System Design for Sustainability
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Week – 04
Lecture -02
Life Cycle Assessment using Software

Hello every one, so we have been discussing about Life Cycle Assessment and how to do it. Today we will see, we how to do this Life Cycle Assessment using a Software.

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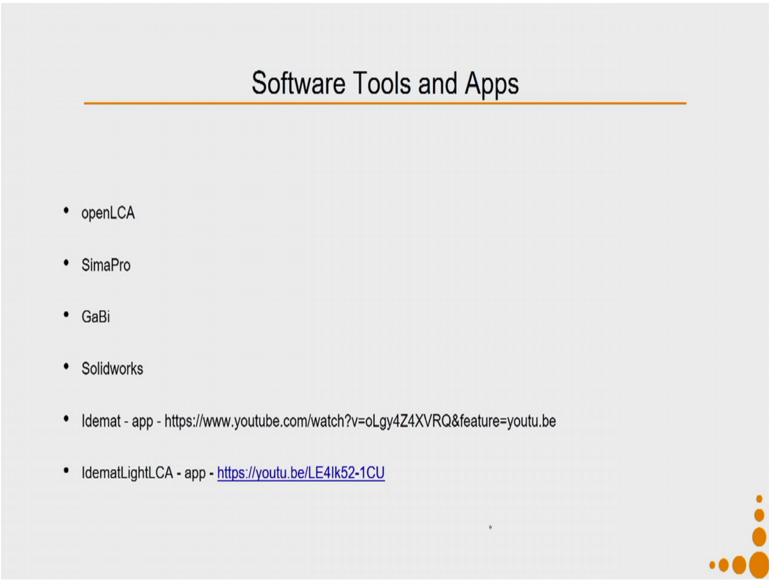

So, there are multiple numbers of tools, software tools as well as nowadays there are also applications apps available which can be used for doing life cycle assessment. So, open LCA is a software which is a free software and it also has lots of free data bases. So, you can go to open LCA you can use SimaPro or GaBi. SimaPro and GaBi both of them are paid software's, Solid works which is a three modelling works it also has certain aspects of life cycle assessment into it. So, when you have designed a particular product and you allocate material to that particular product various parts of the product then you can do a life cycle assessment and you can also make modifications to the material that you have used.

So, say for example, you use material polyethylene, which is a plastic then you identify the life cycle assessment where polyethylene as a material because, polyethylene has a different density as compared to polypropylene. So, you will be able to have bottles if you are making bottles of different weight with the change of the material and as a result the life cycle impact will change for both the designs with changing the material. So, it works allows you to that do that kind of manipulation and see how to make a better product with the given considerations, but that is only for the product assembly that you have at that point of time. So, it is more like a cradle to get LCA.

Then there are two apps, these are very light weight apps and you can use them on any Android or iOS base device. So, the first app is called as Idemat, the next app is IdematLightLCA. So, the Idemat the first app it has data related tool lots of different processes at this moment the data base has some 700 materials and processes and you could pick up all those materials that you require. Then there was an excel sheet available which is connected to this app you can put the require data in that particular app and then do the life cycle assessment calculations, but recently they have come up with a more better application it is a IdematLightLCA in which the app itself you can do life cycle assessment.

So, you can for doing any kind of advance level of life cycle assessment it is very important to know how to use this software's open LCA, or SimaPro, or GaBi because they are very sophisticated software's with lots of data bases, country specific data bases and so on. But they are very difficult to learn. So, what we will do in this course is our aim is that anybody and everybody should be able to do life cycle assessment on the go. So, the IdmatLightLCA app can help you to do that it is very simple to learn. So, we will learn how to use that particular app today.

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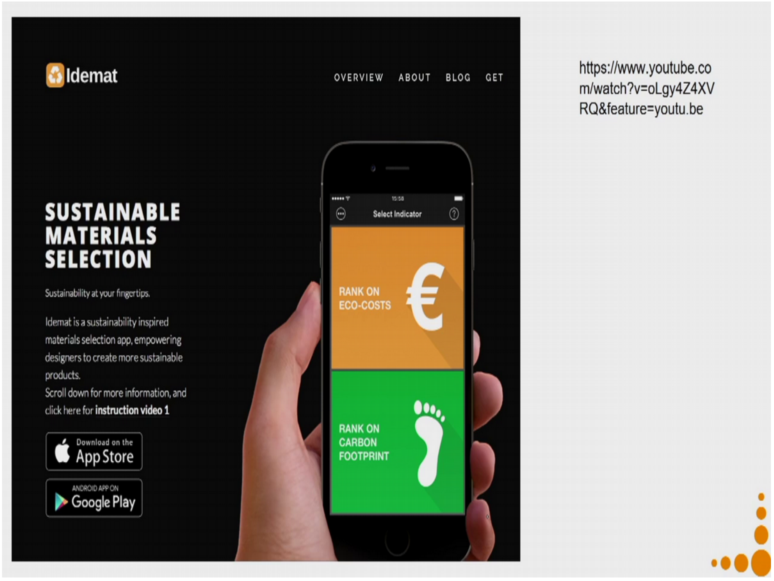

So, there are videos explaining both the apps because the second app is build on top of the first app. So, I would suggest you also look for the first app the video related to it and then also look at the second app and the video related to it. We will also do a demonstration now on how to do this life cycle assessment.

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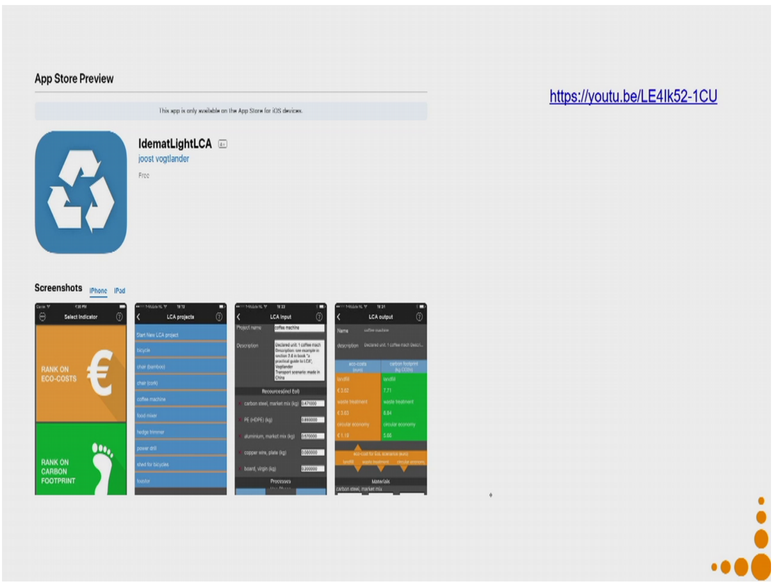

So, the Idemat app as you can see it can it has two columns rank on eco-costs and rank on carbon footprint. So, when you are trying to rank on the eco-costs it gives you more details and you can also go on carbon footprint which gives lesser amount of detail, but the benefit of this software is you can interchange. So, if you are doing it with eco-costs you can at that point of time also change it to carbon footprint. So, it is a very very versatile application.

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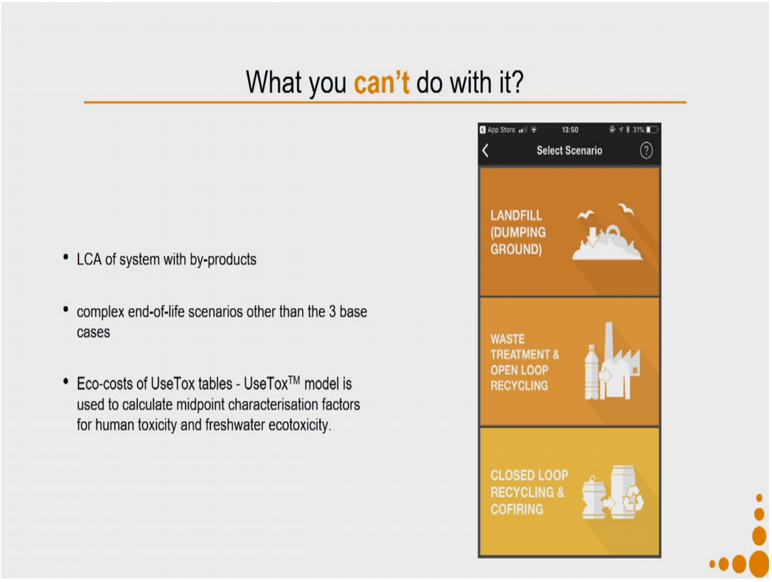

So, let us first start with the basics of this application. So, let us first consider what we cannot do, then we will see what we can do, and then go into the app. So, what you cannot do is so, LCA of a system with by-products. So, you know what LCA of a system with by-products is we discussed that in our previous lectures when we are trying to understand life cycle assessment. So, you cannot do LCA of systems with by-products in this case. You cannot do complex end of life scenarios other than the 3 base cases.

So, the 3 base cases in this application are landfill dumping ground, or waste treatment, and open loop recycling, or closed loop recycling and cofiring. So, these are the only 3 end of life scenarios for which you can a do a life cycle assessment. You cannot do it for more complex scenarios, but in most design cases when you are trying to design new products and solutions the facility which is being given by these 3 scenarios is good enough.

Now, let us go to eco-costs of Use Tox tables. So, Use Tox is a model to calculate midpoint characterisation factors for human toxicity and freshwater eco toxicity, again we do not need to dwell a lot into this. This is something which LCA experts can go ahead with and in case you are interested more in this topic you can do further courses.

So, all the software tools that I mentioned in the beginning of this course all those tools have tutorials some of those tutorials are freely available, for others you can subscribe to their facility on payment basis they teach you using those software's and doing life cycle assessment.

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So, what you can do with this particular app is you can do cradle to grave analyses, you can also do cradle to cradle analyses, you can do benchmarking the advantages of circular business concepts, you can benchmark the difference of innovative product differences. So, I make product a, product b, and product c and so, I can compare the difference between this a b c and also from the existing context. So, that is why it says you can benchmark the difference of innovative product designs.

You can also benchmark the differences in service systems and finally, it can also help you to calculate eco-costs for an environmental product declaration. So, that is meant for EPD declaration, but we will not go into the details of it, because the whole aim of this particular course is to help you in designing for sustainability. So, we are mostly focusing on the design phase of it, where we should be able to quickly decide between options. So, let us look at the app.

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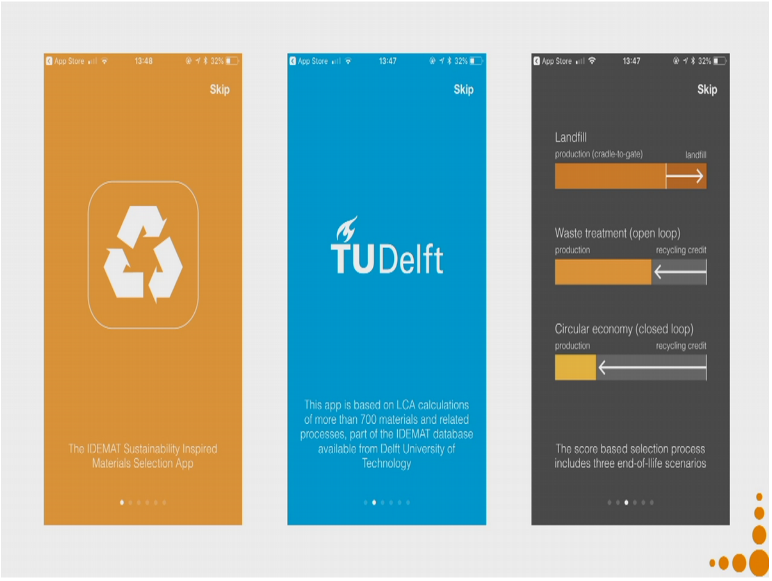

So, the IDEMAT sustainability inspired materials selection app. So, when you first time start this app again you have to be very careful this app is there for all Android and iOS devices. So, you cannot use this application on your computer or laptop. So, the this app is inspired by the IDEMAT sustainability inspired material selection app and it has been concede by TUDelft that is a university in Netherlands.

So, this app is based on LCA calculations of more than 700 materials and related processes and it is part of the Idemat database available from Delft University of Technology. This data base is not very very comprehensive. So, many times you might find that data is missing it is also not very region specific. So, there are few data points available which are for the Indian context, but not all data points for regional context are available.

Then it consists of the all the scores are based on the selection process which includes three ends of life scenarios. So, you have the landfill scenario, you have the waste treatment scenario; that is the open loop waste treatment, and you have the closed loop that is the circular economy scenario. So, if you look at these bars what you can see from the bars you can know what is the impact level, what is the eco burden. So, these bars try to show you the eco impact. So, the eco impact on this particular context is the lowest and in the context of land landfill it is the highest.

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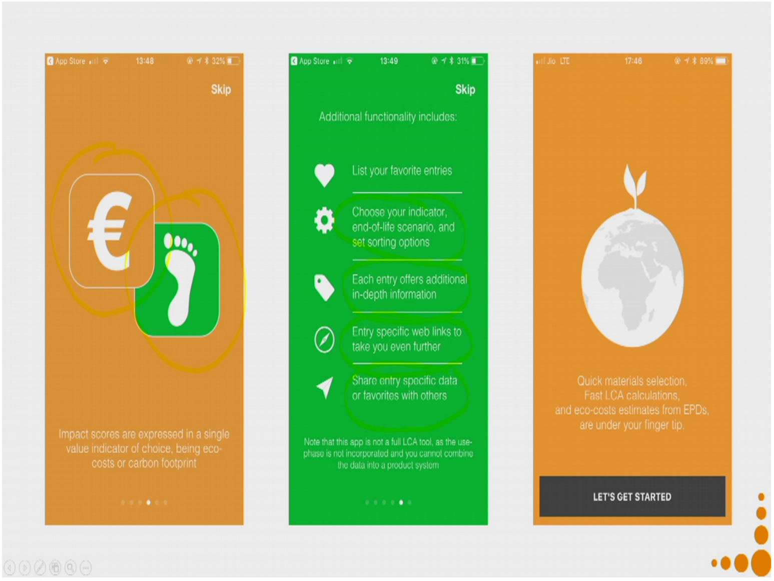

Next what you will see on this app is you can do the impact scores on two value indicators of your choice. So, the orange one it is meant for eco-costs and this green box it represents carbon footprint. It also has additional functionality so you can list your favourite entries say for example, you are someone who designs lot of products in plastics and you are into designing plastics for the FMCG market. So, a majority of them are polypropylene or polyethylene and various grades of polypropylene and polyethylene. So, you might decide to list them as your favourite entries. So, that you can reach to them much faster you can choose your indicator, end of life scenario and set shorting sorting options. We will discuss how we will do that.

There is also each entry offers additional in depth information say for example; you are very very new to this particular platform. You know you want to use plastics for your design. So, this platform helps you to compare all available plastics on its eco-costs as well as on your carbon footprint depending on what option you have selected also depending on the end of life scenario that you have selected, plus it also gives all the mechanical properties all the electrical properties and so on which you might require to consider in order to put a particular plastic into your design. Hence, it is a very very comprehensive app and it is an extremely useful app for all students because, if you do not know so much about material, this app automatically educates you about all those materials.

So, then there is entry specific web links to take you even further and you can share your entry or specific data or your favourite with others. So, all kinds of sharing options are available, sharing through messaging, they are sharing through emailing also all the LCA’s that you do you can share it. So, let us get started with this application. So, now we will do the demonstration of this application.

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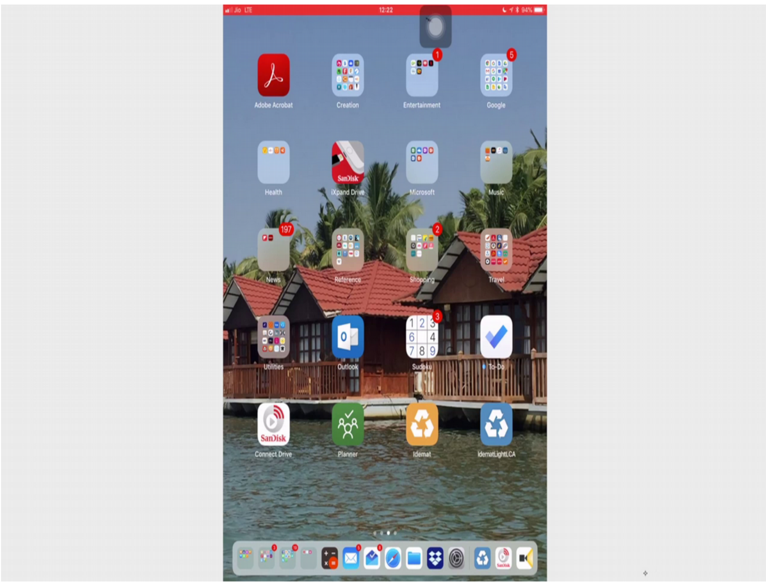

So, as you can see I have both my apps the Idemat app is over here and the IdematLightLCA app is over here. So, let us open the IdematLightLCA app and see how see this app works.

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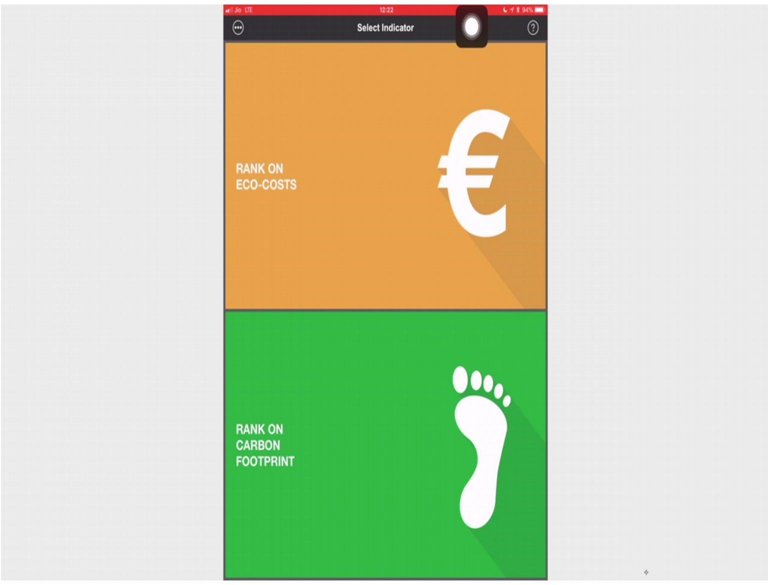

So, on this screen you can see you can select whether you want to rank on the eco-costs or whether you want to rank on carbon footprint. You can see these 3 dots over here at the corner.

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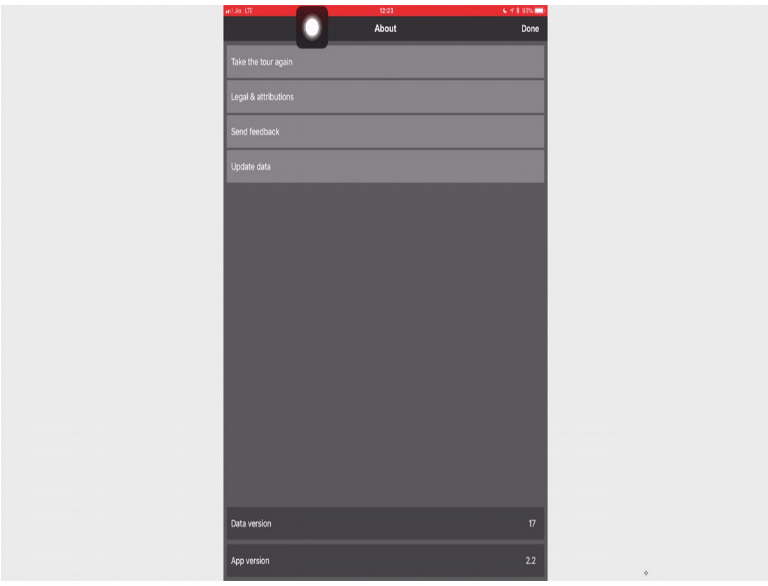

So, if I click on those dots you can take the tour again.

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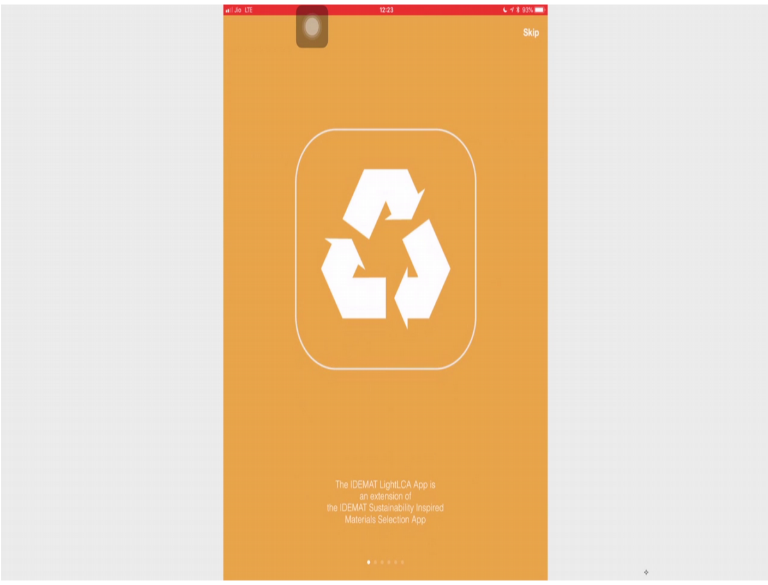

So, if I say take the tour again you go through the slides which I just showed you in the power point. So, you can also see so when you first time install this particular app and you start this app; it is going to say that the data base is old please update your data base. So, you should update your data base currently you can see the data version is 17 and the app version is 2.2.

You can keep on doing the update app, but this app will also automatically update. So, every time there is an update available it will do that job automatically for you. On the right hand corner of this app you will always find an icon other either it is question mark or it is the symbol of settings it differs from screen to screen. So, to know more about all these components you can click on the question mark.

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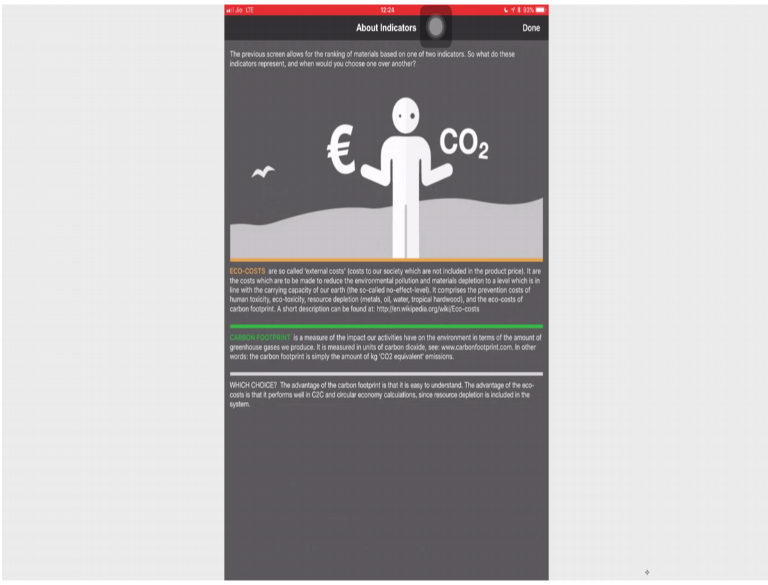

So, when I click on the question mark I can get to know what eco-costs and are and what carbon footprint is. So, let us have a quick recap eco-costs are so called External Costs, costs to our society which are not included in the product price. Carbon footprint is a measure of the impact our activities have on the environment in terms of the amount of green gas greenhouse gases we produce. So, which choice should you; make that is always an important question when we go ahead we can see at any point of the app the let us you to change your choice, but let us start from one choice, but which choice.

So, the advantage of the carbon footprint is that it is easy to understand because you know how many carbon dioxide equivalents your particular design features or the materials or the process used is going to produce. The advantage of the eco-costs is that it performs well in the cradle to cradle and circular economy calculations. Since resource depletion is included in the system, so the carbon footprint it does not talk about resource depletion.

It only talks about the carbon footprint expressed in terms of CO2 equivalents. Whereas, if you select the eco-costs it will also involve the eco-costs because of the carbon footprint and it will also include resource depletion. Let us go ahead and we will know what it actually means. So, let us first select rank on eco costs.

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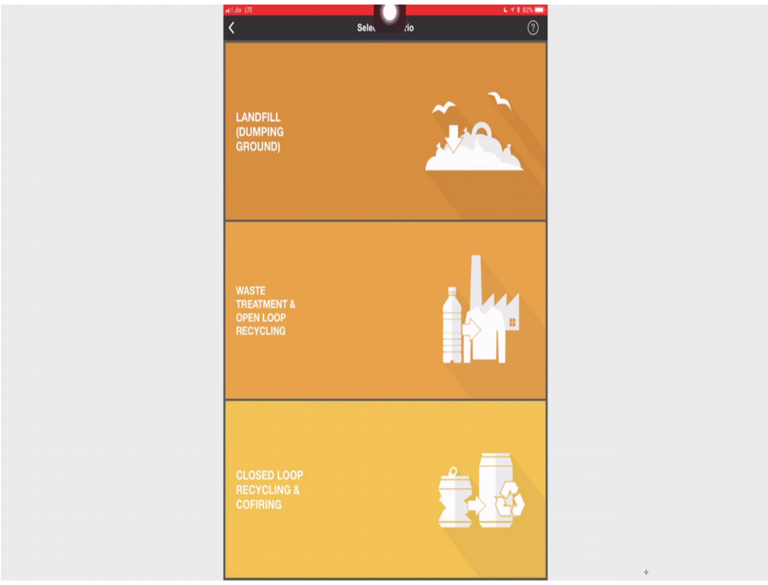

So, once I selected rank on eco costs, then next thing says is select your scenarios, so I have the landfill scenario I have the waste treatment and open loop recycling and I have the closed loop recycling and cofiring. You can again see in this screen also you have a question mark. So, let us press the question mark and see what it has got to offer us.

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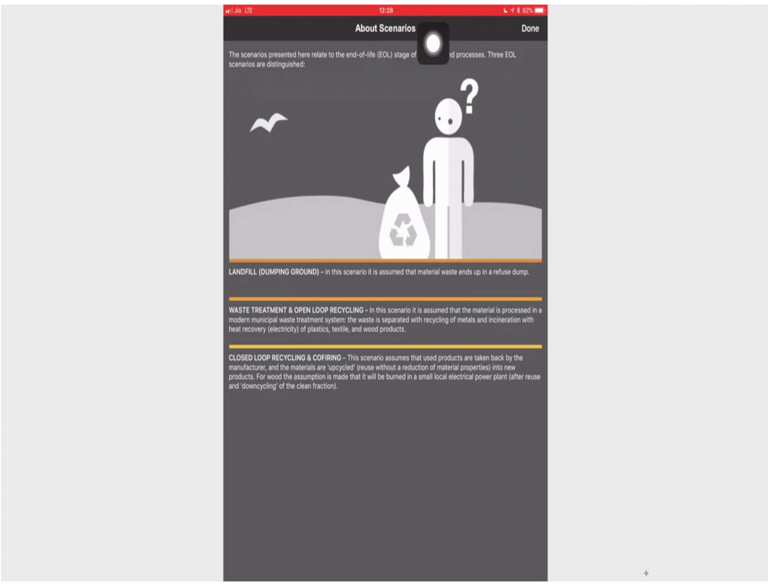

So, the scenarios presented here relate to the end of life stage of materials and processes 3 end of life scenarios are distinguished for the landfill or dumping ground in this scenario it is assumed that material waste ends up in a refuse dump. Waste treatment and open loop recycling in this scenario it is assumed that the material is processed in a modern municipal waste treatment system the waste is separated with recycling of metals and incineration with heat recovery electricity of plastics textile and wood products.

The closed loop recycling and co firing this scenario assumes that used products are taken back by the manufacturer and the materials are up cycled. That is reuse without a reduction of material properties into new products for wood the assumption is made that it will be burned in a small local electrical power plant after reuse and down cycling of the clean fraction. So, now after reading this we precisely know what is meant by each of this end of life scenarios presented in this particular app. Now let us see how what kind of difference comes depending on the data I am going to see. So, let us select landfill and dumping ground scenario.

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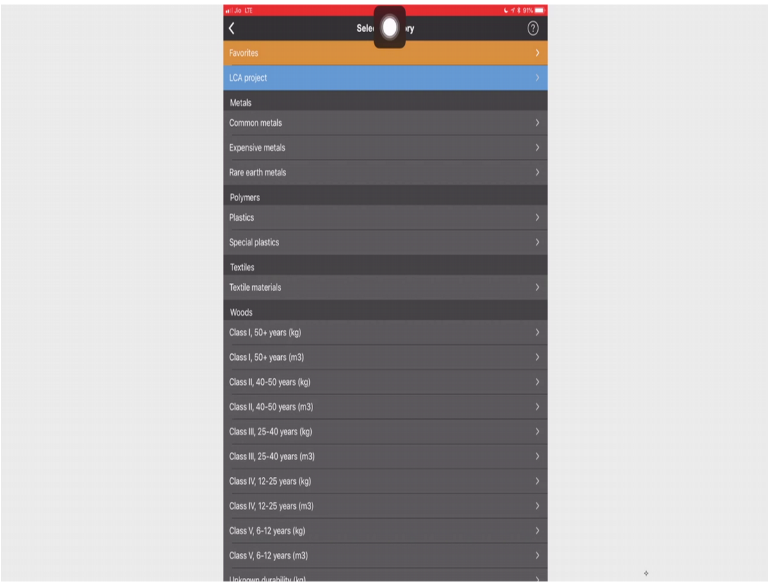

So, here you can see my first tab talks about favourites the second one talks about LCA project. I also have a question mark over here on this tab then I have lots of materials and process. So, I have metals, common metals, expensive metals, rare earth metals. Then I have polymers categorised as plastics and special plastics I also have some textile materials I have different types of wood

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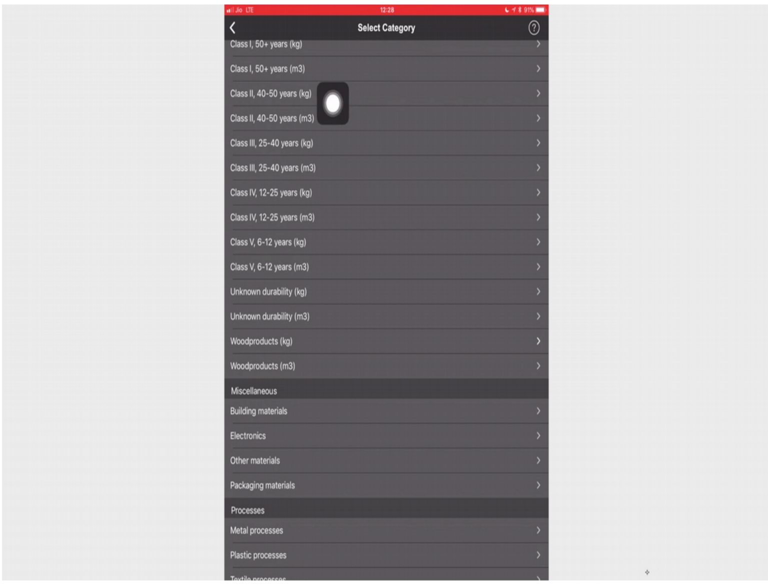

So, you can see the wood has been classified as class 1 and class 2 and as something which is 50 plus year, and something which is 25 to 40 years, or 12 to 25 years. Let us go we will just discuss in a while what that means. Then we have building materials electronics other materials packaging materials. In the processes we have metal related processes, plastic processes, textile processes, and wood processes. We also have data related to energy and fuels transport EPD midpoints will be used in case you want to do a EPD a an analysis for EPD then there is also.

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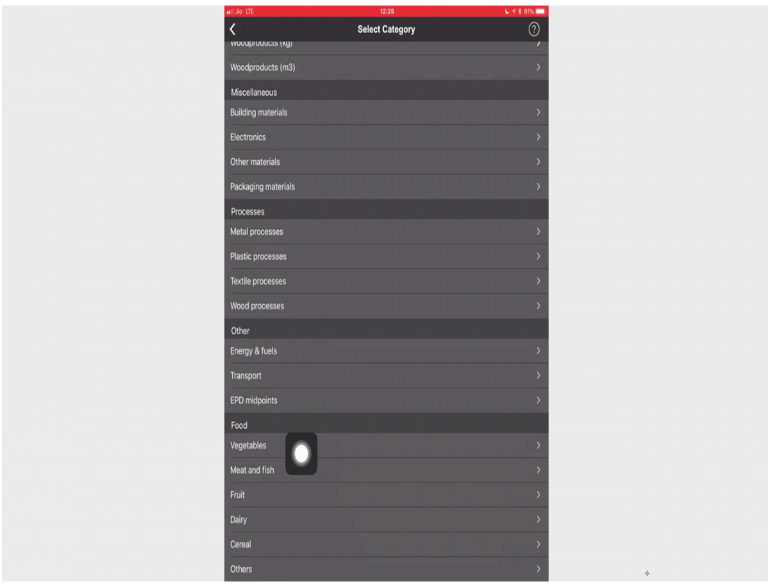

Data basis for different kinds of food like, vegetables, meat, and fish, fruit, dairy, cereals and some other things. So, this is a very comprehensive. List let us click on the question mark on the right hand corner. So, when you see the question mark.

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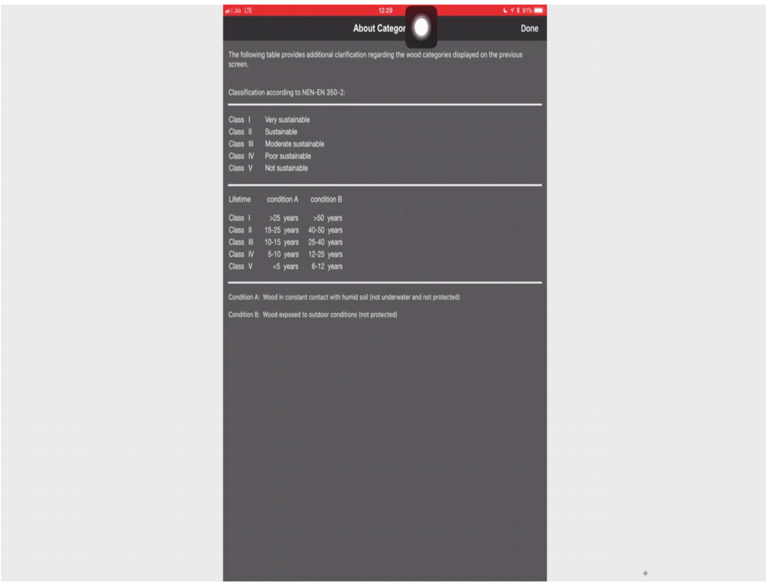

Because in this whole list of materials and processes what was not very clear is what this class 1, class 2 in the context of wood meant. So, this explains that. So, the following table provides additional clarification regarding the wood categories displayed on the previous screen. So, this classification is according to certain standards. So, class 1 implies very sustainable, class 2 is for sustainable, 3 for moderate sustainable, 4 for poor sustainable, and 5 for not sustainable.

Then you have two conditions, one is greater than 25 the other is greater than 50 that is the context of class1. In the context of class 2 again it is 15 to 25 years and condition B is 40 to 50 years. So, that is how the whole condition A condition B is defined. What is meaning of condition A? So, condition A is wood in constant contact with humid soil, not underwater and not protected. Condition B is wood exposed to outdoor conditions. So, it is not protected wood. So, depending on your usage context you will know which particular category it falls to. Now, let us look at the favourites.

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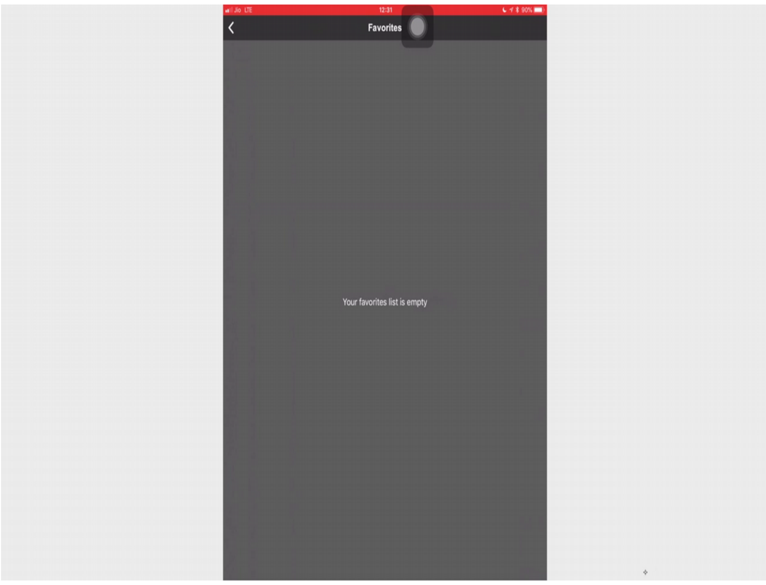

So, when you click on the favourites, all your materials or processes or energy whatever you have put in favourites will come up over here. Let us look into the LCA project so when I click on the LCA project

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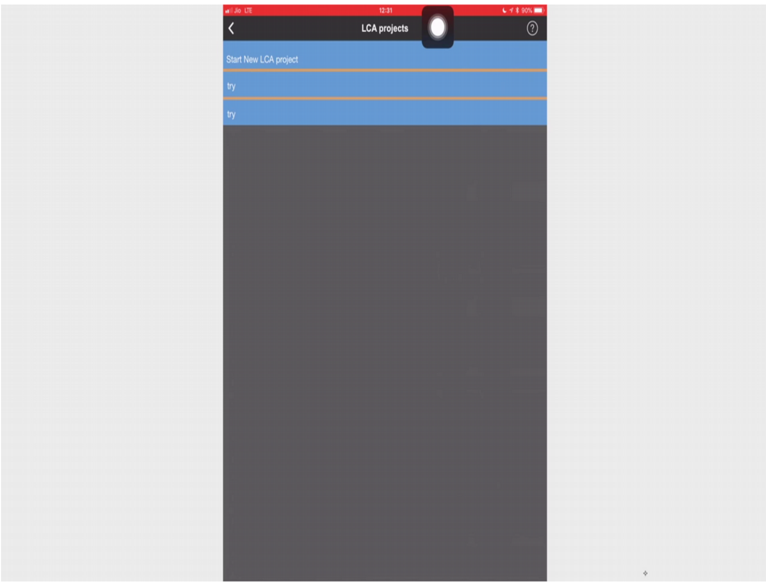

So, here you can see you can start new LCA project and you can also look up your existing LCA projects. Let us say I have this one project over here

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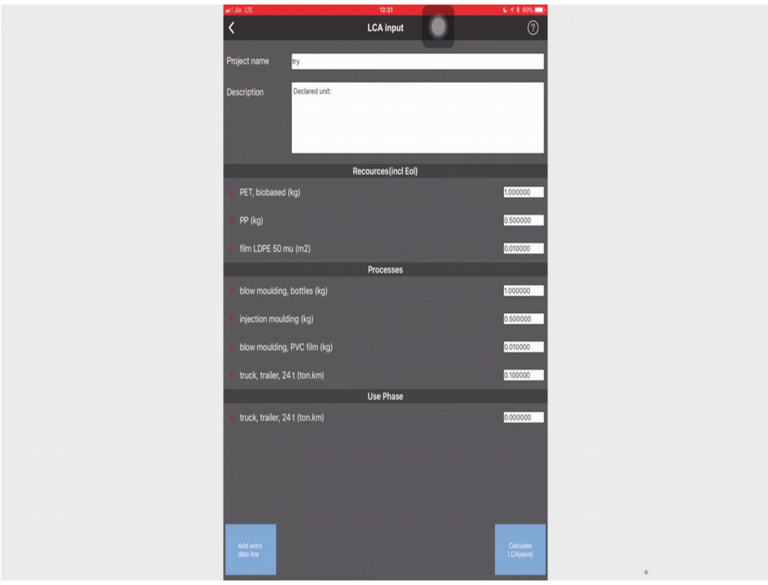

And I can look at the project. So, if I see this dash board first you have to give project name then you have to give the description which will contain either your functional unit or declared unit. Then you will include all the material resources so I have PET bio based the unit is very important. So, here the unit is kg then polypropylene film LDPE so these are the resources. Then I have to put over here the measurement in terms of the unit which is present over here.

Then my processes so I have blow moulding processes, injection moulding process. So I selected the process responsible. Then I also need some truck trailer which is a 24 ton truck trailer and the unit over here is ton per kilometre sorry ton kilometre. Then we go into looking at each of these components you will see that you can select two types of trucks, one type based on ton kilometre, and another type based on metre cube kilometre.

We will discuss about it little later again you put on the measurements, then in the used phase I again need another truck and trailer. So, again I will put data over here when I am done with this process you can prey press calculate LCA or that button also helps you to save it. I can also add on extra data line. So, say for example, let us press extra data line you get your entire list of materials and processes and you can select from there. So, let us say I select a common metal.

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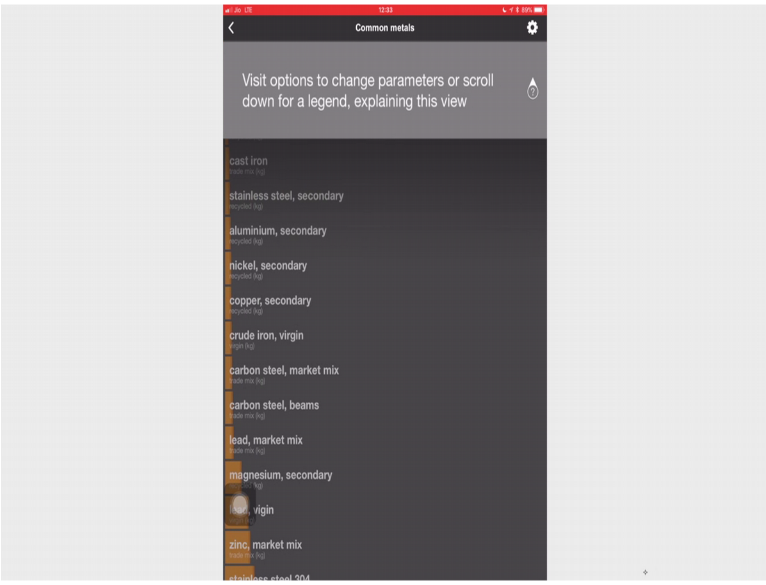

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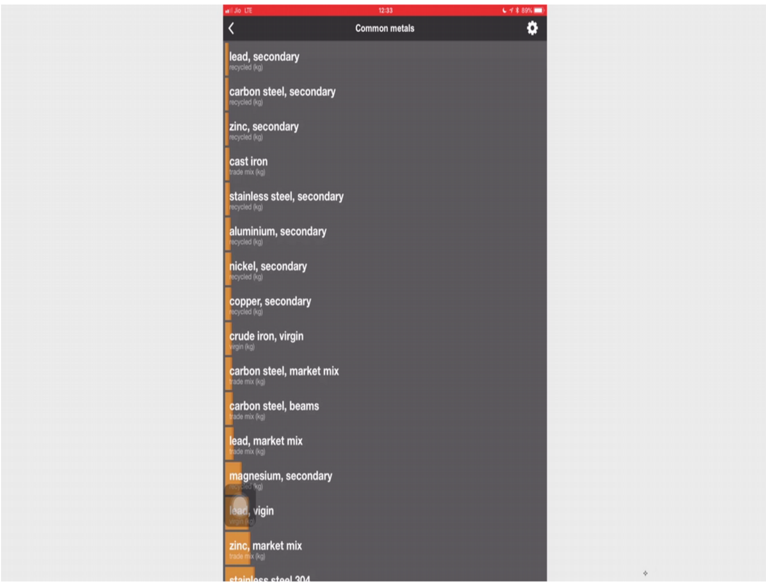

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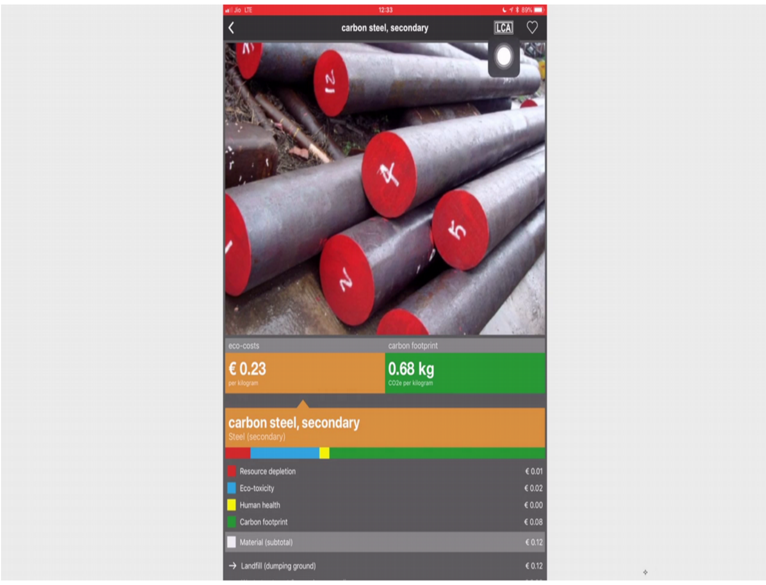

And I want to use carbon steel so, once I have selected carbon steel you can see at this place there is something called as LCA and this is the icon for favourite. So, if I click on favourite it will be added to my favourite list. If I click on LCA it will be added to the LCA document, which from where I came over here. So, let us click on the LCA so I clicked on the LCA it says added to project and now let us go back using this particular icon go back, go back, and you can see I have my carbon steel secondary in kg’s added to this. So, if I add the measurement over here say I add 1 kg and then I say calculate and save.

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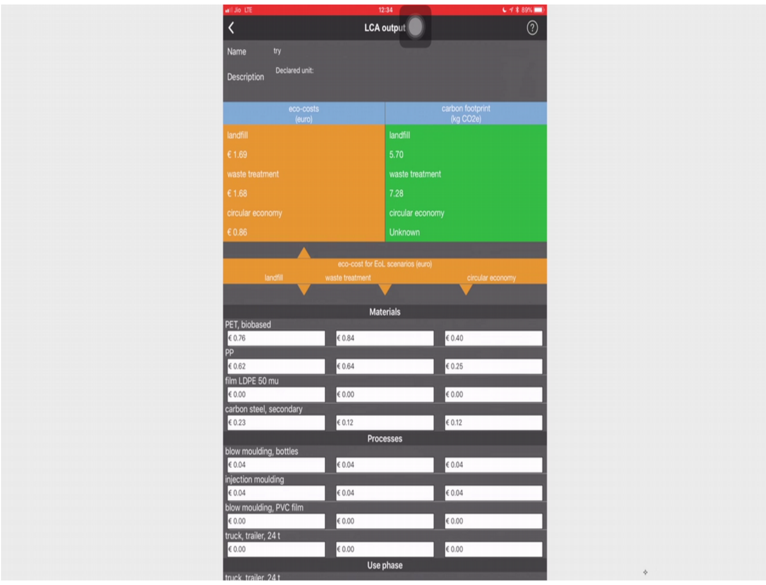

What you get over here is the LCA output. So, right now so because this yellow bar is highlighted so you know that I am calculating eco-costs. I can click on this green space so as soon as I click on this green space, this bar becomes green and now I am trying to see the carbon footprint only. So, that is why I told you that this is very very versatile software and it let us you change your selections at multiple points of time.

So, if I see the carbon footprint calculation, what it gives me? Is landfill related because I have selected the end of life scenario as landfill. So, my carbon footprint of the landfill due to land filling will be 5.7 kg's of CO2 equivalent. The way due to waste treatment it will be 7.28 and because I am not going to circular economy so unknown and over here you get all the for individual material. So, the landfill for the PET bio so PET bio based is not like bio comparitable PET what it means is, bottle grade PET. So, for each and every material I know from here the land filling CO2 equivalent then for each of the processes the waste treatment carbon footprint is given and so on so if I scroll down.

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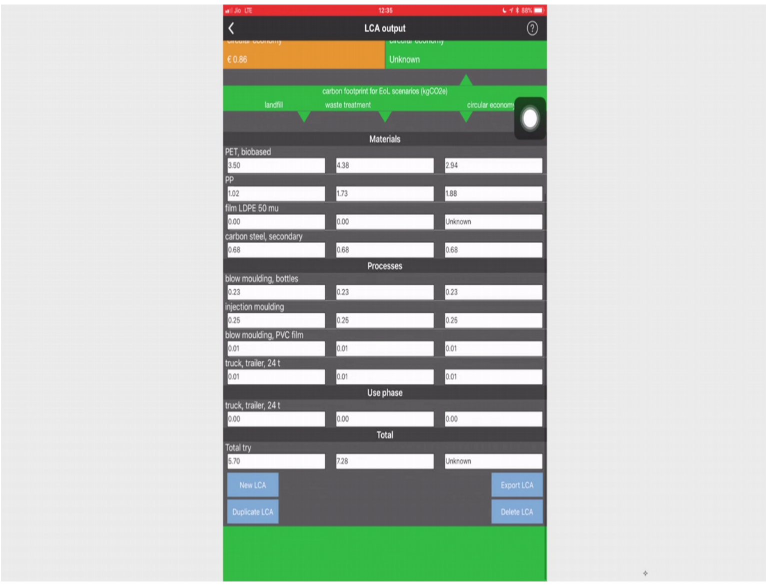

I can see the whole picture then over here you can see you have an option to export the LCA, when I press on export LCA. So, you can see there is this whole data the entire output is given.

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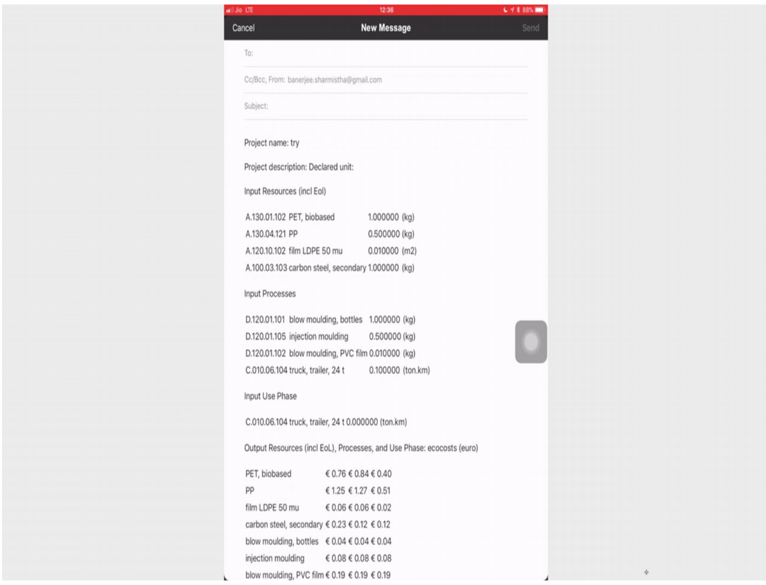

And you can mail it to yourself. You can also delete this LCA so I have an option to delete my LCA. What about what is this duplicate LCA meant for? So, what duplicate LCA will help you in doing is, say you want to compare two products. So, you want to compare between having polypropylene versus having polyethylene. So, when I do duplicate LCA I will get another new LCA which all these resources declared unit everything the same you change the project name over there to not have any kind of confusion.

Then what I will do is you can see this red crosses. So, I can cross the PET bio based and I can add the alternative material which I want to add over there. Similarly I can do the same with the processes so what it helps you is, you will not have to create the whole thing from new because you wanted to check by changing the material. Always remember changing the material when you change the material, you also have to change the weight makers bottle if it requires 1 gram of polyethylene terephthalicdoes not mean it require 1 gram of polyethylene because the density of the material is different you can produce different their thickness related limitation.

So, PET can produce very very thin bottles whereas, the cross section of the bottle wall is very thin whereas, polyethylene or polypropylene the wall cross section of the bottle is very much higher. So, you have to be also careful like what will be, that will an alternative design you should know how much weight that will consider once you change the weight of the materials you will also have to make changes in the transportation. So, let us go back now let us look at these materials. So, say if you go to the materials say we will click on common metals. So, when I click on common metals I get a list of all these materials.

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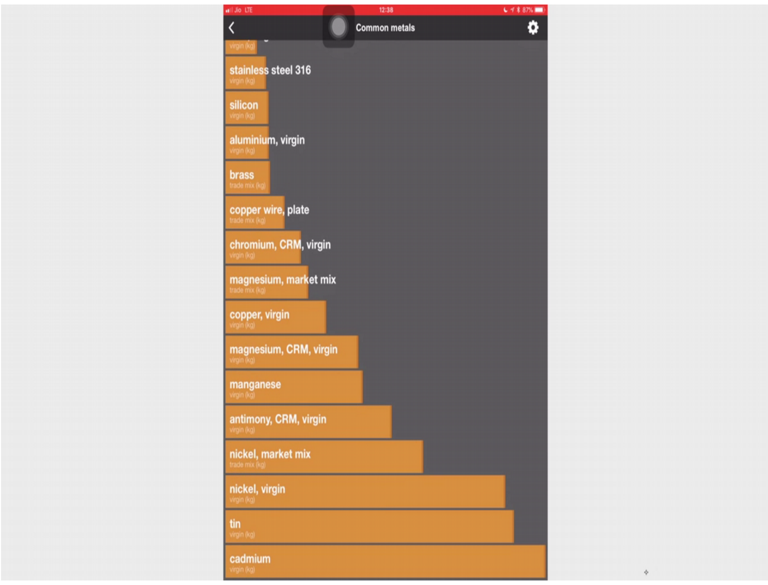

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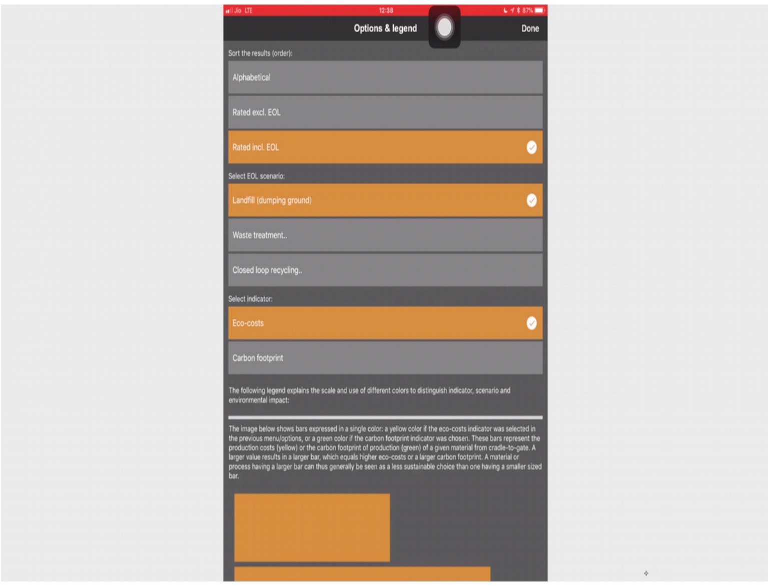

So, here on the right side you can see the a settings icon if I click on the settings icon. What you will have is an option to sort the results on alphabetical order on the order of end of life impact. So, the first one is where you exclude the end of life impact and the rating and then the second one is with the end of life included. So, say for example, when I look at this particular because I started with my eco-costs as the criteria. So, now since it is sorted on the basis of end of life included I know that from top to bottom of the screen my eco-costs increases. In case it is very difficult to find because say you are looking for steel, now you have to look through the entire chapter to find out where steel is. So, you can also sort it according to alphabetically.

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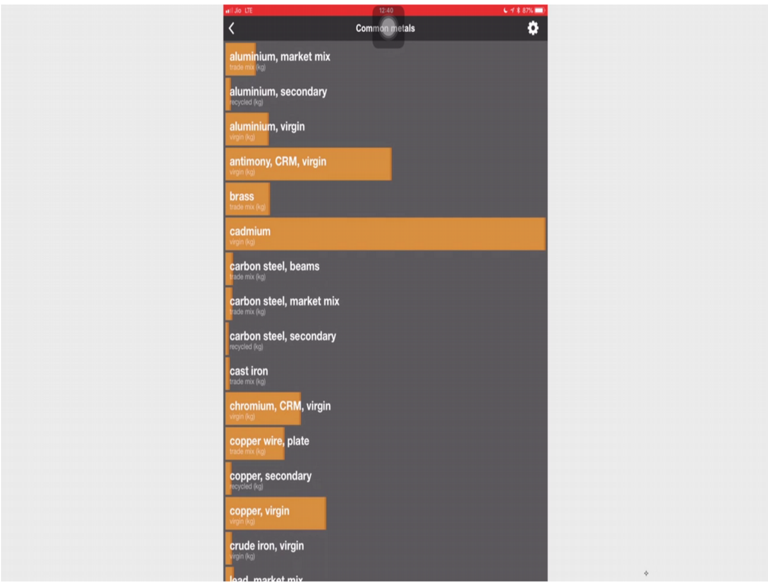

So, in that case it is easy to find, but the they are not on the basis of the carbon footprint. Here you can also see that end of life scenario can be changed. So, what difference does come between selecting landfill, waste treatment, or closed loop recycling that we will discuss now. Then you can also change your indicators so I am on eco-costs I can also make it carbon footprint. Let us make it carbon footprint and when I say done you will see now all your data is available on carbon footprint.

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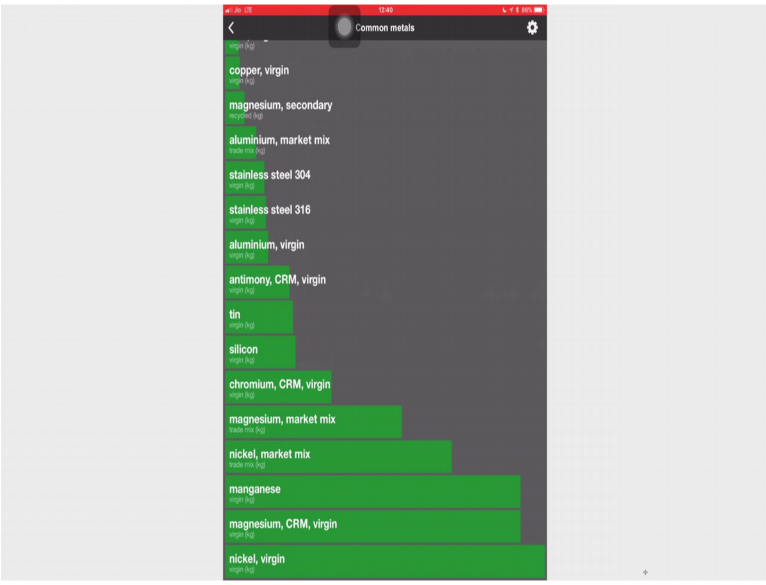

So, let us go back again and then change it to eco-costs where we were. Now there are certain legends which we need to understand what it means.

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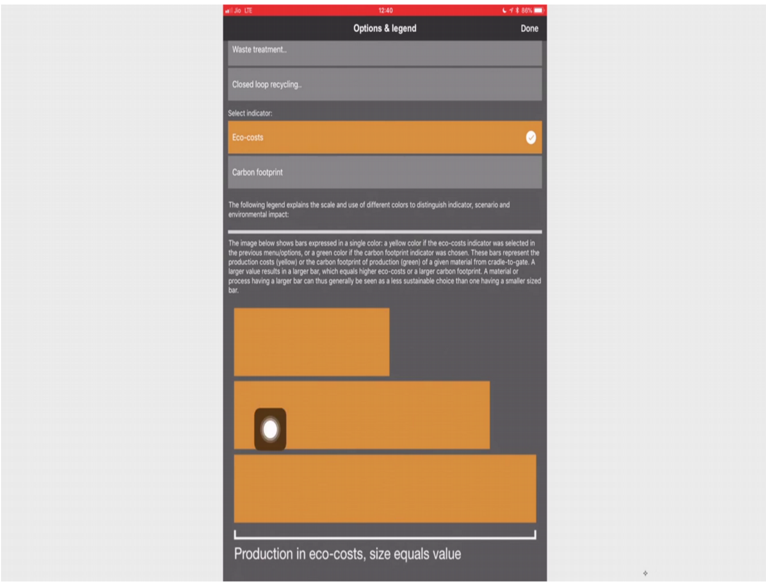

So, this first legend what do these bars mean. So, it is a production in eco-costs size equals value. So, the size of the bar equals the value of the eco costs. Now the image below shows bars expressed in a single colour or a yellow colour if the eco-costs indictor indicator was selected in the previous menu option or it will be a green colour. So, let us say if I select carbon footprint it will be a green colour bar larger the bar the greater the eco-costs or greater the carbon footprint.

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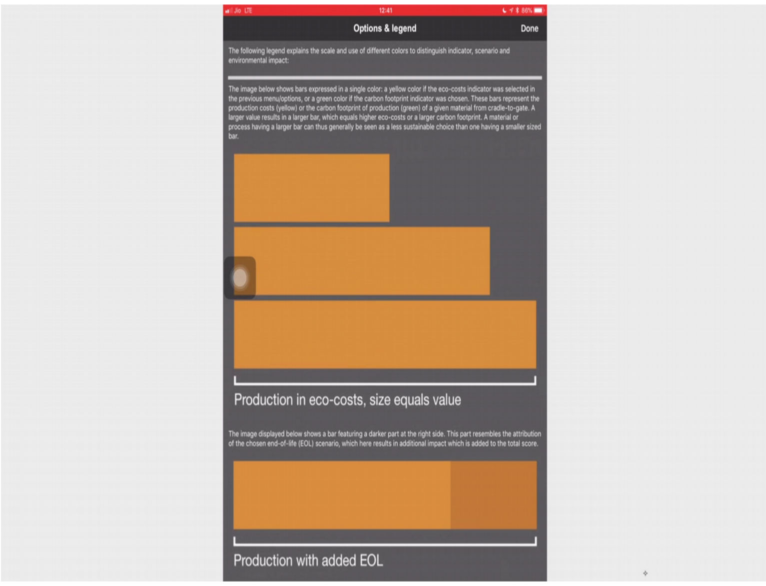

So, now coming to another kind of bar. So, here you can see two different colours if I change it to carbon footprint let us change it into carbon footprint again you can see two different colours so this is production with added end of life. So, if since I if I select only landfill option so if we go back so since I had selected the end of life.

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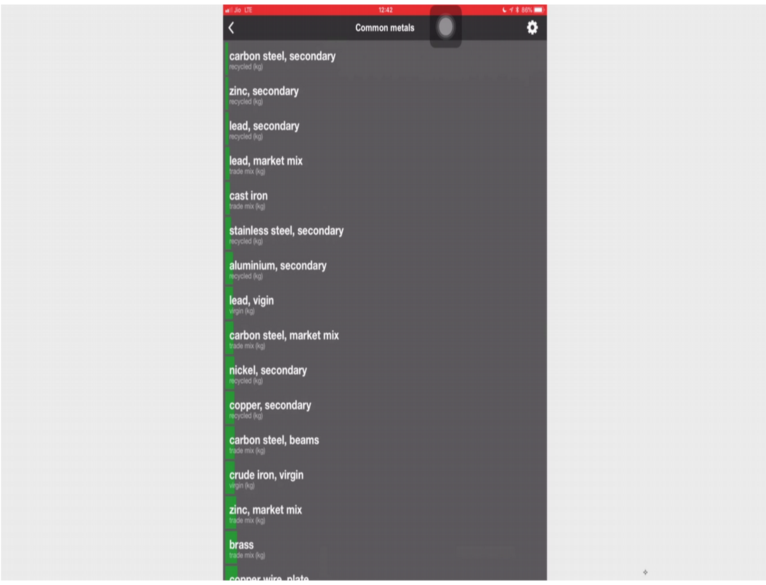

Option as land filling that is why you do not see that darker coloured bar over here let us change it.

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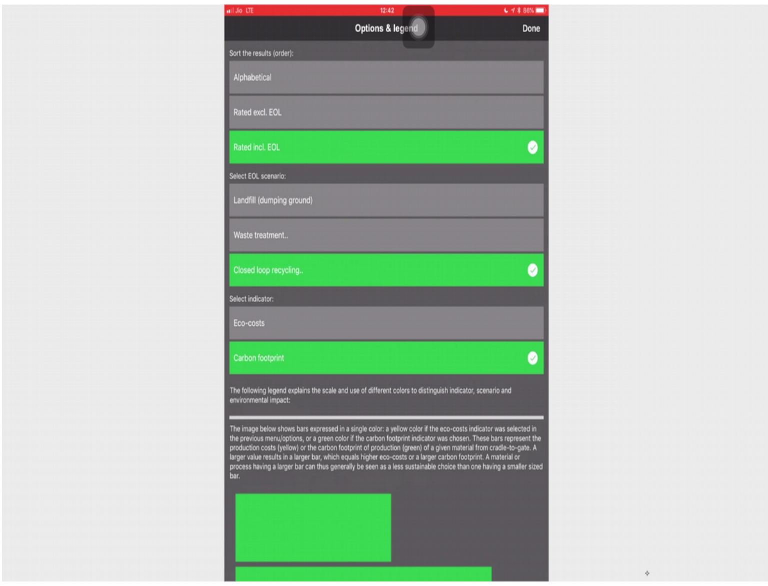

Let us make it closed loop recycling. So, I will have to add the impact caused due to bringing that closed loop recycling.

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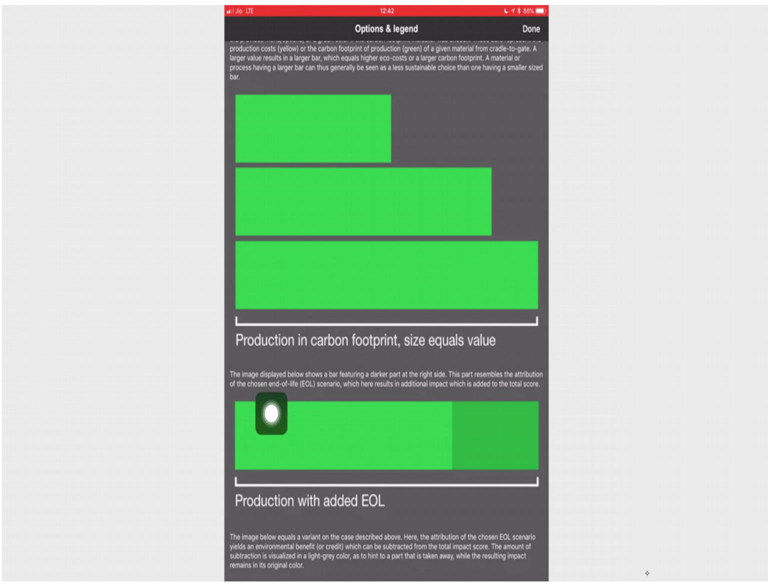

Then you will be able to see this darker colour bar. What it implies is the image displayed below shows bar featuring a darker part at the right side, this part resembles the attribution of the chosen end of life scenario which here results in additional impact which is added to the total score. So, let us go back to our list.

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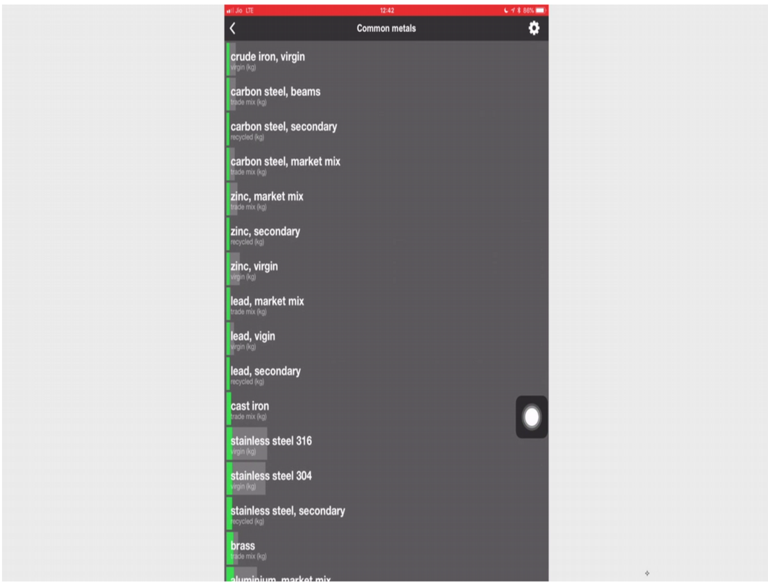

So, you can again see.

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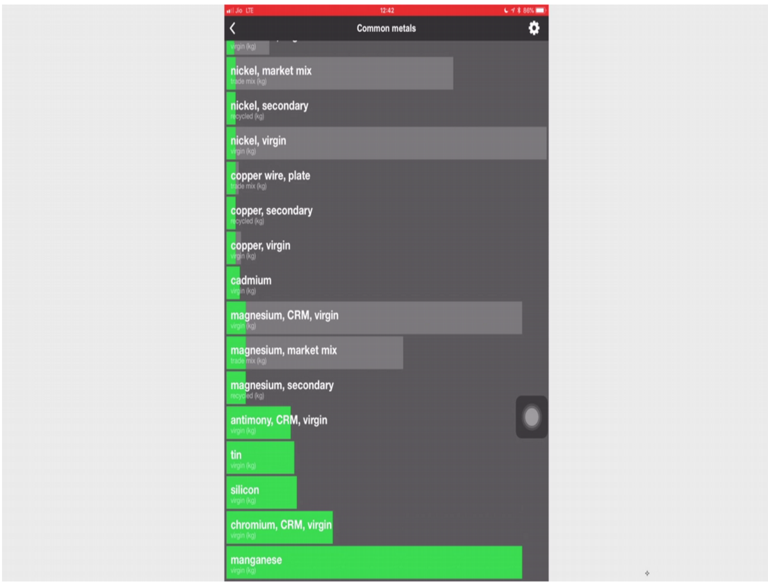

So, not necessarily everybody will have a say for example, for certain things we do not have the darker zone let us again change it to carob to eco-costs and look at this particular list.

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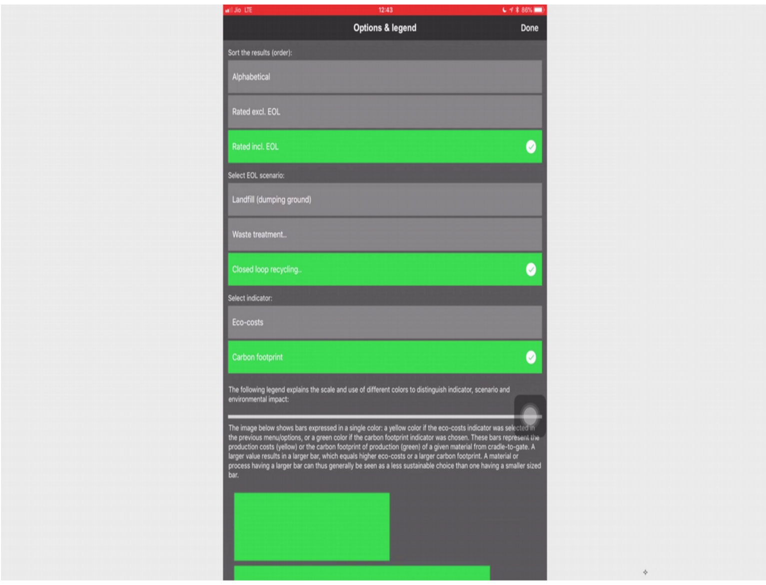

So, this is how my list is looking like if I go into the waste treatment 1 this is how my list is going to look at.

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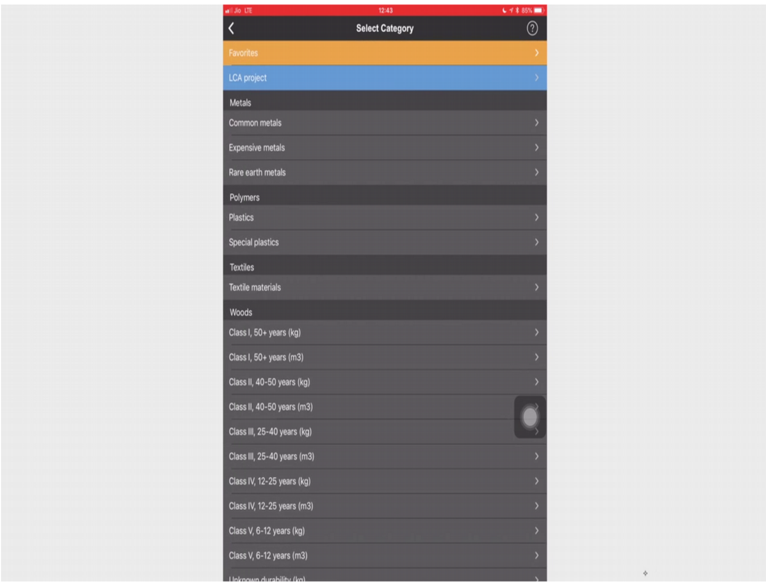

Let us look at the plastics which will give greater quality.

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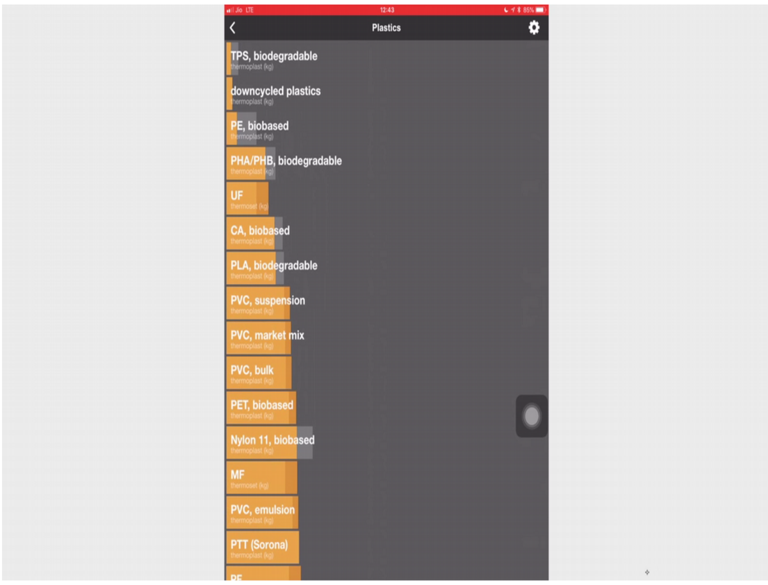

So, here you can see when I look at the plastics there are certain some of these.

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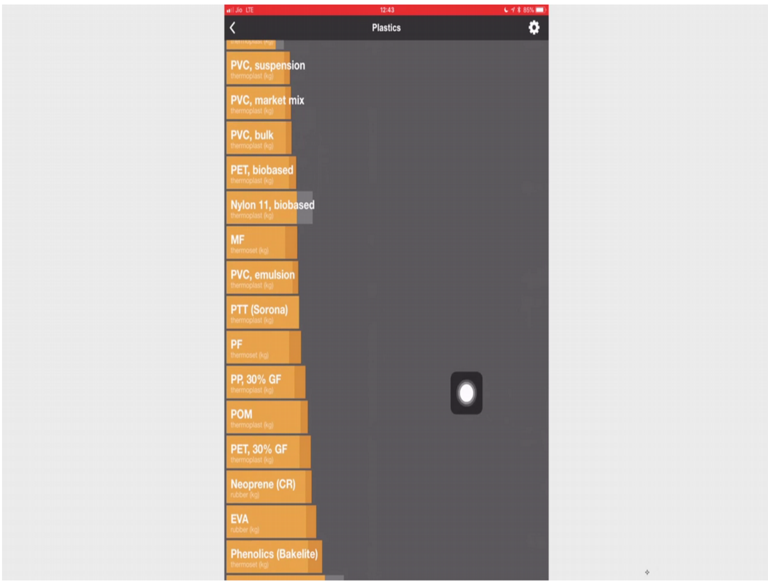

Have this darker zone what it implies is production with added end of life there is another kind of bar which says production with subtracted end of life in case you can use that say for the metals this is what the context that you saw all of them had grey bars.

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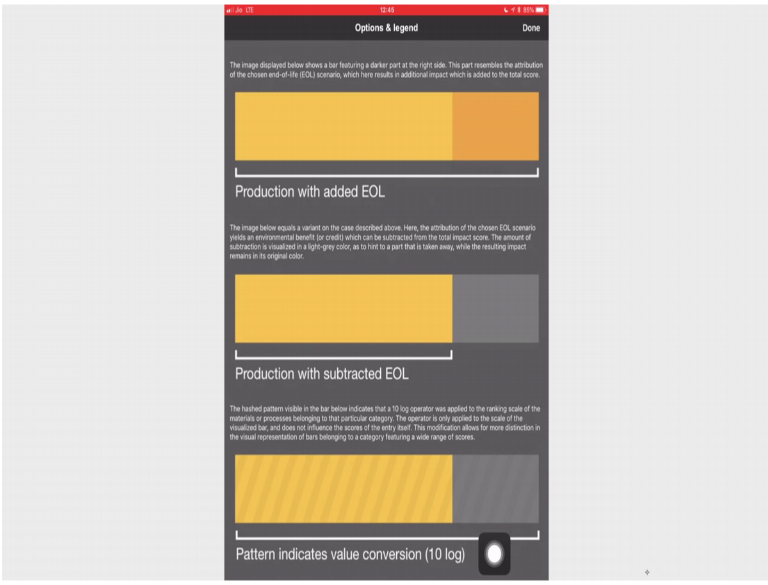

So, when I do a close loop recycling they have a closed bar because of the because of the ah production with subtracted end of life because I am in closed loop and I am taking back the recycling that metal back into becoming metal without loss of properties. So, the image below equals a variant on the case described above here the attribution of the chosen end of life scenario yields an environmental benefit or credit which can be subtracted from the total impact score the amount of subtraction is visualised in a light grey colour as to hint to a part that is taken away while the resulting impact remains in it is original colour.

There is also a third scenario which is a pattern indicates value conversion with an logarithmic scale. So, the hashed pattern visible in the bar below indicates that a 10 log operator was applied to the ranking scale of the material or processes belonging to that particular category the operator is only applied to the scale of the visualised bar and does not influence the score of the entry itself this modification allows for more distinction in the visual representation of bars belonging to a category featuring a wide range of scores. So, if you see at the end of this particular. So, let us go to plastics.

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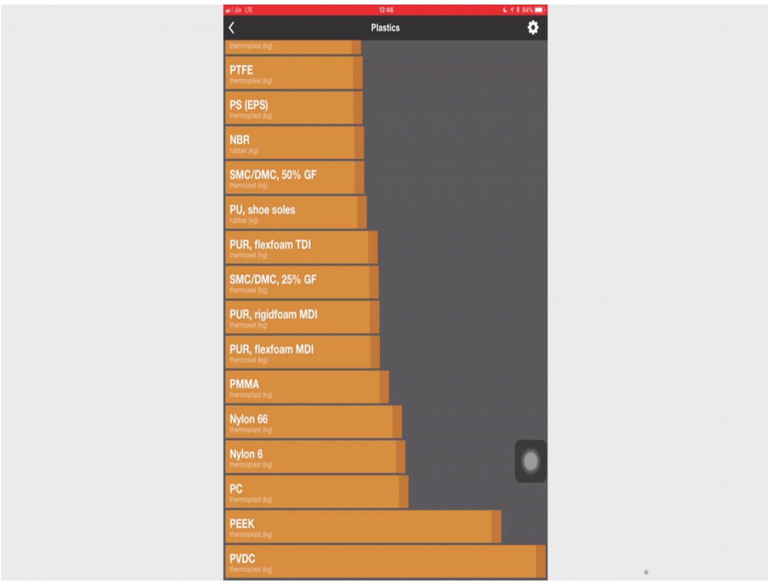

So, if you see some of the last one the if it has this kind of a pattern then it implies that it is an logarithm, but it is only for the visual purpose it is not done on the final value. So, the final value will remain same. So, in the context of metals there is another aspect which needs to be considered.

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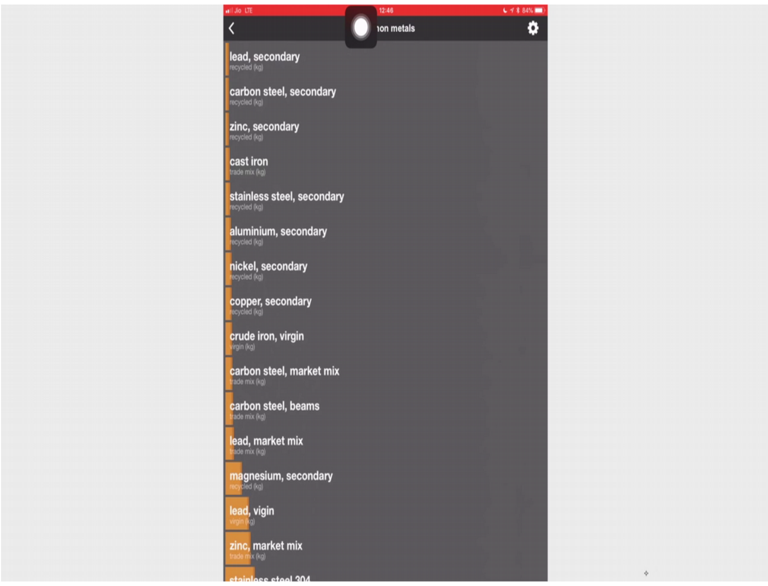

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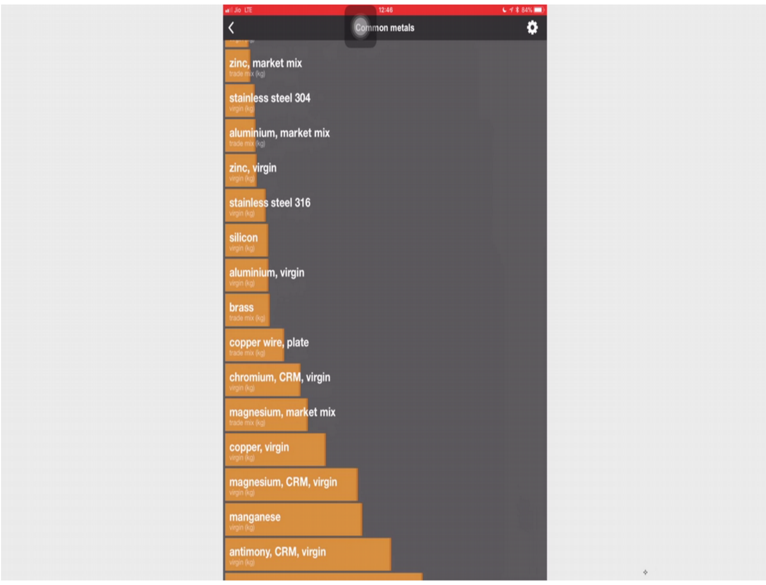

So, if you go through this list of metals you will find that say chromium has, I have chromium over here which says chromium, CRM, Virgin, what does the CRM stands for? So, when I go into chromium.

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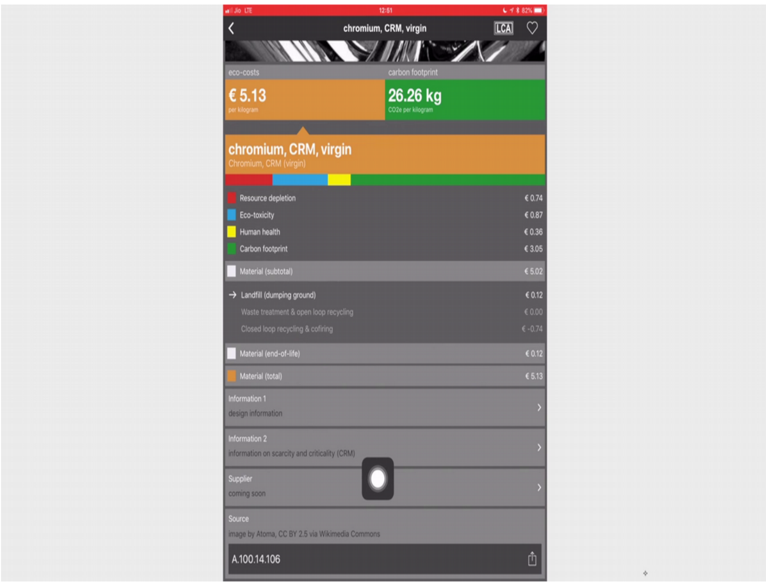

You can see an information tool; it is information on scarcity and criticality. So, CRM stands for criticality of a rare earths metals in terms of geopolitical considerations.

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So, let us see I clicked on that particular thing. So, here you can see scarcity and criticality ranking no bar means not scarce or not critical. So, the green one is for recycling or substitution percentage required for 1000 years of supply the orange one is supply risk index and CRM the critical raw materials with geopolitical risk with sustainability index. So, there are certain materials certain metals which have this CRM related risk. So, you should see whether so because of the geopolitical risk involved it might be better to consider how are you going to use those metals. Now, let us see what this whole.

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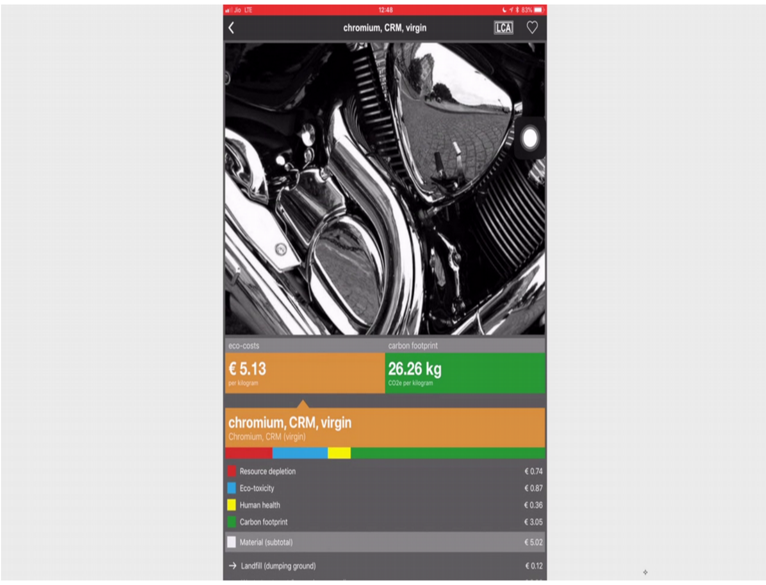

So, if you go to any of those metals first what you will see is the a picture which depicts the kind of application that you can do with that material the eco costs. So, when I am in this orange bar I am looking at the eco costs, if I click on this green bar I look at the carbon footprint. So, let us look at the carbon footprint. So, for this chromium the carbon footprint it is due to the material it is 26.26 kg, for land fill dumping ground it is 0, for waste treatment open recycling 0, and closed loop recycling and cofiring it is unknown, for material end of life again 0, carbon footprint for hence the total carbon footprint for the material is 26.26 kg.

Now, let us click on the eco costs. So, now you can see how the eco-costs give you much more information than carbon footprint. So, the red is resource depletion, the blue over here is the eco toxicity, the yellow over here is human health, the green is for carbon footprint. So, the eco-costs because of the carbon footprint all the costs are mentioned. So, if you see this particular bar or if you see at these values you already know that the highest eco-costs for the this particular material is because of the carbon footprint. So, as we discussed earlier eco-costs gives you an additional idea related to resource depletion which is not covered within carbon footprint.

So, then a you get the total. So, say for the closed loop recycling and cofiring I get a credit of 0.74 Euros. So, then you have material end of life and total material from here. So, here you can see you have information1 so designed information1. Let us click on the information1 you have to have some working internet connection because it goes to that particular website and gives you the information.

Your information 2 was on scarcity and criticality CRM which we already saw that since this application is still under development. So, there is no information or supply, but soon there will be information on the screen. This is to identify your name for this particular material which is used in the data basis. Here also you have a share button which will help you to share the material with your email ID or messaging or any other such possibility which normal mobile or tablet offers you. Now, let us look at the plastics.

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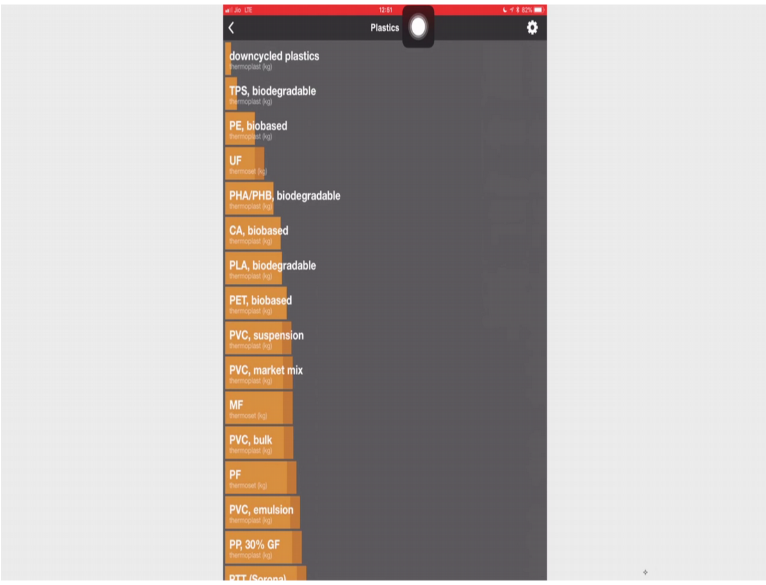

So, I if go into plastics you will have so you can see PE bio based whenever you see bio based.

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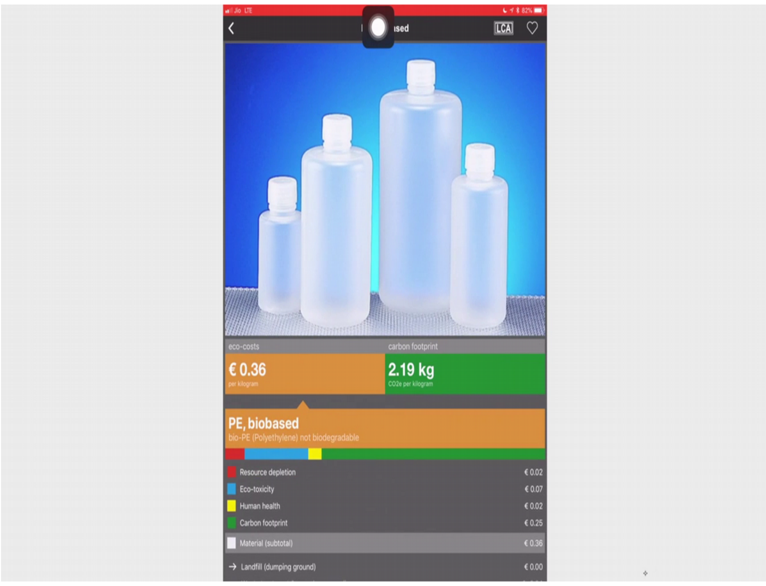

It is not about biodegradable, but it is bottle category. So, again here you can see the image which shows that you can make these kind of bottles of course, you will have many other functionalities also so I have the same thing over here eco costs, carbon footprint.

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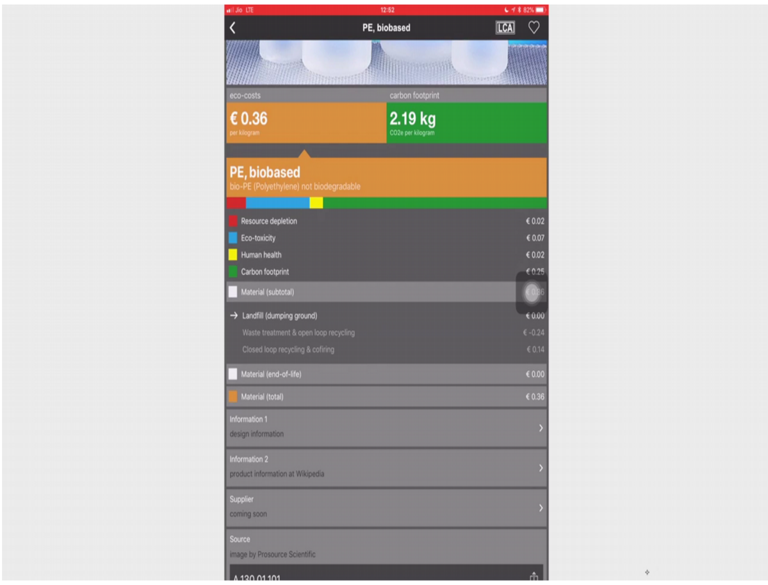

I again have my information design information.

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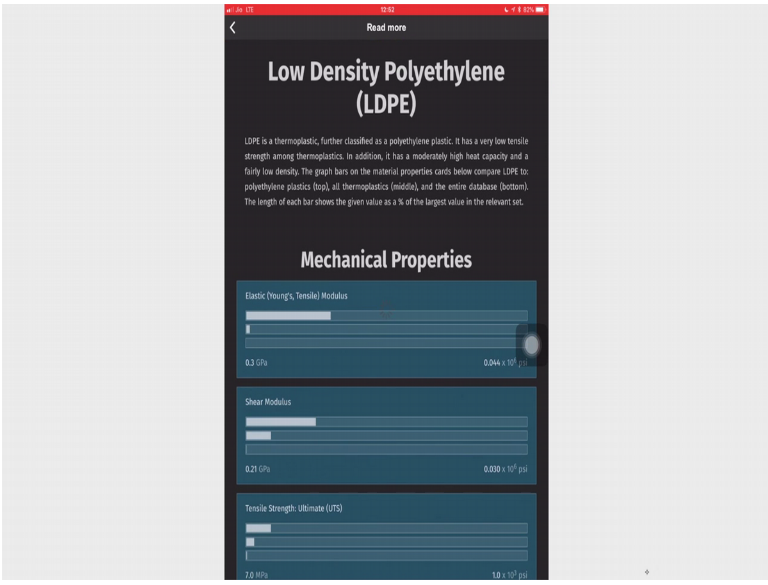

So, when I click on the design information again it goes to a particular website which tells me about the so, what is material is all about the mechanical properties, the thermal properties.

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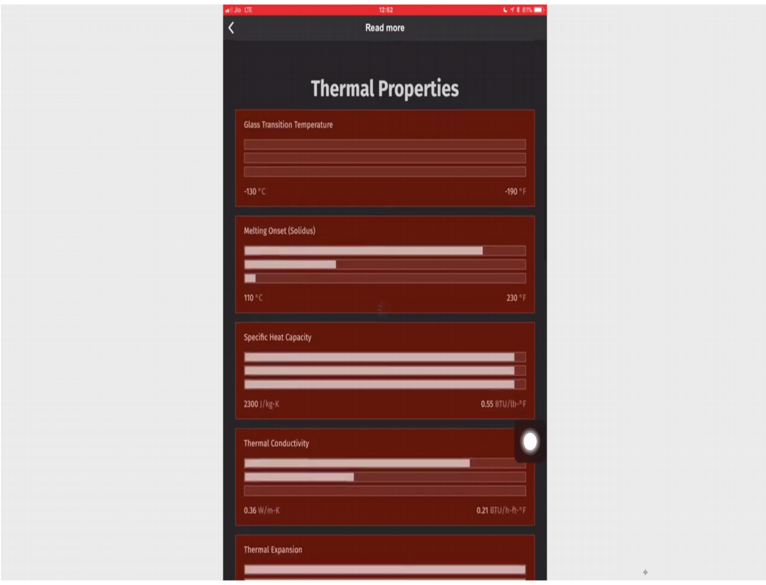

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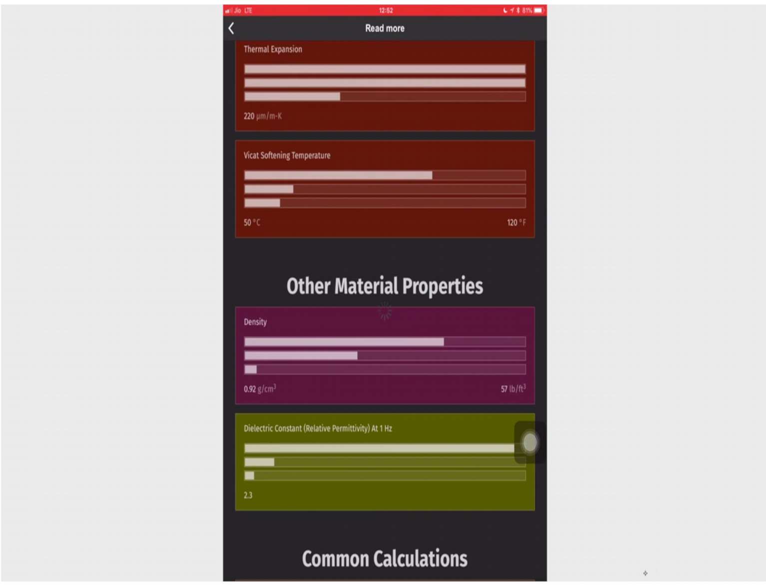

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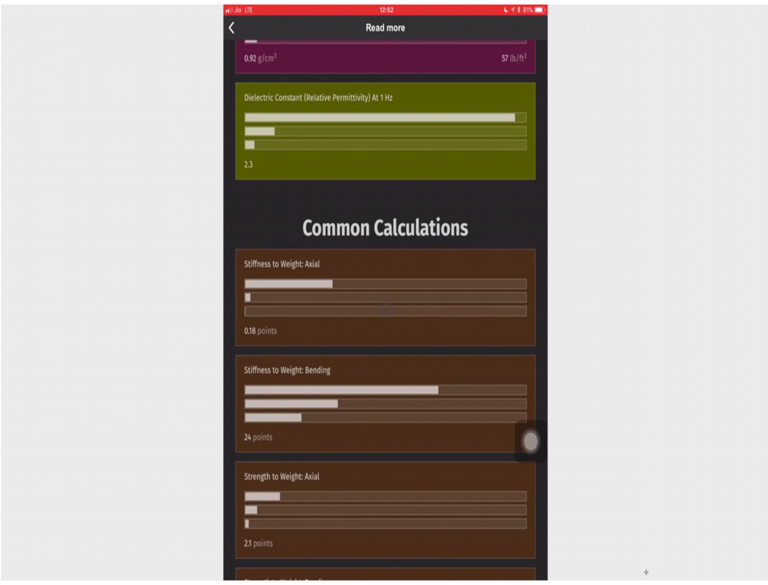

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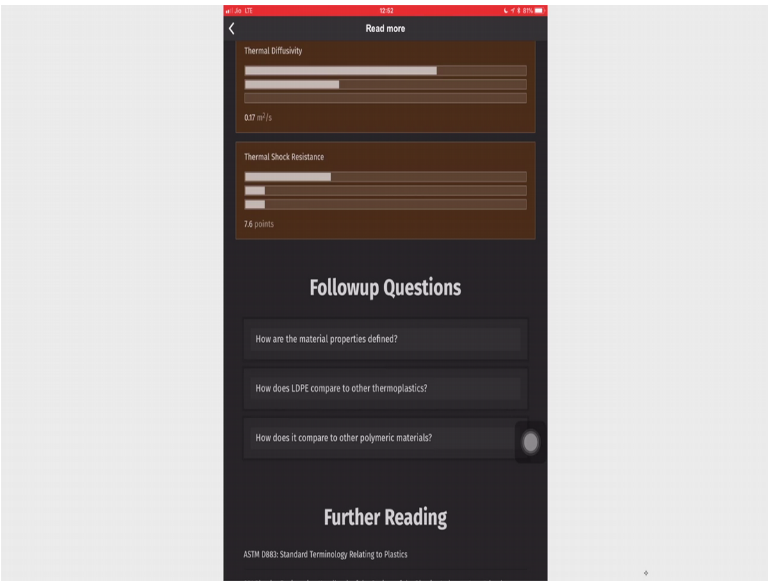

Other material properties and common calculations which are in with respect to this material then you can have more and more information about

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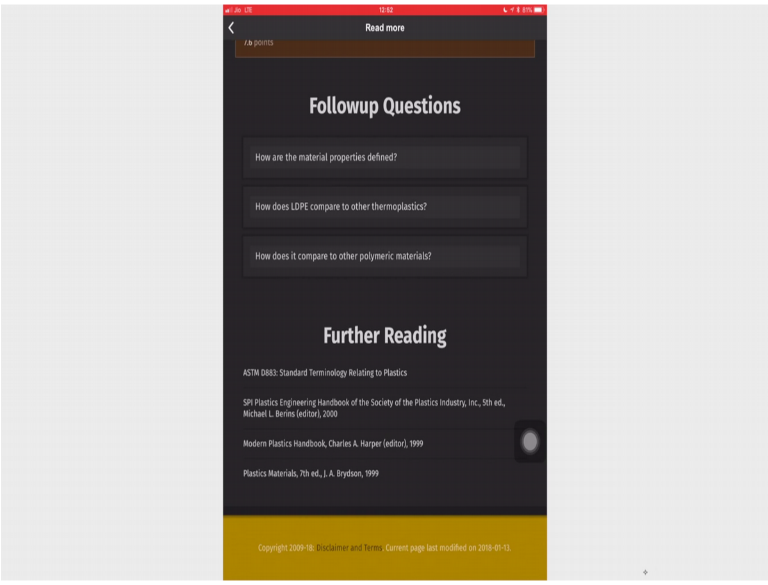

This particular material it also has a link. So, the information two over here has also has a link to Wikipedia which also gives you more information and the same location. Let us go to the processes now.

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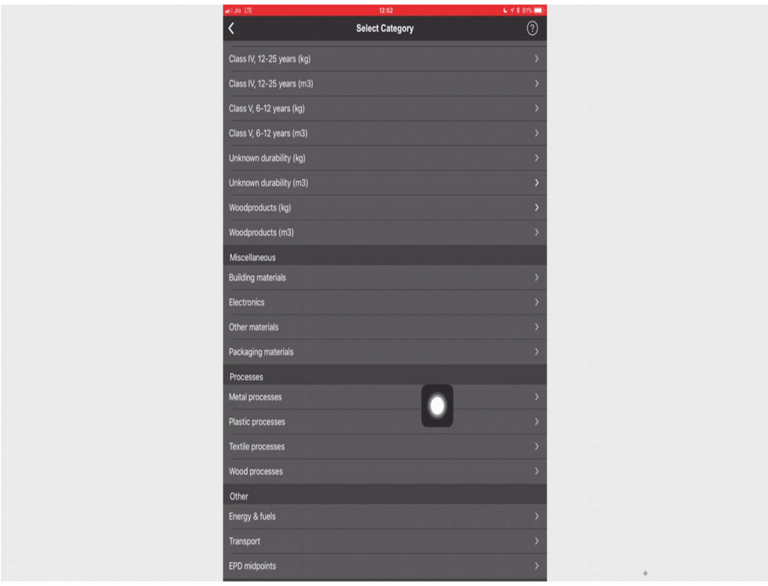

So, let us go to a particular plastic process.

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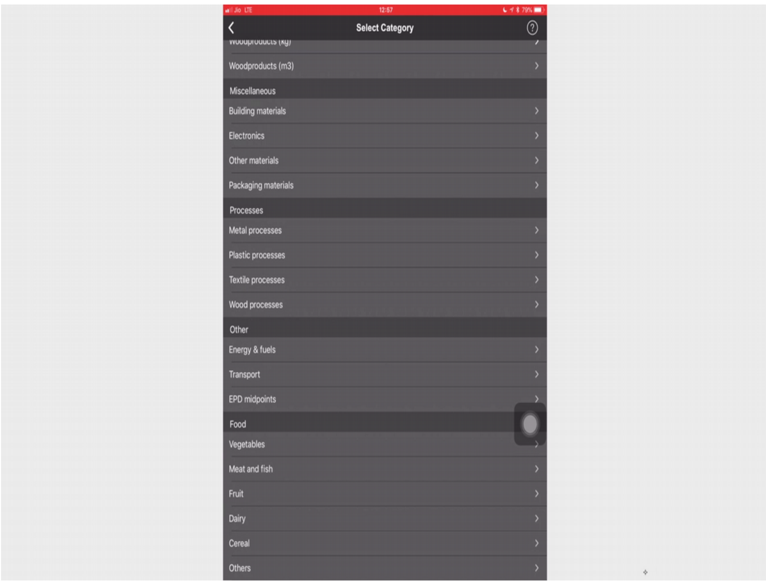

So, if I go to a particular plastic process.

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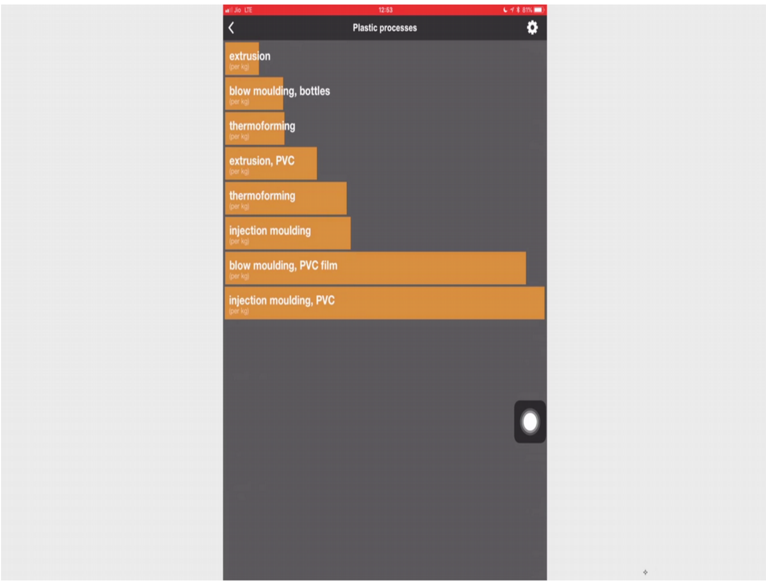

So, say for example, this is blow moulding for bottles, and this is blow moulding for PVC film hm. So, if you want to make bottles the process is blow moulding if you want to make PVC film again the process is blow moulding, but because the both the processes have certain differences in terms of how it is working and hence you should select an appropriate option say for example, I want to do blow moulding of not PVC film, but it is a linear low density polyethylene what do I do I do not have data over there. So, what I do in such context is find out the situation which is more similar to that particular situation. So, because it is film and I need to blow mould it. So, I can take the data which is blow moulding PVC film. Similarly, if we go into the energy and fuels so energy and fuels is very important to consider.

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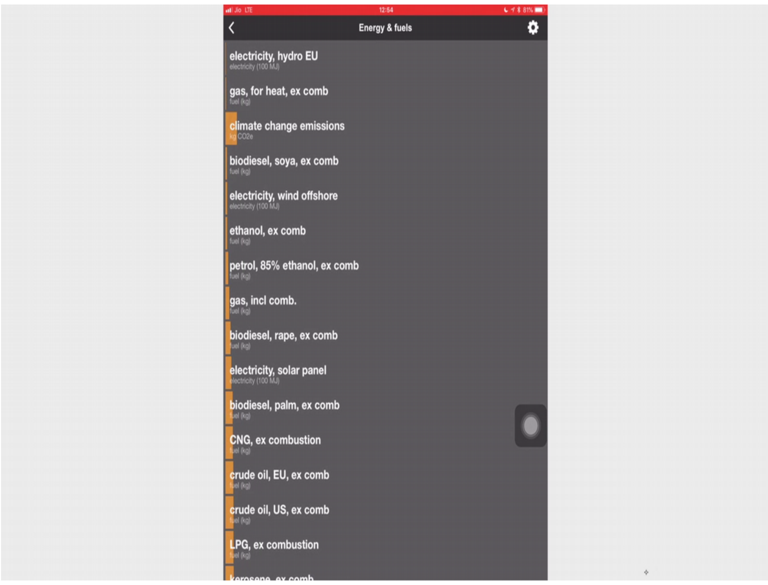

You have to remember that this is not a very exhaustible and it is not geographically contextualised. It is more from the European Union context because TUDelft is located in Netherlands. So, taking into consideration that.

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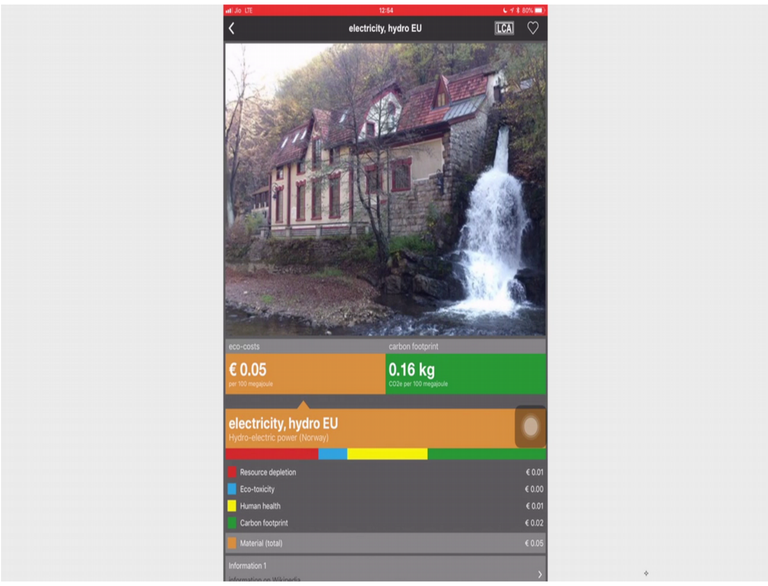

So, say for example, if I click on hydro electricity you can see hydro electrics power generated in Norway. So, the data which is for Norway is not actually similar to what we will have to consider for a hydro electric power plant in India, but again because this is an approximation and it is very easy and simple to do it we are going to use this particular data for the given reason.

Whenever you have to use electricity in your life cycle assessment you have to be very careful say for example, when I use electricity from the main grade that electricity in India is produced by thermal power plants, by hydro electric power plants, by nuclear power plants. So, you have to know that: what is the mix of energy. So, what percentage of energy is produced by thermal power plants, what by hydro electric power plant, what by nuclear power plants? So, you can easily use the you can find this data online for say India, you can find the data and then from here you can select all those categories.

So, I can select electricity from ideal source and electricity from gas, and all those things and when I am assigning those quantities. So, for my entire process I need 1 100 volt hours. So, I will say if I know thermal power is 70 percent in India. So, I have out of that 100 volt hour, 70 volt hour will be the quantity in the context of hydro electricity. So, that is how we try to solve this energy related issue. So, energy is always electricity is always a mix wherever you go.

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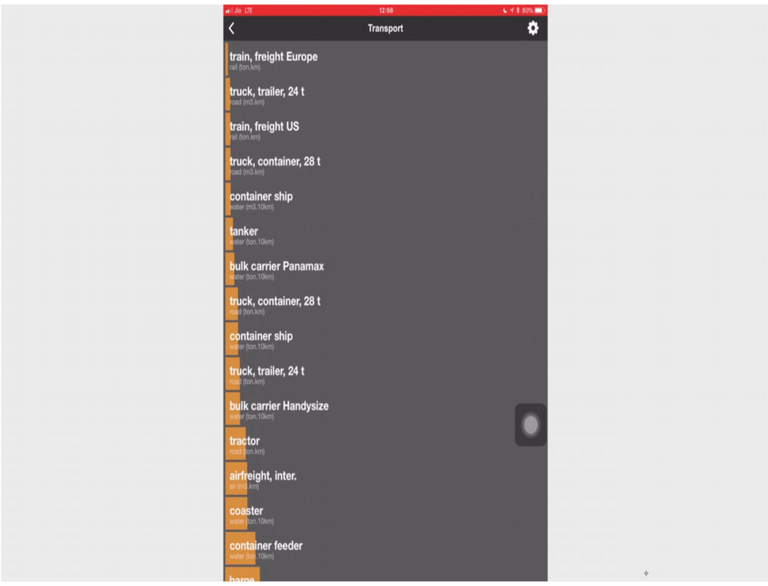

Then you go to transport scenario, you have different kinds of transport scenarios, you have to see which one is applicable for you. In more sophisticated software's like GaBi SemaPro you have the possibility to change the kind of fuel mix that you use for your vehicle. So, truck trailer which is 24 tonnes.

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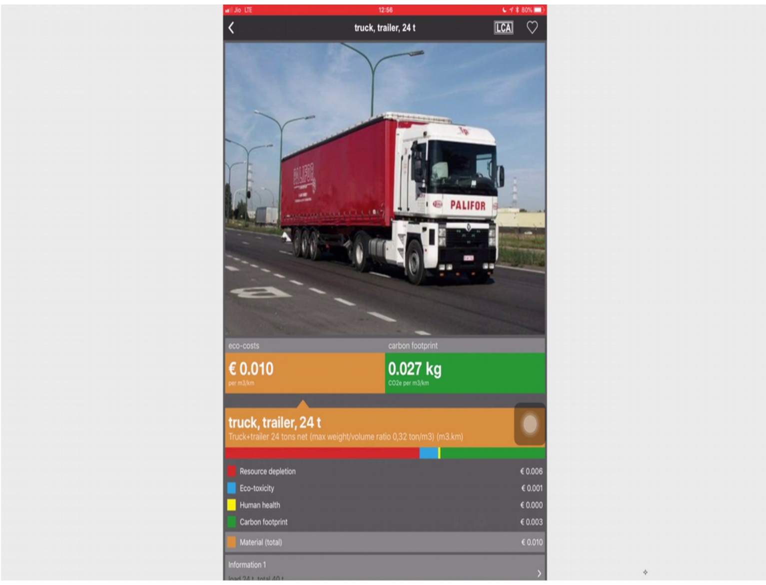

So, if you do not know what a truck trailer is 24 tonnes and when you go into it you will see a picture of it. So, say you the fuel mix used by truck trailer in Europe is very different from that used in India. So, this most sophisticated tool helps you to see input what is the fuel mix. But for our very simple calculation we do not need to bother about so many complications. So, that was about using this particular ah application how to use this app. Now, we will go back to our Life Cycle Assessment we will go through each and every step we will do a Life Cycle Assessment. So, what are the steps for LCA?

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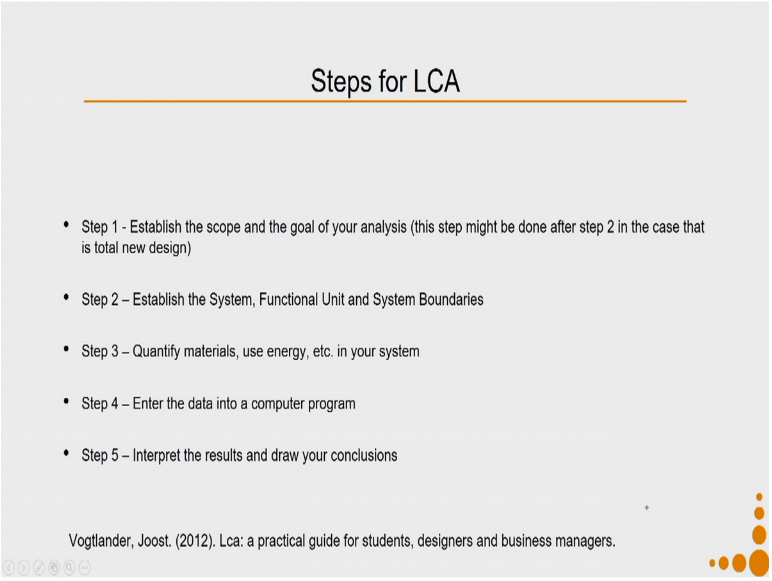

So, the first step for LCA is established the scope and goal of your analysis. This step might be done after step 2 in case it is a total new design, we have already discussed about it. Then we establish the system functional unit and system boundaries. We quantify the materials use energy etcetera in the system. Then we enter the data into a computer program, in our case we will enter it into this particular app. Then we will interpret the results and draw our conclusions.

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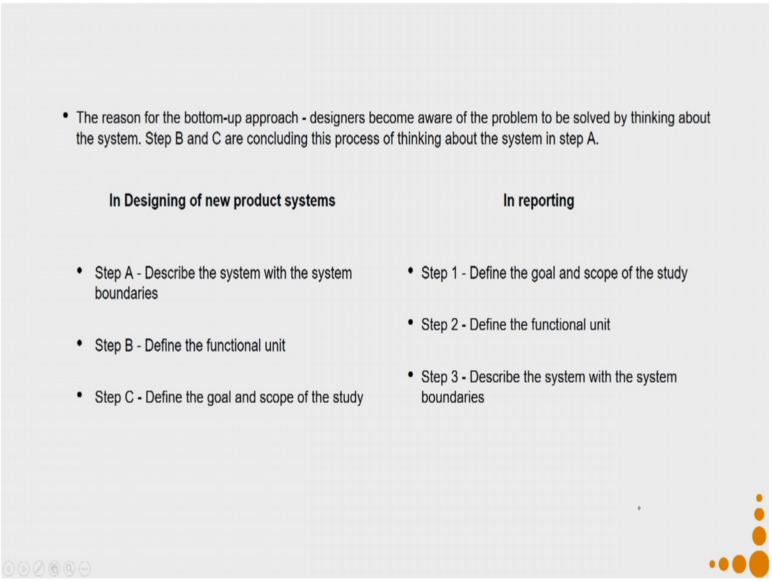

So, in the context of design you do step A describe the system in the system boundaries, then you define the functional unit, then define the goal and scope of the study, when you do the same thing reporting after all your design is finished you will define the goal and scope of the study you will go the reverse order define the functional unit and describe the system with the system boundaries.

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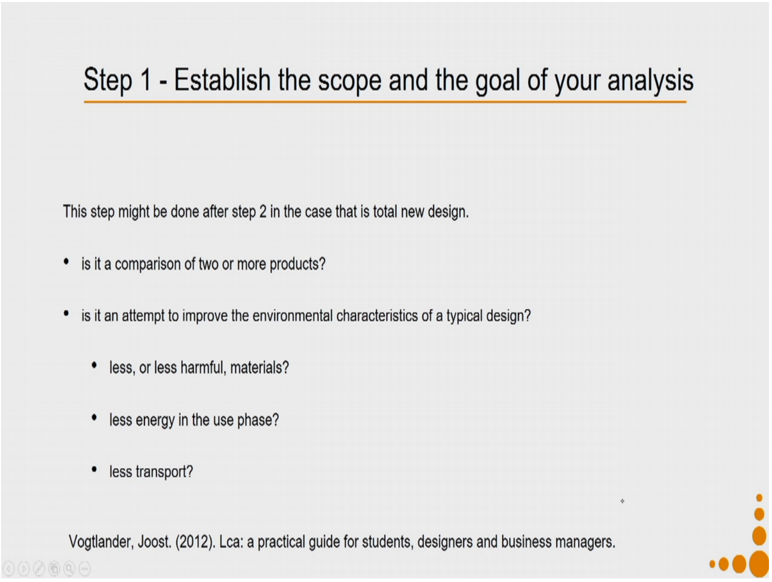

So, let us see how we establish the scope and goal of our analysis. So, this step might be done after step 2 in case that is a total new design. So, when we are trying to establish the scope and goal of our analysis. Our approach can be either we want to compare 2 or more products. So, when you get the eco-costs or the carbon footprint of a product that information per say makes no meaning makes no sense until and unless you do not compare it with other products, If an attempt to improve the environmental chare characteristics of a typical product.

So, I know that after doing an LCA with the impact that the source depletion level is very high. So, my aim is to improve the environmental characteristics of that design on that particular aspect, so less or less harmful materials, less energy in the use phase. So, it depends after doing my first LCA what do I identify as my aim for improvement less transport,

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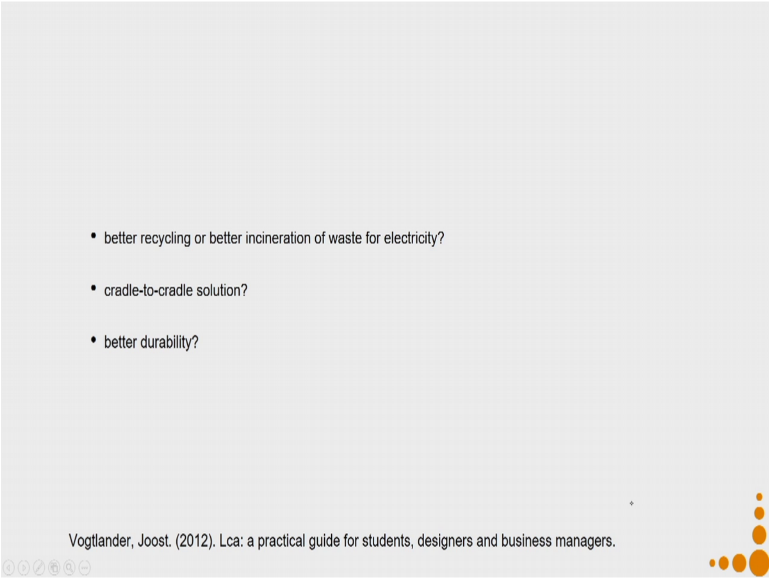

Better recycling or better incineration of waste for electricity, cradle to cradle solution, better durability. So, now we will take this example of comparing of a PET bottle verses a polyethylene bottle. So, as we discussed our step 1 is to establish the scope and goal of our analysis. So, out of all the possible so in establishing the scope and the goal of our analysis, we decide that we will compare 2 products how we distinguish between the 2 products is.

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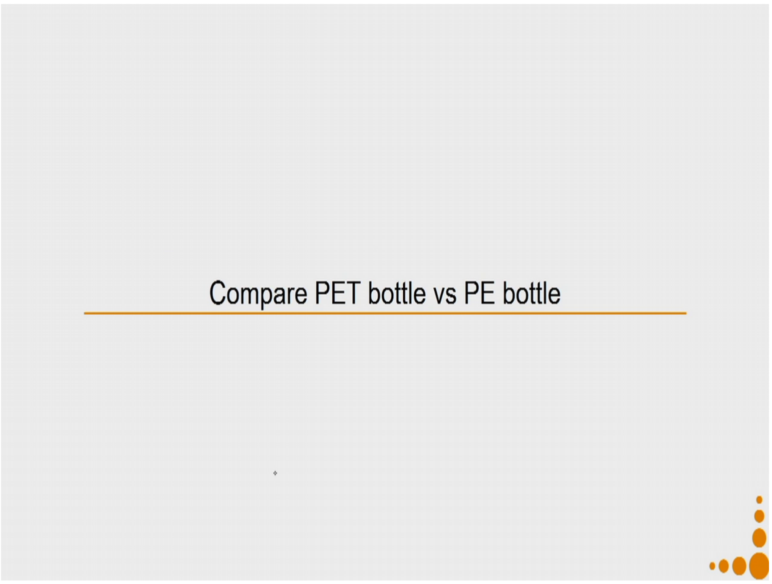

Because as we have already discussed that the functional unit or the declared unit has to be same the product should be comparable. So, we are going to compare this PET bottle and PE bottle on a functional unit which is same for both. So, let us see what, so once I have established like what I want to do I want to compare these two my next task is establish the system functional in a unit and system boundaries.

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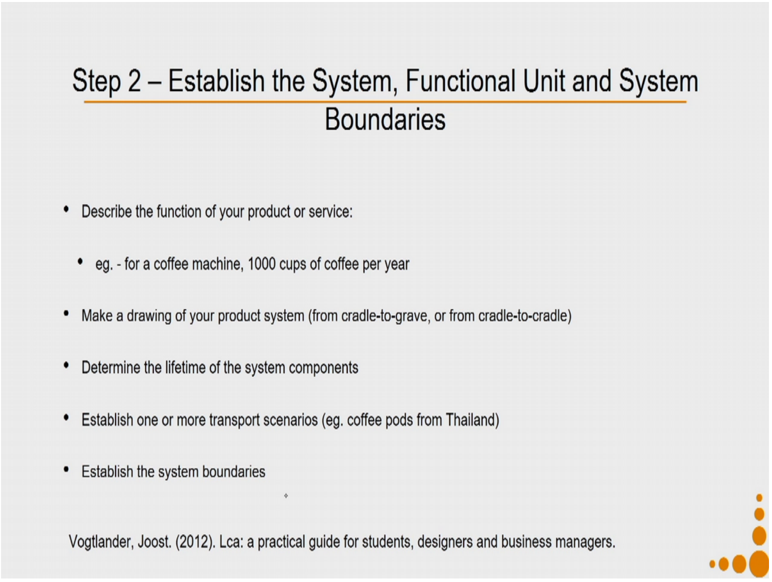

So, what we do in this case to do this is first we describe the function of our product or service. So, say for example, a coffee machine which makes 1000 cups of coffee per year can be a definition of the function. So, like we discussed already it can be a functional unit or it can be a declared unit.

Then you make a drawing of your product system. So, you will consider whether you want to do a cradle to grave, or cradle to cradle, or cradle to grave, what kind of analysis? Then you determine the lifetime of the system components. Next you will establish 1 or more transports scenarios example coffee pods travelling from Thailand. Then the next step is you establish the system boundaries. So, let us see how to do it in the context of the example that we have taken.

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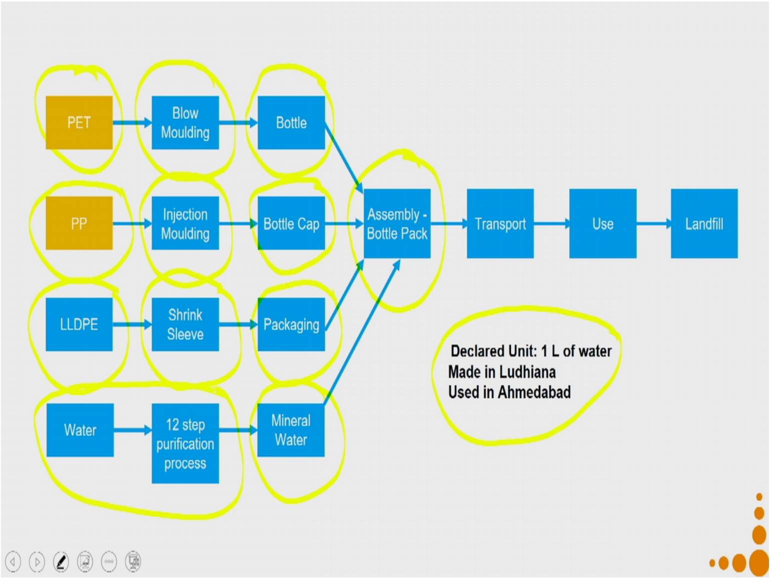

So, we want to compare a PET bottle versus a polyethylene bottle. So, let us first try to draw the what will be the components of this particular system. So, in this particular context you can see that my bottle assembly pack is going to consists of certain components before that let us look at the declared unit; so, my declared unit because the decal functions should be same. So, my declared unit is for carrying 1 litre of water. I have to also determine a transportation scenario. So, the transportation scenario is made in Ludhiana and used in Ahmadabad you can define appropriate transportations scenario.

Why, where it is made, and where it is used? Is important because that determines the distance that determines how will it travel? If it is like if it has to travel over sea, if it has travel over air, or it can do land transportation and so on. So, keeping that declared unit I talk about my assembly of bottle packs so it will consist of the bottle itself. So, in case of the polyethylene PET bottle, the bottle will be made of PET that is a plastic material and it will be made by a process called blow moulding.

Then the bottle will have to have a cap. So, my bottle cap and I will make it by injection moulding and it will be made with polypropylene. Then the bottle packs will have to be packaged in secondary packaging so that it stays safe during transportation. So, that packaging will be made up of shrink sleeve and the material which will be used will be LLDPE. Also in the bottle I will have to fill up mineral water and the mineral water will be purified using a 12 step purification process.

Now, let us see how this whole system will look in the context of the polyethylene bottle. So, again my declared unit remains the same that is 1 litre of water made in Ludhiana and used in Ahmadabad. So, I have my assembly which is the bottle pack, now my bottle is going to be made up of polyethylene. The process remains same that is blow moulding. I will also have a bottle cap in this particular case my bottle cap will be made up of polyethylene. So, if you compare these two steps what you see is that the difference lies over here that is PET and polypropylene used for making the bottle and the bottle cap.

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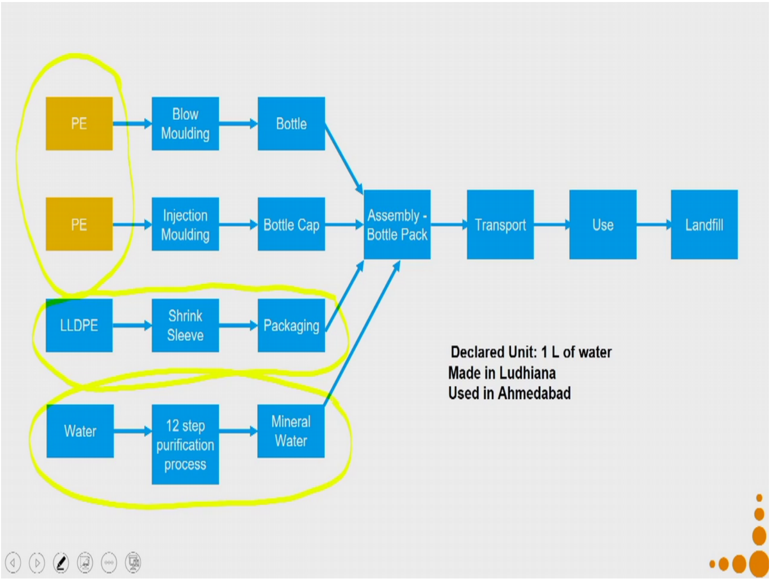

And in this particular context it is polyethylene bottle as well as polyethylene bottle cap. Again it will have packaging the packaging will be made by using LLDPE and it will be the LLDPE film will be made by using blow moulding process and it will be put on the on those packets of bottles. So, like 12 bottles kept together by using the process shrink sleeve, then I have water into which it will be purified using the 12 step purification process.

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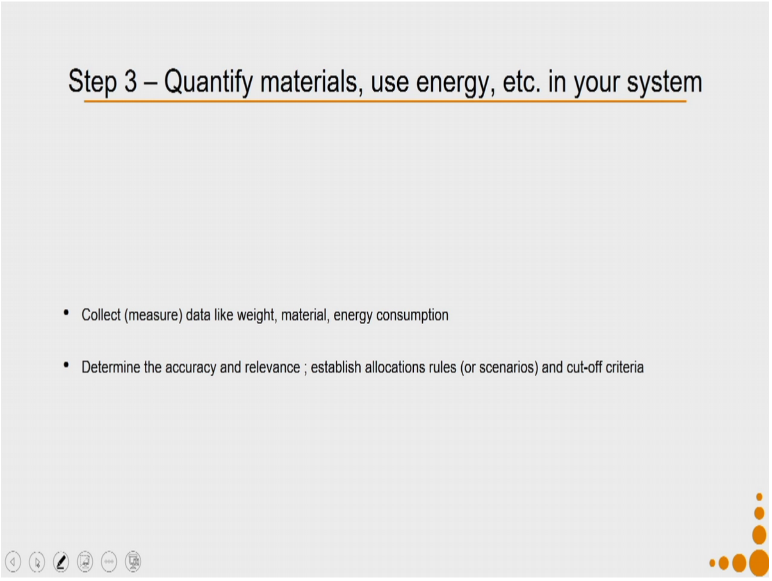

Now let us see how do I my step 3 come over here, which is like quantifying the materials use energy etcetera in your system. So, in order to achieve the life cycle assessment that is eco-costs assessment, as well as the carbon footprint. I need to now understand for each of these steps, what will be the amount of polyethylene required for packaging 1 litre of water? What will be the amount of polyethylene required in the bottle for packaging this 1 litre water? And similarly what will be the amount required for in the polyethylene terephthalate bottle?

In this particular context, we will when we are talking about the transportation, we will also have to talk in terms of either tonnes in a kilometre or metre cube kilometre. So, any particular truck it has a certain limitations in terms of the volume that it can carry. So, there is a maximum limit to that the volume that it can carry and there is a maximum limit on the weight that it can carry. So, whichever reaches first the volume limit or the weight limit that becomes the limit for carrying that particular product for that particular truck or container.

So, we have to first figure out that context of our bottles which are like also filled up with 1 litre of water and we consider certain kind of trucks in which I will be transferring my product from Ludhiana to Ahmadabad. So, what will be the best unit when we are doing this quantification in our life cycle assessment and accordingly I will select the unit and then I will quantify the material.

So, you will collect all measure data like weight, materials, energy consumption, then you will determine the accuracy, and relevance, establish allocation rules, and cut off criteria. What does this allocation rule imply? So, allocation rule implies say for example, I am producing in the same factory bottles, toys, and some other products. So, now there is certain energy consumption which is happening because of the production process.

So, the blow moulding machine is consuming certain amount of energy that part is already absorb in the blow moulding process itself, but apart from that because you are having human beings, who are doing your work, you have lights in the factory, you will also have some associated offices, where there will be energy consumption. Now, your factory if it was only producing your bottles. So, all the extra energy which you are using to run your office to run your factory, it could have been put on to your bottle context, but not that is not true because most factories make more than 1 type of product. So, in that particular context you have to determine.

So, if I consume 100 units of energy. If I consume 100 units of water for operating my operations and I have 5 different products. How will I allocate the energy and other such resource consumption on to each of those products that I am producing? So, that is meant by the allocation rules or scenarios and then the cut off criteria.

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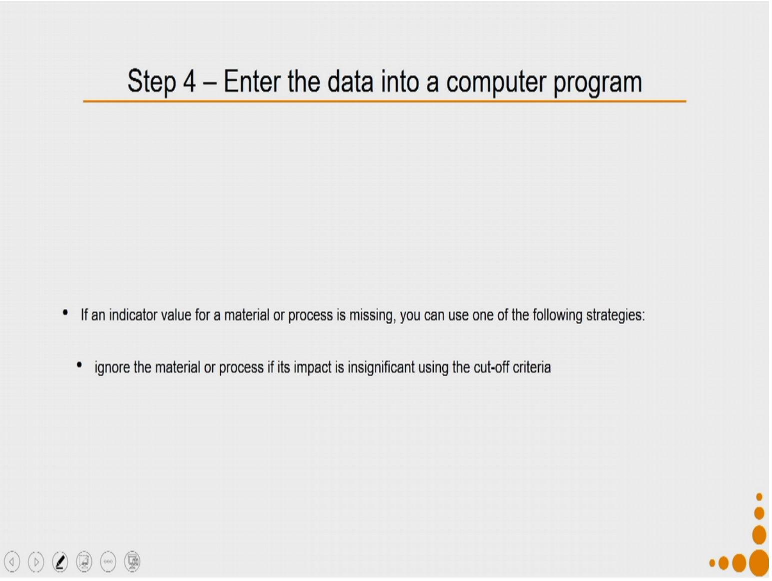

My next step is I enter the data into a computer program. So, we will shortly see entering all these data into the computer program. So, if an indicator value so when we are trying to enter this data in computer program we might come up with certain issues. So, if an indicator value for a material or process is missing, you can use one of the following strategies. First you can ignore the material or process if it is impact is insignificant using the cut off criteria.

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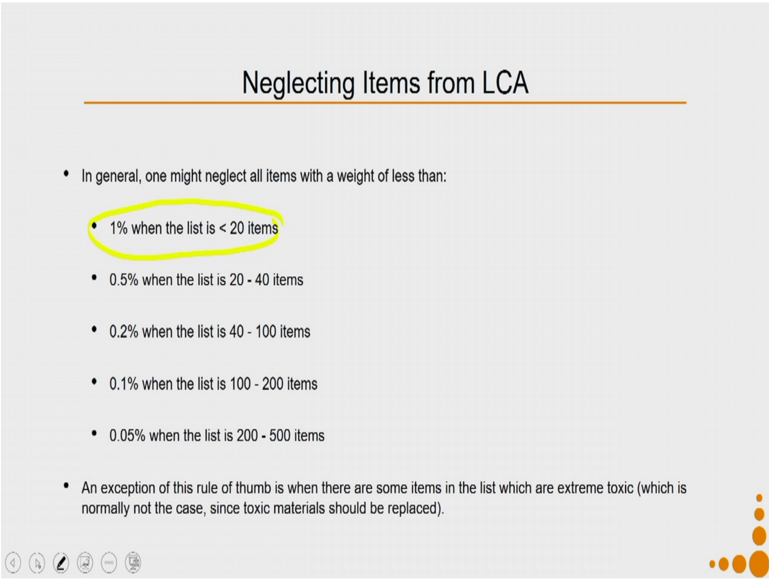

So, what were the cut off criteria we already had a discussion on cut off criteria. So, you can neglect items from LCA in general on the basis of weight. So, if your weight is less than 1 percent when the list of total number of items is less than 20 or if it is if the total the weight of that particular item is 0.5 percent then the list is between 20 to 40 items. So, say for example, in the PET bottle context that we considered my bottle consists of the bottle body, the bottle cap, the packaging shrink sleeve, and the water into it, so there are 4 items.

Now if I have to neglect something, I can neglect something if the weight of something is 1 percent because, in this particular context I lie in this category 1 percent when the list is less than 20 items, 0.2 percent when the list is 40 to 100 items, 0.1 percent when the list is 100 to 200 items, then 0.05 percent when the list is 200 to 500 items, also you have to be very careful about this exception.

So, when there are some items in the list which are extreme toxic which is normally not the case since toxic materials should be always replaced and should not be used, but in case the item that you think lies under this rule, but if it is very very toxic then you should not be neglecting it.

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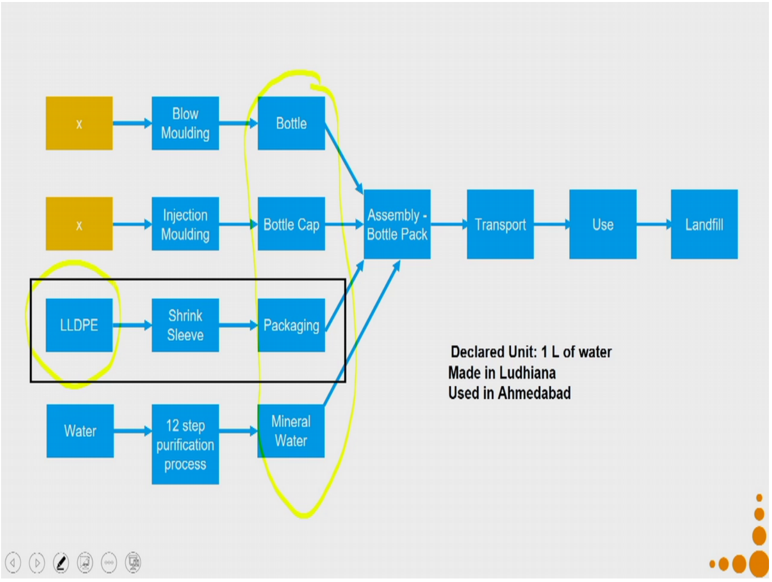

So, let us see in our particular context as we discussed that we have 4 components the bottle, bottle cap, packaging, and the mineral water. The LLDPE, shrink sleeve film if I take the weight of that with respect to the total weight of the bottle comes out to be less than 1 percent. So, I might reject it, but do that only when your data regarding that domain is not available, in case data is available just put it data into it and see if it creates any significant amount of impact.

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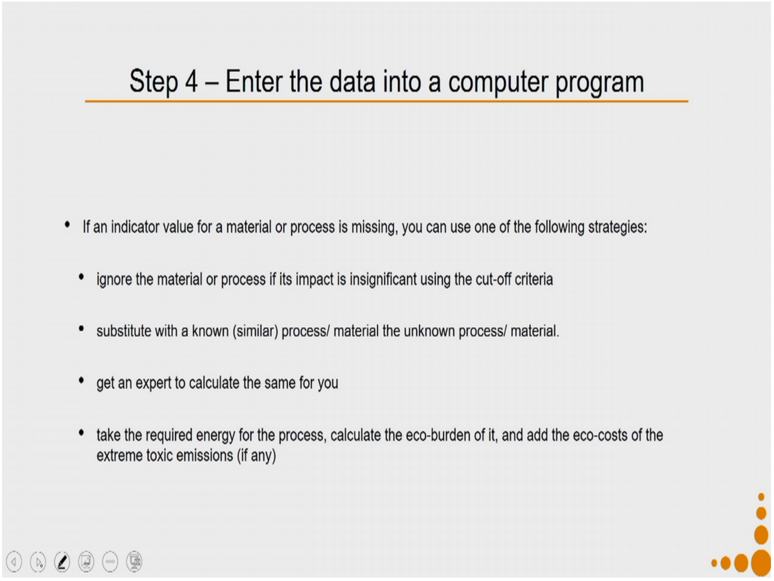

Now, the next thing about entering the data in the computer program; you will substitute with a known similar process or the material the unknown process or material. So, I do not so as we discussed in the data we had blow moulding for PVC films. Now in the example that we have taken we have to do blow moulding of LLDPE to manufacture that. So, because that is not available so I will substitute it with known example which is so instead of blow moulding of l LLDPE film I will use blow moulding of PVC film.

You can get an expert to calculate the same for you. So, an expert might use more advance software's like SemaPro and GaBi to calculate that for you if you want to be very sure about the value. You can take the required energy for the process calculate the eco-burden of it and add the eco-costs of the extreme toxic emissions if any, that is also a possibility.

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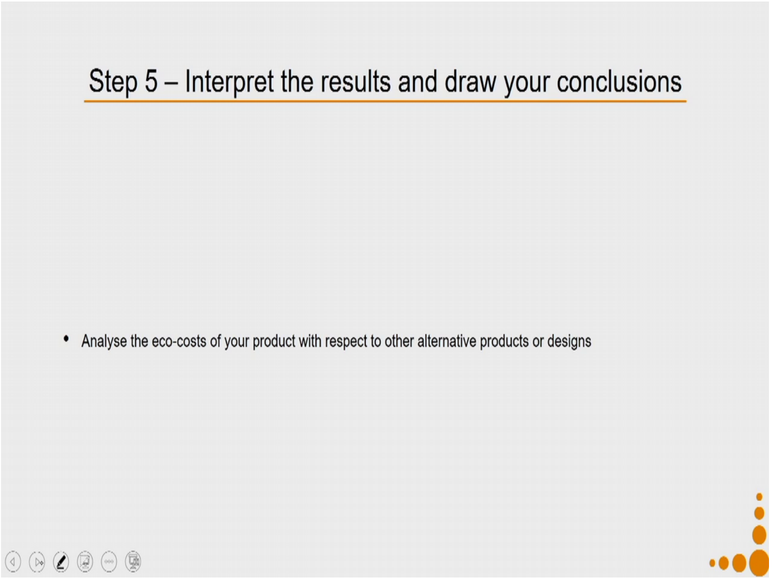

Then finally, so you will get some values like we when we are trying to understand software we saw that whatever if we put some inputs you will always get some outputs, related to eco-costs and related to carbon footprint. The values as such make no sense the values will make sense only when we interpret the result and draw your conclusions. So, how do you do that? So you analyse the eco-costs of your product with respect to other alternative products or designs and then you get your results. So, let us see how we will do these 5 steps on our software.

So, we will take our context we will go to first we will start from our system definition. So, our system definition was for the PET bottle. So, I have my flow diagram available to me let us do a eco-costs analysis. So, I will do rank on eco-costs the scenario that I have selected for the given LCA analysis is landfill. So, the end of life scenario I will select as landfill. Then I will start creating a new LCA project.

So, here is my creating a new LCA project. So, let us create a new LCA project. So, I will say start new LCA project. So, if you have already have an LCA project open it will ask you the question whether you want to close it first or not. So, you can close it. So, you can see I have project name. So, let me put a project name which will make it recognisable enough and also I will say PET bottle polypropylene cap. Then I have to write the description so, in the description I will talk about my declared unit. So, my declared unit in this context is 1 litre in a water, made in Ludhiana and sold in Ahmadabad.

So, now the project is created. What I will do is the next step when I will say add extra data lines this will help me to add all the materials and processes. So, let us say add data lines. So, my first material that I have to add is PET. So, I go to plastics in the plastics I will try to find out pet. So, here you can see this PET bio based which is PET meant for making bottles. So, it is not biodegradable or bio based plastic what it means is it is a bottle grade plastic. So, I will select this option LCA so I click on LCA it is added to the project, then my next product will be added is polypropylene. So, I will try to find out where is polypropylene you can see here it is written polypropylene 30 percent gf.

So, this if you are confused if this might one that you want. So, see this not the one we are looking for what it implies is probably propylene filled with 30 percent glass. So, that is the composite so what I am looking for is only polypropylene. So, here is my polypropylene the thermoplastic which I am looking for so I will click on polypropylene and I will again add it to my project. Now, my another material is LLDPE so LLDPE is over here and let me select LLDPE and add this to the project, now I have added all the materials let us add the so we will not consider the water component over here we could have considered the water component over here, but unfortunately the data base does not have water in the 12 step purification process that is carried for making a mineral water.

So, we cannot add anyways it will not make much difference because here in this context what we are trying to do is compare PET bottle verses polyethylene bottle. So, if you remember the concept of streamline LCA all we need to do is even we do not need to calculate for the LLDPE all we need to do is calculate for the once which are different. So, for this case I need to only calculate the PET, PP verses the PE. But still I have added LLDPE because I am interested seeing in what is the degree of importance of that category. So, I added that all my materials are added next I will have to add the processes. So, I will go to the processes here you have plastic processes so let us take plastic process. So, I need blow moulding of bottles.

So, this will be applicable both for my polypropylene sorry polyethylene terephthalic bottle polyethylene bottle so I added my LCA project. Then because I have a film so I need the blow moulding of PVC film which is the approximation for the blow moulding of LLDPE.

So, I select that particular option again press LCA added to project I have to do injection moulding of my cap. So, I will select injection moulding, again press LCA to add to the project. I need shrink sleeve, but shrink sleeve is not available over here let us see is it available in packaging materials. So, if I click packaging materials and I will have to so you can see it is very very difficult to search in this particular manner. So, let us sort it alphabetically and try to see if shrink sleeve is available somewhere. So, you can see there is film LDPE 50 microns which is a very close thing. So, let us add this one as a process.

You can read a more about those processes to understand what exactly is covered in the LCS calculation, that will give you better idea with the unit to select that process or not. Then I need to add some amount of transport so let us add transport. Why I am adding transport? Because both my PET bottle and polyethylene bottle will have different weights hence, the transportation will be important to consider. So, let us look for let us say our product is going to travel by a trailer trucks. So, you can see that I have an option which is metre cube kilometre and tonne kilometre. So, the first one talk in terms of value, volume and second one in terms of the weight that it can carry say for example, in our context let us say that the tonne kilometre is a more applicable unit. So, I will select this and add it to my product.

So, now let us go to my project and have a look at what all it has. So, you can see that I have all my materials added I have all my processes added transport is added at the process level as well at the use phase. So, this is when it needs to travel in the use phase it needs to travel in the processing phase. So, now we will put all the values so, the values can be put over here. So, let us say for 1 litre of water to travel I need one gram of a PET. Normally my unit over here is kg. So, I will convert it convert this gram into kg's.

Now say for my polypropylene I need also kind of 3 grams of polypropylene. So, I will add polypropylene then the weight of LLDPE will be extremely small per bottle. So, if like twelve bottles I used in one to be packed together then you will divide it and put that value. So, now, you can see it is very very important to know actual weights and measures that are going to come for your product only then you can do any meaningful calculation over here.

So like you can see when we were looking for the materials, we selected polyethylene LLDPE, but we also found something which was a the process plus material included together. So, at this point let us say we will delete this one because we have a better option available. So, I will delete it I will also delete the blow moulding PVC film option from here because they no longer applicable. So, let us put the value over here.

Now, you again put the appropriate values of for these manufacturing. In the truck and trailer you will put how much tonne kilometre is to be carried. So, let us say I am going to carry 1 tonne kilometre in the use phase again I have to say what it will be. So, now I will do calculate or save LCA. So, you can see all the so the eco-costs for our declared unit is coming out for landfill is 0.06, for waste treatment 0.07 Euros, for circular economy 0.06. I can click on the green and also see what are the so in detail I can see the impacts over here.

Now let us use the duplicate LCA because I do not want to repeat the whole process again. So, I will say duplicate LCA and here I will change it the name of the file. So, this is my PE cap, PE bottle. Now I will replace the materials which I do not need and let me put extra materials which I will be required. So, now I am going to make my bottle out of polyethylene. So, you can see this is the polyethylene which is for making bottles. So, I will add this material then I also need to find the polyethylene which can be made used for making the caps and that is the same kind of polyethylene. So, let us go back. So, I have my polyethylene over here because it may use for making the cap as well as the bottle it will be the combined weight as we already discussed if I replace polyethylene with PET the waste do not stay same any longer because of the cross sectional differences in density.

So, say the total weight of the product will be now 10 grams rather then what we started with 1 gram apart of this will be use to make the bottle. So, let say half of it is used for making the bottle so I out that in blow moulding and half of it will be used for making the cap part of it so I put that in injection moulding. In because my weight increases so much in for the bottles that for the truck and trailer will also will increase. So, let us ah

So, let us right now adding values arbitrarily, but in practice you have to find actual values and add them. So, now I can again do a calculation of this particular process. So, you can see all the eco costs, the carbon footprint; of different materials, of different stages, of different processes, and you can export this data you can export both of the data if I go back. You can see I have all my data already saved. So, any point of time you can go back to your previous data and work on to it further.

So, this is an extremely simple version of simplified version of doing a life cycle assessment it makes life cycle assessment easy and accessible to anybody and everybody and it just takes no more than 5 to 10 minutes to complete this, but if you want to do a more exhaustible life cycle assessment you need to develop skills in using say the open LCA software's SemaPro or GaBi software.

So, in the next lecture what we will be discussing about is, how do we design keeping into consideration this life cycle assessment in mind.

Thank you till then.