Integrated waste management for a smart city
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Lecture 39: Thermal Treatment (Continued)

Ok welcome back, so we'll continue our discussion on this thermal treatment and my goal is to kind of complete this discussion on thermal treatment during this particular module, so as we know like if you remember from the last video towards the end, we were looking at some examples of how this waste to energy thermal treatment is being used around the world,

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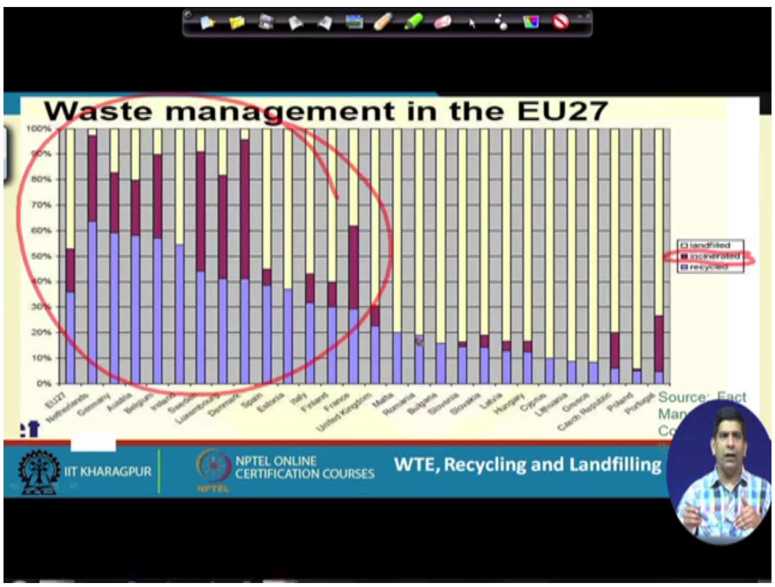

European union is kind of leading the pack in terms of having. Especially western European countries as you can see in this particular slide, in this particular bar chart here on the left hand side, in this the middle one the magenta color is the incineration so as you can see on the left hand side we see more and more of incineration happening and the blue one is you recycle, so more recycles are also happening and more incineration is also happening and then the light yellow color that you see is the landfills.

So as you go from the western European countries to the eastern European countries you see more and more land fillings taking place over there, but even waste to energy is very powerful in western European countries, it’s popular in other countries as well especially in South Korea, Japan and you’ll see some examples and some of these are being build in a very fancy way,

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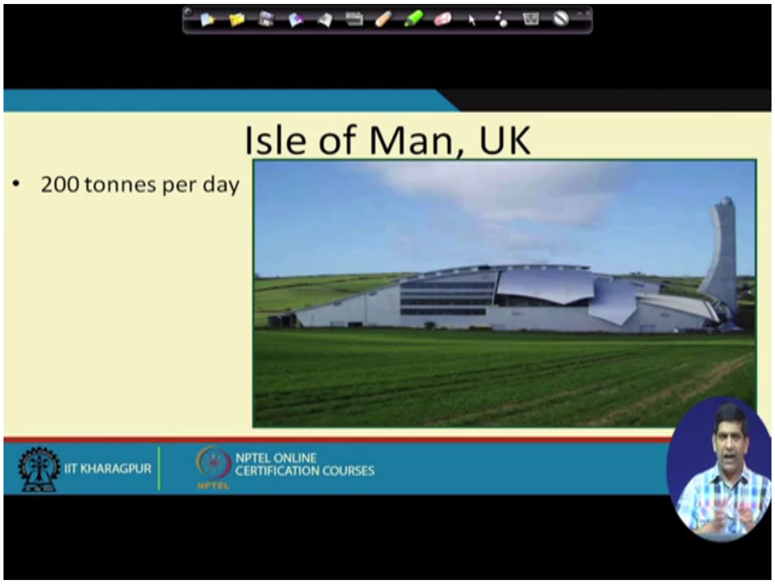

As you can see on this particular, I showed you this picture in the last video as well. I just wanted to kind of a recap few slides just so we can continue this discussion, so here the small facility not big 200 tons per day in UK,

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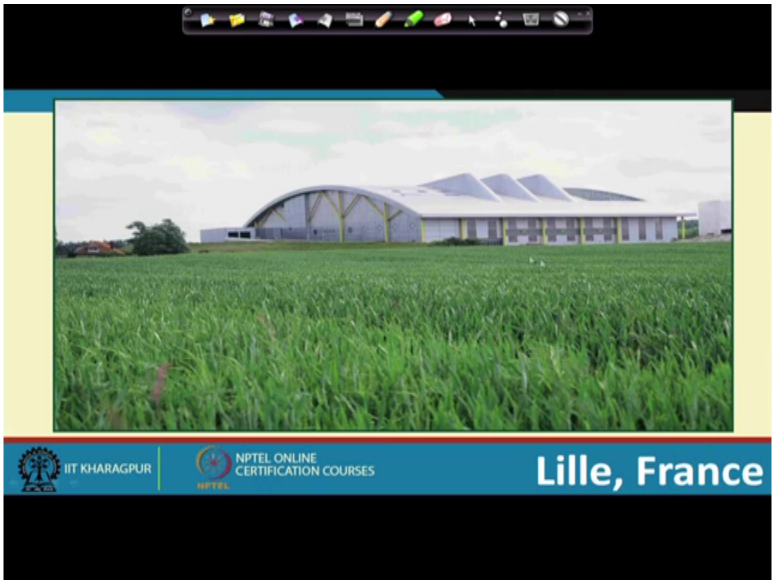

Then we have in Lille, France, this is a another waste to energy plant very close to a cultural area.

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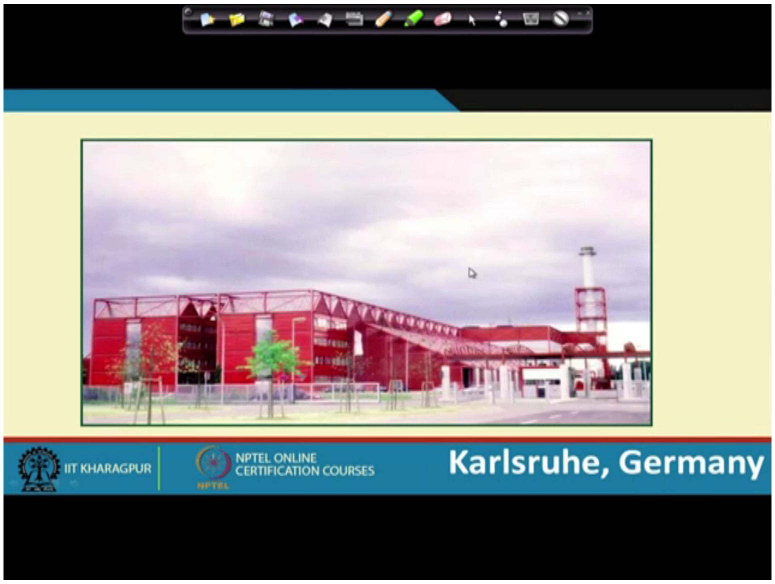

So then we have Karlsruhe, Germany another waste to energy plant over there,

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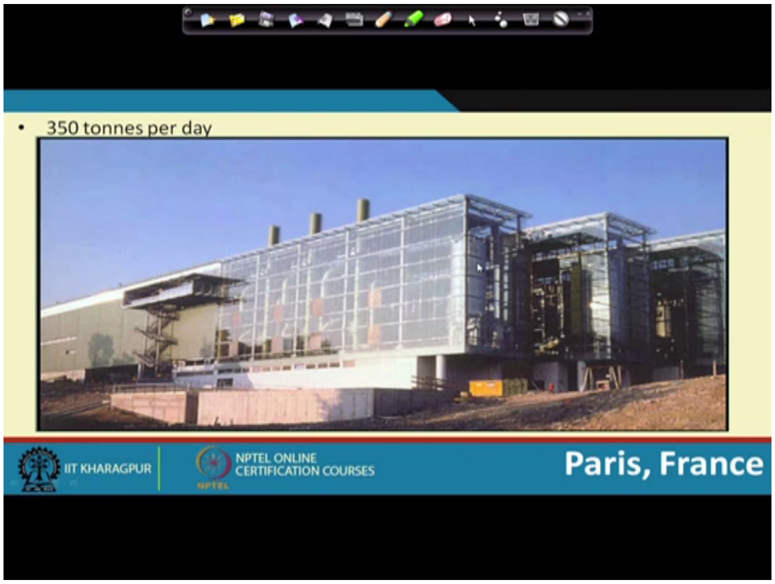

Paris, France, you can see another waste to energy 350 tons per day, not a huge plant but pretty good and this one is what we were looking at.

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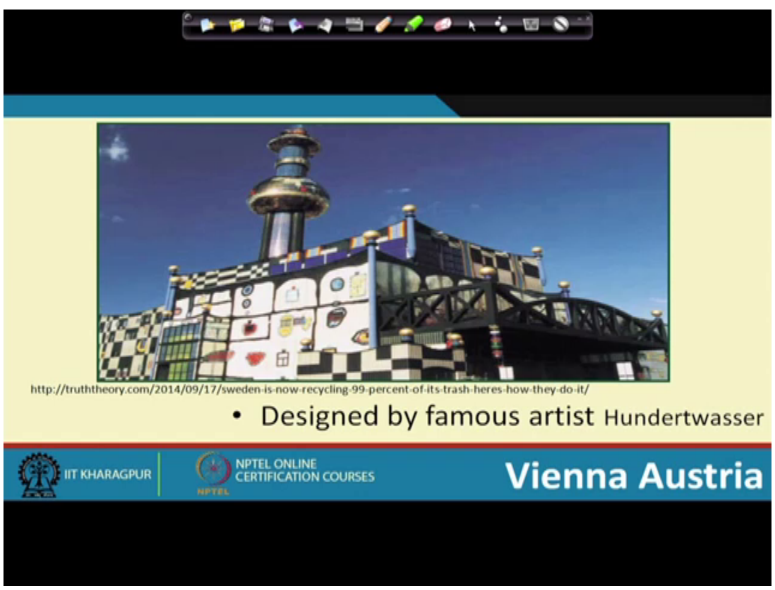

Towards the end on the previous video, it's in Vienna, Austria and I told you that if you been to that area for whatever purpose it could be make some time to go visit this facility, you will really enjoy that, it has a waste to energy museum as well and you see this, this is actually the chimney that’s what you are looking at is a chimney and it goes taller the picture is kind of cut at that particular point, so that’s the chimney where that air emission stack.

So you can think it’s made very beautiful, it looks very nice, it’s kind of very close to residential neighborhood but people appreciate this system and then the air pollution is so less, it’s actually the air coming out of it is very pretty clean, so it meets all the air quality standard,

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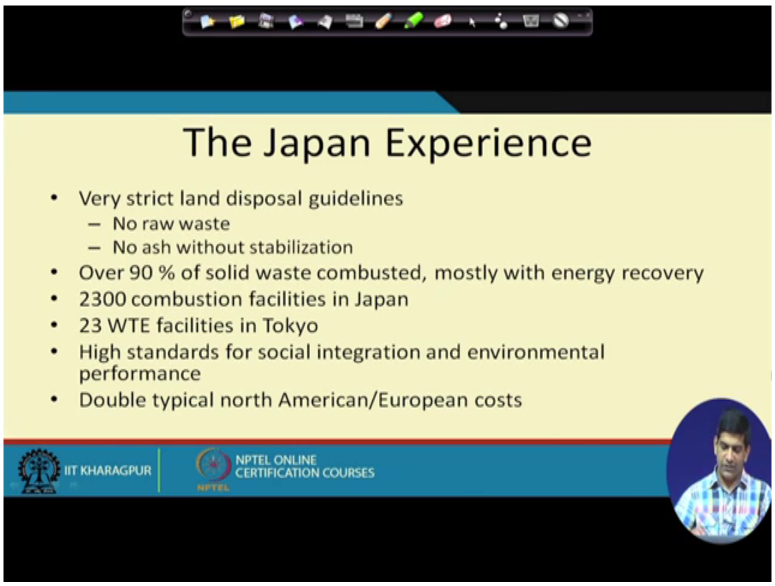

Then there was in Japan as I said earlier 90 percent of the solid waste is combusted mostly with energy recovering, so in Japan they are doing it, 2300 combustion facility in Japan.

So think about that tiny country, it has 2300 combustion facility and in India we are still less than 10, so I should not have said that because what happens is people take it literally like sense Japan has so many, why don’t we build so many, first of all we need to make sure whether our waste will really work in this imbustion facility, we have to work on the collection system, we have to make sure our waste doesn’t get mixed with construction demolition.

Streets weeping, lots of moisture and those things actually becomes a detrimental to the success of waste to energy plant because the your energy balance doesn’t work, you will not be able to produce good amount of energy, if it doesn’t come out again if all falls down to the economic viability of the plant and in terms of the economic viability the input material, see if the coal is bad, in Indian context we always here about that our coal is very bad.

So we need to import from Australia and other countries, similarly like municipal solid waste feed going to these waste to energy facility, if that's bad then we need to make sure that it's a good quality, when I say good quality it should be of good calorific value and it can be done, the thing is that what we need to do is we need to make sure that the municipal solid waste incinerator only gets municipal solid waste and specifically if you can remove this wet and dry.

As per municipal solid waste management rules 2016, we have to the suppression of wet and dry, so that's actually number one if you want to take number one message out of this course at the end of this course is wherever you go, whether you are in industry, whether you are working for state pollution control board, central pollution control board, swatch Bharat mission directed, what which over a position you are in right now if you can advocate.

For wet and dry separate collection, if we do that throughout the country especially in the urban areas, we will actually solve half of the waste management problem, our half of the waste management problem is right there in the collection, technology we have in the country, we don't have to worry about the technology but if we can do this wet and dry separation, take this dry waste do waste to energy, take this dry waste if try to take out.

Some of the recycle hole switches still there, so those things can be done, wet waste urban centers probably anaerobic digester is better than composting because of the land requirement and all that, in aerobic digester you can generate some energy and you can use that energy in those urban centers and then you don't even have to put it in the grade it could be just a local system and then you have the sludge from an aerobic digester.

Gets mixed with other cultural and other waste which cannot be treated in an anaerobic digester kind of system, so that could be composed, so the area required for composting will be much less again if we take entire food waste of say Delhi or Bombay or Calcutta and Chennai and try to make a huge compost facility out of there, if it works it's great, but first of all we need to sse whether the market is there, we have to do a very thorough market analysis and honest about it.

If it's not there it's not there we cannot really create the market, we can but the regulation has to be in place and there is lot of things goes in there but if the market is not there for composed, just making composed because it sounds good to make composed I don't think that's going to work on a longer period of time, initially it may work when the government is subsidizing it but that compose somebody has to buy, the plants composed plants has to stands on its own feet.

And that's why I say that in the urban especially in the urban highly urbanized area, let's take the food waste do the anaerobic digestion and then sludge from anaerobic digestion mixed with other moist which could not be an aerobically digested, do composed for that, so in terms of waste to energy again waste to energy for the dry waste, waste to energy could be a solution, we have to look at the calorific value.

We have to make sure if we have low calorific value what kind of technology will work with this low calorific value, so here they have in, for example in Japan they have very strict land disposal guideline, no raw waste or no ash without stabilization it can go to the landfill, and I said 90 percent of the waste in Japan is combusted, 90 percent 2300 combustion facility, 23 waste to energy facility only in Tokyo, and then they have very high standards in terms of air quality.

So high standard for social integration and environmental performance, it's a double of typical North American and European cost, but Japanese people are ready to pay for it, so if they are ready to pay for, they are ready to pay either in the form of taxes or fees or whatever and it's working over there, so it's again if a ball sound to everything like economics has to be strong, if economics is not strong the thing is not going to survive for a long period of time.

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Here they have a waste to energy plant and then they have a sludge burning plant side to side, they have a waste to energy plant, sorry let's go back, here , so they have a waste to energy plant and we have a waste to energy and the sludge burning plant, so what they are doing is they are generating from the waste to energy plant, heat is generated, the heat is used to dry the sludge then the dried sludge has good calorific value.

So that can even go back to the waste to energy plant again, so it's kind of win win for both so they have, as you know sludge has lot of moisture, the moisture has to be removed, we have talked about that already because of the latent heat of the projection, so we can do this waste to energy and take the heat use it for sludge, especially the heat which could not be captured such as like a waste heat, that if we can capture those heat and take it to the sludge facility.

Where you have dried sludge and then use that dried sludge as a feat for the waste to energy plant as well,

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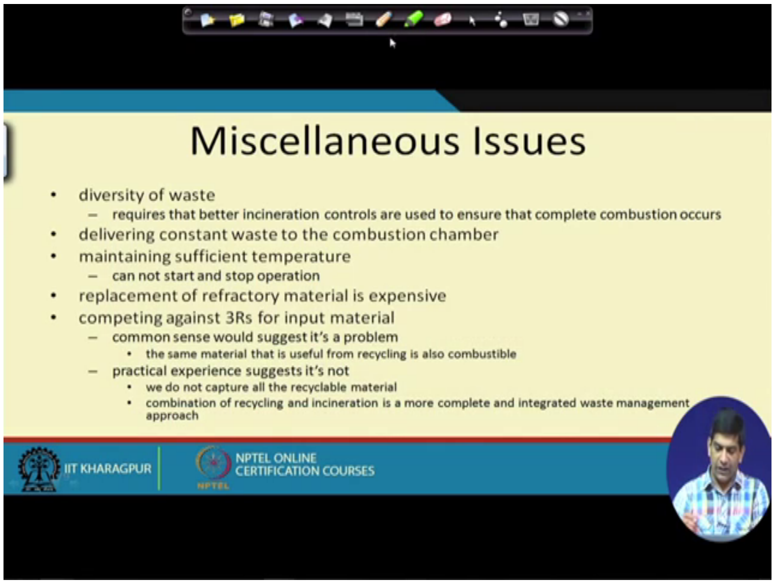

So there are some miscellaneous issues associated with waste to energy system, first of all diversity of waste, so again waste to energy system it's a plant, any plant any process requires, actually at some sort of consistency in the field, so if you think about the coal if you have two much variety of coal.

Think about that you have a process in there just in black like a here we are thinking about this, I put a red box and then we have a feat coming into the system and there is some reactions going out and then we'll have some products coming out of that, so this reaction which is going in there if we can provide a constant feat, if the feat it is going into the system is of consistency, it's of same consistent kind of quality.

Then the process works much better the efficiency of the process is much better, so that's what because of the diversity of the waste it requires that better incineration controls are use to ensure complete combustion, so since the waste is so diverse we have to make sure that we have a better control on that, then delivering constant waste to the combustion chamber, constant waste would be going into the combustion chamber.

Maintaining sufficient temperature we talk about that, you cannot start and stop the operation, once the operation is on it's on, replacement of the refractory material is expensive, once it's costly, and then it does compete against three hours for input material because you've reduce, reuse, recycle, if you do the reduce, reuse, recycle for most of are the material, the common sense says that it would be a problem.

But if you do lot of reduce, lot of reuse, lot of recycle, since those material will not end up in a waste to energy plant and then the our combustible like the heat value will go down, so the same material which is useful from recycling is also combustible, some has a good calorific value but what we have seen from the practical experience for the western European countries from the Japan, Korea and other places, it say that we do not really capture all the recyclable material.

Because of the mixture with non-recyclables and we have in the western European experience have shown that combination of recycling and incineration is a more complete and integrated waste management approach, as I showed you the few that the first slide if you look into this video, as you saw from the western European countries they have high recycling as well as the same time high combustion facilities like high per percentage of waste going into combustion facilities as well.

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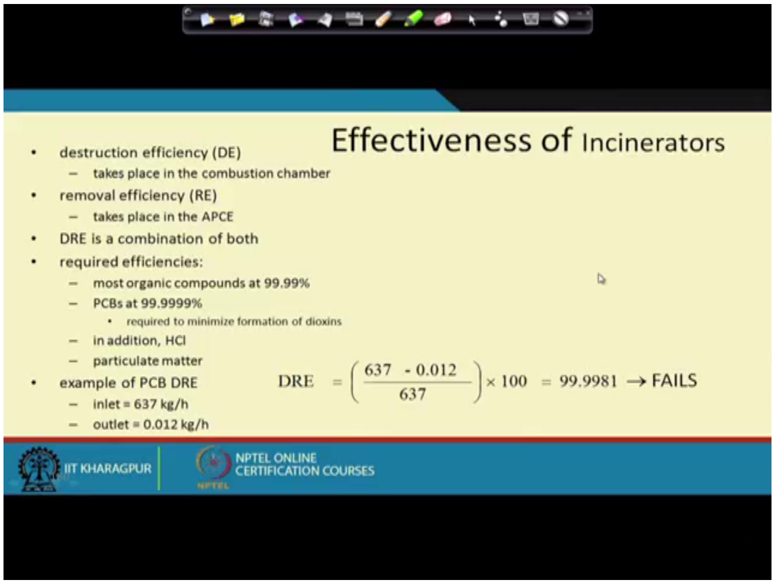

So then the other thing is that we have to look at in terms of the effectiveness of incinerator effectiveness is essentially form the air pollution control point, one of the major thing we worry about in terms of, which gets lot of attention from environmental stand point is the air pollution, air pollution coming out of these waste incinerator whether we are able to control that so for that there is a term used.

Which is known as like a destruction efficiency which is DE, so that's your destruction efficiency the De which is used as if term of De, it takes place in the combustion chamber, then we have another one which is known as the removal efficiency which takes place in air pollution control environment, so there are the two, so in most of places you will see that people are combined these two together and call DRE, so this is DRDA and removal efficiency is RE.

So together it is DRE, DRE is a combination of both, so the required deficiency so for most organic compounds we require a efficiency of 99.99 percent and for PCB's 99.9999 percent so up to four decimal places, so we really want it to be removed in terms of the air pollution, so think about so strict air pollution control requirements are there for these waste incinerator, so if you have a, in addition we have for HCL, particulate matter and all those things are there.

So in, now what example is here, so if you look at PCB initially the initial values and the outlet value, initial value is what how much PCB is going into the system is provided to us and in the outlet in terms of what is going to come out of the chimney stack that's also provided to us, so inlet is 637 kg per hour, outlet is .012 kg per hour, we can calculate the DRE, DRE will be whatever is the input minus the output divided by the inlet concentration.

So input minus output divided by the inlet concentration and that's multiplied by, convert that to 100 percent, so we get 99.9981, so but that is going to fail, why it is failing because it says for PCB we need 99.9999, so it's less than that so that means it fails, so we have to improve upon in terms of air pollution control system, so look at from 637 kg per hour to .012 kg per hour and still it fails, so think about how strict we are in terms of the air pollution control.

As long as we follow the rule, rules are there, as long as we follow the rule properly and we do this as I have been saying that again and again and again if we keep our feet correct, waste to energy systems can work in India, the bottom line is keep the feet correct and that's is where we fail, where our systems have been failing and I think we are not paying too much good attention on that side.

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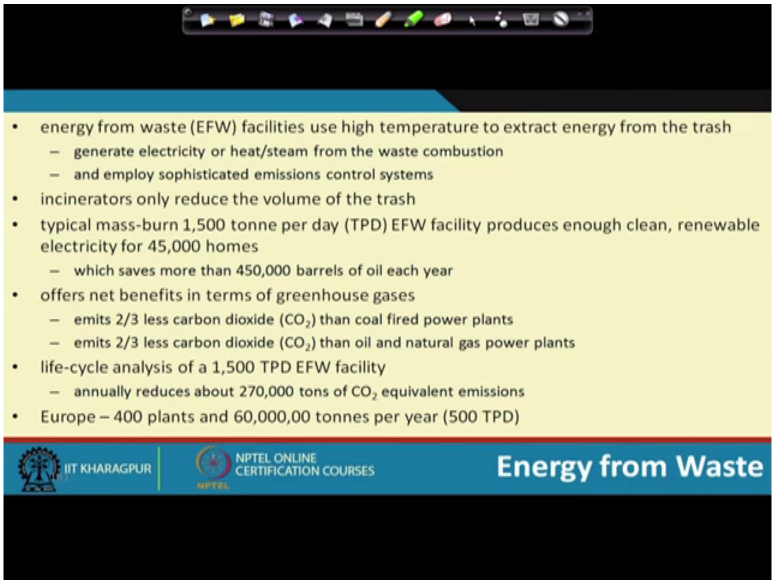

So energy from waste facilities use high temperature. They do to extract energy from trash, they need electricity, heat or steam and employ sophisticated the emissions control system, Incinerators reduces the energy from waste facility, if you use the incinerator usually for hazardous waste or biomedical waste, it's only reduces the volume of trash and makes it less harmful, typical mass burn is 1500 tons per day, EFW facility, it produces enough clean renewable electricity for 45,000 homes.

Which saves around 450,000 barrels of oil each year, and often with benefits in terms of green house gas, it has been shown that it emits two third less CO 2 than coal fires thermal power plant, so it's two third less so it's nearly removes 60 percent saving and emits less than two third less CO 2 than oil and natural gas power plant, so it's actually if you do the life cycle analysis of 1500 TPD (tons per day) EFW facility.

We see that it annually reduces about 270,000 tons of CO 2 in equivalent emissions so 1500 tons per day EFW facility reduces 270,000 tons of CO 2 equivalent, things have been going to the landfill, in Europe we have 400 plants all together with 60 million tons per year like 500 tons per day or this much waste that is being dumped in Europe but the entire Europe 500 tons per day, in India we produces much much more than that.

So there is a in India if we can keep our feet correct, we can make this waste to energy system works in Indian contest.

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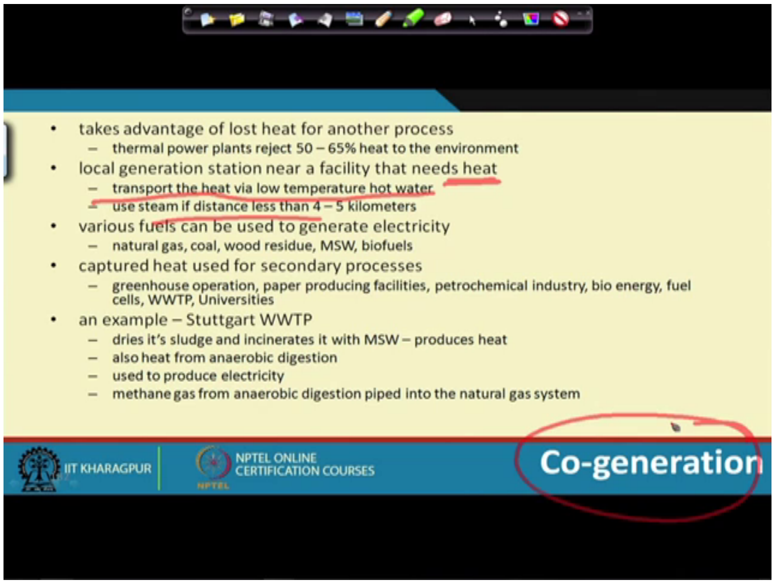

So there is some lost heat nearly 50 to 60 percent of the heat is lost, so it can take advantage of lost heat for another process, so it can do that local generation station near a facility that needs heat, the heat can be used then transport the heat via low temperature hot water, use steam of distance is less than 4 to 5 kilometers.

So various fuels can be used to generate electricity, natural gas, coal, wood residue, MSW, bio fuels, so those are all use to generate electricity, we are talking about as part of the co generation, it can capture heat used for secondary processes, like green house gas operation, paper producing, petro chemical, bio energy, fuel, so all these, the captured heat can be used in these secondary processes.

For example in a Stuttgart waste for a treatment plan they dries it sludge and incinerates, so they dry the sludge and incinerate with MSW that produces heat, also heat from anaerobic digestion and then they use the heat to produce electricity, then methane gas from anaerobic digestion is piped into the natural gas system, so that's all kind of integrated management system where you can taking advantage of two three different technologies.

Two three different feet and complement each other, so that's how things become much nicer in terms of integrated waste management system.

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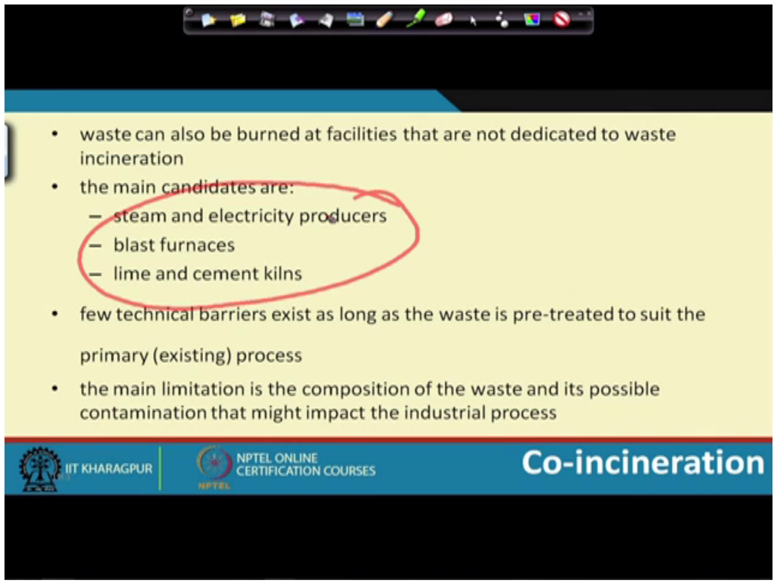

Co incineration waste can also be burned at facilities that are not dedicated to waste incineration, like for example mostly it is used for steam and electricity producers, blast furnace, lime and cement kilns, so those are the places where it is used, there are few technical barriers as long as the waste pre treated to suit the primary process.

The main limitation is the composition of the waste and it's possible contaminations, so that's we have to worry about, so the composition of the waste and possible contamination that might impact the industrial process, so those things need to be kept into mine,

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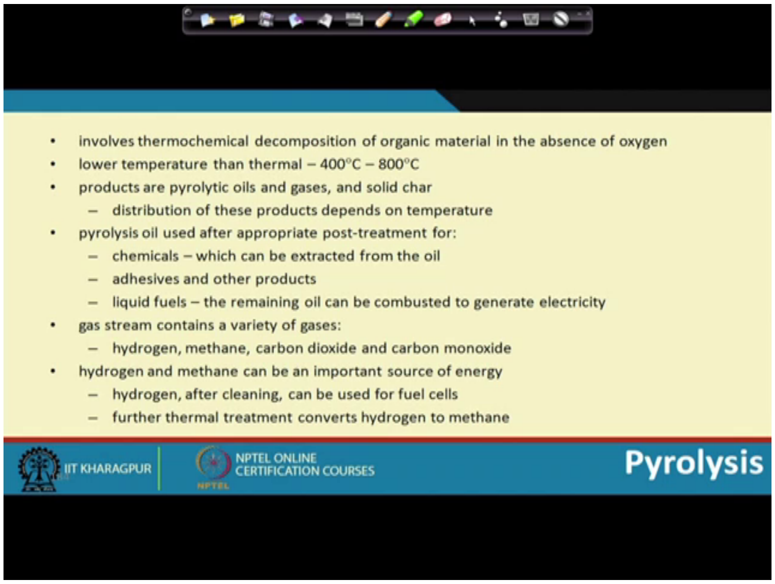

And then are other technologies out there pyrolysis. Pyrolysis it involves thermo chemical decomposition of organic material in the absence of oxygen, it’s the lower temperature then thermal.

So it’s 400 to 800 degree centigrade, so that’s the temperature it uses in terms of pyrolysis, products are pyrolytic oil, gas and solid char, so and how they are distributed it depends on the temperature whether it more pyrolytic oil, more gas or more solid char whatever is made, so it depends on the temperature, oil is used for post treatment, you can use it for chemicals which can extract from the oil, you can use for adhesives, you can use for liquid fuel.

And then oil can be combusted to generate electricity, gas stream contains a variety of gas like hydrogen or methane, carbon dioxide, carbon monoxide and those things, hydrogen and methane can be an important source of energy, hydrogen after cleaning can be used for fuel cells, that’s microbial fuel, those things are used as well, further thermal treatment converts hydrogen to methane, so those things can be used like hydrogen can be used as a fuel, so this pyrolysis is done.

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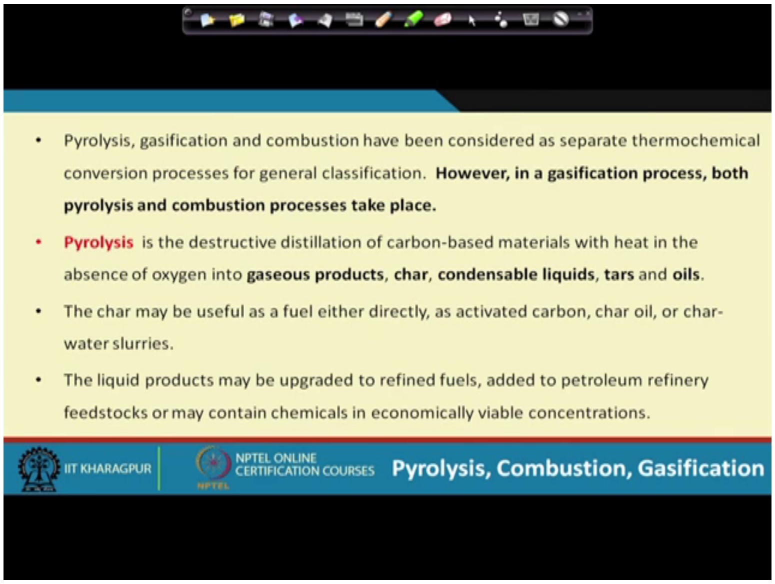

So pyrolysis, gasification and combustion considered as a separate thermo chemical conversion process, however in a gasification process you have both pyrolysis as well as combustion does take place, so pyrolysis what happens is it’s takes the carbon-based material, it have it reaction done with heat, in absence of oxygen and it produces gaseous products, some char, some oil and those kind of stuff.

Char can be used as a fuel activated carbon or char oil or char water slurry, the liquid product can be upgraded to refined fuel added to petroleum refinery feed stock and all those different kinds of, so pyrolysis thus help in terms of converting again from waste into different forms of energy, so that’s done for that.

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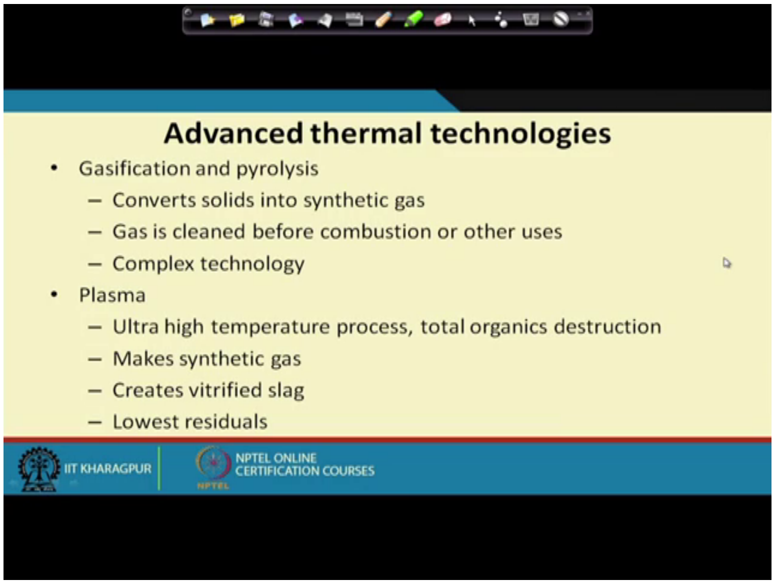

So in terms of advantages we kind of talked about that for incineration remember early as well. It converts solid to synthetic gas. Gasification and pyrolysis, it converts solid into synthetic gas, gas is cleaned before combustion or other uses and little bit complex technology it is compare to regular waste incinerator, plasma is a very high temperature process total organic destruction, makes synthetic gas, creates vitrified slag, lowest residual amount with different but plasma requires lots of energy, so it has to be energy neutral at least if it not energy positive.

So but most of the time people are afraid that plasma system will be actually energy indicated, so you will be inputting more energy to run the system rather than getting any energy out of it and that may work ok for hazardous waste or to some extent and also for biomedical waste for municipal solid waste since we have so many other options out there, this may not work in a long term unless it's at least energy neutral or ideally like you have more energy coming out of that.

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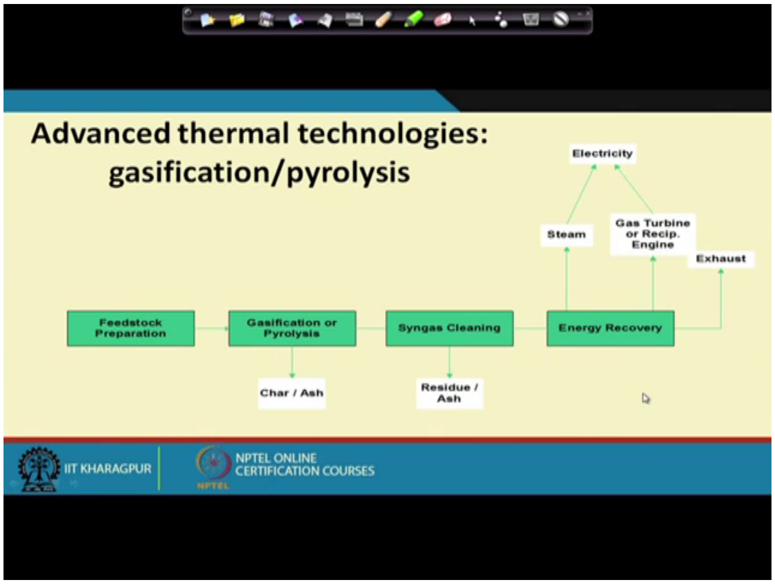

So in terms of advanced thermal technologies the pryolysis and gasification is there so you can use as you can see over here you have the feedstock preparation, Then you have gasification and pyrolysis, syngas cleaning, energy recovery which is you can use it for steam, gas turbine, you can have an exhaust and then for both steam and gas turbine you can generate electricity out of that, so it's you can use it for electricity generation.

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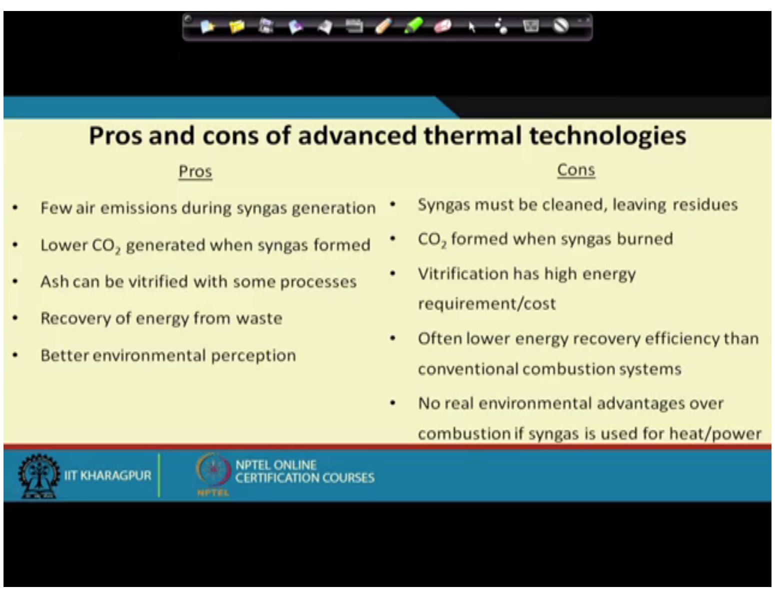

So what is the pros and cons of this advanced thermal technologies. So what is the benefit and some of the challenges, so pros means few air emissions during syngas so we have less air emissions coming out, low CO 2 is generated into the system so that's also better, can be vitrified with some process, recovery of energy from waste, better environmental perception in terms of pyrolysis gasification people have better perception.

Suppose to going for traditional waste incinerator with all those chimneys, actually it's chimney which could, lot of things going into the head of people, if we do things properly the air coming out of those chimney can be very very clean actually,

Maybe cleaner than the embed air around it, but as long as we meet the air pollution quality standard, some of the challenges syngas must be cleaned so you need to clean the gas otherwise you cannot limitation use of is limited.

CO 2 is formed in which syngas is burned, now when you try to go for vitrification like in plasma arc, high energy requirement and cost is there, often low energy recovery efficiency than can western combustion system,

So energy efficiency is low, no real environmental advantage over combustion if syngas is used for heat and power, so if you are going to go back and use the syngas for heat or power, why don't we go directly for a combustion, because essentially you are doing the same thing doing in two different steps, rather than doing it in one directly.

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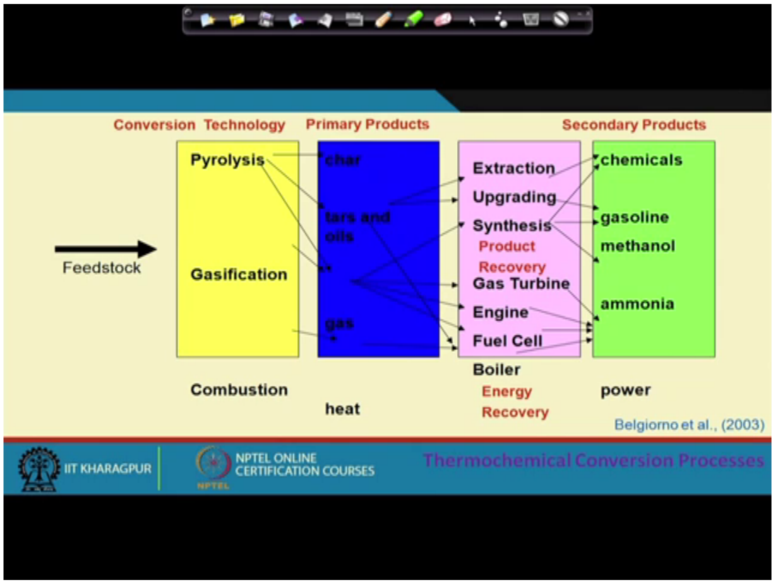

So here is some like an example of different technologies like conversion technology. We have the pyrolysis, we have gasification and then these are the some of the products, it will have char, tars and oils, some gas is there, then you have extraction, upgrading synthesis, gas turbine, engine, fuel cells, in terms of the energy recovery.

Then you have some for the power like chemicals gasoline, methanol, ammonia those things are also used, so those kind of just a take sary of that.

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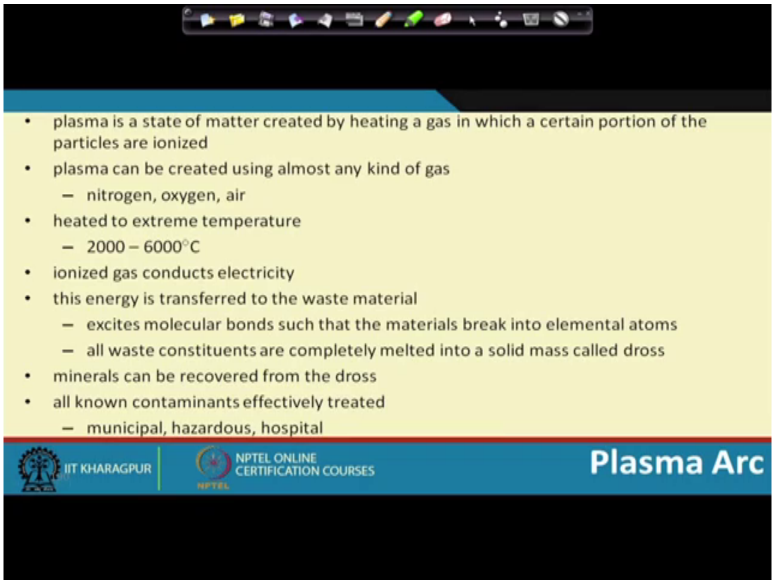

So plasma it's a state of matter created by heating a gas in which certain portion of particles are ionized, plasma can be created using almost any kind of gas, you can do nitrogen, oxygen air, you take to a very high temperature like 2000 to 6000 degree centigrade, sometimes it goes all the way to 10,000 degree centigrade.

As well for the plasma system especially goes up to that degree centigrade ionized gas conducts electricity, energy is transferred to the waste material, it's excites the molecular bond such that materials is break into the elemental atoms,

You know elemental atoms things gets excited so electrons will go into the higher excitation level, then it will kind of reduce back into the lower excitation the normal level and it will reduced the electron.

So all waste constituents are completely melted into solid mass called dross and the minerals can be recovered from dross, all known contaminants is effectively treated like municipal, hazardous, hospital, you see more and more of hazardous waste or hospital waste into plasma arc,

You don't see that much in the municipal solid waste unless in some specific cases, maybe some pile study here and there, but not a single at least that I am aware of if you are let me know.

I don’t know any single like a full fledged big municipality where they are using this plasma arc as a treatment system for treating the municipal solid waste.

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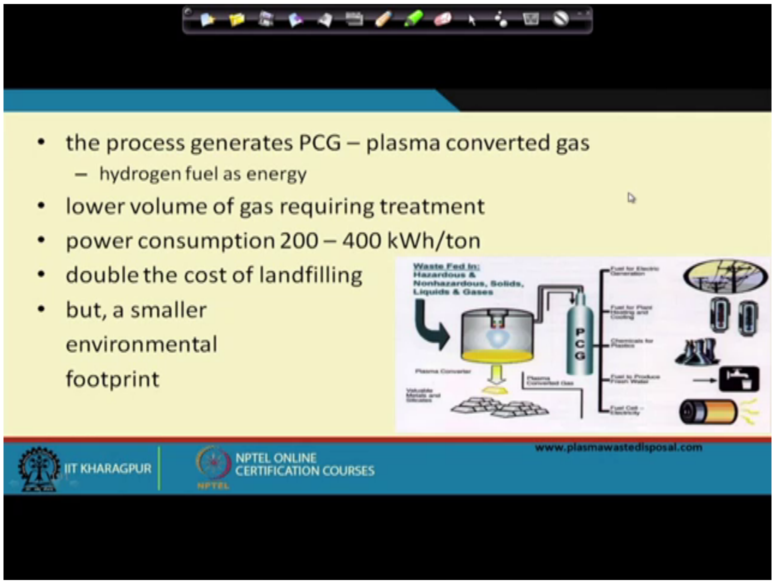

The process generates PCG which is called plasma converted gas hydrogen fuel is also there as an energy, large volume of gas requires treatment, so you need to have a treatment in terms of large volume of gas is there which requires treatment, power consume is 200 to 400 kilo watt hour per ton.

So it’s double the cost of land filling, but a smaller environmental footprint, so that’s what they claim, of course we need to find out whether the claim is true or not, so here how it works, the west feet in goes there hazardous or non hazardous,

This is where the things are coming in, it’s gets heated up at a very high, this is the plasma which is generated from the torch on top and then things get treated, you have plasma converted gas coming out of that.

Then you have some of these vitrified material as a slack, then the PCG which is the plasma generated gas, you can use it for fuel to electricity generation, fuel for plant, chemicals for plastics and fuel to product, fuel for electricity, so lot of things can be done for using this PCG, plasma generated gas.

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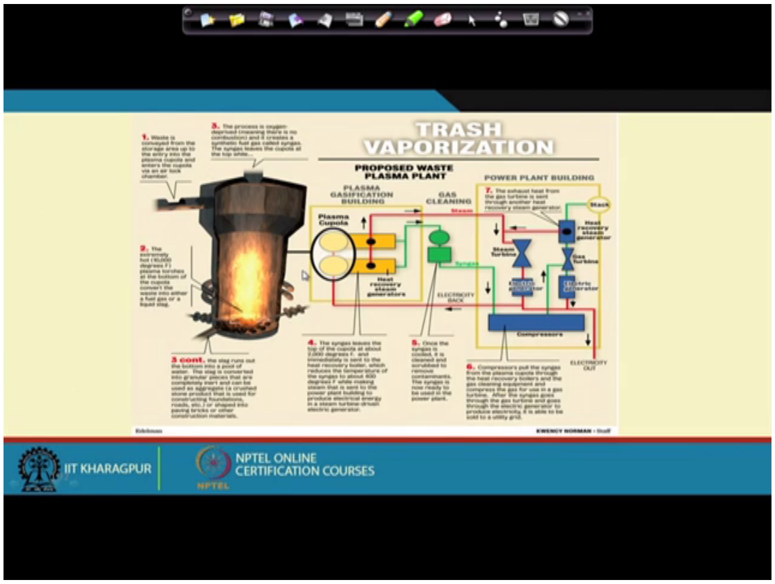

So this is some of the like, I would say more like an advertisement from these plasma arc companies, you can look at that, this is from the plasma arc where they are looking at the different components of the plasma arc.

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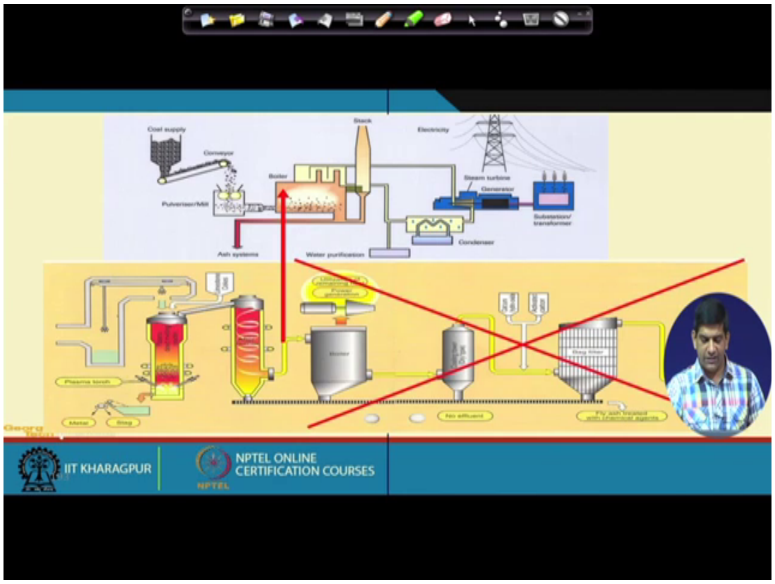

This is another sketch essentially for those website as you can see on top, that's the you can have a plasma arc facility fit there in a traditional incineration and then we can get rid of many of these stuff which we need it in terms of boiler kiln tower, back filter, those things can be, we don't need those anymore if we can go for a plasma arc, but again plasma arc is costly so you need to look at economics.

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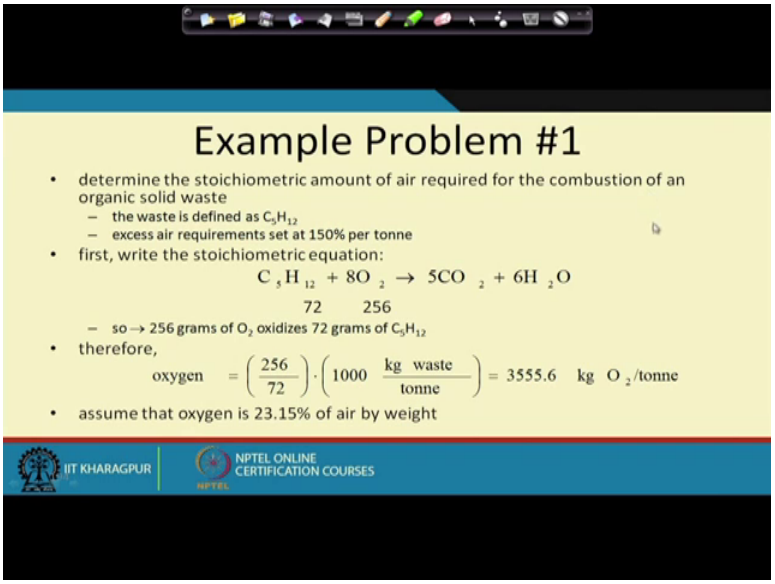

So let's quickly look over these problem and then we'll kind of wrap this particular topic, so in terms of the, if we have to find out the stoichiometric the amount of air required for combustion, if the waste formula is given and you have been told how much extra air is like 150 per ton,

So you write down these equation which is stoichiometric oxidation equation, you find out how much moles, so one mole of this will require 8 mole of oxygen.

So how much moles are there in terms of 72 grams, so which you know the number of mole, you multiplied by how you will use 8, like one mole of this we'll use 8 moles of that, so based on that we'll find out that altogether it comes out to be around 3556 kg of oxygen per ton.

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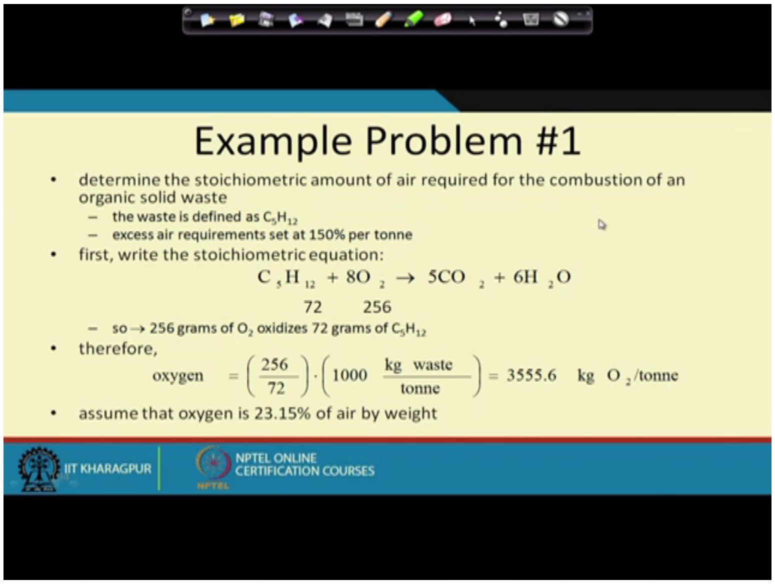

So that's the amount of oxygen that is produced per ton, so this is the oxygen required per ton, and then if you can convert that from oxygen to air. With 23 percent of air we know that how much will be the air requirement and from air requirement we can even go further, this is the air requirement so that's for per ton and if you convert that so this much of air, this is the kg of air,

So in terms of volume of air we can convert that, so density of air is this much, so therefore one ton of waste requires 11800 meter cube of air, so that's what it is, this is the other formula for calculating how much oxygen is required. So we can use the simplified equation or we can go by step by step like you would do in a simple way.

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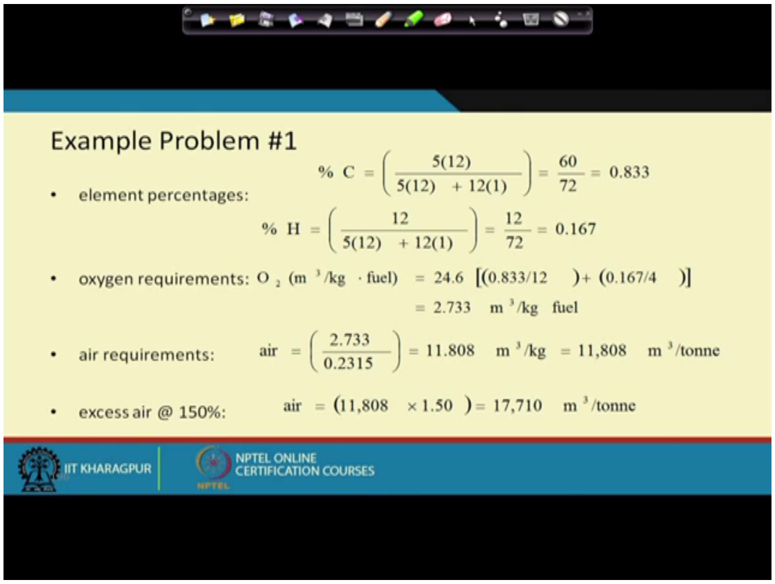

So and then you can find out elemental composition for each one oxygen requirement, how much oxygen is required, the air required from there, excess air at 150 percent, so you multiplied by 150 1.5 to get the excess air, so those things can be done.

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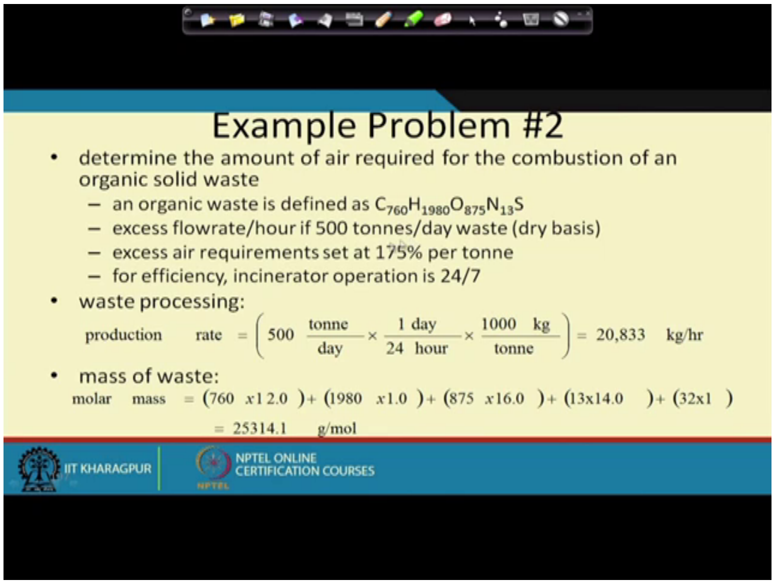

And this is another example you have the organic waste, this much that's the big formula for the organic waste. We have been given 500 tons per day, excess air is 175 percent for efficiency the plant is working 24 hours a day, so we can find how much this much 500 tons per day.

So this is how much kg per hour so we get that value in terms of the kg per hour value, so this is our kg per hour value, so this is the how much kg per hour, so we can calculate the molar mass, because the formula is given to us, so from where we can calculate.

So I am not walking you each line by line, I did that for biological treatment examples so for this one I am expecting you to go through line by line and then if you have any questions let me know although it's kind of explaining with detail,

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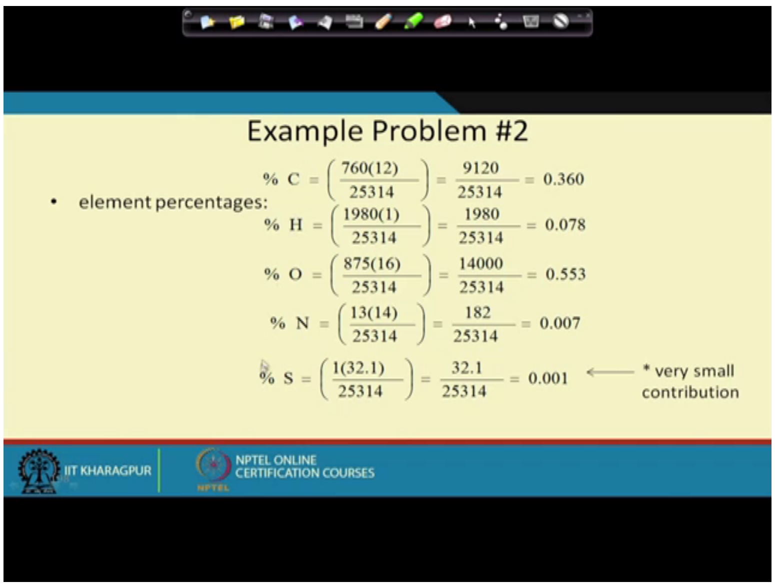

So you can find out the percentage carbon, hydrogen, oxygen, nitrogen and sulphur so you get those,

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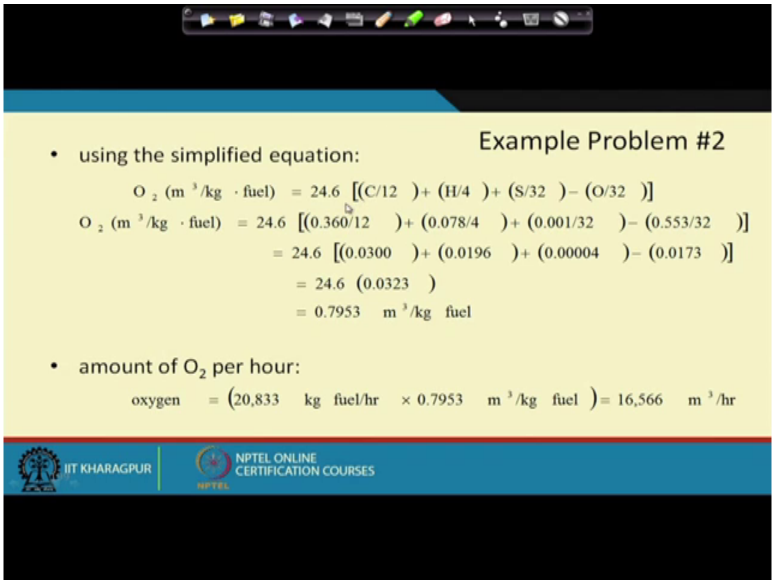

Sulphur has a small contribution we can ignore that, then you can use the simplified equation. Which was shown at the end few slides back where you can put this so meter cube per kg of fuels, so that way if you put those numbers we get that unit point 8 meter cube per kg of fuel.

So in terms of the oxygen requirement we can calculate how much oxygen will be required, because we know that 20833 kg of fuel per hour, so from there we can find out this much, how much meter cube per hour

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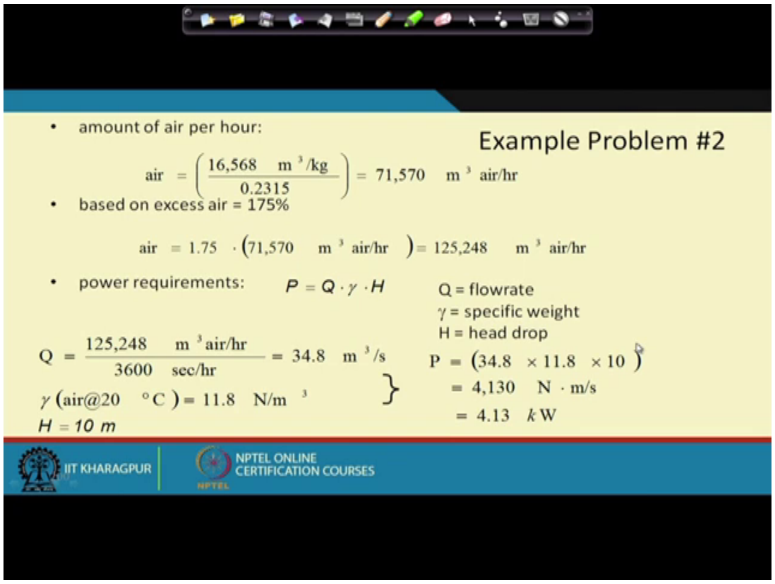

And once you know meter cube per hour of air. From oxygen we can calculate for air, multiply by 175 you get that number and then if ultimately you need to calculate what should be the power of the blower which will blow the air through,

So you can use this power equation which is right over there, you can use that power equation and come up with how much you will be requiring in terms of how much standard cubic feet per minute the pumps.

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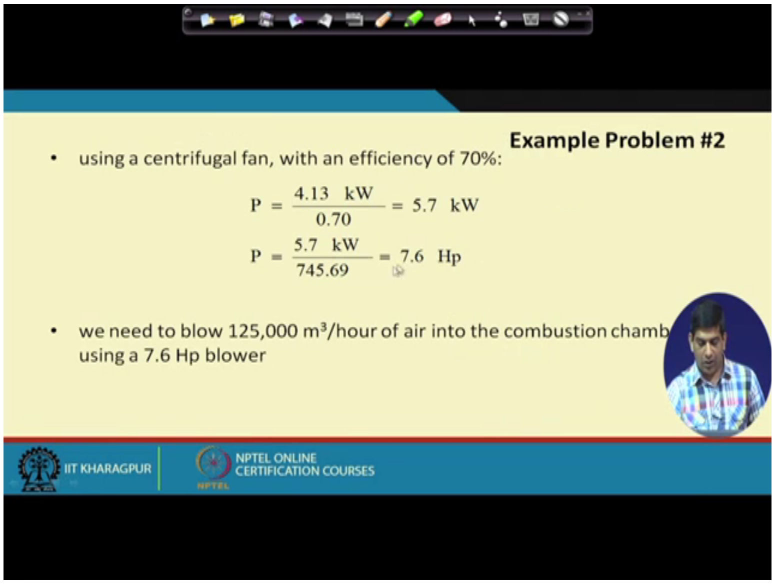

So or horse power so we get like a horse power of around 57.6 hp is what is needed in terms of for this waste combuster to keep on burning.

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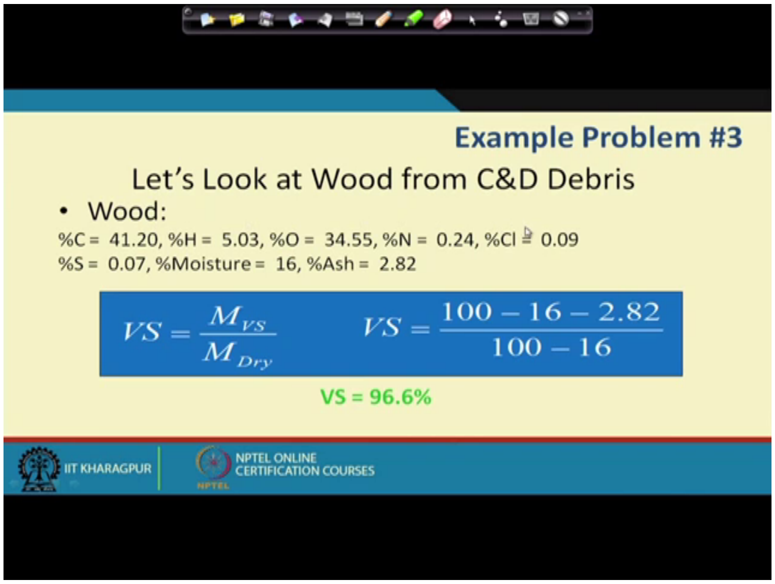

So if you look at the wood it's a example from C and D debri, you have certain woods which is in percentage carbon, hydrogen, oxygen is given to you, you can find out the volatile solids so volatile solid will be the total minus whatever is the moisture minus the ash, so that's will be the volatile solid.

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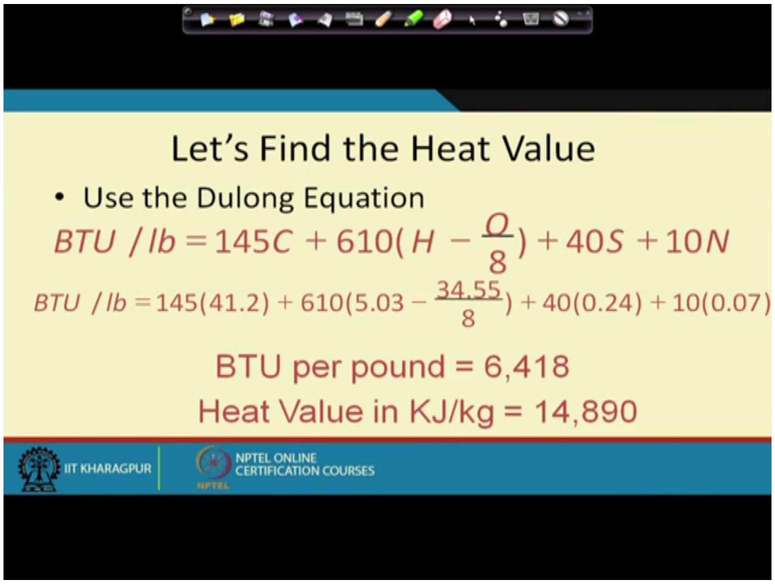

Then you can find out the heat value, we get the heat value of around 6400 BTU per pound or nearly 1500 kilo joule per kilogram.

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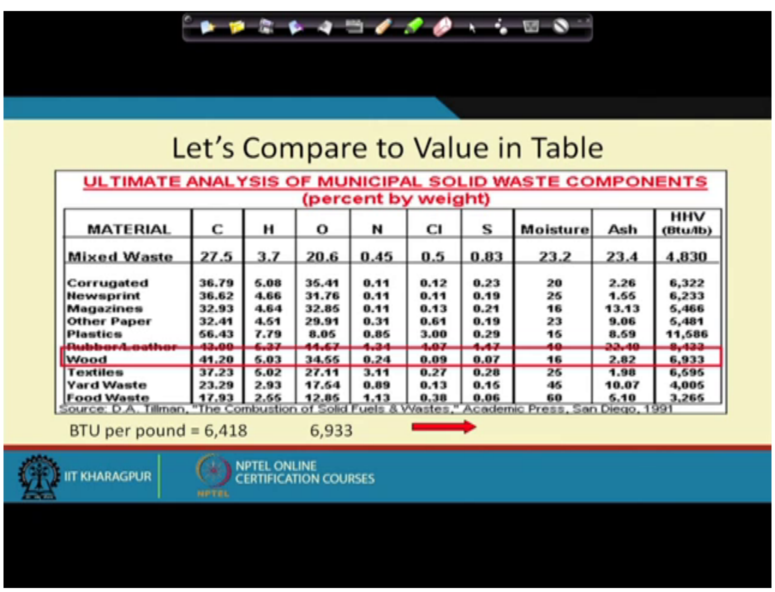

ULTIMATE ANALYSIS OF MUNICIPAL SOLID WASTE COMPONENTS
(percent by weight)

MATERIAL	C	H	O	N	Cl	S	Moisture	Ash	HHV (Btu/lb)
Mixed Waste	27.5	3.7	20.6	0.45	0.5	0.83	23.2	23.4	4,830
Corrugated	36.79	5.08	35.41	0.11	0.12	0.23	20	2.26	6,322
Newsprint	36.62	4.66	31.76	0.11	0.11	0.19	25	1.55	6,233
Magazines	32.93	4.64	32.85	0.11	0.13	0.21	16	13.13	5,466
Other Paper	32.41	4.51	29.91	0.31	0.61	0.19	23	9.06	5,481
Plastics	56.43	7.79	8.05	0.85	3.00	0.29	15	8.59	11,586
Rubber/Leather	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	10	[illegible]	[illegible]
Wood	41.20	5.03	34.55	0.24	0.09	0.07	16	2.82	6,933
Textiles	37.23	5.02	27.11	3.11	0.27	0.28	25	1.98	6,595
Yard Waste	23.29	2.93	17.54	0.89	0.13	0.15	45	10.07	4,005
Food Waste	17.93	2.55	12.85	1.13	0.38	0.06	60	5.10	3,265

Source: D.A. Tillman, "The Combustion of Solid Fuels & Wastes," Academic Press, San Diego, 1991

And that kind of the number matches with what is there in the typical table BTU per pound v guard from to long is 6418, where the paper we have searched 6933, so kind of checks us that it's on the same range.

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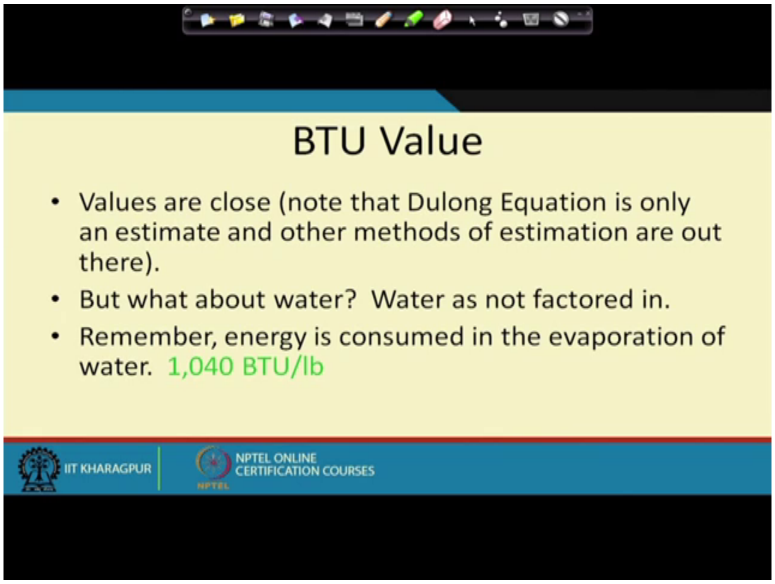

So once we have to incorporate the water as well so that's kind if reduces the BTU value.

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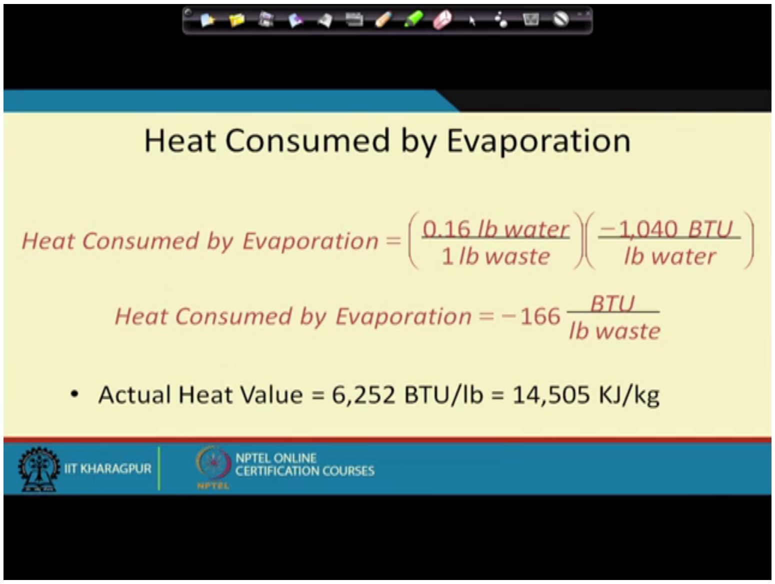

We can calculate how much will be the heat consumed by evaporation so we get the actual heat value subtracting that so that's comes down to 6252 so that's this much of heat value coming out for the particular waste,

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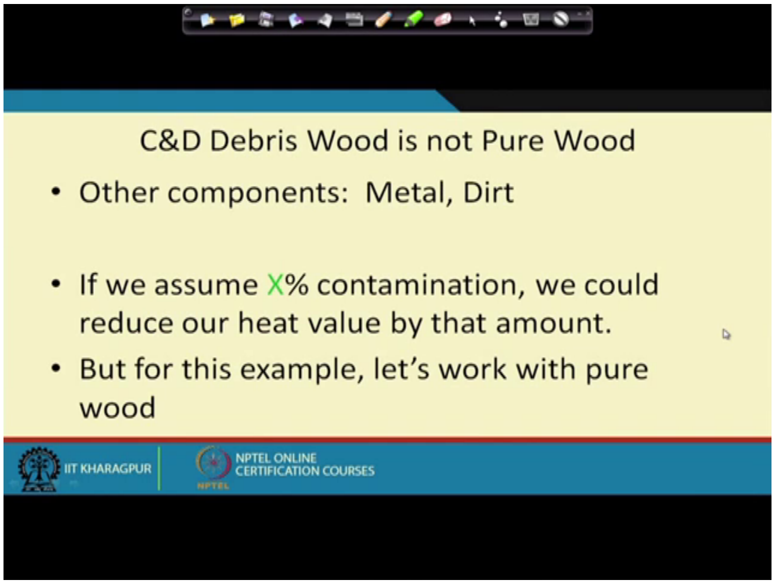

So then CND is not pure wood, there will be some metal, there will be some dirt, so we can assume certain percent of contamination then we reduce the heat value for that but for this problem let's walk to the pure wood.

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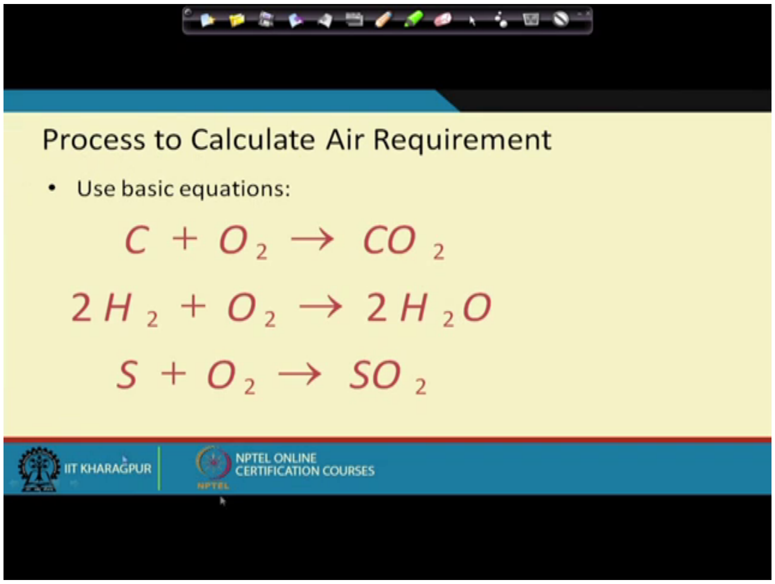

So use this equation basic calculation for air requirement,

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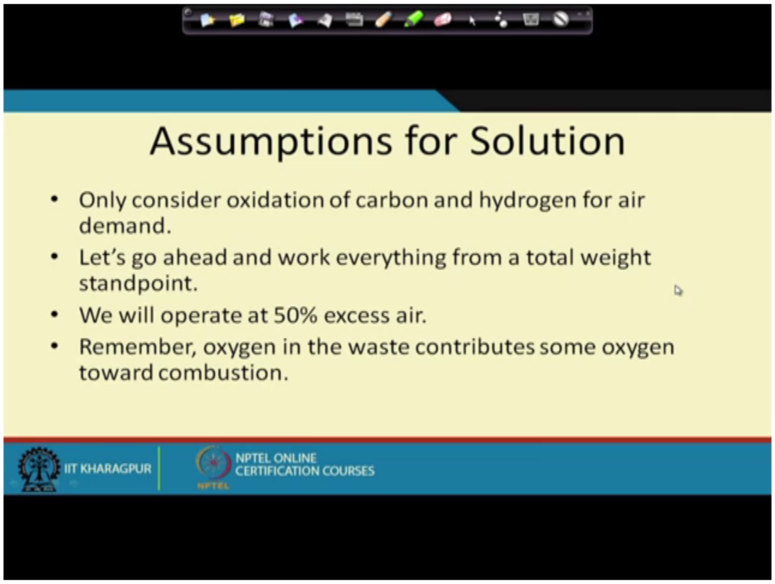

The assumptions that only consider oxidation for carbon and hydrogen, and we operate at 50 percent excess air, oxygen is there in the waste that will contribute to some oxygen towards combustion,

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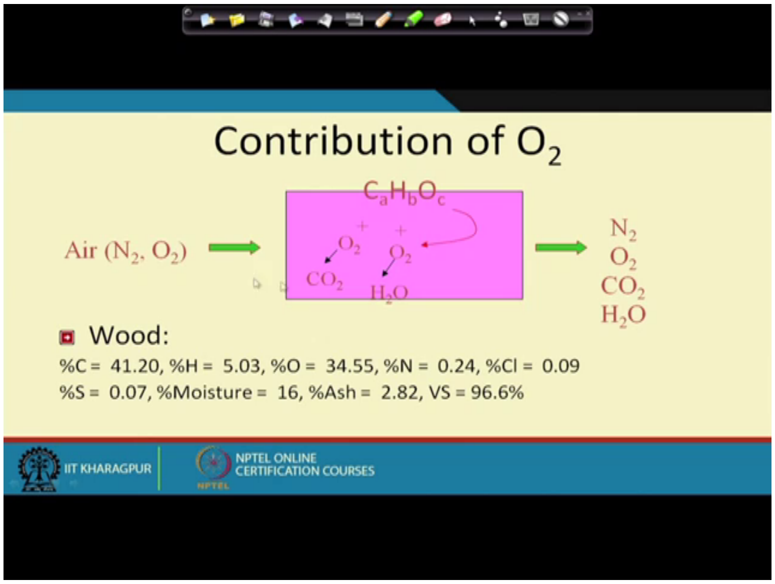

So you can do this air going in to this waste and producing these gases out there, the percentage of wood and all that.

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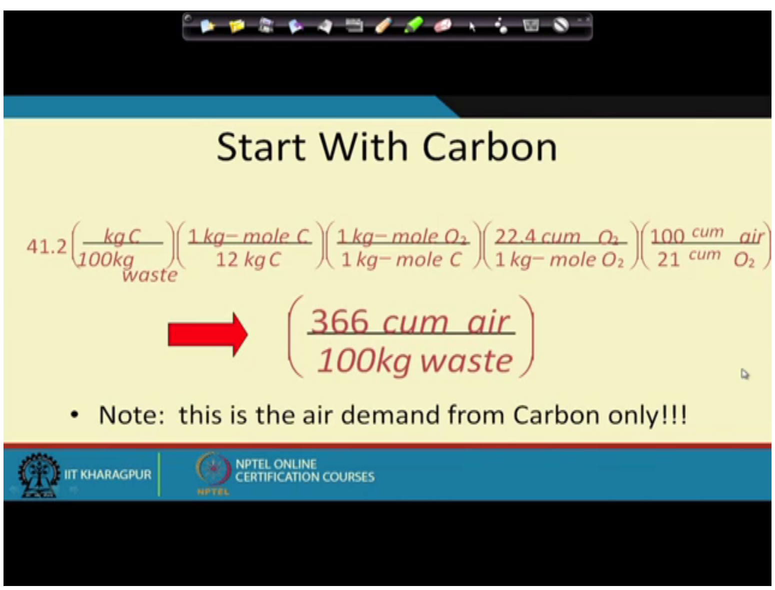

So you can calculate for carbon how much air will be required. Again I am not going through step by step details, calculation has been shown to you but I want you to walk through the calculation and ask us any question if you have, it should be ok but just in case, so this much kg of carbon we can find out how much air will be required.

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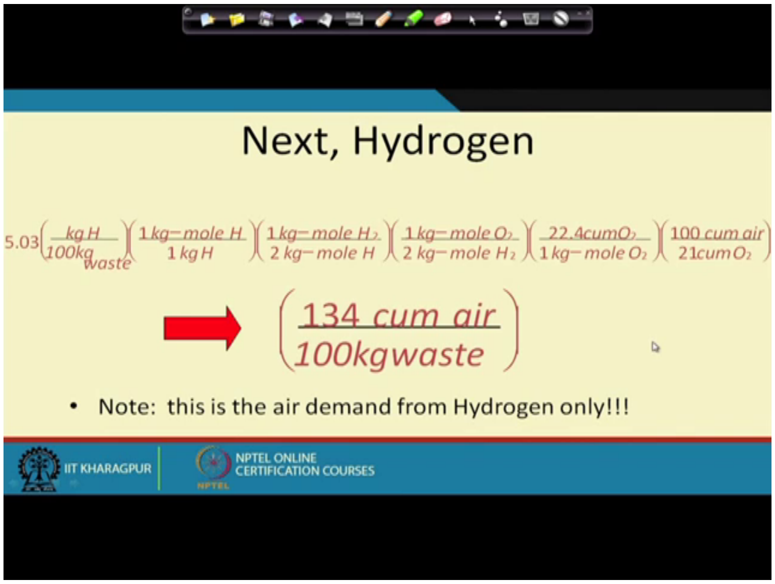

Similarly for hydrogen we can find out how much air will be required,

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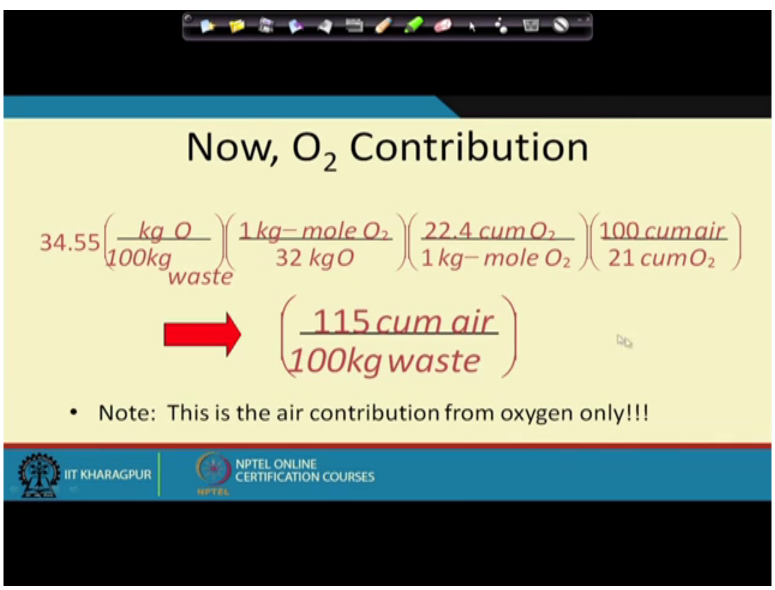

Then oxygen is already there so how much oxygen in terms of the oxygen requirement. How much oxygen is already present in the waste, we can find out those.

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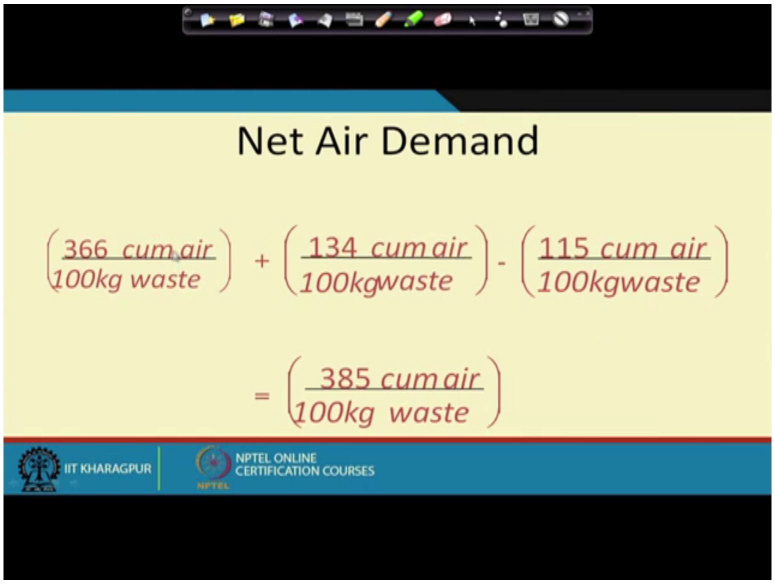

And then how much is required for hydrogen, how much is required for carbon, carbon and hydrogen with those numbers are given here and what is there from the oxygen that has been minus, and then effectively we need 385 cubic meter of air per hundred kg of waste,

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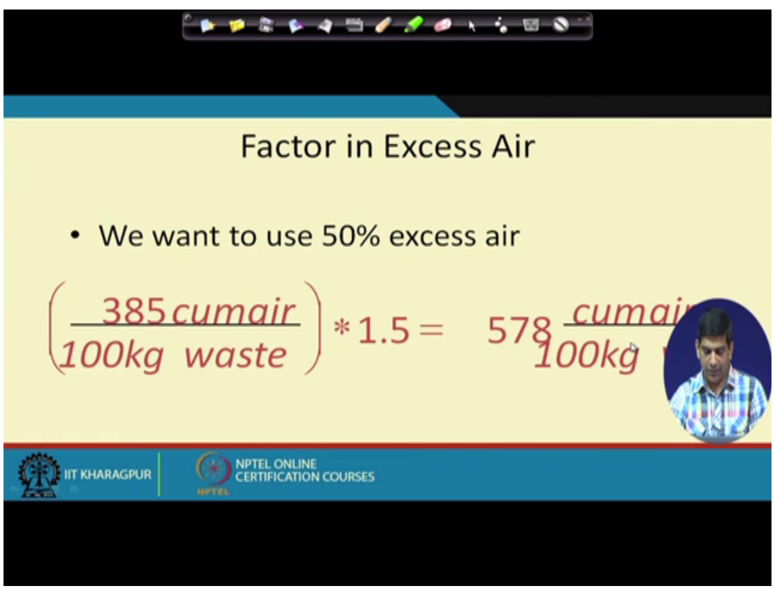

So with that number we can calculate excess air, with excess air of 50 percent we can find out how much air will be required.

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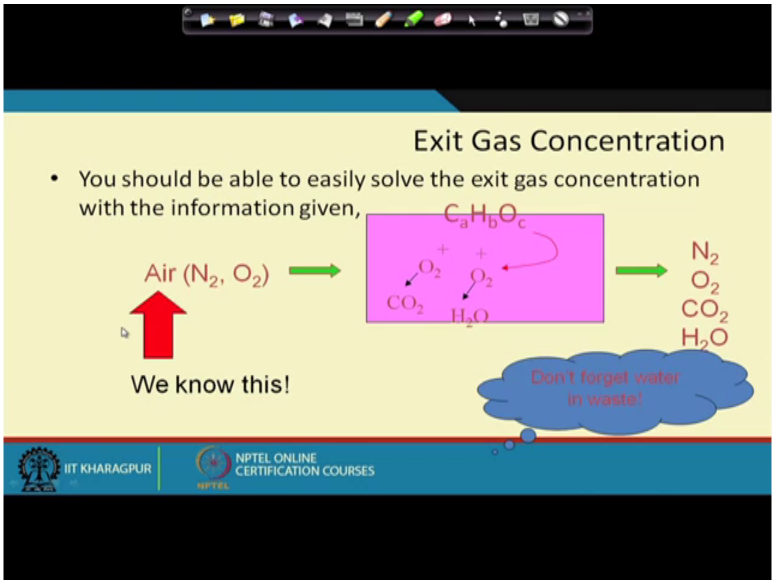

And then you should be able to easily solve the exit gas, so we know how much air will be required so we know this input if needed we can calculate all these things coming out from there as well, what are the concentration of those things can be worked out.

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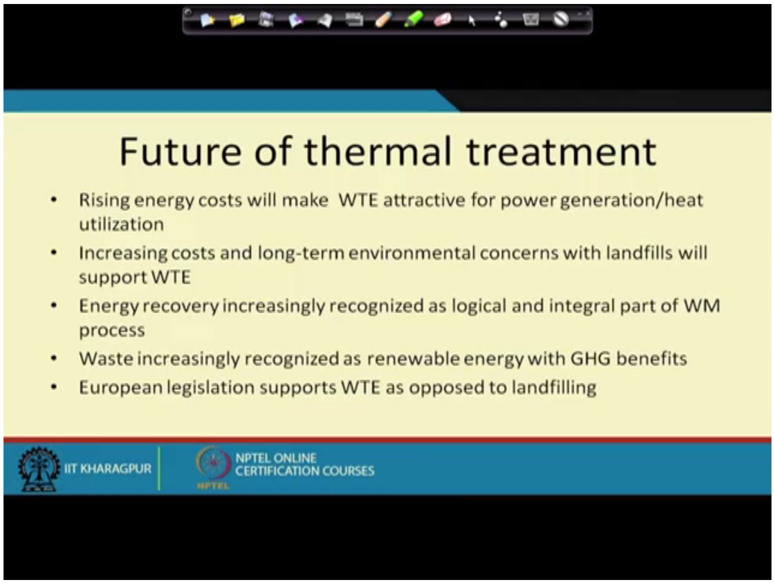

So in terms of the future the rising if the energy cost goes up, right now the energy cost is a bit lower, so energy cost goes up the waste energy becomes more attractive.

Increasing cost in long term environmental care with the landfill actually we'll support waste to energy, so in an country like India waste to energy has a future, again we have to make sure the collection system,

The collection system has to do its job to supply good quality waste material which has good calorific value, which should not diluted from other kind of low calorific value waste material, energy recovery is recognized as one of the important integral part of waste management,

It's a renewable energy, some countries are also called it a renewable energy, green house gas benefit, European legislation has support waste to energy as opposed to landfilling,

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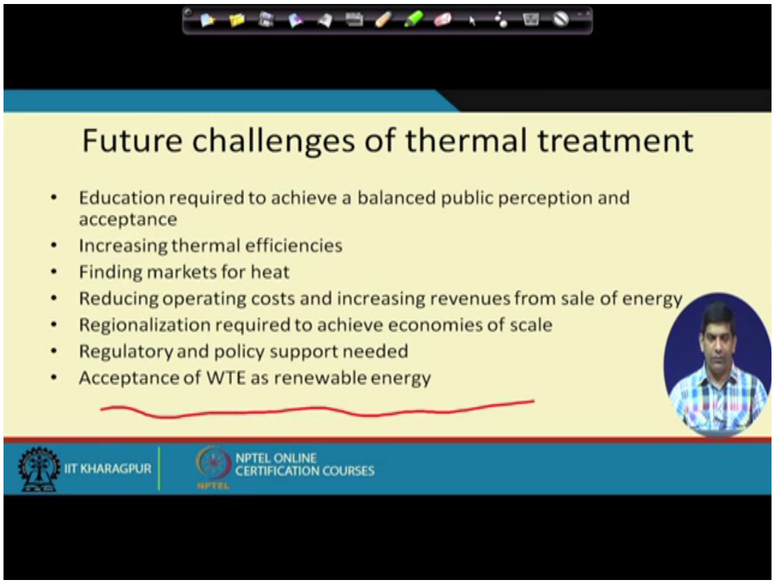

And then future challenges education requirement, we have to get the public on both increasing the efficiency, finding market for heat, the heat that we are loosing, if you can find market that could be another revenue source.

Reducing the operating costs, increasing revenue from the sale of energy, regionalization requirement to have a economy of a scale, you cannot have a small small waste to energy plants, you need the regulator policy support and their acceptance of waste to energy as a renewable energy, so those things will help this particular industry and I know this video kind of got little bit over 30 minutes but I just wanted to complete this thermal treatment chapter.

So that we can move on to landfill disposal and with this we complete the discussion on the thermal side, I hope you have a better perspective of the thermal treatment and what are the challenges from the Indian contest and if you are a city engineer, you are a municipality engineer taking this course or anybody taking this course will be working on this will make sure our feed is correct,

That's the number one message I want you to take it from this particular chapter for waste incineration for a waste to energy plants, I am talking from a thermal treatment perspective to walk in Indian contest we have to make sure the feed going into those systems are correct, technologies well established is pretty much and it's being used many places in the world, so it is nothing magic in the technology, it's the feet which is holds the key so with that let's close this video and I'll see you again in the next module.

Thank you.