Urban Services Planning
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Lecture 26
Waste processing, recycling and recovery Part 1

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Welcome to module 6, this is waste processing, recycling and recovery planning. And we will start the first lecture which is part one, this is lecture number 26.

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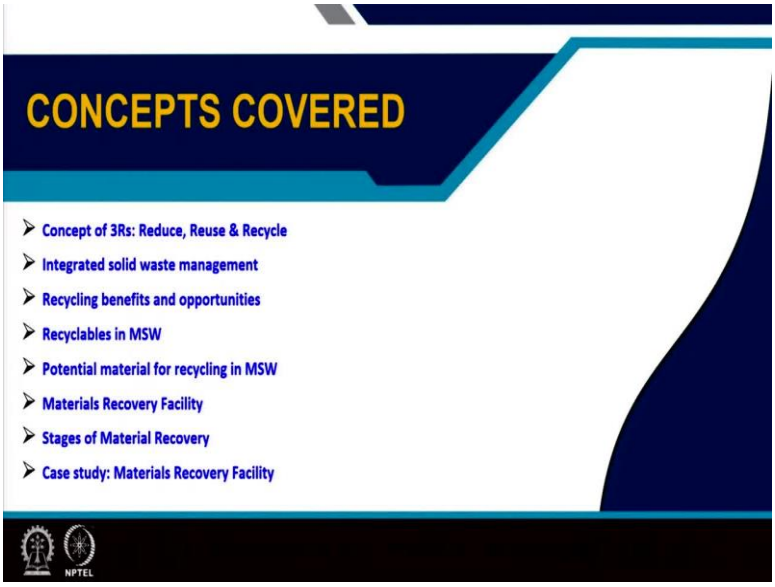

The concepts that we will cover are our what we have already learnt a little bit earlier as well that is concept of 3 R's Reduce, Reuse and Recycle. Then we will talk about integrated solid

waste management, then recycling benefits and opportunities, recyclables in MSW, potential material for recycling in MSW, material recovery facilities, stages of material recovery and finally, a case studies on Material Recovery Facility.

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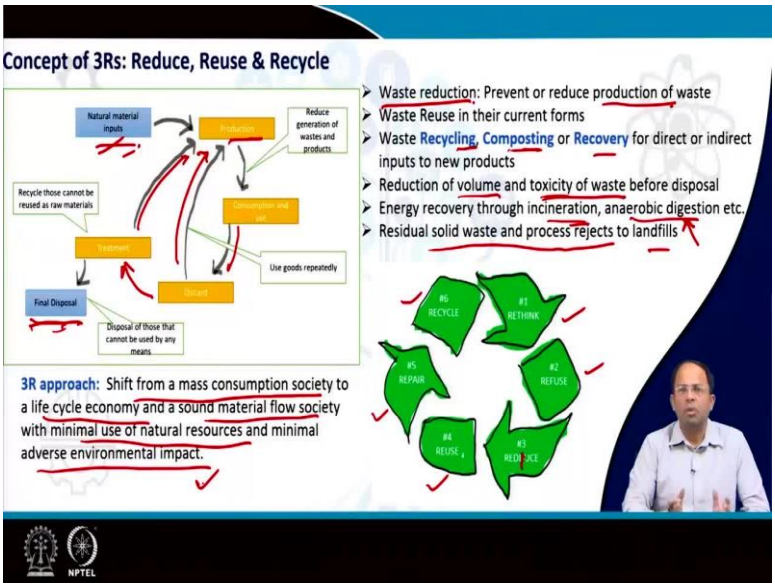

So, we have already learnt about the concept of 3 R's where we talk about initially reduction of waste and then eventually reuse and recycle of waste. So first of course, is the process of waste reduction where we want to generate the, we want to generate less waste in the first place, and we want to prevent or reduce production in the first place, so that is the first stage of it. And then whatever waste is being produced over here you can see we will you consume it that means, we use the product and we will try to reuse it again.

So I we can discard the product, that means, once we have used it, we will discard it, but at the same point of time, there will be somebody else who wants to use the product again, that means, when you buy or sell a car and then it is being bought by another person and used again then it is a reuse of that particular product. So that means we are again go instead of production, we are again going back to the same point where it is being consumed.

So once it is discarded then after that, we if we cannot reuse it, then we should definitely think about doing something about it in that case comes recycling, composting and recovery. So this recycling, composting these are different processes of course, that is we can recycle some of those quantities that we are discarding maybe as a whole or maybe as a part or we can also go for if it is organic matter then we can convert it and then we can convert it into

fertilizer and then we can use it as compost that is composting and then we can also do recovery of certain materials from the waste streams we can that we can use.

So that means some certain materials instead of sending for final disposal, we will try to use them or we have to do some amount of processing to those particular materials and then we can again put them back into the production process. So that means instead of getting natural input materials or virgin materials from the mines or from the environment, instead we get some of those materials back from the discarded products.

So the product itself can be reused or components of the product or parts of the product after certain amount of pricing can be again taken back to the production process, which will reduce the amount of natural materials that are required to produce that particular product. So once nothing works, that means we cannot recycle, we cannot reuse we cannot compost in that particular case, we will finally dispose of the product in the landfill site. So that is the concept of 3 R's.

Now, some people have even said that instead of 3 R’s we can also think of 6 R’s. For example, people have talked about rethink, then refuse that means first you think about the usage of the product and why are you using it and what will be the alternatives and so on then you refuse, like you refuse to use extra and then you reduce, so you reduce the quantity that you are consuming. Then once you are doing that, then you can reuse you can repair it to a certain extent and again reuse or you can recycle it recycle could be in different ways. So these are also other ways people have proposed this particular concept using the R’s some have given 3 R’s, some have given 5 R’s, some of you and even 6 R’s.

So our primary goal is to reduce the final volume of waste that is going for disposal and we need to reduce both the volume as well as the toxicity of waste, so this is a basic concept. That means not only we are trying to reduce the total volume that is going to a landfill site but we are also to improving the quality of the waste that is going, or the (reg) of the final waste that is going to the landfill by improving its quality or reducing its toxicity. So that means, we have to take out the toxic materials so that it does not contaminate either the groundwater or the soil surrounding soil of that particular landfill site.

So some, once we are reusing, recycling, all these things are done, we will still find that there is something intermediate between sending our waste to the landfill site and utilizing it. That means, what we can do is we can convert our waste or we can convert it to energy that

means, if I have got organic waste, then I will definitely compost it, if I have got inorganic waste, I will try to recover all the materials which can be reused or recycled from that, whatever remains, I will then take a look at it and see if that waste we can generate some amount of energy.

So that is where we have already learnt this earlier that if the waste has a calorific value higher than a particular threshold, which is 1500 calories kilocalories in that case, we can actually reuse that we can actually burn that product to produce energy. So either by incineration or by pyrolysis or this kind of combustible technologies or in other technologies like bio methanation, which are chemical biological processes, using those we can also generate some amount of energy.

So energy recovered through incineration, anaerobic digestion, which is bio methanation. Actually, bio methanation actually generates the methane gas, which could be used to burn and produce energy eventually or sometimes that waste will be directly burned, which is through incineration. So using this we can generate energy, but of course, this will result in some amount of emission which is also not good for the environment. So we have to take a call should we go for energy production or should we go take the waste to the landfill, so whichever is better overall that we have to get a choose.

At some case we have limitations like we do not have adequate area for landfill site, so in that case, incineration may be a good option or maybe the waste is so good that we could be able to generate a lot of energy and we could reduce the burning of fuel like burning of coal or bonding of oil for generation of electricity. So in that case, we can also burn waste as well. So ultimately whatever is remaining the residual solid waste and the process rejects this goes to the landfill site. So that means the minimum amount of waste, which is the final quantity, which cannot be we cannot do anything with that goes into the landfill site.

Now, this 3 R's approach basically is a shift from a mass consumption society. So this is a the background theoretical perspective you can say like, we have to ship from a consumption society that is our society is geared towards consumption, you produce more you consume more, everybody is trying to do that. To a life cycle economy and a sound material flow society, to a life cycle economy means we have to consume those things, which are environmentally friendly over its entire lifecycle, not only we can say it is a green product, but it is we have to see how much energy is being used to produce it, what kind of processing

it requires, if the entire life of this particular product is green or not. So we will learn about lifecycle analysis later.

And the sound material flow society means, that means, the material each material it has to be utilized as many times as possible, eventually, it will may go to the landfill site, but we have to keep on using it so that we reduce the use of natural materials or virgin materials. So with minimal use of natural resources and minimal adverse environmental impacts. So that is the overall goal, keeping this goal in mind we have to design our recycling system or designing our waste management systems.

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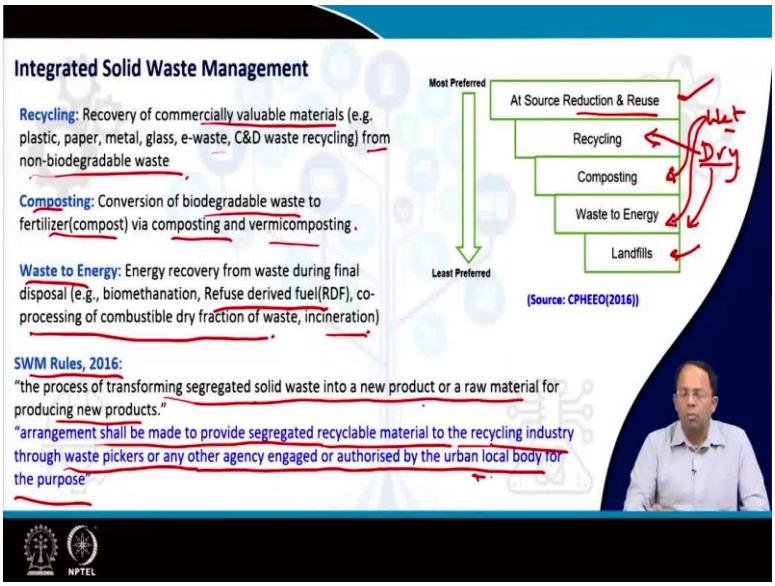

So coming to integrated solid waste management, we have already learnt about this earlier. So the first tip is of course, to add source reduction and reuse that means, we need to reuse the product again and again or reduce the use of the product in the first place, so that is the first step. So this is the demand side what is the demand side approach to reduce the consumption of waste, generation of waste or so on. But once the waste is product is being consumed then the waste is generated, then you have to really think about the wet fractions of the waste and the dry fractions of the waste.

So for wet fractions, we will think we will try to go for composting and we can also go for another method which is called bio methanation. So composting and bio methanation both utilizes organic waste to generate some amount of byproducts which we can use. Composting generates mostly your manure or fertilizer, whereas bio methanation generates both this CH 4 gas because it is a difference between the processes the biological processes that we employ

in composting we employ aerobic crisis mostly not always. Whereas, in case of bio methanation we use in anaerobic process which leads to more about the methane production.

Now, when more amount of methane is produced, we can use it as energy, so this wet waste can also be converted into energy. Whereas dry waste some of it can be recycled, we will try to recycle some of the waste so that we can recover some of the products, some of it can be used as could be converted to energy by burning it. So we have incineration or we can convert it into a material which could be used as a fuel for some other industry or so on, so refuse derived fuel or it could be used as co-processing of combustible dry fraction of waste, which is whenever like in cement industry and other industry we can use this as a material which could be used for co-processing and for burning or generating energy in those industries as well. So this is where this dry waste also could be utilized.

So once all this utilization is done whatever remains goes into the landfill as we just discussed earlier. So coming to the definition, recycling is recovery of commercially viable materials, valuable materials, or you can say viable as well. Example plastic, paper, metal, glass, e-waste, C and D waste all this comes under the recycling program and this is usually from non-biodegradable waste.

But if the waste is mixed, sometimes we do not have a wet or dry waste separated at source, so in that case if the waste is mixed, in that case, if the waste goes into the composting process, may we may need to do presorting of that particular waste and we may generate some amount of material which could be recycled as well. So but in general we say that dry waste component or non-biodegradable waste could be recycled.

Composting is a conversion of biodegradable waste to fertilizer via composting and vermicomposting, this we will learn in the subsequent lectures. And waste to energy is, energy recovery from waste during final disposal and different process could be employed such as bio methanation which is using organic waste or wet waste, refuse derived fuel, co-processing of combustible dry fraction of waste and incineration. So this is the three options that we have got to reduce or reuse or to adhere to the 3 R’s principles.

So coming to software management rules 2016 what it states about recycling is, the process of transforming segregated solid waste into new product or raw material for producing new products. So that means we transform segregated solid waste into a new product or raw material for a new product. So I directly we can make it into a product or we can create raw

material using which we can create a product. And not only that, there has to be an arrangement made by ULB's to provide segregated recyclable materials to the recycling industry through waste pickers or any other agency engaged or authorized by urban local bodies.

So that means it is not only the recycling process is now mandatory, but also making sure that recycling industry is supplied by materials as well as engaging waste pickers and other informal workers to do the sorting and all those other work that is required to recover this kind of material, this is made mandatory for the urban local bodies.

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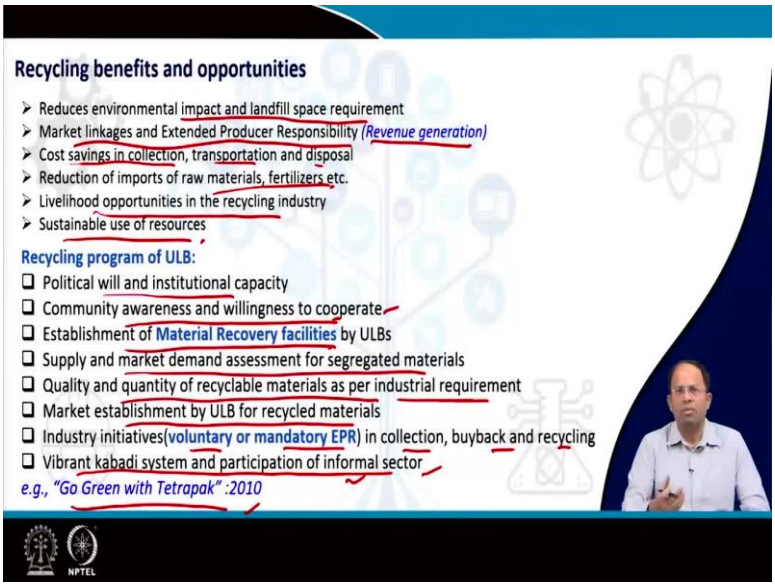

So what are the benefits and opportunities in regards to recycling? Of course, it reduces environmental impact and landfill space requirement. Then market linkages and extended producer responsibility is very, very important, why? Because I may recycle a lot of products, I may get a lot of products from my waste stream, but at the end of the day, I have to have markets to sell them or I have to have certain agencies or certain agreements with certain recyclers so that they will take my product. If I am not able to sell my product when there is no point of producing it in the first place.

So there is extended producer responsibility program we have discussed this earlier. So there we make direct contact with the producers or other companies which can take our waste directly and then they can sell it or use it for some other purposes. Like for example, a bottling plant for soft drink, they may take back the aluminium cans and, and they may also

give some incentives for the consumers to return those aluminium cans. Same goes for glass bottles, same goes for plastic bottles and so on or paid bottles.

So some amount of revenue generation is also involved in this. So that means the consumer gets certain amount of revenue, and that actually makes sure that they will recycle. So overall recycling leads to cost savings in collection, transportation and disposal, because once the recycling product is ready, then it is the responsibility of the recycler, to process it further and so on, so the cost gets into their processes, the cost becomes a part of their process. So the ULB does not have to spend money on transportation, collection and disposal.

Reduction of inputs of raw materials like fertilizers, raw materials and fertilizers as well. So sometimes our country inputs fertilizers from outside or inputs raw materials, which is used for making certain kinds of materials, so if I do composting and obviously, I will produce this kind of inputs. Then livelihood opportunities in the recycling industry that means you can create jobs, so that is a good point. And finally, sustainable use of resources.

Now, the recycling program of ULB's are different that means, as per the law it is now mandated, so every ULB is now looking into how to expand this recycling programs. Now, first of all, there has to be a political will and we have to develop institutional capacity to implement those political wills of course, so both is important. Community awareness and willingness to cooperate, so the community has to be involved. So first of all, we have to tell them that this is what we are deciding to recycle, you have to segregate this kind of waste and so on and also they people need to participate in these programs.

Then establishment of material recovery facilities, so without this kind of facilities you cannot do any kind of recycling program. Supply and market demand assessment for segregated materials, so you have to do the market demand assessment first. Quality and quantity of recyclable materials as per industry requirements. I can recycle, but it may not match the quality required by the industries, so they will not accept it. So wherever we are designing a recycling facility or the recycling processes, it has to be done in such a way so that the industrial requirement is matched. So that means we produce good quality recycled materials.

Market establishment by ULB's for recycled materials. So ULB has to engage with industries and other recyclers so that they can dispose of their product. Industry initiatives either voluntary or mandatory EPR as we are discussing now, in collection, buyback and recycling.

Then a vibrant Kabadi system and participation of the informal sector. So usually in Indian cities, the people households sell their papers, some plastic directly to waste pickers or directly to informal recyclers, and this is the kabadi system.

So if that part is very vibrant in a city that means that market linkages are there or the market is already existing, we can actually promote it further. So this kind of industry helps in the overall recycling process. So one example is that Go Green with Tetrapak in Mumbai this campaign was adopted, which helps the recycling of lot of Tetrapaks or some form of your packaging material.

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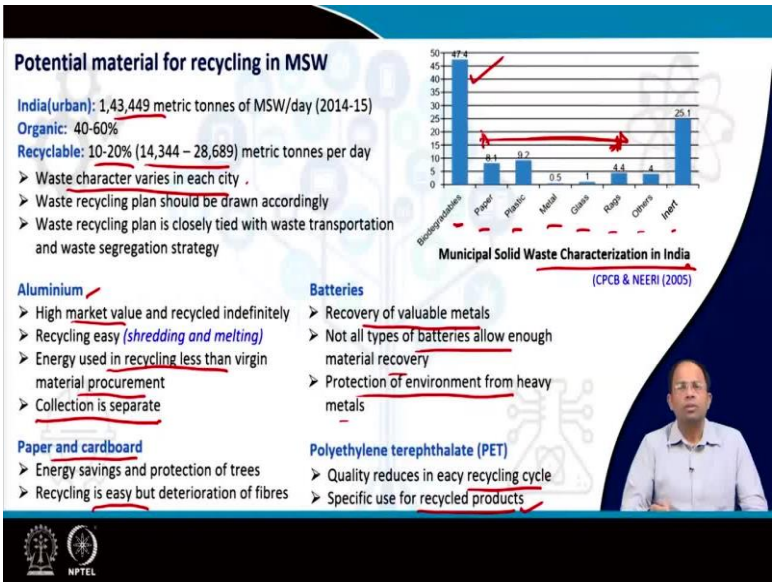

Now, coming to potential of material, recovery or recycling in municipal solid waste. As you can see from this graph around 47 percent is organic, paper is around 8.1 percent, plastic 9.2 percent, metal 0.5, glass 1 percent, racks 4.4, others 4 percent and inert particular 25 percent. So we have huge potential for material recovery. So this is the part which we can recover. So this is the part which goes for composting or even bio methanation, this is the part which we can recycle and recover.

So in India out of the overall 143,000 thousand metric tons of waste generated per day, we can recover around 10 to 20 percent and which comes to around 14,000 roughly 15,000 to 30,000 metric tons per day which is a quite a lot of amount of waste which could be can generate, which we can recycle sorry. And this but to set up any kind of recycling program we have to really look into the waste characterization of a particular city.

Even though this shows that general waste characterization in India, but whenever we are setting a program, it is (()) (20:06) ULB itself. So we have to look into the waste character for each city because that varies from city to city. And waste recycling plan should be drawn up actually based on what kind of waste is generated, what kind of segregation strategy is being adopted and what kind of waste transportation strategy is being adopted all these influences recycling strategy for the particular city or ULB.

Now, coming to the different types of items that are available in municipal waste and what we can how we can recycling there. For example, aluminium is there it is it has got quite a bit of market value and it can we can keep on recycling it indefinitely that means, we can keep on melting it and we can shred it and then keep on melting it and then it would whenever we melted it, it returns back to the this its original quality and specifications, so we can keep on recycling it.

Energy used in recycling is less than virgin material procurement. So we have to bind aluminium process it and then make it into aluminium can, instead you gather material from the urban area, you melt it and again use it for this cost actually less. So of course, this is the good proposition for recycling. So collection system for aluminium is separate from other wastes that means it has to be separately collected otherwise when it gets mixed, it will introduce a lot of contaminate.

Batteries is something where it is not exactly your value for money for example, some valuable materials are there in battery but not all types of batteries allow enough material recovery to make the process financially viable. But if I consider protection of environment from heavy metals and all in that case we should definitely take out batteries from municipal waste stream.

Then paper and cardboard, energy savings of course and protection of trees. So we save a lot of trees in this process, recycling is easy, but there is gradual deterioration of the fibers, because you cannot keep on using the paper multiple times that eventually you will be using it as cardboard or packaging material and then you have to discard it. Then paid bottles or polyethylene terephthalate so that is where here also the quality reduces in each recycling cycle, that means you cannot keep on recycling it indefinitely and only we can use develop certain kinds of recycled product. So we cannot make it again into a paid bottle but we can develop other sorts of recycled products using this particular kind of plastic.

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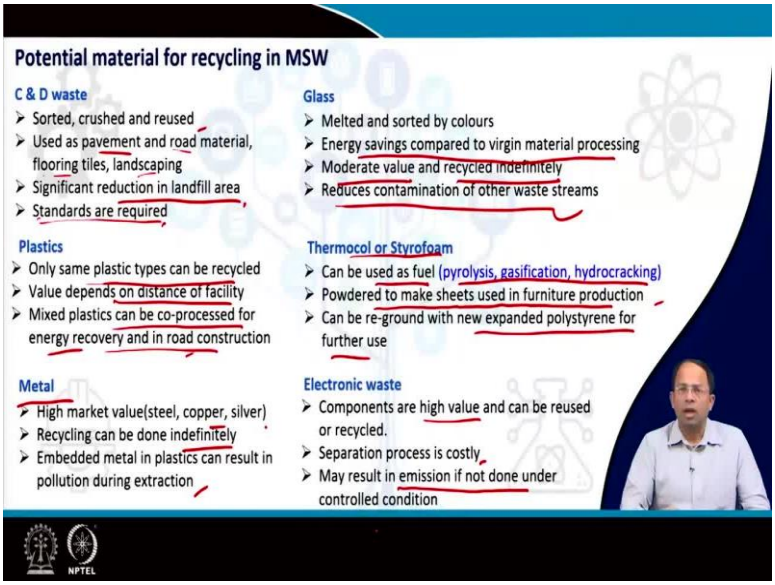

Then coming to C and D waste, it can be sorted crushed and then reused, usually we use this kind of waste it construction of pavements or as road material or sometimes it will be used as flooring tiles or even landscaping of certain areas. And the idea is of course, it is costly to do this kind of processing or all these things, but this will reduce significant landfill area requirement for the particular ULB, but there are not proper standards which are defined yet, so those has to be defined.

Then coming to glass, the glass can be also it is a moderate value that means the amount of money you can recover is less, but we can recycle it indefinitely as well. The only problem with glass is, glass has got different colors and you have to separate each glass of different colors, not all colors of glasses can be recycled. So it depends on what kind of dye are being utilized and so on. So energy savings compared to virgin material processing. So we will be able to save energy compared to virgin material processing in case of glass. And another one of the main reasons why we should do it is because it reduces contamination of other waste streams, that is glass gets mixed with other ways to add it is hazardous. So that is why it is better to remove glass from the waste stream.

Then coming to plastic, only same types of plastics can be recycled that means it will be recycled into same thing. Values depends on distance to facility, if your recycling system is far away, then there is probably you will not be able to make any money out of recycling. Mixed plastics can be co processed for energy recovery and in road construction. In case the plastic is mixed and all then you cannot recycle it directly but you can use it for energy recovery or you can burn and also use it for road construction as well.

Then Thermocol or Styrofoam not everything can be recycled, particularly used once not fully soiled and used once it is difficult, but it could be used as for burning, like pyrolysis gasification, hydrocracking, is a different incineration processes there are we can use it as a fuel but we cannot recycle it directly. It could be powdered to make sheets used in furniture production, so this is one form of recycling you can say. Can be re-ground with new expanded polystyrene for further use to a certain extent.

Then coming to metals, all metals have got high market value steel, copper, silver and so on. So if you can recycle them, you will be able to generate adequate amounts of money and we can adequately we can keep on indefinitely recycling them. And but the problem is when metals are embedded in plastic, that means, we have a metal container with a plastic lead, then when you recycle, then you melt the metal this plastic will also burn that will contaminate that particular metal. So we have to be careful about those kinds of waste features mix plastic and metal together.

And electronic waste also come contains high value components, some of it can be reused or recycled, but the separation process is costly. And also again here a lot of plastic is embedded into the electronics and all these are inside this kind of waste. So it may result in emission if not done under controlled conditions.

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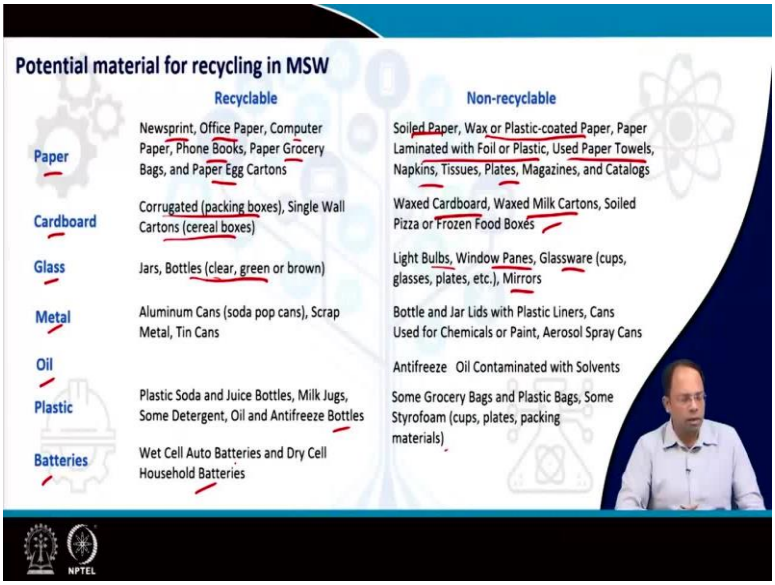

Now, just to elaborate further, we have paper, cardboard, glass, metal, oil, plastic, batteries, this kind of waste in our waste stream but not all of them are recyclable that means not all paper is recyclable. We can recycle newsprint, means newspapers, office paper, computer

paper, phone books, grocery bags, paper cartons, but soiled paper, wax or plastic coated paper, paper laminated with foil or plastic, use paper towels, napkins, tissues these cannot be recycled.

So not all paper can be recycled. Same goes for cardboard boxes, some single wall corrugated packing boxes, carton cereal boxes for morning breakfast, so those kinds of things can be recycled. Whereas waxed boxes, waxed milk cartons, the one with your a nice smooth layer surfaces those cannot be recycled. Say glass again some glass some bottles can be recycled, whereas bulbs, windowpanes, glassware or mirrors this cannot be recycled, because of extra coatings and other processes that are given to this particular kind of material. Plastics again some can be recycled, some can be not. Batteries, it can be mostly recycled, but maybe it is not that much viable financial.

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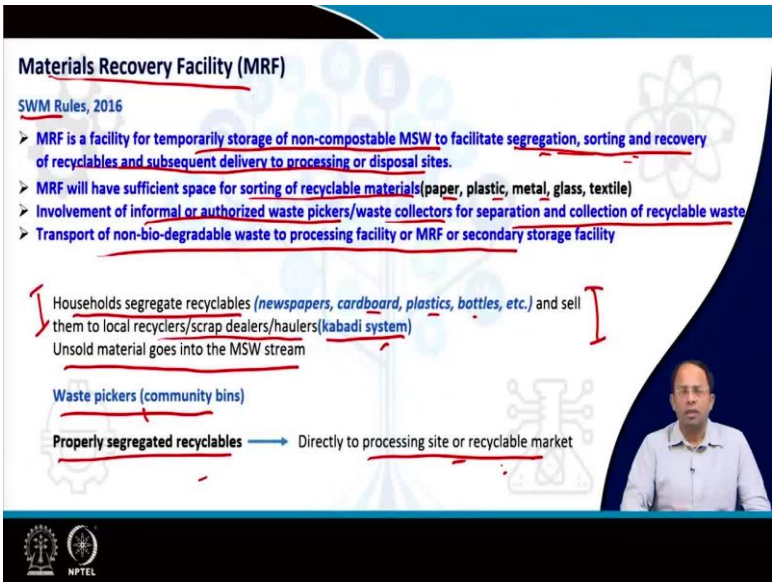

So as per the software management rules 2016, now we have every ULB asked to set up material recovery facilities and MRF is a facility for as defined by solid waste management rules 2016. MRF is a facility for temporary storage of noncombustible MSW to facilitate segregation, sorting and recovery of recyclables and subsequent delivery to processing or disposal sites. So that means MRF are areas where we do not process it, sometimes we can process it, but usually it is for segregation, sorting and recovering.

So if you want to process the waste further like you want to bail it and all these things or you want to make it into some pellets and all you have to take it to some other plant, but sometimes this sorting, recovery and also baling of waste is done together. So that means

primarily material recovery facilities are called recovery of the material, not for further processing, but some amount of processing can be done as well. MRF will have sufficient space for sorting of recyclable materials like plastic, paper, metal, glass and textile and so on.

And there has to be involvement of informal or authorized waste because of waste collectors for separation and collection of recyclable waste. So we engage informal workers usually for this, there could be mechanical processes also which we can involve or it could be a mix of mechanical and manual processes, but usually in Indian conditions we have found based on the kind of waste we get, it is better to use manual segregation, and it is also affordable at this point of time, but in future we may find that to be very costly and we may have to totally shift to mechanize processes.

Transport of non-biodegradable waste to pricing facility is also a part of this particular rules. So as we were discussing earlier, households usually segregate the recyclables like newspaper, cardboard, plastic, bottles, and then they sell them directly to local recycler, scrap dealers or waste haulers. So this is the kabadi system. So in India, we already have a very, very robust this kind of recycling collection system at the household level. And unsold material goes into the whatever cannot be sold by the household goes into the municipal waste stream.

So that is where we are and that means if I can, improve this part further then the total cost of recycling for the ULB will be definitely reduced or the amount of material that ULB has to recycle is also be much less. Then waste pickers we have a ban on manual scavenging of course, but still there are waste pickers who are engaged and some of them collect used to collect mostly from this recyclable materials from the community bins, so this is sort of sorting of waste from the community bins itself.

And then nowadays, because we are doing segregation from door to door, so properly, if the waste is properly segregated, then this can be one cities and then we can recover that waste. If it is and if the household is actually segregating some amount of recycles not only they segregate dry and wet waste, but they are also segregating some amount of recyclables directly we can send them to the processing site or to the recyclable market. That means vehicles will come, primary collection vehicles will come and they will take up this waste directly to those processing sites or this recyclable market, so if you are doing it at door to door.

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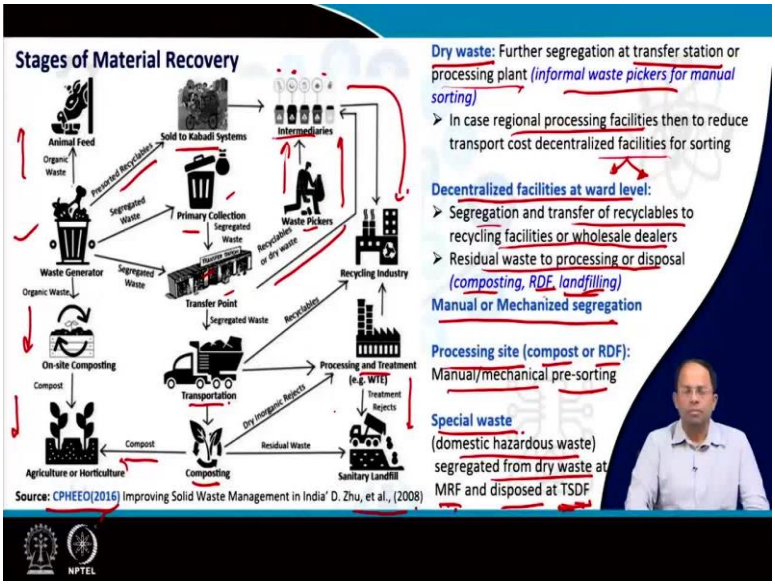

But in most cases, we do not do it like that, in most ULB's we are now having dry waste and wet waste categorizations. So usually there are two containers, dry and wet waste, wet waste is organic waste, whereas dry waste is actually considered for further recycling. So recycling is done at the transfer station or at the processing plant. So this MRF facility could be within a transfer station, along with the transfer station or it could be a processing plant as well that means wherever we are creating pellets for refuse derived fuel or we are doing some amount of other processing, there we can set up the sorting centers and all and we can also engage in informal waste pickers as well for this.

But sometimes what happens if this itself this facilities is far away, it is a regional facility in that case, instead of taking all this waste there and then doing the sorting, if I can set up some decentralized facilities at that local level or even a centralized facility at the city level for doing some amounts of sorting and all then I will categories the waste into different categories there itself and then directly take it to the respective processing facility. So I do not have to waste time and again re transporting them back for between the processing facilities or from processing to the landfill site. So some sorting could be done at the Urban level as well ULB level in this MRF facilities.

So we can set up decentralized facilities at the ward level, where segregation and transfer of recyclables to recycling facilities or wholesale dealers take place. So first we segregate and then we transfer them and then the remaining residual waste can go for RDF, landfilling, or even composting if you have got mixed waste, then we also get waste for composting as well.

So that means, we first take out the recycling if I ever got a mixed waste stream, I will first take out the recyclable whatever remains there I will find the organic part, the inorganic part and the inorganic part will go to RDF, whatever cannot go to RDF that is whichever has calorific value less than 1500 it will go to the landfill sites along with the inert materials and this all this pricing could be done manually or via mechanized means.

Now, even the processing site that is not in MRF that means the processing site where we either produce compost or RDF there also we can engage manual or mechanical presorting that means before we actually do the process of actually converting that waste into something usable we can do some sort of presorting of waste to take out either the recyclables or to take out some other inert materials and so on.

And similarly, special waste such as domestic hazardous waste, it has to be segregated from dry waste at MRF and then dispose to a TSDF. So this is where this hazardous waste is being dealt with and this is again also a disposal facility that we have to also that means instead of sending to a MRF we will send it to a TSDF. So this image actually illustrates this is from Zhu et al. 2008 and we have adopted it from CPHEEO manual.

So you can see that waste is being generated, some can be used as animal feed in the house itself, some can be we can do local organic composting inside my residences, and we can use it for agriculture or we can segregate the waste, then we can send it to a primary collection, this through primary collection it goes into the transfer station, and some presorted recyclables can be already sold to the kabadi system from there it can go into the different waste streams for plastic, paper and all and eventually it reaches the recycling industry.

Or through transport through this transfer point, we can do this MRF we can set up the MRF facilities where sorting is done and then again we can take it to this intermediaries and finally, it goes into the recycling industry. And in between waste pickers can also get waste from the community bins and again sell it to the divide the waste into different categories and sell it to that different recyclers.

So from transfer point some amount of waste is transported to the processing and treatment facilities and some from there, the rejects goes into the landfill sites, some amount directly is taken to the landfill site of course, and the other goes into the organic facilities where compost organic waste is taken to the composting facilities and eventually you can use that compost. So more or less this is how the materials can be recovered from the waste stream.

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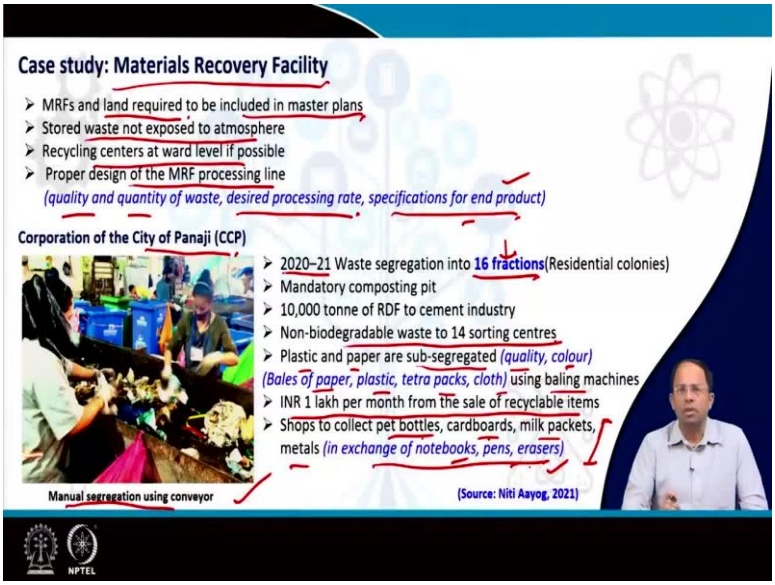

So now, we will talk about some case studies like for example, wherever we are talking about setting up material recovery facilities, we have to decide what amount of land is required and we have to include this in our master plan, that means in master plans we have to make provisions for land required for setting up this MRF within the city itself, maybe the decentralized ones. And stored waste within the MRF the stored waste should not be exposed to the atmosphere, so of course, it should be within shades and all.

Recycling centers should be set up at ward level if possible, if not at least for a group of wards we consider one facility. And the design of the MRF processing line that is the sorting line that has to be designed properly, it is based on the quality and the quantity of the waste that we receive, if it is mixed with the sorting line would be different, if it is segregated versus the sorting line will be different. That desire processing rate at what rate I am going to recover the materials.

So if I want to recover more, so I have to have more number of people engaged, so the processing line should be bigger and specifications of the end product, how much categorizations we want to recover that means should I recover paper and the different categories of paper or plastic and different categories of plastic, so what hierarchy of waste that has to be determined based on what is my requirement for end product.

So if in case of Panaji, as you remember from we have learned this earlier as well, the here the waste is divided into 16 fractions, why? Because there is a they have made the city has made agreements with Tetra pack companies, they have made agreements with this milk

plastic packet companies to send those packets back to them. So of course, they will have so many attractions, so not only plastic, they will subdivide it into Tetra pack, then they will make this milk plastic and all these things.

So this from 2021, they have started dividing the waste into 16 fractions. And out of this they will they have non-biodegradable waste is sorted in 14 sorting centers as you can see over here, this is manual segregation is being done but we are using a conveyor belt, the waste is first loaded put into the conveyor via some hopper and then from the conveyor people can pick up the waste feature to be recycled.

And plastic paper are sub segregated. So that means paper and plastic are further categorized like based on quality and color of this particular material. And finally, bales of paper, plastic, Tetra pack, clothes are prepared using baling machines and then they are transferred to their respective processing sites. And usually they are generating around one lakh rupees per month from the sale of recyclable items.

And there are shops in that ULB, in Panaji, which will collect pet bottles, cardboard, milk packets, or metals, in exchange of notebooks, pens and erasers. That means people will get this notebooks, pen, erasers if they can give this pet bottles, cardboards back to those particular shop that is reducing that effort of the ULB that is the investment of the ULB as well.

So that means wherever we are setting up of a MRFs facility or a recycling plant, we are preparing a recycling plant for an urban area, we have to think we have to make agreements with different recyclers, we have to design systems of collection, some of it could be voluntary like this off, it could be like your mandatory collection and then segregation and sorting. So we have to overall plan this entire process.

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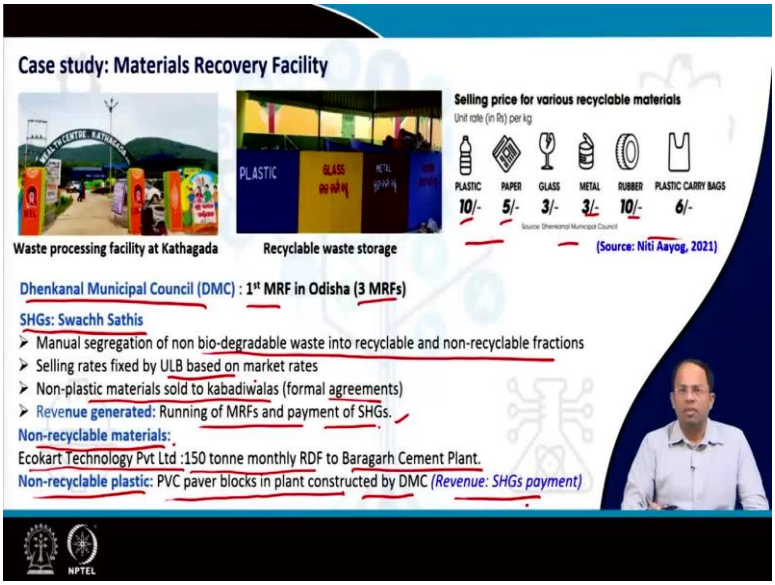

So next coming to the Dhenkanal Municipal Council. They set up the first MRF facility in Odisha. Now they have got three MRFs and they are using self help groups Swachh Sathis to sell to do this kind of sorting. Manual segregation of non-biodegradable waste into recyclable and non-recyclable fractions, they sell the rates fixed by the ULB as you could see that these are the rates fixed by this ULB, plastic bottles 10, paper rupees 5, and this is per kilogram. Metal rupees 3 per kilogram, rubber rupees 10 per kilogram and so on. So this is the rate that has been fixed.

Non plastic materials are sold to kabadi wala's through formal agreements. So that is a paper and all these things are said to those kabadi wala's and there are agreements in place for that. The overall revenue that they are generating is used to run the MRF's and for payment of this Swachh Sathis workers. So that means they are utilizing the money they are generating to do the payment and to do this operate this kind of facility.

The non-recyclable materials, materials which is cannot be recycled directly we can have an option to make them into this refuse drive fuels. So they are employed EcoKart technology Private Limited they collect around 150 tons of RDF and they take it to the Baraga cement plant where they are used as well as. And non-recyclable plastics could be is converted into PVC paver blocks in, in a plant constructed by DMC themselves, whatever revenue is generated by this plant is again used for payment of SHG's, self help groups.

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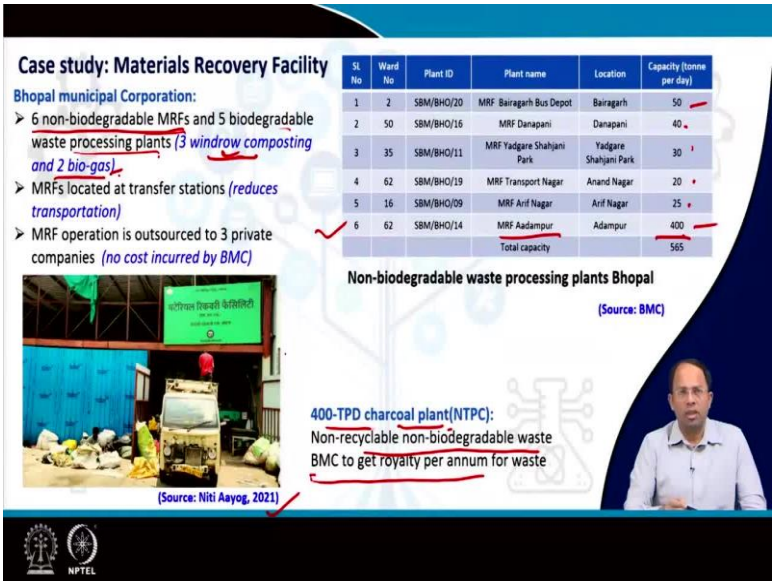

SL No	Ward No	Plant ID	Plant name	Location	Capacity (tonne per day)
1	2	SBM/BHO/20	MRF Bairagarh Bus Depot	Bairagarh	50
2	50	SBM/BHO/16	MRF Danapani	Danapani	40
3	35	SBM/BHO/11	MRF Yadgare Shahjani Park	Yadgare Shahjani Park	30
4	62	SBM/BHO/19	MRF Transport Nagar	Anand Nagar	20
5	16	SBM/BHO/09	MRF Arif Nagar	Arif Nagar	25
6	62	SBM/BHO/14	MRF Aadampur	Adampur	400
			Total capacity		565

Then coming to Bhopal Municipal Corporation here MRF is done at a very large scale it is very effective also, they have six non-biodegradable MRFs and five biodegradable waste processing plants, three windrow composting and two biogas plants, we will learn about this window biogas all these things later on, biogas is the bio methanation. So organic waste is either composted or we do bio methanation. So whereas you we have six non-biodegradable MRFs and you can see the list of these six plants over here, and the capacity of this plant ranges from around 50 tons to even 400 tons. So this is a centralised one. So it is a big one whereas, these are smaller ones.

So in addition to this they have a 400 tons per day charcoal plant, which is run by NTPC and non-recyclable, non-biodegradable waste is actually can use by this plant and this is used as well of course, and the Bhopal Municipal Corporation gets royalty per annum for this particular waste. So you can see the image of one of this recycling (cent) or this material recovery centers.

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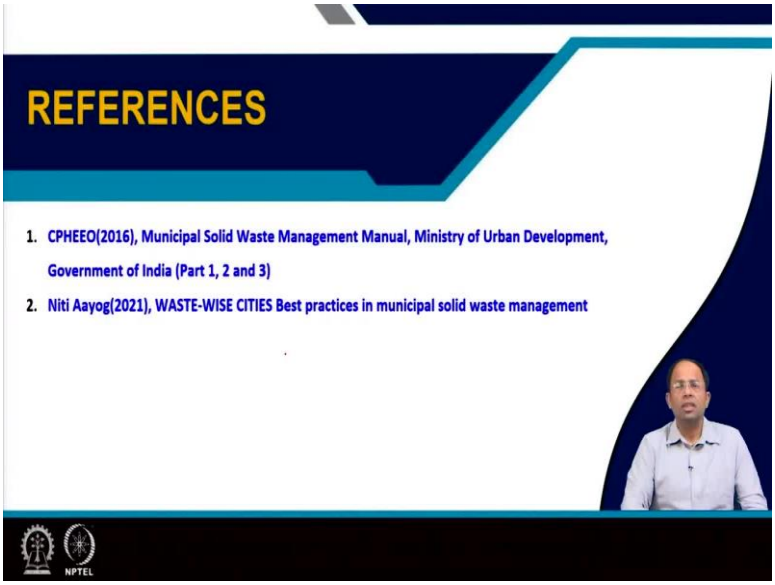

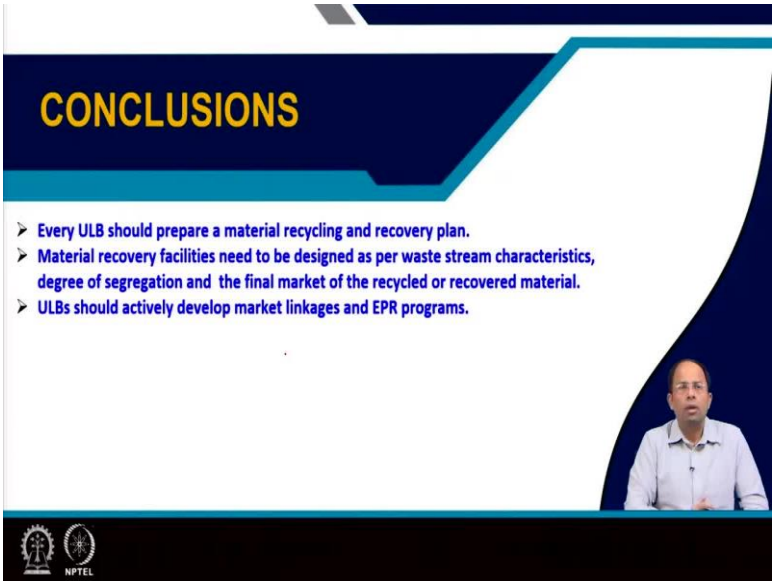

So these are some of the references you can study. To conclude every ULB should prepare a material recycling and recovery plan. Material recovery facilities needs to be designed as per the waste stream characteristics, degree of segregation at the final market of the recycled or recovered material. And ULB should actively develop market linkages and EPR programs. Thank you.