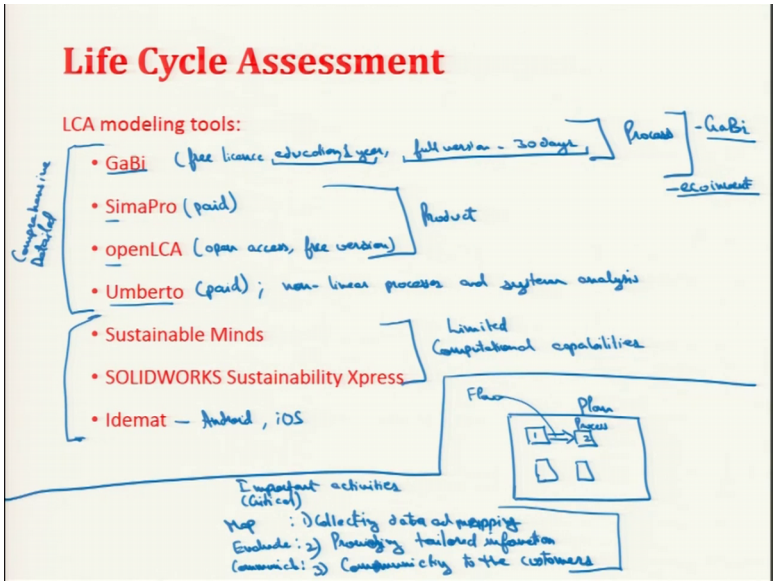
Advanced Green Manufacturing Systems
Prof. Deepu Philip
Dr. Amandeep Singh Oberoi
Department of Industrial & Management Engineering
Department of Mechanical Engineering
Indian Institute of Technology, Kanpur

Lecture - 34
Life Cycle Assessment, process-based software

Good morning. Welcome back to the last lecture in this module design for environment. I will discuss Life Cycle Assessment, process-based model as I said, I will discuss GaBi software and this is a small demonstration on how to make a plan and put processes and flows in it.

(Refer Slide Time: 00:34)



So, there are different kinds of process based softwares as I mentioned GaBi, SimaPro, openLCA, Umberto, Sustainable Minds, SOLIDWORKS Sustainability Xpress, Idemat. Now, out of these this first four are comprehensive models and these last three have limited capabilities like SOLIDWORKS, Sustainability Xpress is an extension of SOLIDWORKS designs software or CAD and CAE software Computer Aided Design and Computer Aided Engineering. In which we can compare two different materials; for instance I am going to manufacture this stylus I can think of whether to put this as nylon or I have to put it as polypropylene which kind of plastic they have to put.

So, what is the life settle assessment? So, where from where do material come? Just it is limited to few applications. Similarly, this Idemat this is Android or iOS based software, this cannot be run on the Windows. So, this is just the mobile small application. This is limited to 2 or 3 scenarios like landfill or dumping to ground, waste treatment for closed loop recycling. It does not have an extensive application, but yes you can download is in the Android and there are videos available to learn how you can work on these. Sustainable Minds is also one of the sort which has limited capabilities.

These four softwares on the top these are comprehensive and detailed. These have extensive capability and you can build your whole model, you can point compare the two products, you can compare the processes used to manufacture a product. Or you can make a full factory, keep on adding the flows, the processes, keep on adding inputs through the processes ok, electricity. Then an material flow, then what is the emission that is the outflow. So, input and output all those can be added; people have different opinions and different choices of choosing the software.

I have picked GaBi as the software which I will try to explain. Features of these four softwares this openLCA is an open excess software or free and GaBi also has free licence, it is education licence for 1 year. This is only education version for 1 year and we have full version for 30 days this is available; for the students or the practitioners to practice and for SimaPro all licenses are paid. So, this is completely paid, we do not have the free version for this. So, Umberto is also paid; now while openLCA and SimaPro are only focused on one product this are these are most focused on product.

This is more focused on process; however, we can also consider the product in GaBi, but SimaPro and openLCA are more focussed on product. This is what I have slowed and all of these four softwares have approaches are suitable for the straight forward life cycle assessment. Now, SimaPro and GaBi both used in databases from GaBi and eco invented databases one is GaBi database which GaBi has developed through its 20 years of experience in life cycle assessment.

They have different associations like plastic associations, world steel association is also provide the data and tell that what will be the use of steel, what will be the impact of steel, what are the inputs to the steel, when we manufacture steel. So, also like GaBi eco invent is very commonly used data base which GaBi also uses and SimaPro also uses.

Umberto this is used for generally non-linear processes and for system analysis. Now, searching the whole system and its interactions before breaking it down to the single linear product systems; so, this software is particularly useful when you want to explore your complete production system; like I said the complete factory. So, these are the certain applications that high level both GaBi and SimaPro share a common purpose that is whereas, to identify environmental hotspots of product systems at levels of assemblies, processes, flows, plans they mainly differ in that sense of database they have.

Gabi has both GaBi and eco invent database, but SimaPro have has the eco invent database so, that is the difference. So, like this solidworks sustainability Xpress sustainable minds. So, these are also some streamlined software LCA softwares, but their computational capabilities are limited. I will put computational capabilities are limited. So, this is the basic difference. Now, we will discuss about GaBi software and we will have a demonstration on this what specifically is GaBi software based upon it is based upon plants. So, if you remember we had a factory like this in which we have small unit processes. So, this big factory this is out plan, this is our process.

And if material flow happens from one process to second process this process one process to this is flow. So, it is based upon plant processes and flows. The most critical path which is identified in conducting a life cycle assessment is number 1 collecting the data from both inside the organisation and from outside organisation and then mapping the data and then getting information from the data. This is point 1, second point is I would say important activities or in place in what I would say critical activities; 1 is collecting data and data mapping. So, like this then providing the tailored insides that departments and business function and how this can be used that is second critical activity providing information. So, these are information in a way.

For instance I will taking sample of manufacturing a clip a paper clip. So, this is a kind of a paper clip that we have. So, it is a steel wire paper clip. So, that we will show how to bend this, how to make this we will do and this paper clip is made of a steel wire. When the steel wire comes people also know people the manufacturers only know what is the total weight or total length of the paper clip that we have used. So, total weight is the factor that we will use you here, that is the only information they have. Now, from where is this steel brought?

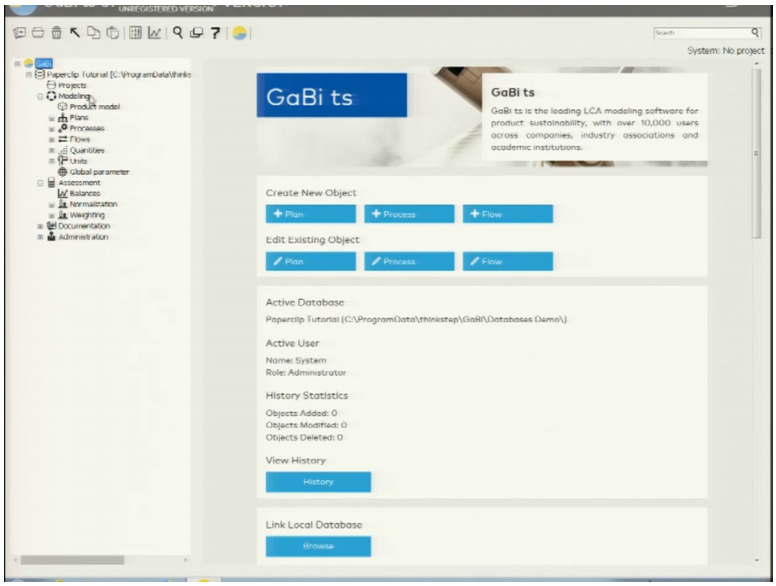
It is brought from steel billets and it is transported and the steel billets have converted the billets into this wires and the wires have been bended, that manufacturing processes that may be used. So, providing the tailored information is important that what specifically needs to be done. So, communicating the product sustainably performance to customers is a third point; communicating to the customers. So, this softwares had to cater these challenges I would say in collecting the data and then data mapping, then providing tailor information and communicating to the customers.

We can generate reports in report, we can show that what is the environmental impact of our product in comparison to the competitors product or in comparison to the previous product that we were manufacturing. So, there are certain paybacks in a way the cost we can optimise the material energy and resource across the value chain. We can optimise internal processes and we can gain visibility into the supply chain. And in that way we can mitigate risks from materials and processes of concern this can enhance the brand and reputation of the company. So, this is all that we can do in using the softwares ok.

So, three points can be put as map, then evaluate ok, then communicate. So, with this I would like to take you to the software interface that is GaBi software. And we will see how do we work on this software and how do we create the plan processes and flow. I will just take an example of the inbuilt database that is there, that is manufacturing of the steel wire clip and you can; obviously, develop your own processes based on the different materials that you have.

Just this is a introduction and this is a tutorial that is there on the GaBi website as well, the PDF tutorials are available, you can read them and I am also trying to replicate that tutorial again in this lecture. So, let us come to the GaBi interface and see how does this work?

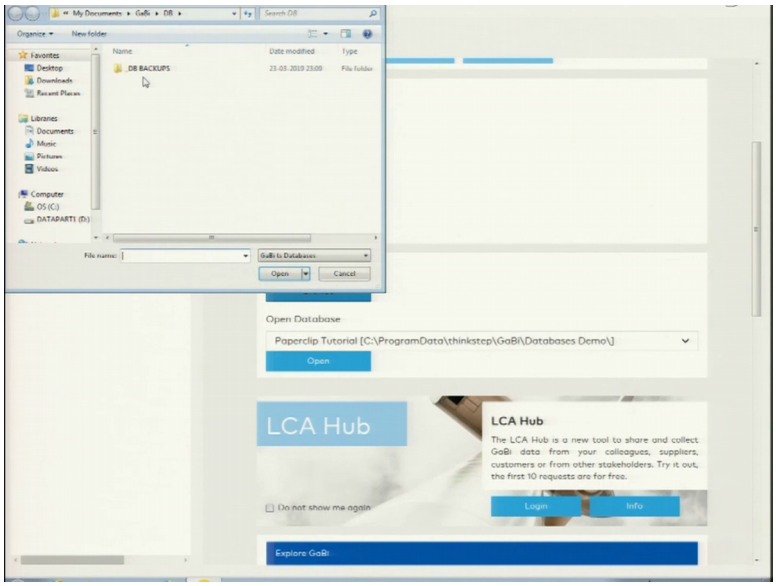
(Refer Slide Time: 11:50)



So, this is the GaBi interface, this is an evaluation version that is there for 30 days. This is a full evaluation version and we have taken this to demonstrate the GaBi software capabilities. Not the all capabilities, but to introduction of what we can do in the software. So, this has like I said plan, process and flow; again plan is the life cycle you are analysing; it is a boundary that we are working on. Process is the place on the plan which shows an elemental activity.

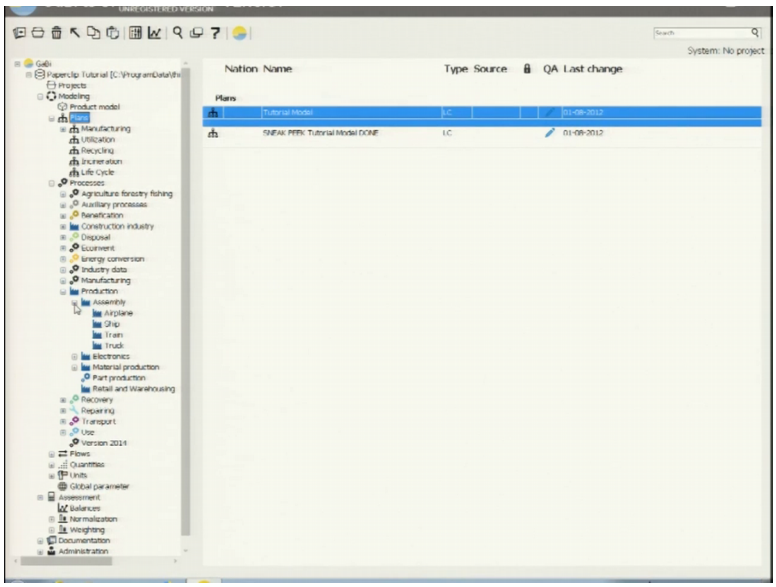
So, this can be some manufacturing like milling, turning, bending, packaging to these are processes. Flow is the connection between two processes, it is the connecting the energy material. It flows generally mass, energy and cost; anything that is moving around the system that is connected using this flow.

(Refer Slide Time: 12:58)



We can go here and browse for the database. Since this version does not have a database very large databases in it; so, we can just have this tutorial database that we can just open. If you open the database you will see it is opening or we can even double click here paper clip tutorial and database will be opened. So, it is loading the flows, yes the database is open. Now, it has this tutorial if I go to projects, modelling, processes, plans.

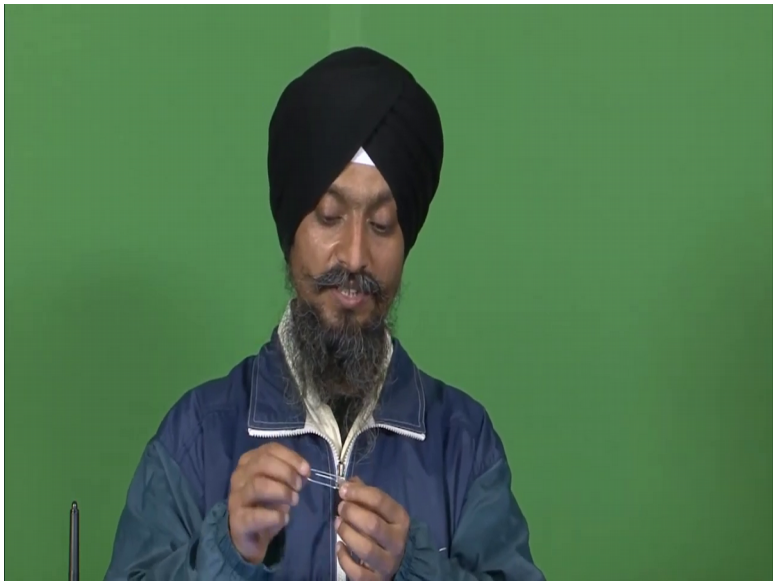
(Refer Slide Time: 13:42)



So, it has this tutorial model; a model that is there to develop paper clip to manufacture a paper clip. The paper clip as I mentioned is made of the steel wire and the steel wire is

only the raw material that is coming and it has to be bent. The steel wire has to be bent so, the process there here is bending.

(Refer Slide Time: 14:09)



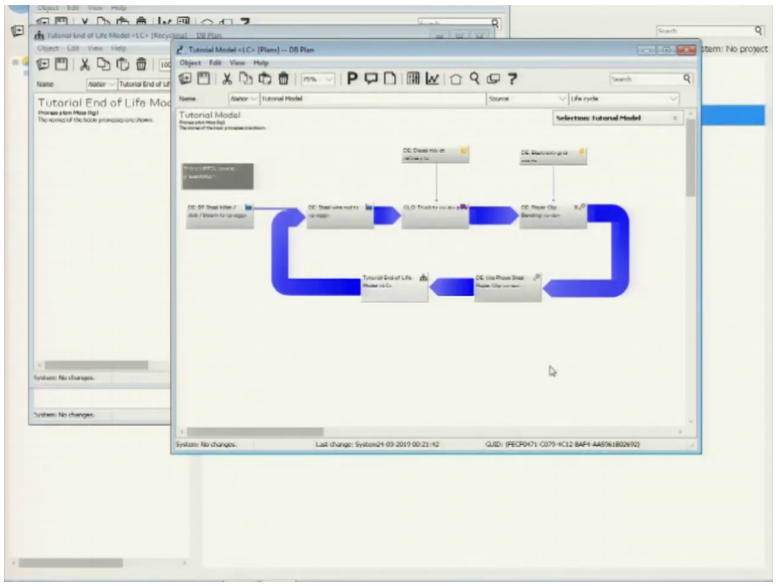
The bending process is here that has to bend this into certain that the bending process is there that has to bend it at certain point and make the proper paper clip like this. So, the input is steel wire; from where is this steel wire made that we need to need know. So, we will make a model we will work in this sequence any plan, processes and flows. So, what are the plans? Manufacturing plans, utilisation plans, recycling plans, incineration plans and life cycle plans. Processes are there so, these are the classification characters or catheterization characters in the software which are there these are all objects here.

So, in processes we have agriculture and forestry, in agriculture and fluency if I expand this it will have crop and animal in crop and animal it is animal production, growing non-perennial crops, growing perennial crops. So, many things are there. So, we are more concerned in manufacturing and production. In manufacturing it is showing manufacturing of beverages, manufacturing of food products. So, GaBi has classified manufacturing in a way that only beverages and food products are there in manufacturing. But, (Refer Time: 15:17) manufacturing that we think of is in production.

In production it is assembly, assembly are the big assemblies like airplane, ship, train, truck. How to assemble the big system or big system of systems and work on that; then it has electronics in production and in material production it has certain material

production: plastic production, production of materials for renewables all those things and part production specific part production. So, this is a kind of a part production that we can see bending that we put as a process. So, these are certain options available. To make a model the first step is to open a project; so, these are the projects.

(Refer Slide Time: 16:05)



So, I will just go to project in right click; right click sub menu opens and we can open new here, click on new. The new project that I will open here is LCA paper clip or I would say NPTEL Advanced Green Manufacturing Systems paper clip demo ok. I have made this project, now we do to save the project. Save the project in a way this project can be used in future and the data basis those we develop in this product and connections that we are making. This project can be added to the existing database, if something extra is added. So, we need to save it that happens from activate project here, we activate project now project is activated here.

So now, we can close this window, next is we need to work on the plan. In this project we need to add a plan, we go to plan and add new; we can name this plan, also you can see the plan. We can tell in which country are we working on, these are the country codes right. So, we can pick IN for India actually it might not have the databases or the grid or electricity grids for India. So, let us keep it nation for now and what kind of plan it is. We need to see is it a life cycle plan, is it a production or manufacturing plan, is it a use plant, is it end of life EoL is End of Life, is it recycling, is it incineration.

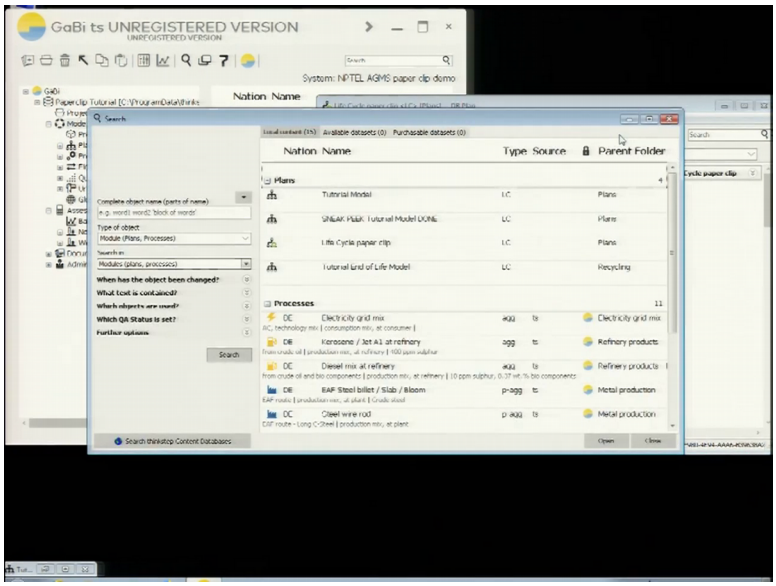
So, I will say it is life cycle. So, I will say name the plan as Life Cycle paper clip ok. Then I for saving the plan I just need to click save, the plan would be saved here. So now, the plan is saved. So, this is the area on which I will work, this is the area on which the whole processes and flows would come and would connected and finally, we will analyse using the results calculation. So, this is the icon of results calculation and this is search icon that we will use many times in this presentation.

So, to because we need to work on this area it is better to cascade windows. So, as we can see this area and keep on dragging the objects if required; plan framework or the plant area is there now. Now, in the plan predefined data base models can be added and also we can define our own model.

So, we will see we will do both the things. So, with the features that is whether you finds your speed and thousands of things step consulting projects. This software has support at every stage of life cycle and assessment from data collection and organisation to presentation of results and stakeholders engagement. So, it automatically tracks all material, energy, ambitions and these flows as well as it defines the monetary value, working time, social issues giving instant performance.

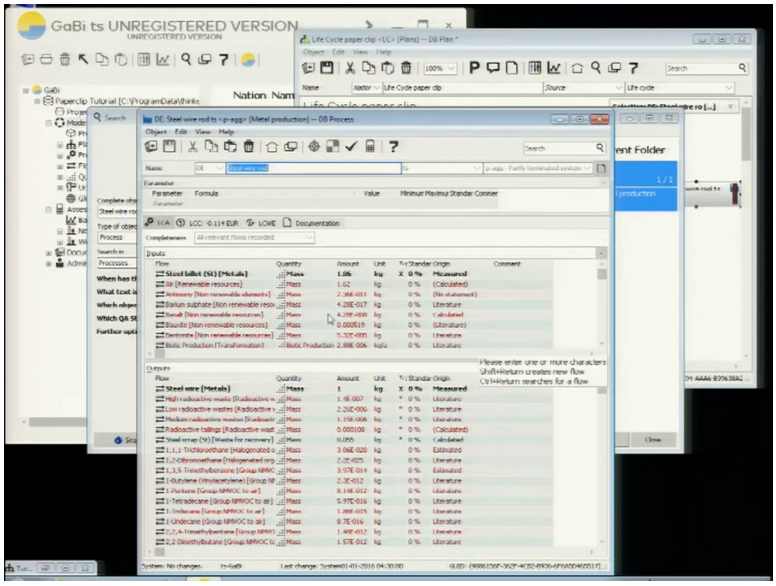
So, we will see when we will add processes. Next we need to add processor, to add a process either we can go from here; we can manually select the process if you know that where is the specific location of the process. So, or we can just search the process from this search bar.

(Refer Slide Time: 19:43)



We need to put here what are we trying to search; is it process, is it plan, is it flow what are we are trying to search? We are trying to search a process here I will select process in the object type and put steel wire. So, if I put steel wire rod it is showing this position it is showing the steel wire rod. So, I will just drag and drop it here in the plan. So, drag and dropped the steel wire here which is input to my process. So, what is p and I will just tell you what is this process.

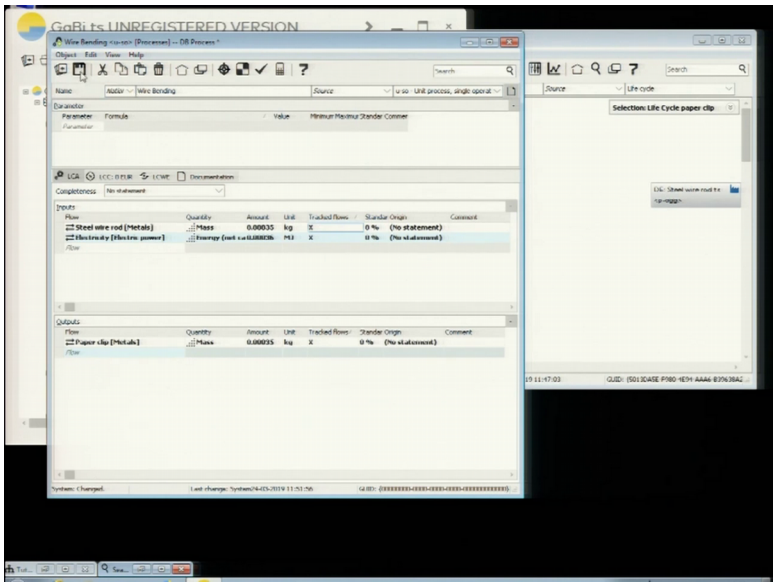
(Refer Slide Time: 20:36)



So, I will tell you one thing if we open this; if we open this is trying to open it from internet. This is the list of the materials or all the connections or inputs and outputs that it has that this process has. So, these are the input output. So, this is the list, this is known as life cycle inventory. This life cycle inventory is a list of resources input and output, input might be hard coal, output might be the emissions to air maybe carbon dioxide which are elementary flows to the system. So, it has largest internally consistent data sets with available, data sets have from eco invent.

You can even see the eco invent is one of the dataset here in processes, the eco invent processes are here this is call from eco invent. So, this is the life cycle inventory; if we remember first step is there we need I have we have to define the scope that we will work on life cycle analysis of this paper clip steel paper clip. Second step is life cycle inventory that is there if some inventory would not be there, we can add that. First step is life cycle impact analysis or that we will do and then you will try to intermit the results. So, this is just to show you the life cycle inventory, now this process is added.

(Refer Slide Time: 22:19)



Next I need to add a process that is bending, in that way bending process is not there a in the database I can make a new process. I will just go to process, right click some menu, click on new, single click on new; now it is opened a option for adding new processes. So, this new processes I will put bending or wire bending wire bending process, the process can be unit single operation, unit black box, life cycle inventory that is

aggregated, partly terminator system or avoided product system; what does his 5 processes?

What is specifically USO? USO is Unit Single Operation which is referred to as unit process or gate to gate process. This process contains only the data for one specific process that is there is no other connected inputs and other connected outputs. It is a single process they are not second tire, third tire, fourth tire connections. It is a single person this is data is coming or some connection is coming and the connection is going out from this, this is single process.

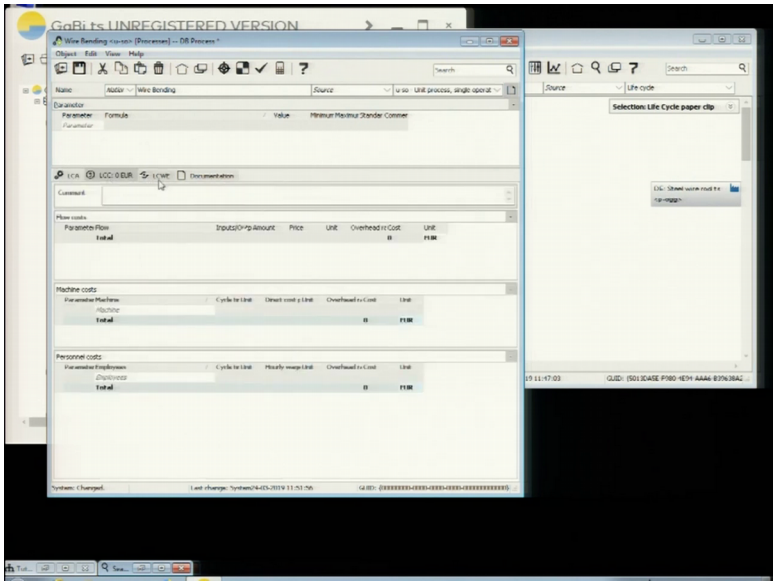
Second is unit process black box, unit process black box this is a multifunctional process or process chain at a plant level. This type of process may represent a group of processes rather than a single process. For example, the entire production chain of manufacturing and automobile. So, in place of just assembly in place of just like fixing wheel to the automobile it is assembling the whole automobile. So, this is used when we are using the multiple processes in one process rather than individual manufacturing, transport processes these processes can be used.

Next is agg this is LCI results, agg is actually aggregated. So, this is life cycle inventory results, that contains the entire life cycle data for part or for the complete life cycle of a product system. So, this kind of data set is obtained referred to as cradle to gate system, as I said cradle means from the very birth from extraction of ore to gate, gate is the point where we are putting this process. Now, this is p-agg, p-agg is Partly terminated system. This is represented here, it contains the life cycle inventory data for all the processes except for one to one product flows that required additional modelling. Next is aps Avoided product system all inputs and outputs flows are set to negative values or all inputs are converted to outputs or vice versa.

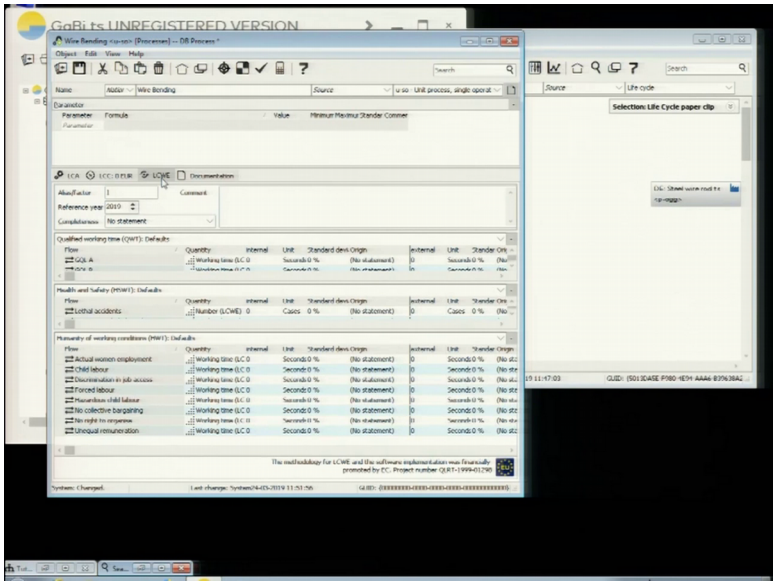
So, this is just to confirm the data that were putting in if we do the vice versa, if it make it negative positive to negative and the other way does it work in that way or not what are the results in that way. So, in this way the use of certain materials energy is avoided by the product system and the study, so, this can be done. So, what is this wire bending process? Wire bending process is essentially a single unit process. Now, you can often see there is a parameter frame here. The parameter frame here, parameters are when we

need to analyze the different parameters were affecting the process as for now we leave it.

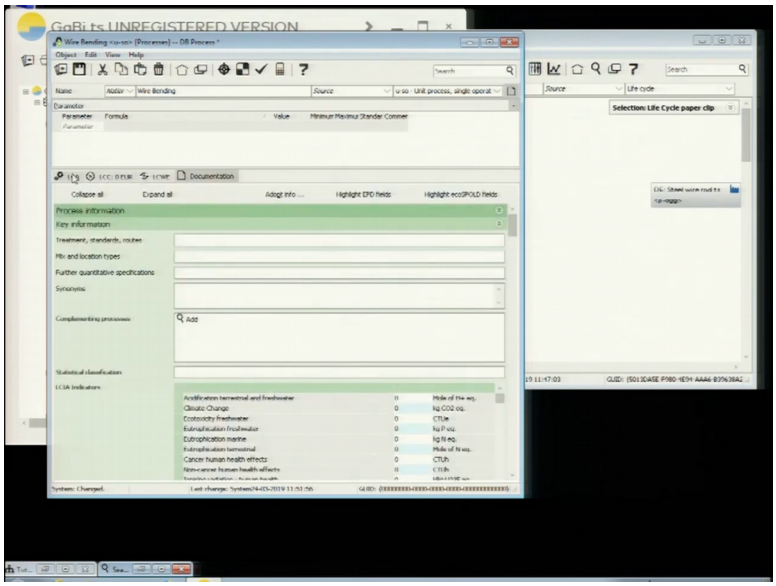
(Refer Slide Time: 25:34)



(Refer Slide Time: 25:36)



(Refer Slide Time: 25:38)

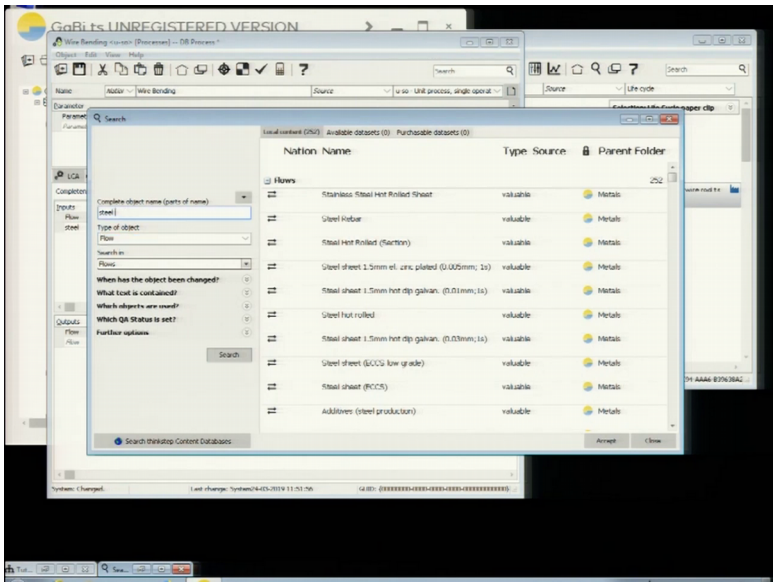


Next we have LCA, LCC and LCW and E and documentation. LCA is Life Cycle Assessment, life cycle assessment that will work on life cycle costing is the financial aspects in life cycle. And LCW is a social life cycle in a way. So, if you remember I showed you three pillar of sustainability; three pillars of sustainability were economic, environmental and social.

So, it is environmental as LCA then life cycle costing that is for economic and LCWE that is for social, this is a social LCA. It is trying to conduct the life cycle assessment for all the three pillars of sustainability. So, in social LCA you can see there will number of lethal accidents those occur, these are a kinds of humanity actual women employment, child labour discrimination and job access.

So, as per data which has documentation is when we need to add some documents and we need to produce report this and these which standards of those things can be putting here. So, we have specifically now working in life cycle analysis here. So, here we need to put flows. First flow to wire bending would be against steel wire rod, I will put steel you can say it is the auto prediction function that is working. If I see s t double e l it is trying to predict what I am trying to ask here.

(Refer Slide Time: 27:04)



So, if I put steel it will put everything that is the word steel here. So, this is in the flow object because, I am trying to put the input flow so, this is steel, I will put steel wire rod steel wire rod. So, you can search steel wire rod yes, steel wire rod is there you will just select this and accept. Now, this is added as a flow here, now the amount the quantity can be the mass and the steel and iron meter, the mass amount that we can put here is 0.000 35 kg for 1 click so, this is the mass for that.

So, also the input to this process would be electricity. We need power to work on it say electricity. Now, it is asking to make a new object because say electricity does not exists which is not the case actually there is a spelling error, it is electricity. So, it is showing electricity for product for credit I will put the parent electricity here consumption mix at consumer. So, we can even have for instance we if we know that the specific electricity that we using this coming only for the thermal power plant; it can show here we can pick electricity from hard coal, electricity from natural gas from hydropower.

So, the hydropower would have less environmental impact in comparison to hard coal, this is obvious. I will pick electricity consumption mix at consumer accept. So, this is again a flow. So, this electricity consumption in megawatt or in kilowatt hour you can change its units, here units are mega Joules, Btu, calories, giga Joules all those units are there. I will pick kilowatt hour and put as 0. 0001 kilowatt hour of energy is used electricity used to produce this clip.

So, if you see if I put this value and now I will change the units it will by itself convert the value into mega Joules 0.001 kilowatt is equal to 0.0036 mega Joules. So, these are the input flows, output here would be we will get a paper clip. We will have a paper clip, enter there is no object in the name of paper clip not the asking to make a new object, yes we can make a new object. But, now need to locate the object; paper clip is a metal item we can put it in the specific place and also we need to understand that how is the data classified here. How is the flows and processes classified? So, in the flows will put paper clip in valuable substances then materials in material specifically it is a metal material ok. So, this is the location I will name it paper clip.

And what kind of flow is this? Is it an input or output? It is an output here ok, it can be input or output both. So, we can click save here which is saved ok. Now, this paper clip is saved and that is we can put the amount of paper clip. The weight of steel wire should be equivalent to the weight of paper clip that we get. So, it is again 0.0035 kg kilograms that is 1 paper clip. Also you can see a cross here, the cross means this is a tracked flow. So, there actually two major kinds of flows; one is elementary flow and one is non-elementary flow. In elementary flow what is there? Elementary flows that enter the techno sphere directly from nature, that is one we can find here in the sources flow folder and the flows that exit the techno sphere directly to nature.

So, those are elementary flows; these elementary flows can be emissions to air, water and the emissions to land. So, in our system this iron ore so, the productions of steel is an elementary flow entering in the paper clip techno sphere. So, carbon dioxide emissions arriving from production or elementary flow leaving the paper clip techno sphere. Non-elementary flows are the flows that move only within the techno sphere. They are not entering directly from the natural world and do not exit the techno sphere to the natural world. So, these are non-elemental flows. One is tracked flow if I put here cross; that means, is tracked flows ok.

If I put star; that means, no statement is there. Tracked flows; tracked flows include valuable substances energy flows that can be used in another process. The tracked output input flow can be connected to a other tracked input or output flow or the following process in the process change; the connection between plants and processes by tracked flows is also possible. So, if we save a flow and that can be again tracked in some other kind of processes that is a tracked flow; if you have been it to make sure that is a tracked

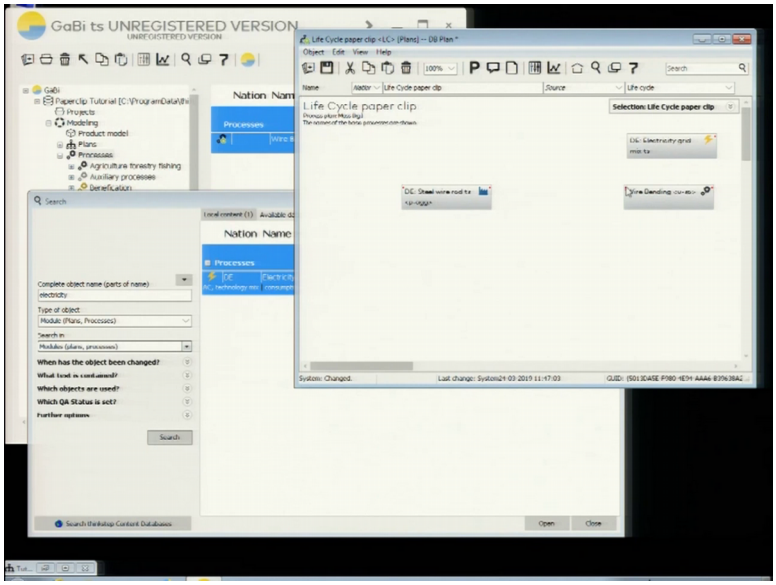
flow here. So, that is why it is crossed in t 3 flows here to input force to output force, now this wire bending processes we can save it and we can drag it here.

I will have to tell you other than tracked flows there are waste flows, waste flows are the flows that need some processing to work on them and they can be reused again though those are other kinds of flows which exist. So, this is we have two processes here, this box represent processes steel wire rod. I will put it here steel wire bending, I will put it here and there has to be electricity, I will put new process here search electricity.

So, this is electric capacity grid mix Germany DE company electric city grid mix which is available in the database. So, I will put it here which will also go as inputs to the wire bending because, it requires power to work on. Also they has to be use face, the wire bending has to be used so, that use faced also has to be added.

Before that I will show you one thing, I will go to view this drop down menu and I will click here show tracked inputs and outputs. If I click it here you can see these red dots here red dot; red dot two red dots here. One red dot here one red dot here, red dot from the left side means inputs. This wire bending require two inputs two input flows, this has one output flow that the grid has one output flow, this steel wire rod has one input flow and one output flow. So, what are this flows that we can see the input flow steel billet, the input output flow is steel wire. In this case we have made this new process, there are two input flows which are electricity in steel wire and paper clip is the output.

(Refer Slide Time: 35:15)



So, this is important to see when will connect this red dot would convert to black, the number of red dots means number of flows those need to be corrected. So, next I need to add a new process here that is use face. So, it has an output is or this output would be wire bending only the input here has to be steel billet. So, I have to add steel billet here steel billet. So, that two steel billets: one is electric arc furnace steel billet, next is blast furnace steel billet. So, I will pick blast furnace steel billet as an input to this open.

Open will just open the life cycled inventory, I will just drag and drop steel billet here steel billet is here now. Let me make the window a little larger, the steel billet wire bending electric grid; to transport this steel wire to the wire bending to the factory then is to be some transport mode. So, I can as a transport mode so, if I know where it is located that I can just go here in processes transport road transport truck. So, this GLO truck can be added as a transport mode. It has two inputs here two red dots are here, when input what would be steel wire, also it would need cargo carbo steel wire, it would need diesel.

So, in this case I need to add diesel here as well. So, search diesel enter diesel mix at refinery drag and drop ok. Then this diesel will be collected to trucks here ok, this is almost ready. After wire bending we need to use one has to use this is a use face now, in use face we have to create a new process. Let me add a new process here new I will make it paper clip usage paper clip usage.

This is the name, the input to this has to be the paper clip paper clip ok. The amount is again 0.00035 kgs and the output would be the scrap steel scrap; steel scrap its trying to search steel scrap here. So, they have might be certain kinds of steel scrap.

So, we can pick one that is fitting best in our model. So, steel scrap product steel scrap steel wire. So, I will pick steel scrap St that is a waste type of source, the waste types of flow I will either said waste type of flow is the one that can be worked on that can be recycled and then used again. So, we will accept this. So, this is steel scrap amount here again has to be 0.00035 there is no reduction amount. So, save this close paper clip usage I will put this as the process it has one input here in it. So, it has one input with it there is no output this is not ok.

We has to be some output let me try to edit it, to edit any information I can click just go at the process right click, right click some menu will open and I can click the database

settings. So, what is the wrong in database setting this is not a tracked one. So, I need to convert into cross. So, when you convert it to cross, now save, now output also come.

Now, you can see input and output one input could be wire bending, input would be the paper clip that comes from wire bending, output would be steel scrap and after this we need to have end of life plan here; end the life plan is this has to be recycled. So, for that I create a new plan we are go to plan click new, new plan I will say EoL End of Life paper clip right.

This is the new plan and this is an end of life plan. So, it is of a choice only we can even pick end of life or life cycle in it. So, I have picked end of life here so, the input to this would be steel billet steel billet process. So, here I will pick electric arc furnace EAF is for Electric Arc Furnace steel billet, this I will pick and drop it here drag and drop close. So, this is in this the input flow has to be mentioned, output flow would be the billet here. The input flow would be the scrap, if it is showing the input and output flows electric arc furnace has its own built in database. So, will just fix it also I need to tell one very important thing we need to fix the processes.

We need to fix a reference process in each plans like in this plan we has to be one reference process based upon which life cycle assessment would happen. Because, each process has its own connections, has its own databases, has its own quantitative come in. So, based upon wire bending I can fix my model. In that case I will just double click this and there is a scaling factor here, scaling factor if I say let me say 1000. 1000 if I put here you can see this number is converted to the scale there 0.00036 is converted to 0.36. And if I put it let me 1000000 it has shown the similar input and output flows; let me just fix it 1000 and I have to here, fix means now this is fixed as the reference process; when I do this I say will find a cross here.

This red cross means in this plan this process is fixed. Similarly, there is a plan in plan that is sub plan in this case also the process has to be fixed, I will just keep the scale factor 1 and fix it is cross. So, this is the plan in itself that is complete. So, let me close this save changes here. So, this plan end of life paper clip this I will put it here in my main plan ok. So, we can even change the sizes of the boxes like we can just make it bigger or smaller or I can just change the size of all the processes here. I am just

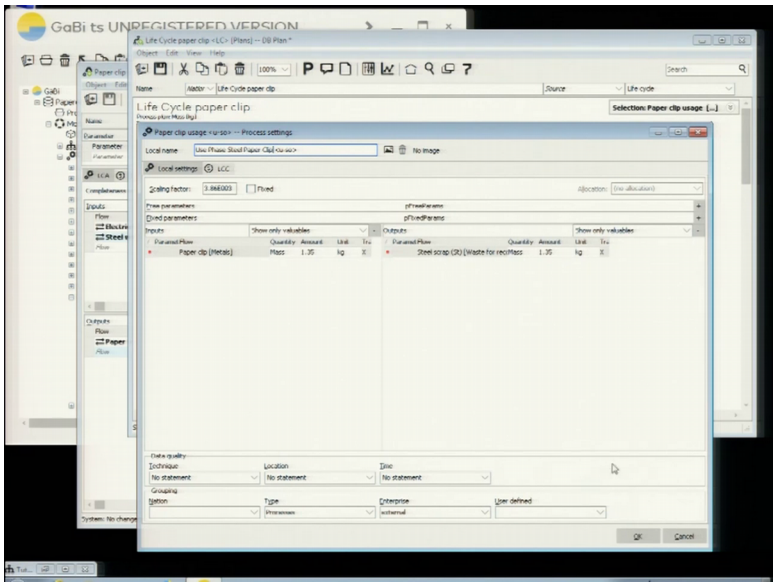
selecting all of them and making them bigger or smaller together, so, this can things can be done.

So, almost we have all the processes yes we have all the processes, now not we just need to connect may be connections. Now, if I go here this red line means it needs to be corrected somewhere. So, this would be connected with the steel wire rod that is connected with the GLO trucks. If you see when I am connecting it will ask this is the sources this is the (Refer Time: 43:20) things. So, source would be steel wire sink would be the cargo ok. So, you can see this red spot is now turned black; that means, the connection is made. In this case one red spot is still there; that means, some more connection is required.

In this case also there is much red spot so, I will connect this with here. So, this is connection is made here. So, I will just make the connections ok. So, these connections are re-made also I can even put comments here. This is the comment tab here I can put a comment here. For instance I can put some information here, I could put this is NPTEL course presentation ok, this is the comment that I have put here, I can change the background colour of the comment. So, many things can be done. So, I can work on these settings of this. So, colour change colour, we can change the background colour to may be let us say black ok. So, this is black now and I can even change the font colour.

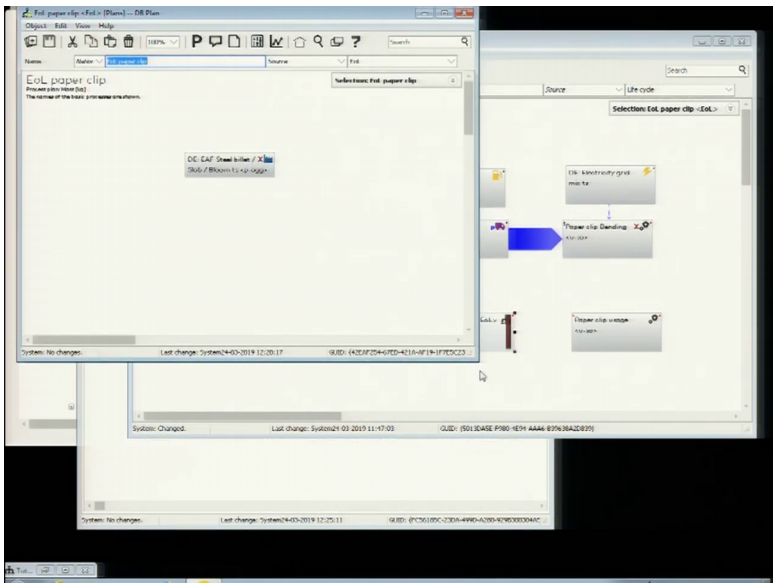
Font colour was also black and I can make it white. So, that it looks here so, this says I can even change the size of the box. So, this small changes can be made, now this is done and I can even rename the processes if I change go to database. However, rename is not recommended I will wire bending and put paper clip paper clip bending ok.

(Refer Slide Time: 45:17)



If I put the set as paper clip bending and say save I have to change other names as well. So, in this paper clip uses I will just rename it use face steel paper clip ok.

(Refer Slide Time: 46:07)

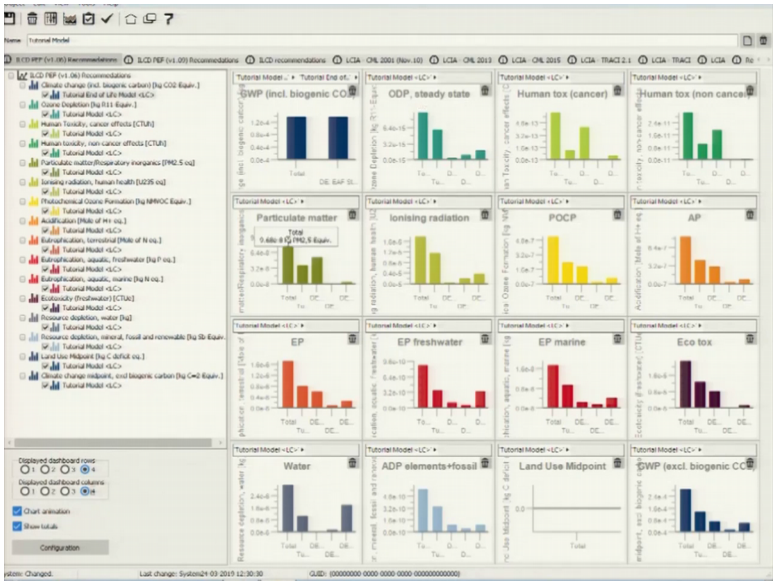


This EoL I am just making the names what were given in the tutorial that we had. So, this is tutorial End of Life end of life save. So, this a error in here course spelling ok. So, this is renaming and making the flows so, we have made the flows already ok, these two flows are left. We to connect this here and we need to connect these paper clips usage to

end of life and that also needs to be connected to steel wire rod as input. So, let us make this connections.

So, I make certain changes to the names and we are ready with the model now. So, this is the model that we have let me make it bigger size. So, this is a model for the plan that we have the power plan is now complete with all the connections here. Now, we need to analyze the data, now this is we have made the plan for the specific product. We can analyze the data, in that case we need to analyze the life cycle impact.

(Refer Slide Time: 47:33)

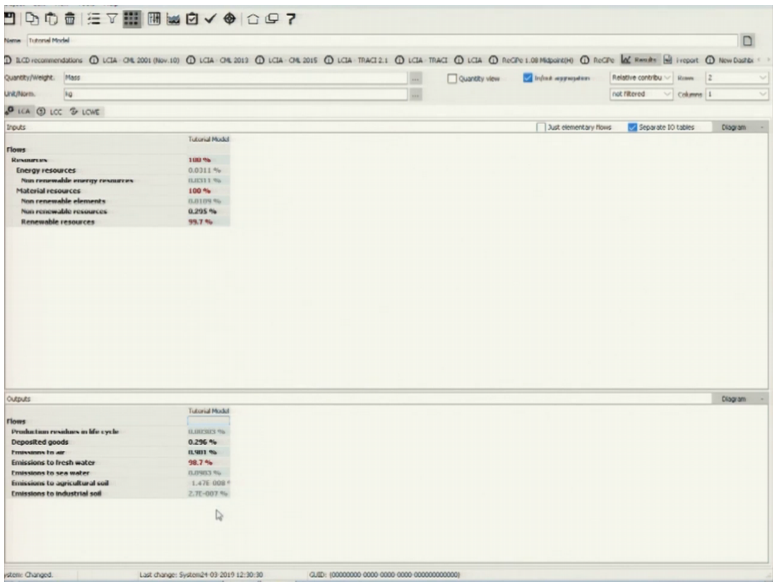


So, that I click result calculations here this is result calculations so, it is calculating. So, it is showing these charts here. So, you can see global warming potential, ozone depletion then human toxicity cancerous and non-cancerous these are the output those are coming here. So, we can just click at one bar. So, double click at one bar it will show the next tier of the connections here. So, we can again click it here. So, we can see the next tier total what is happening, it is showing here double click. If I double click here it is showing the next tier tutorial end of life model, carbon dioxide equivalent, if I double click here it is showing that one.

Also we can see how many charts are be displayed on a dashboard. So, we can set display in rows only 1, it is showing only 1 row and 2 in column. If I say only 1 by 1 it will show only 1 chart ok, if I say 4 by 4 it is showing 4 by 4 16 4 into 4 16 charts here. So, it is showing everything here. So, these are again global warming potential are same,

these are first four charts then particulate matter which is PM 10 and PM 2 levels and ionization radiation. So, these are the charts which is showing; please let me make it 2 into 2 again. These charts can be copied if I just right click I can say copy to clipboard and that can be pasted in the report. So, those things can happen.

(Refer Slide Time: 49:54)



Also we can make our own dashboard, if I go to plus sign here and click it is asking to make a new dashboard. A new dashboard I can change some specific requirements which I need. So, I can name the new dashboard here inputs and name here. So, if I in this case I would say let me say change the quantity, in quantity I will go to environmental quantities; I just need to work on the global warming potential.

So, I will go to CML 2001 global warming potential for 100 years ok. So, it is showing chart for that. So, here also I can copy and paste information ok. So, this is we can build our own dash board, these are the different reports which is showing life cycle impact analysis for CML 2015. So, different models you showing here.

Also we can see results, if I go to results here it will not show results in a list form. In the list form we can copy and paste the results in our excel sheet and work on them. Other than just getting the histograms, we can even make the line diagrams or pie charts using this if I click here double click here it is expanding and further it is expanding expand and collapse to see what are the impacts. So, this is inputs and outputs, also these are just

elementary flows. If I unclick this it will show all the flows valuable substances and production residuals in the life cycle.

So, it is non-elementary flows it is also showing, then separate input and output tables. Now, these are all the flows if I need to separate input tables and output tables I need to click here, this checkbox it separate the input tables and output tables ok. So, in an out aggregation it can be shown aggregation and it can show in unaggregated way. So, it can also see life cycle costing for resources and valuables it was total 2000 model it is showing some values here for resources, for valuable substances life cycle based upon the data; though within and put these are the inputs, but it is still having some data that was connected when with the maybe to transport, the lethal accidents that might be road transport no lethal accidents.

So, these are the data which are available this impact an LCA's can be done. Also we can get the values in relative in the percentage form. These are the absolute values we can go to relative value here and if I put relative value it will show the percentages, resource is 100 percent in the 100 percent resource is material resources is a 100 percent. Energy resources are 0.0311 we can see emissions to freshwater is the most significant impact that is there from our process other are all negligible in comparison to this. So, these are all in valuable substances is the no value; no value means it is not having any impact. A very important expect in this software is this can see this icon this is weak points.

So, this is now the interpretation of results, if I click weak points here it will bring me three colours red, grey and black. Red colour means which is very significant ok, red colour is significant, red colour means the total impact for instance in specifically renewable sources total effect is 99 percent. Anything that is more than 10 percent would be red; that means, more than 10 percent of impact is coming from the specific activity or the specific category no that will be red. Grey means that is not at all significant, that is in negligible. Black is in between red and grey black is in between red and grey.

So, these are the ways we can just copy the data and put it in the excel sheet, if I put click here in this frame then click control a it is copy data then I right click and copy; now this is copied and I can paste it in my excel sheet. So, this is a brief introduction on working with GaBi software and you can definitely work on this that task, that I like to give you today is; this is the truck. The steel wire rod is transfer it should truck, to try to see the

impact using this truck and also you can change this you can, put a transportation from air like flight is bringing the steel wire rod to the bending process. In that way you can find it here in processes you will find transport; transport is air transport.

So, its air transport it is cargo plane, if I put it in my plan cargo plane. So, it has you can open it to see what are the inputs and outputs here, the inputs are cargo and kerosene; kerosene from refinery output is cargo. So, we need to put kerosene in place of diesel mix, then we need to search for kerosene. This is a task for you kerosene, diesel, kerosene this one, drag it here ok. Now, please delete this one I am just clicking on it diesel mix, put click delete. Click on truck click delete and I will put it here. Now, you please make connections this to this the connections from here and make connections from here and see what is the change.

In place of the truck I have put the plain please compare these two results, in that case in comparison between the transportation. Now, this is the transportation model we have to picking the same kind of material. We have not changed steel to some other row material; it might be some plastic or polymer clip that we can use. So, I am just changing the transport medium here from truck to a travel from cargo plane. So, this comparison you can make. So, this software is used for comparison for life cycle impact analysis and the whole scenario analysis can be done that is another level of the software.

This is a comprehensive software and we can work on this to have the life cycle impact analysis for our whole system, may be for a single product and process and or for a whole system that can be the small small plans can be put in a bigger plan to make it a big system. So, this is all in this week where we have discussed the design for environment, we have discussed life cycle assessment as a part of design for environment and a two demonstrations. One is on online tool EIO-LCA, second one is a GaBi software which we have just taken the evaluation version, we have worked on that. We will meet next time and discuss more on advanced green manufacturing systems.

Thank you.