific value is nearly half on an average. There would be few places in India where the calorific value could be higher than that. And then quarter tonne of coal. So even if it is $1/8^{th}$ of tonne of a coal.

That is if you have 24 tonnes of waste, that can provide all the electricity for a Canadian home for a year. This study was, actually the data came from the Canadian context but in Canada, they need much more energy than what we need in India because they have to heat the home, they do have liked a lot of lot of gadgets going around in the home which does require this energy requirement.

So based on, so we actually will need much less. But we need to look at the what is the waste calorific value. So those those things are there as well. So if one home for 4 persons, but 1.5 kg per person per day, 4 person house, 365 days, so 2.2 tonnes. So 1.5 kgs say in Indian context, say half of that. So we will have around 1.1 tonne. So but we are trying to say is that this is the amount of waste produced from individual houses is a significant amount and that can be used to we can use that for to produce electricity, that is actually a good thing to do like because we can capture those energy and we can use it for our as part of our regular energy stream. So how this thermal treatment works? So we will kind of go into a little bit into technical details of how these different units actually work.

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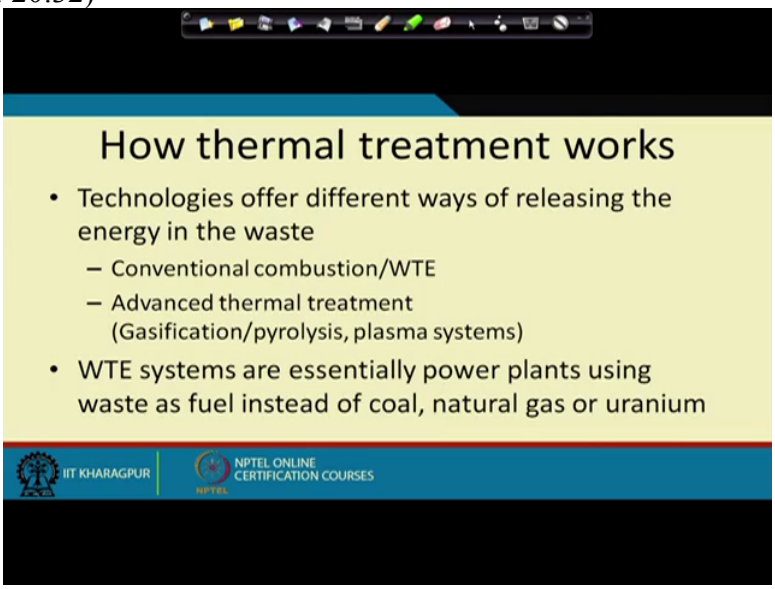


So technology offers different ways of releasing the energy in the waste conventional combustion or waste to energy plant, we have that. So we have conventional combustion and waste to energy, then we have advanced thermal treatment which is gasification. So waste-to-energy systems are essentially power plants using waste as a fuel, rather than coal, natural gas, or uranium. So with the waste, they are using waste as a fuel. So it is a kind of powerplant where waste is used as a fuel rather than some other material being used as a fuel over there.

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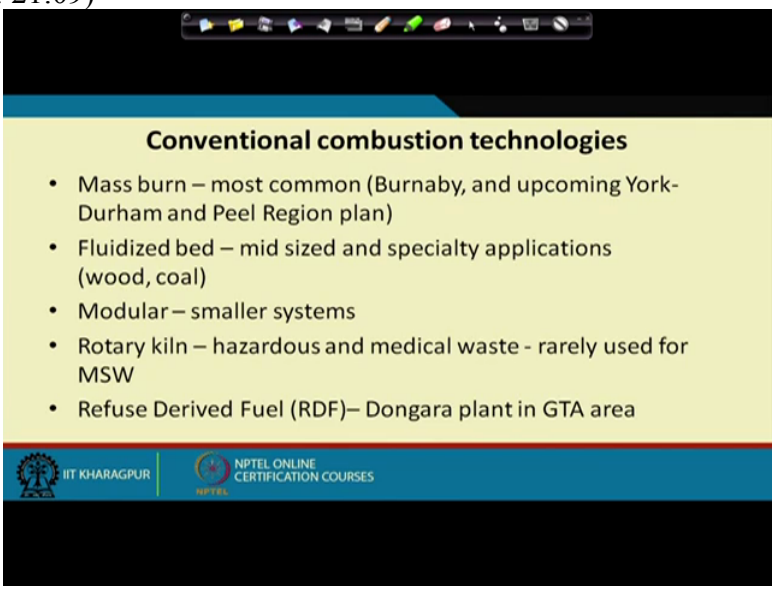


So conventional combustion we already kind of talked about. Mass burn, we did look at the Mass burn. It is the most common. And here, there are some examples of Canada plant has been given. Do not worry about that. We do not like there are in Indian scenario, most of the plans that we are building in India also Mass burn. So that is, we are using mass burn technology, the picture that I showed you was also mass burn.

You can have fluidised bed. There is a fluidised bed. Its technology is also there, mid-sized and people use it specially for speciality applications. And then there could be a modular which is a smaller system. You have a rotary kiln for the hazardous and medical waste, rarely used for MSW. Then you have RDF which many plants do that and we had many there are systems out there which makes this refuse derived fuel which can be used for like used as a fuel. So that is that is done as well.

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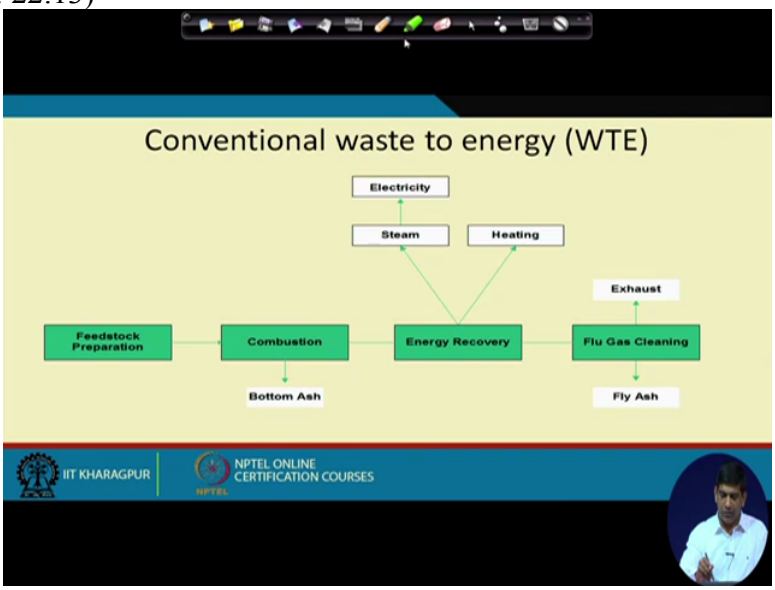


So conventional waste-to-energy plant, you will have, this is just a layout. You will prepare the feedstock. So you have feedstock preparation and then you will have a combustion. Combustion, you will have some bottom ash being produced. Then there will be energy recovery in terms of either heat or stream and then you have the flue gas cleaning. Then you have some fly ash, you will have some exhaust going around and then for the energy recovery, you are producing some electricity, some steam and some heat.

So all those different things happens in a conventional waste-to-energy plant. And if you can just think about, if you rather than putting a waste, if you just say even coal-based thermal powerplant this is essentially what happens there as well. It is a coal based thermal power plant. It will happen similarly. So what we have done is, replace the coal with a based material which has high, sometimes higher calorific value.

Recently I was, we had a like an assignment from Chhattisgarh High Court if I say that correctly, so where we were looking at the pollution being caused by this coal based thermal power plant in Raigad area which is in Chhattisgarh. So we went around, when I say we, like myself, I am a part of the team. I am not the PI on that project. So we, we went around, we were 4 of us. So we went to those different, specially those are mostly are coal generation plants.

So it is a steel plant most many times it is a steel plant which has their own coal-based thermal power plant and the thing that we found is for most of the places, there are lot of environmental issues. There were a lot of things which could easily be fixed. So we have we have given them the recommendation for those but still the coal quality was a bit, throughout that trip, visiting around 13-14 plants, there was one of the major complaint was the coal, the quality of coal.

Because as in the Indian context, we do have coal but our coal calorific value is very low or the coal ash content is very high. So that is creates a problem in terms of energy production. So many times what we do we take our local coal and then try to mix it with some other coal which has a high calorific value to get a little bit higher calorific value going into the system. So that is if you look at this particular stuff so rather than like if you have a low quality coal, if you have a low quality coal, it is better to and we have municipal solid waste being produced in the area engine if we have to, we do not have the availability of good coal, this could be used as a energy sources.

The only thing is that the coal based thermal power plant is kind of design for a more homogeneous fuel. So maybe RDF may work on this better but then again the legislations on all these has to come in picture and air pollution control system has to be looked into this to make sure everything will be okay, we do not get into any problem later on. So that is the conventional waste-to-energy plant.

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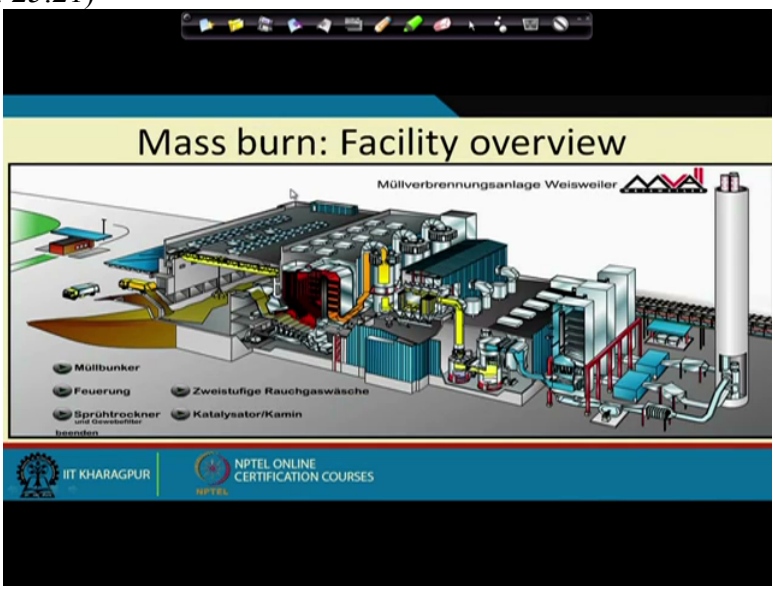

And then this is a mass burn facility overview. So as you can see, the waste will come in, so here if you can watch this, this is again, this is from that Amsterdam plant layout. So you have this truck coming in, getting dumping the waste over here. The truck comes in, dumping the waste over here, the waste is getting into this area just kind of the storage area which can store waste for a few days. And then, here you can see the crane.

The crane is left in the waste and then it will drop it over here. Let me clear this up so that you can see it little bit clearer. So that crane will actually move and drop things over here where it will it will pass through these grate systems where the reaction will take place and where all the heat produced will be used for the heat exchanger, for the stream and all those different kind of stuff with that. And we have this air pollution control system to take care of the air pollution system and finally things will whatever emission will happen through this stack.

And so we have this fly ash handling, bottom ash handling, all those things are part of this system over there. So it is a mass burn facility, very common, you see many places, it is essentially a mass burn.

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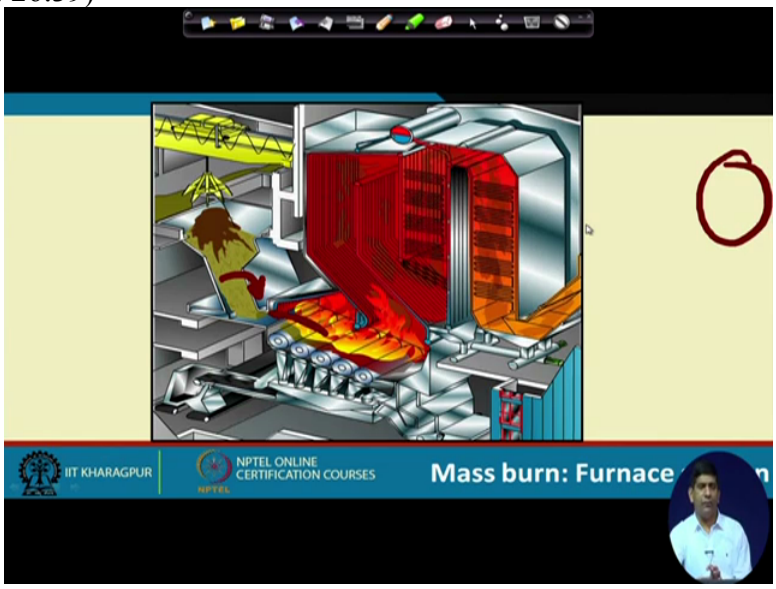


Just a closer view of the grate system. This is a roller grate rather than a step grate. I think we talked about that earlier as well in it is a roller grate. So and then we will be supplying oxygen.

So the oxygen will be supplied from this side, so you will have the oxygen being pumped in. So since we do not pump oxygen, we pump air. So we will be pumping the air through the system, so the waste will burn essentially in this particular area and once the waste is burnt, we will the heat is produced and there is a heat exchanger visible capture those heat and then it will be converted to steam and this team will be used for electricity production and all that.

So it is kind of similar to a coal based thermal power plant but there are some issues in, there will always be some dissimilarities because of the heterogeneity of the waste material.

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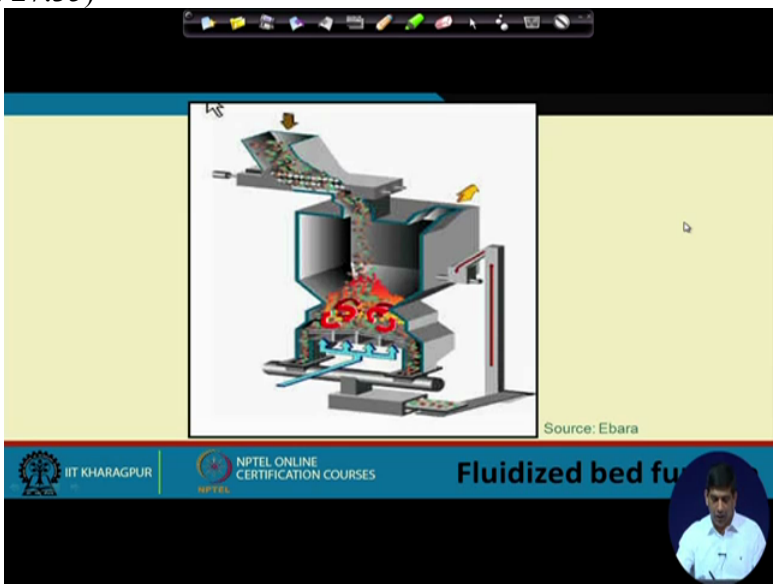


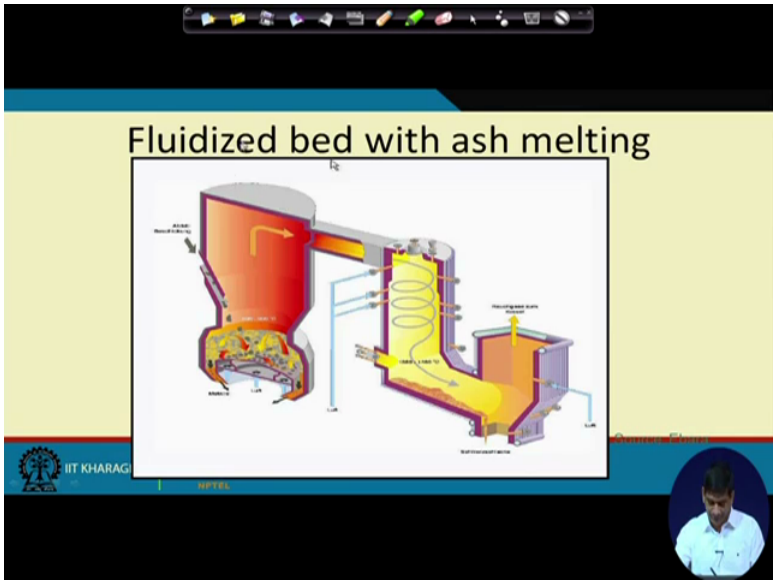

This is another one, it is a fluidised bed furnace where you have a fluidised bed. Again you have air being supplied from the bottom. You can see the air being supplied at the bottom over here, the things are burning and then it produces energy from here. So fluidised bed with ash melting. So we have fluidised bed where things are burning, it is kind of turning a little bit as well. Just some agitation going around and then waste once burns the gaseous emission from that kind of goes up into this particular chamber and then it passes and reaches to another chamber where it kind of gets cooled down, 1st it things are treated and then it cools down and then it then we will get some fly ash also coming out of that and then the bottom ash will come over here.

So both need some sort of good management system, both fly ash as well as the bottom ash. So that is for this particular type and we will look at some of the other types and then we will…

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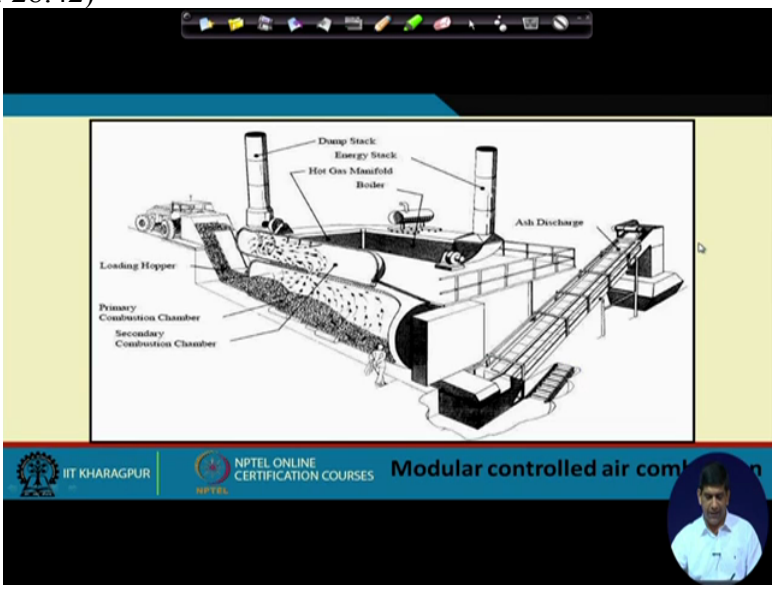


So this is a modular system. It is again waste being dumped into here, as you can see waste is being dumped into on this place and then it reaction takes place over here. So in terms of the reaction, as we know from our chemical kinetics, the time required for the complete reaction and the time required for the grate system to move the waste from this point to this point, we have to match those. In fact, the time taken to travel from this point of this point should be more than what is the time required for the reaction so that we have the complete combustion rather than an incomplete combustion.

And this is a modular system can be taken at different places, even at the war zone and other bridges where you can do those treatment of waste. So that is in terms of that.

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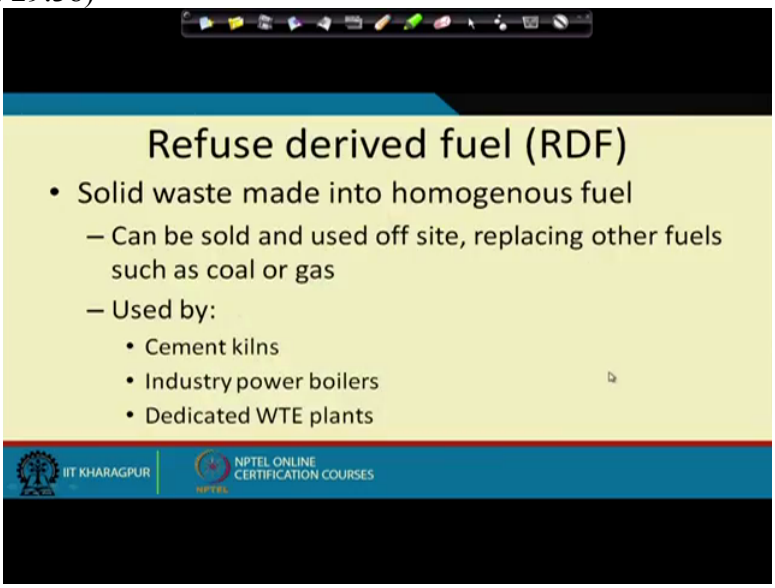


And then other thing is our refuse derived fuel. A refuse derived fuel is as we have been saying, most of this municipal solid waste is it is non-homogeneous. So RDF is a homogeneous. So homogeneous, it can be with using RDF, we can make it a homogeneous mix. It can be sold and used outside, replacing other fuel, it is used in cement planes, industry power boilers, dedicated waste to energy plant is there which is also using RDF.

So and then there are, so let us kind of stop here and then we will continue this discussion in terms of different types of incinerator and all those (())(30:13) what are the benefits and drawbacks of each of those incinerators and what kind of waste can be treated over there. So hope you are enjoying this course. We are making we are almost kind of in that 3rd phase of this course now, almost getting there.

So keep focus, keep working on the course, I know there are a lot of material that you may have to go through. But I look forward to having most of you doing really well in the examination. And if you are taking one and then of course, if you have any questions, put it in the discussion board and all that and we will be happy to answer. Some questions which is more like outside of

the scope of this course, I may answer them but it is better to be more like a general answer because if I do not know what exactly you are sometimes it is kind of get gets difficult.

So those cases, I will just let you send us communicate like using my email address of IIT Kharagpur and you can just send me an email and then we can see what we can do about that. But for this course, discussion board is the place for where all the discussions will take place. Nowhere else. No whatsApp group, no other groups, this is just the discussion board where we are going to do all our discussion. So with that, let us stop at this particular point and then we will continue in terms of looking at other aspect of thermal treatment in the next video. Thank you.