

REFERENCES

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APPENDICES

Appendix A LCSoft Manual

A.1 Main Menu

When start, the user enters LCSoft in the "Main menu" page as shown in Figure A1.

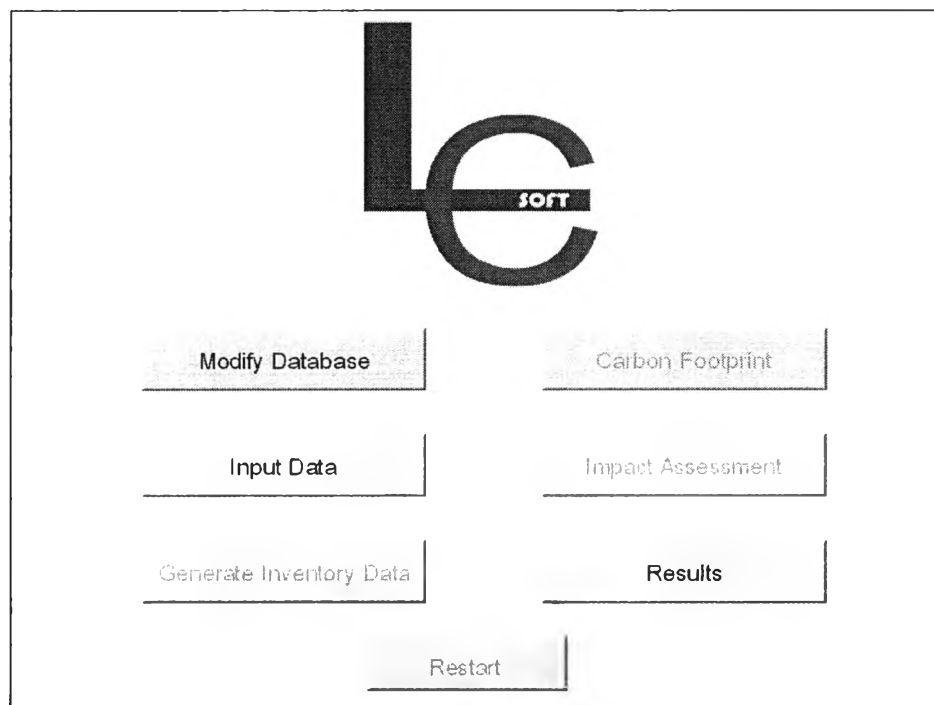


Figure A1 Main menu page.

From the picture, at start “Generate Inventory Data”, “Carbon Footprint” and “Impact Assessment” button are not enable because the necessary data are not imported yet. Therefore the only section that user can access is input data section and modify database section (user can also access to results section but there is no any result). By clicking “Input Data” button the program will go to input data section (see Figure A2).

A.2 Input Data

On input data interface user must input all required data. The following data are require to input to the software: stream table of designed process from PROII, equipment table of designed process from PROII, input-output stream name, quantity and type of hot/cold utility, product and/or by product's name, fuel type, location and quantity of renewable energy.

Input Data

Import Stream Table

Import Equipment Table

Define Input/Output Stream

Hot/Cold Utility

OK

Define Product and Functional Unit

Type of Fuel

Fuel Type	Energy (GJ)

Country: Renewable Energy: MMBtu

Cancel

Figure A2 Input data interface.

A.2.1 Import Stream Table

“Import Stream Table” button is shown in Figure A3. By clicking this button, the “open file” window will be activating (Figure A4) to let user choose the desired stream table. The format of stream table must be the same as Figure A5. The first cell of stream table must be cell C:2, the first component’s name must be cell D:10 and the first stream name must be cell F:3.

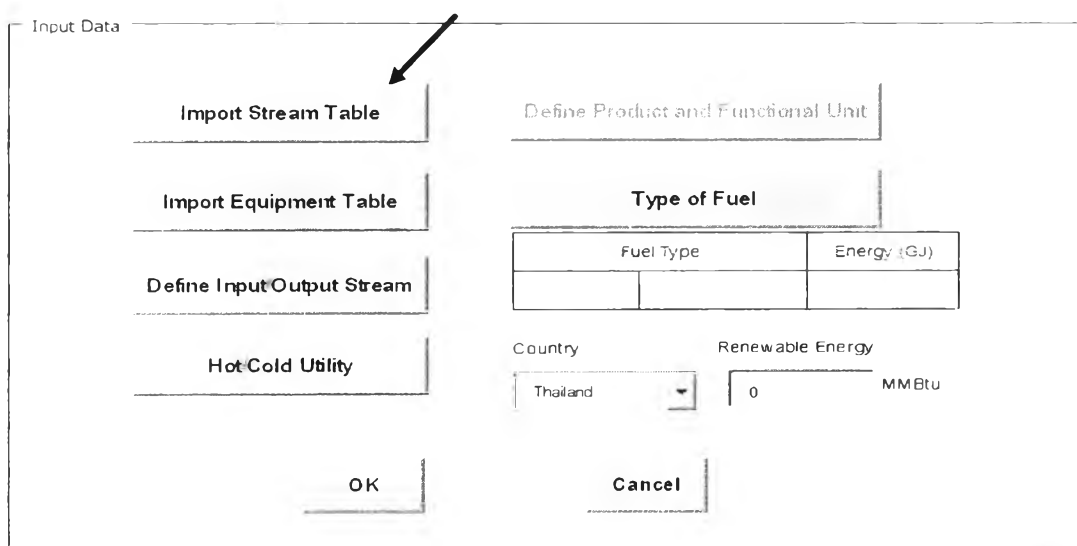


Figure A3 Import stream table button.

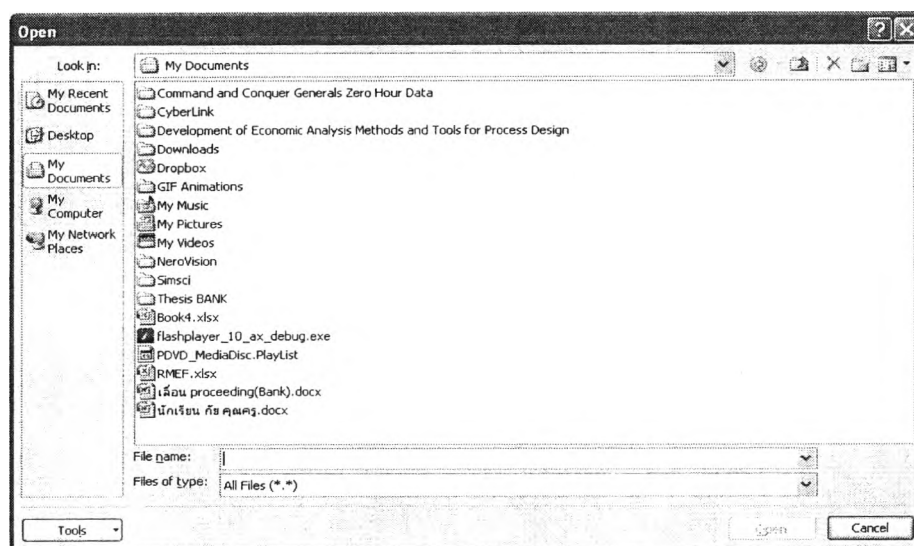


Figure A4 Open file window.

Component Rates					
Stream Name		S1	S2	S3	S4
Description					
Phase		Liquid	Liquid	Vapor	Vapor
Temperature	C	29.85	48.99	82.60	329.85
Pressure	ATM	1.00	1.00	1.00	1.00
Molecular Weight		42.03	43.73	43.73	43.73
Component Molar Rates KG/HR					
	ETHANOL	14.729.40	22.937.90	22.937.90	22.937.90
	WATER	977.07	1.697.84	1.697.84	1.697.84
	ACETALDEHYDE	233.91	351.32	351.32	351.32
	HYDROGEN	0.00	0.00	0.00	0.00
	ETHYLACETATE	0.00	2.488.63	2.488.63	2.488.63
	ACETIC ACID	0.00	0.00	0.00	0.00
	BUTYLALCOHOL	0.00	0.00	0.00	0.00

Figure A5 Stream table format.

When import stream table, the user form name “Confirmation” (Figure A6) will appear. Click “Yes” if the user wants to use imported stream table, if not click “No” to delete imported table.

Confirmation ✕

Do you want to use this stream table

Figure A6 Confirmation form.

A.2.2 Import Equipment Table

After import stream table, the next thing to import is equipment table. To import equipment table, click “Import Equipment Table” button (Figure A6) the “open file” window will be activate like import stream table in Figure A4. The format of equipment table must be the same as Figure A7 (this table can export from PROII). The first cell of equipment table must be cell C:3, Equipment list started from F:3

Input Data

Import Stream Table

Import Equipment Table

Define Input/Output Stream

Hot/Cold Utility

OK

Define Product and Functional Unit

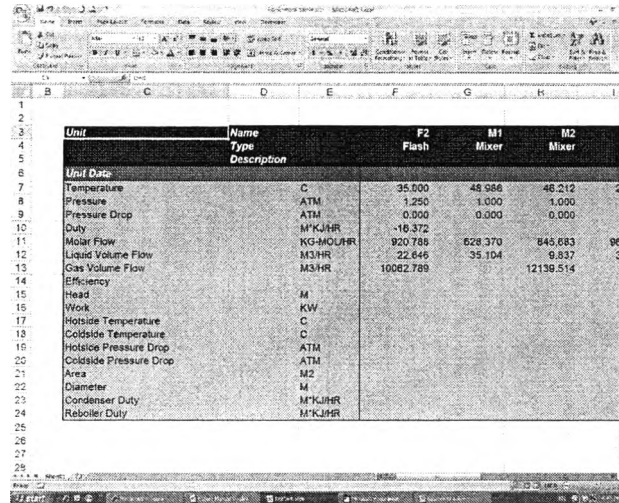
Type of Fuel

Fuel Type	Energy (GJ)

Country: Renewable Energy: MMBtu

Cancel

Figure A7 Import equipment table button.

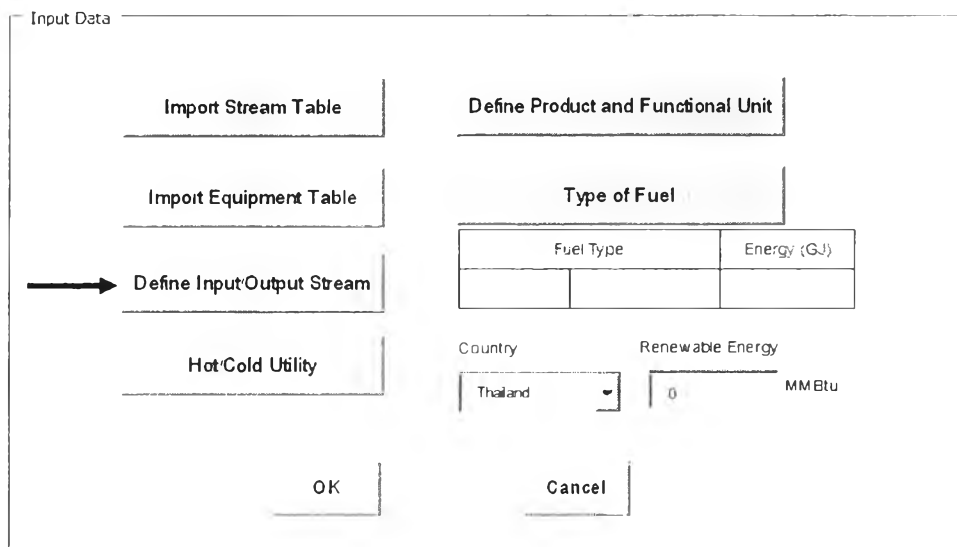


Unit	Name	Type	Description	F2 Flash	M1 Mixer	M2 Mixer
Unit Data						
Temperature	C			35.000	48.086	48.212
Pressure	ATM			1.250	1.000	1.000
Pressure Drop	ATM			0.000	0.000	0.000
Duty	M ³ /HR			-16.372		
Molar Flow	KG-MOL/HR			920.788	628.370	845.683
Liquid Volume Flow	M ³ /HR			22.646	35.104	9.837
Gas Volume Flow	M ³ /HR			10062.789		12139.514
Efficiency						
Head	M					
Work	KW					
Hotside Temperature	C					
Coldside Temperature	C					
Hotside Pressure Drop	ATM					
Coldside Pressure Drop	ATM					
Area	M ²					
Diameter	M					
Condenser Duty	M ³ /HR					
Reboiler Duty	M ³ /HR					

Figure A8 Equipment table format.

A.2.3 Define Input and Output Stream

Click “Define Input/Output Stream” button (Figure A8) to activate define stream page. On this page user need to define the name of all input and output stream including product stream manually. For output stream user must define stream name for output stream to soil, output stream to air and output stream to water separately as shown in Figure A9. After define all input/output stream name click “Done” button to return to input data page.



Input Data

Import Stream Table

Import Equipment Table

Define Input/Output Stream

Hot/Cold Utility

Define Product and Functional Unit

Type of Fuel

Fuel Type	Energy (GJ)

Country: Thailand

Renewable Energy: 0 MMBtu

OK Cancel

Figure A9 Define stream name button.

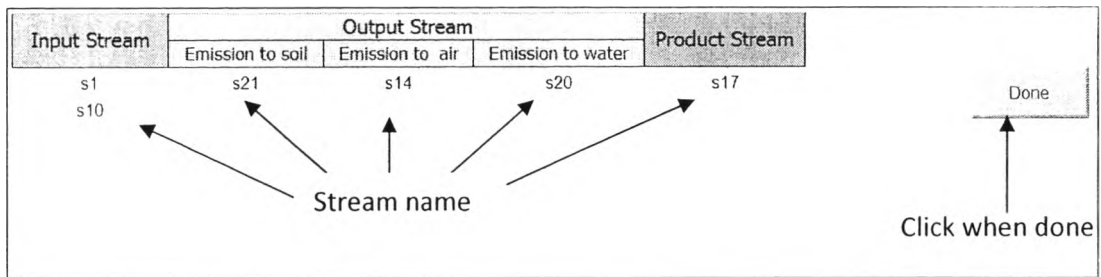


Figure A10 Define stream page.

A.2.4 Define Hot and Cold Utility

Next step is to input type and quantity of hot and cold utility by clicking “Hot/Cold Utility” button (Figure A10), the worksheet name “utility entry” will activate.

Figure A11 Hot/Cold utility button.

When access to utility entry page, “Utility entry” form will populate to help user to define hot and cold utility (Figure A11). **At start only steam is available for hot utility and only cooling water is available for cold utility** but user can flexibly add more databases later.

Figure A12 Utility entry form.

After select type of hot and cold utility, the amount of energy (in GJ) from hot utility and mass (in ton) of cold utility usage must be define. When done click “OK” button in the form, type and quantity of utility will show in the Excel sheet (Figure A12).

Hot Utility	Energy (GJ)	Cold Utility	Quantity (Ton)	Add More Item
Steam	189.55	Cooling water from engine-driven chiller using natural gas	2979.82	Done

Figure A13 Utility entry page.

From Figure A12, click “Add More Item” to call utility entry form again and click “Done” button to return to input data page.

A.2.5 Define Product and Functional Unit

After import stream table and define stream LCSoft will read all chemical name from stream table and automatically put it into combo box in “Define product and functional unit” page (see Figure A13) so user can choose product name from the combo box. For by product, user can define it by clicking “Add by product” button to call “Add by product” form as shown in Figure A14.

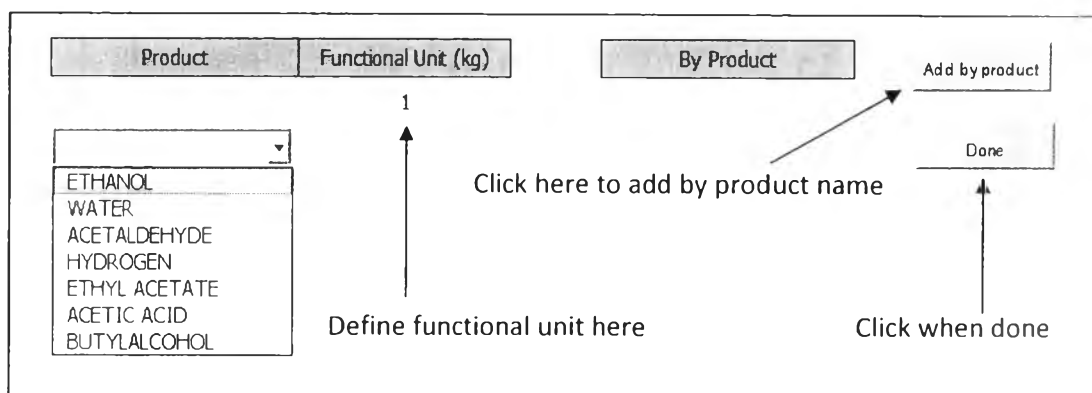


Figure A14 Define product and functional unit page.

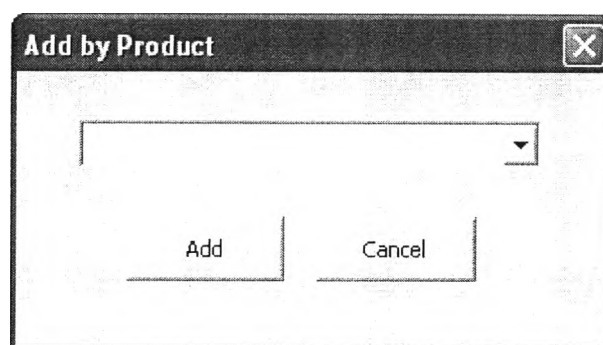


Figure A15 Add by product form.

A.2.6 Specify Type of Fuel

Come back to input data section, next thing to do is to specify type and energy of fuel use in the process. To do this click “Type of fuel” button as shown in Figure A15 to call “Fuel use” form (Figure A16).

Input Data

Import Stream Table

Import Equipment Table

Define InputOutput Stream

Hot/Cold Utility

OK

Define Product and Functional Unit

Type of Fuel

Fuel Type	Energy (GJ)

Country: Renewable Energy: MMBtu

Cancel

Figure A16 Type of fuel button.

Select sub-fuel type

Select fuel type

Fuel Use ✕

Type of Fuel

GJ

OK

Cancel

Energy from fuel

Figure A17 Fuel use form.

From Figure A16 user must select fuel type first by choosing from the left combo box. The list of sub-fuel type is then appearing in the middle combo box for user to choose. Finally define energy from fuel (in GJ) in the text box on the right then click "OK". Selected fuel and energy now show in the area below "Type of fuel" button as shown in figure A17.

Input Data

Import Stream Table

Import Equipment Table

Define Input/Output Stream

Hot/Cold Utility

OK

Define Product and Functional Unit

Type of Fuel

Fuel Type		Energy (GJ)
Coal	Bituminous coal	27.03

Country: Thailand

Renewable Energy: 0 MMBtu

Cancel

Figure A18 Energy and type of fuel use in process show on input data page.

A.2.7 Select Location (Country)

User must select country name from the combo box shown in Figure A18. This data is required for calculate emission from electricity.

Input Data

Import Stream Table

Import Equipment Table

Define Input/Output Stream

Hot/Cold Utility

OK

Define Product and Functional Unit

Type of Fuel

Fuel Type		Energy (GJ)
Coal	Bituminous coal	27.03

Country: Thailand

Renewable Energy: 0 MMBtu

Figure A19 Select country box.

A.2.8 Define Energy from Renewable

Beside the country combo box is an area available for user to specify energy from renewable used in the process (Figure A19).

Input Data

Import Stream Table

Import Equipment Table

Define Input/Output Stream

Hot/Cold Utility

OK

Define Product and Functional Unit

Type of Fuel

Fuel Type		Energy (GJ)
Coal	Bituminous coal	27.03

Country: Thailand

Renewable Energy: 0 MMBtu

Cancel

Figure A20 Text box for input energy from renewable.

When all required data has been input to the program user must go back to main menu interface again by click “OK” button. If any required data is missing the program will not allow the user to leave this section.

A.3 Generate Inventory Data

User can access to generate inventory data page after input all required data in input data section. Therefore on main menu interface, “Generate Inventory Data” button and “Carbon Footprint” button are enable this time (Figure A20). By clicking “Generate inventory data” button on main menu interface, LCSoft will read data from stream table and show it in inventory data page as shown in Figure A21.

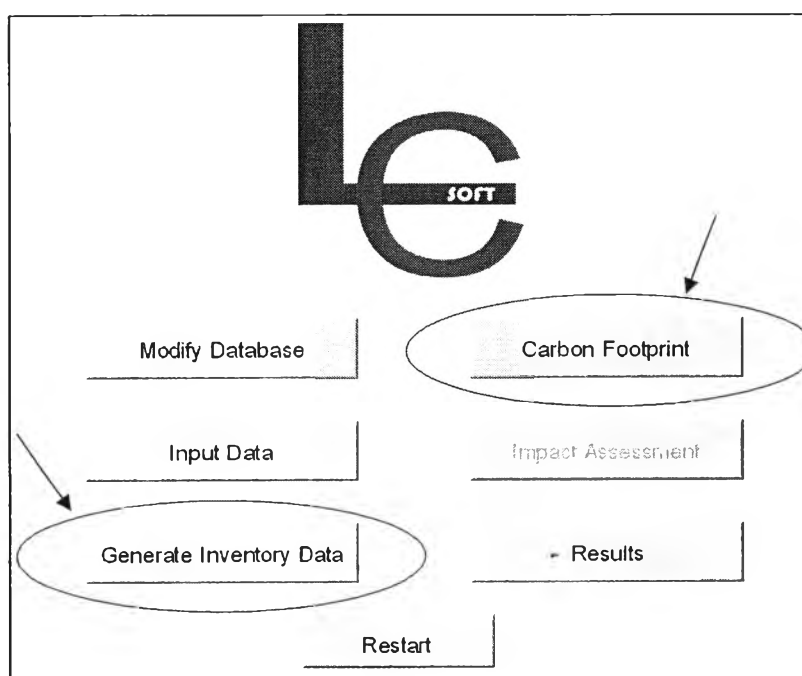


Figure A21 Main menu interface with enabled button.

Inventory Data		Calculate	Main Menu
ETHANOL	Quantity (kg)	Direct emission	
WATER	7237.28	Emission to air	
ACETALDEHYDE	233.31	ETHANOL	782.54
HYDROGEN	0.00	WATER	86.56
ETHYL ACETATE	0.00	ACETALDEHYDE	10.31
ACETIC ACID	0.00	HYDROGEN	607.85
BUTYLALCOHOL	0.00	ETHYL ACETATE	231.29
		ACETIC ACID	0.00
		BUTYLALCOHOL	0.00
		ETHYL ACETATE	231.29
		ACETIC ACID	0.00
		BUTYLALCOHOL	0.00
		ETHYL ACETATE	231.29
		ACETIC ACID	0.00
		BUTYLALCOHOL	0.00

Substance	Raw Mat	Energy	Unit
CO ₂			
CH ₄			
SO ₂			
N ₂ O			
N ₂			
CFC			
HFC-12a			
H ₂			
HCl			
HF			
NMHC			
PM ₁₀			

Fuel consumption	kg
Total energy consumption	GJ
Percentage energy from renewable	
Product	Energy consumed Unit
ACETALDEHYDE	
By product	Energy consumed Unit

Figure A22 Input/Output data show in inventory data page.

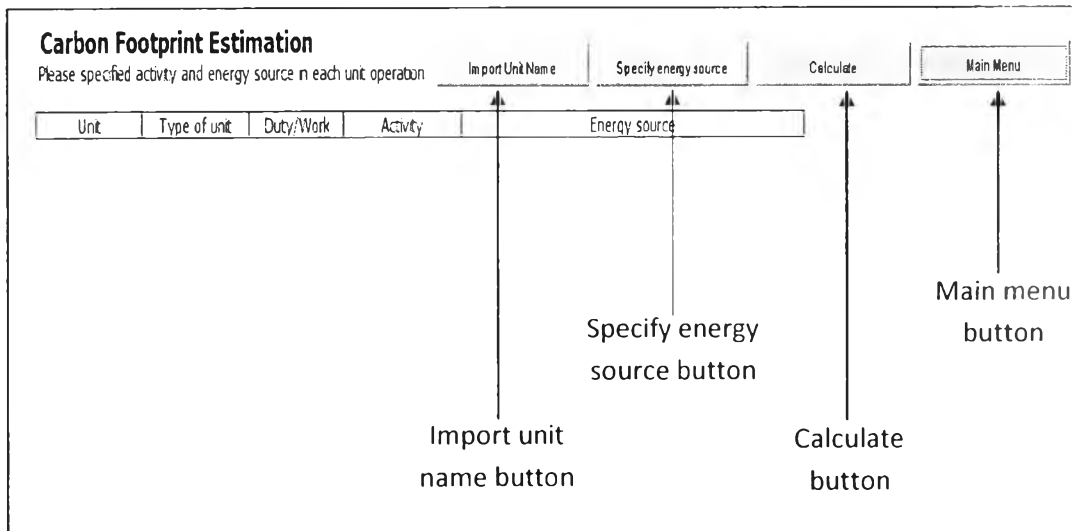


Figure A24 Carbon footprint page

A.4.1 Import Unit Name from Equipment Table

Click “Import unit name” button to read information (name, type and duty) of each equipment from equipment table and put it into the first three column of the table as shown in Figure A24.

Unit	Type of unit	Duty/Work	Activity	Energy source
F2	Flash	-16.3715		
E1	Hx	26.6809		
E2	Hx	0.2316		
E3	Hx	4.9220		
REF-E3	Hx	4.9220		
R1	ConReactor	23.2307		
SC1	StreamCak	-0.3781		
SC2	StreamCak	-5.6077		
T1	Column	3.1599		
T2	Column	0.4059		
T1Condenser	Condenser	-130.4285278		
T2Condenser	Condenser	-28.87660408		
T1Reboiler	Reboiler	133.5884552		
T2Reboiler	Reboiler	29.28252792		
C1	Compressor	117.5615463		

Figure A25 Equipment data from equipment table.

A.4.2 Specify Energy Source

Next step is to specify activity and energy source of each equipment. By clicking “Specify energy source” button, The “Define energy source” form will appear (see Figure A25).

The image shows a software window titled "Define energy source". Inside the window, there are three columns of dropdown menus. The first column is labeled "Unit name", the second is labeled "Activity", and the third is labeled "Energy source". Below these columns, there are three buttons: "Add", "Done", and "Cancel".

Figure A26 Define energy source form.

From Figure A25 there are three combo boxes in the form. The first one on the left is combo box contain list of unit name for user to select which unit that wants to specify activity and energy source. The second one is in the middle of the form. This combo box use to select activity of the selected unit. The last combo box is use to specify energy source.

After specify all information in these three combo box, user must click “Add” button to add information to the selected equipment in the last two columns of the table as shown in Figure A26. User must proceed this step until all activity and energy source of every equipment has been defined.

Carbon Footprint Estimation

Please specified activity and energy source in each unit operation

Unit List Bank Specify energy source Calculate Main Menu

Unit	Type of unit	Duty/Work	Activity	Energy source
F2	Flash	-16.3715	Cooling	Cooling water from engine-driven chiller using natural gas
E1	Hx	26.6809	Heating	Steam
E2	Hx	0.2316	Fuel combustion	Fuel
E3	Hx	4.9220	Cooling	Cooling water from engine-driven chiller using natural gas
REF-E3	Hx	4.9220	Cooling	Cooling water from engine-driven chiller using natural gas
R1	ConReactor	23.2307	Fuel combustion	Fuel
SC1	StreamCak	-0.3781	Cooling	Cooling water from engine-driven chiller using natural gas
SC2	StreamCak	-5.6077	Cooling	Cooling water from engine-driven chiller using natural gas
T1	Column	3.1599	Fuel combustion	Fuel
T2	Column	0.4059	Fuel combustion	Fuel
T1Condenser	Condenser	-130.4285278	Cooling	Cooling water from engine-driven chiller using natural gas
T2Condenser	Condenser	-28.87660408	Cooling	Cooling water from engine-driven chiller using natural gas
T1Reboiler	Reboiler	133.5884552	Heating	Steam
T2Reboiler	Reboiler	29.28252792	Heating	Steam
C1	Compressor	117.5615463	Electric usage	Electricity

Figure A27 Specified information.

A.4.3 Start Calculation

Start calculation for carbon footprint by click this button. Results from this calculation will show in result section. User can access to result section from main menu interface. To return to main menu, click “Main menu” button.

A.5 Impact Assessment

In order to calculate environmental impact user must click “Impact assessment” button on main menu interface (see Figur A27). This button will enable when all inventory data has been generated. By clicking this button, LCSoft will start calculate environmental impact and move to “LCIA Results” section automatically. LCIA result page is shown in Figure A28.

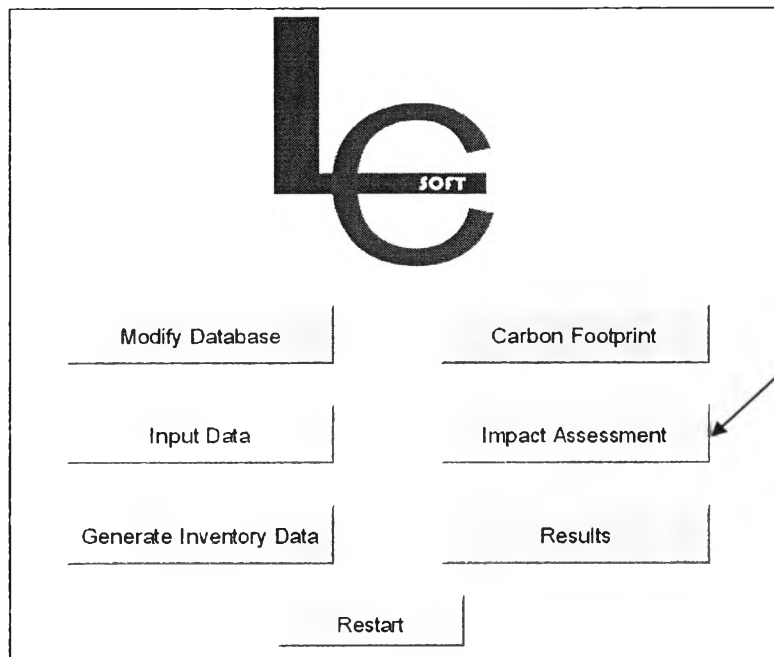


Figure A28 Impact assessment button.

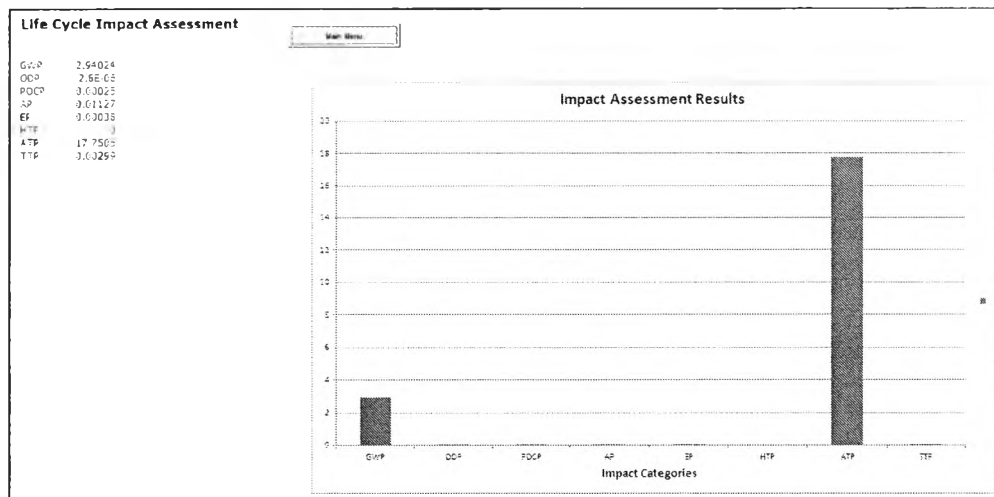


Figure A29 Impact assessment result.

A.6 View Result

On main menu user can go to result page by clicking “Results” button. After click, LCSOFT will call “Results” form for user to choose which result the user wants to see. “Results” form is shown in Figure A29.

The image shows a 'Results' dialog box with a close button (X) in the top right corner. Inside the dialog, there are two radio buttons: 'Carbon Footprint' (which is selected) and 'Impact Assessment'. At the bottom of the dialog, there are two buttons: 'Go' and 'Cancel'.

Figure A30 Results form.

From Figure A29 if user wants to see carbon footprint result, choose carbon footprint option on the form then click “Go” button LCSofT will move to carbon footprint result page immediately. If user want to see impact assessment result just choose impact assessment option instead of carbon footprint.

Carbon footprint result page is shown in Figure A30 and impact assessment result is shown in Figure A28.

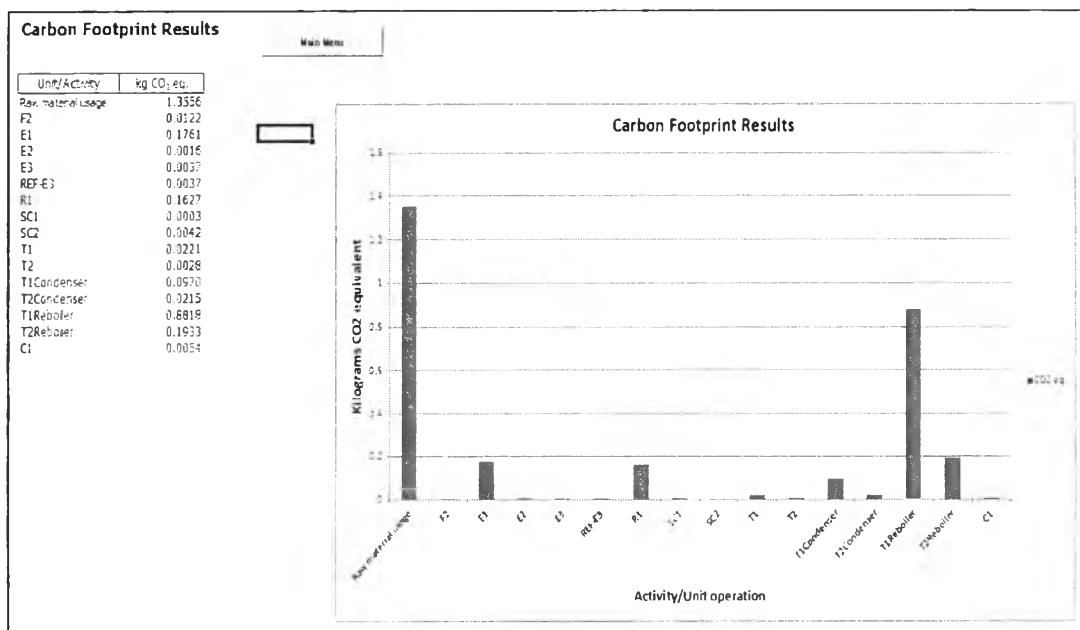


Figure A31 Carbon footprint result page.

A.7 Modify Database

User can add more database by click “Modify Database” button as shown in the figure below. After clicking user will be allow to select which database user want to add (Figure A33).

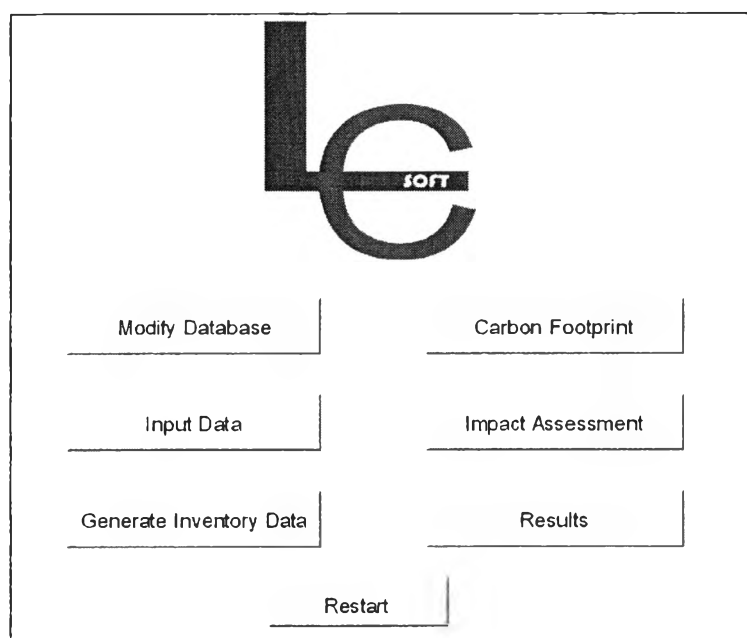


Figure A32 Modify database button.

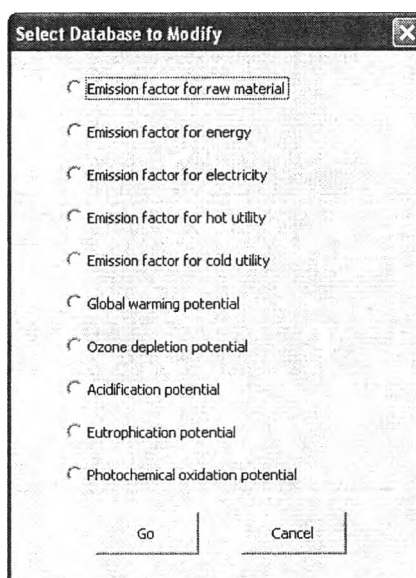


Figure A33 Select which database to modify.

A.8 Restart Button

To rerun the program, click “Restart” button as shown in Figure A34.

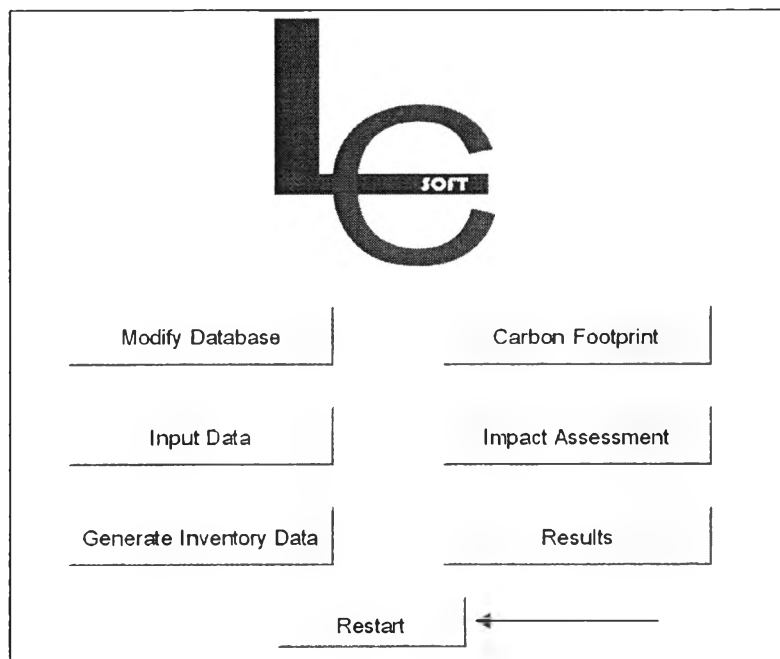


Figure A34 Restart button.

Table B1 Stream summary of acetaldehyde production process

<i>Stream Name</i>		S1	S2	S3	S4	S5	S6
<i>Phase</i>		Liquid	Liquid	Vapor	Vapor	Vapor	Vapor
Temperature	C	29.85	48.99	82.60	329.85	329.85	64.18
Pressure	ATM	1.00	1.00	1.00	1.00	1.00	1.00
Molecular Weight		42.03	43.73	43.73	43.73	29.84	29.84
Component Molar Rates	KG/HR						
	ETHANOL	14,729.40	22,937.90	22,937.90	22,937.90	9,168.28	9,168.28
	WATER	977.07	1,697.84	1,697.84	1,697.84	1,618.46	1,618.46
	ACETALDEHYDE	233.91	351.32	351.32	351.32	12,831.88	12,831.88
	HYDROGEN	0.00	0.00	0.00	0.00	607.85	607.85
	ETHYLACETATE	0.00	2,488.63	2,488.63	2,488.63	2,747.46	2,747.46
	ACETIC ACID	0.00	0.00	0.00	0.00	370.76	370.76
	BUTYLALCOHOL	0.00	0.00	0.00	0.00	131.02	131.02

Table B1 Stream summary of acetaldehyde production process (Cont'd)

Stream Name		S7	S8	S9	S10	S11	S12
Phase		Vapor	Vapor	Liquid	Liquid	Vapor	Mixed
Temperature	C	79.60	35.00	35.00	29.85	26.85	46.21
Pressure	ATM	1.25	1.25	1.25	1.00	1.25	1.00
Molecular Weight		29.84	18.86	42.74	18.02	2.02	18.50
Component Molar Rates	KG/HR						
ETHANOL		9,168.28	971.39	8,196.89	0.00	0.00	971.39
WATER		1,618.46	179.01	1,439.44	6,260.22	0.00	6,439.24
ACETALDEHYDE		12,831.88	6,963.70	5,868.18	0.00	0.00	6,963.70
HYDROGEN		607.85	606.36	1.49	0.00	1.49	607.85
ETHYLACETATE		2,747.46	656.95	2,090.51	0.00	0.00	656.95
ACETIC ACID		370.76	4.78	365.99	0.00	0.00	4.78
BUTYLALCOHOL		131.02	1.87	129.15	0.00	0.00	1.87

Table B1 Stream summary of acetaldehyde production process (Cont'd)

<i>Stream Name</i>		S13	S14	S15	S16	S17	S18
<i>Phase</i>		Liquid	Vapor	Liquid	Liquid	Liquid	Liquid
Temperature	C	26.85	26.85	26.85	26.85	20.85	78.61
Pressure	ATM	1.25	1.00	1.00	1.00	1.00	1.00
Molecular Weight		42.81	2.02	27.64	34.27	44.10	30.08
Component Molar Rates	KG/HR						
ETHANOL		8,196.89	0.00	971.39	9,168.28	14.16	9,154.12
WATER		1,439.44	0.00	6,439.24	7,878.68	1.42	7,877.26
ACETALDEHYDE		5,868.18	0.00	6,963.70	12,831.88	12,703.56	128.32
HYDROGEN		0.00	607.85	0.00	0.00	0.00	0.00
ETHYLACETATE		2,090.51	0.00	656.95	2,747.46	27.47	2,719.98
ACETIC ACID		365.99	0.00	4.78	370.76	0.00	370.76
BUTYLALCOHOL		129.15	0.00	1.87	131.02	0.00	131.02

Table B1 Stream summary of acetaldehyde production process (Cont'd)

<i>Stream Name</i>		S19	S20	S21	S22
<i>Phase</i>		Liquid	Liquid	Liquid	Liquid
Temperature	C	74.82	95.76	74.82	74.82
Pressure	ATM	1.00	1.00	1.00	1.00
Molecular Weight		46.31	19.17	46.31	46.31
Component Molar Rates	KG/HR				
ETHANOL		8,971.04	183.08	762.54	8,208.50
WATER		787.72	7,089.53	66.96	720.77
ACETALDEHYDE		128.32	0.00	10.91	117.41
HYDROGEN		0.00	0.00	0.00	0.00
ETHYLACETATE		2,719.98	0.00	231.20	2,488.78
ACETIC ACID		0.00	370.76	0.00	0.00
BUTYLALCOHOL		0.00	131.02	0.00	0.00

Table B2 Equipment table of acetaldehyde production process

<i>Unit Data</i>	<i>Unit Name Type</i>	F2 Flash	M1 Mixer	M2 Mixer	M3 Mixer	SP1 Splitter	E1 Hx
Temperature (°C)		35.000	48.986	46.212	26.850	74.822	-
Pressure (atm)		1.250	1.000	1.000	1.000	1.000	-
Pressure Drop (atm)		0.000	0.000	0.000	0.000	0.000	-
Duty (M*kJ/hr)		-16.372	-	-	-	-	26.681
Molar Flow (kg-mol/hr)		920.788	628.370	845.683	966.753	272.242	-
Liquid Volume Flow (m3/hr)		22.646	35.104	9.837	39.839	16.412	-
Gas Volume Flow (m3/hr)		10062.789	-	12139.514	-	-	-
Efficiency		-	-	-	-	-	-
Head (m)		-	-	-	-	-	-
Work (kW)		-	-	-	-	-	-
Hotside Temperature (°C)		-	-	-	-	-	164.000
Coldside Temperature (°C)		-	-	-	-	-	82.602
Hotside Pressure Drop (atm)		-	-	-	-	-	0.000
Coldside Pressure Drop (atm)		-	-	-	-	-	0.000
Area (m ²)		-	-	-	-	-	0.000
Diameter (m)		-	-	-	-	-	-
Condenser Duty (M*kJ/hr)		-	-	-	-	-	-
Reboiler Duty (M*kJ/hr)		-	-	-	-	-	-

Table B2 Equipment table of acetaldehyde production process (Cont'd)

<i>Unit Name</i> <i>Unit Data</i> / <i>Type</i>	E2 Hx	E3 Hx	REF-E3 Hx	C1 Compressor	R1 ConReactor	SC1 StreamCalc
Temperature (°C)	-	-	-	79.601	329.850	26.850
Pressure (atm)	-	-	-	1.250	1.000	1.250
Pressure Drop (atm)	-	-	-	0.250	0.000	0.000
Duty (M*kJ/hr)	0.232	4.922	4.922	-	23.231	-0.378
Molar Flow (kg-mol/hr)	-	-	-	-	920.788	423.339
Liquid Volume Flow (m3/hr)	-	-	-	-	-	-
Gas Volume Flow (m3/hr)	-	-	-	25488.113	45561.184	-
Efficiency	-	-	-	80.000	-	-
Head (m)	-	-	-	1570.173	-	-
Work (kW)	-	-	-	117.562	-	-
Hotside Temperature (°C)	-273.150	64.184	64.184	-	-	-
Coldside Temperature (°C)	329.850	-273.150	44.972	-	-	-
Hotside Pressure Drop (atm)	0.000	0.000	0.000	-	-	-
Coldside Pressure Drop (atm)	0.000	0.000	0.000	-	-	-
Area (m ²)	0.000	0.000	0.000	-	-	-
Diameter (m)	-	-	-	-	-	-
Condenser Duty (M*kJ/hr)	-	-	-	-	-	-
Reboiler Duty (M*kJ/hr)	-	-	-	-	-	-

Table B2 Equipment table of acetaldehyde production process (Cont'd)

<i>Unit Data</i>	<i>Unit Name Type</i>	SC2 StreamCalc	T1 Column	T2 Column
Temperature (°C)		26.850	78.607	95.759
Pressure (atm)		1.000	1.000	1.000
Pressure Drop (atm)		0.000	0.000	0.000
Duty (M*kJ/hr)		-5.608	3.160	0.406
Molar Flow (kg-mol/hr)		845.683	-	-
Liquid Volume Flow (m3/hr)		-	-	-
Gas Volume Flow (m3/hr)		-	-	-
Efficiency		-	-	-
Head (m)		-	-	-
Work (kW)		-	-	-
Hotside Temperature (°C)		-	-	-
Coldside Temperature (°C)		-	-	-
Hotside Pressure Drop (atm)		-	-	-
Coldside Pressure Drop (atm)		-	-	-
Area (m ²)		-	-	-
Diameter (m)		-	0.000	0.000
Condenser Duty (M*kJ/hr)		-	-130.429	-28.877
Reboiler Duty (M*kJ/hr)		-	133.588	29.283

Appendix C Hand Calculation

Process used in this calculation is acetaldehyde production process. The process flowsheet is shown in Figure B1. This calculation consists of five main steps as follow.

C.1 Collect Data

All necessary data of the process can be obtained from Table B1 and B2 in Appendix B. These data will use to calculate indirect emission from all activity in the process and some of them are the direct emission and can be use directly in carbon footprint and impact assessment calculation. However user must define some additional data especially input stream to know what raw materials are input to this process and output stream to know the direct emission that come out with the output stream. User define data are shown below.

Functional unit: 1 kg of acetaldehyde

Input stream: S1, S10

Output stream: S14 (Hydrogen release to air)

S17 (product)

S20 (waste water)

S21 (release to soil)

Utility: - Total Steam use 189.55 GJ = 179.52MMBtu

- Total Cooling water (CW) use 2979.82 ton

(Cooling water at 30 °C, 1atm)

Type of fuel: Bituminous coal 27.03 GJ = 25.60 MMBtu (100%)

Renewable energy: None

C.2 Emission Calculation

This step split into 3 parts which are emission from raw material calculation, emission from energy calculation and emission from utility calculation.

C.2.1 Emission from Raw Material Calculation

Input stream S1 and S10 is ethanol and water respectively. So there are two raw materials going into the process.

C.2.1.1 *Emission from Ethanol Input*

Emission factor for ethanol: $EF_{CO_2} = 0.819 \text{ kg CO}_2/\text{ kg Ethanol}$

$EF_{CH_4} = 0.00112 \text{ kg CH}_4/\text{ kg Ethanol}$

$EF_{N_2O} = 0.00105 \text{ kg N}_2\text{O}/\text{ kg Ethanol}$

Functional unit = 1

$m_{\text{product}} = 12703.56$

From equation $((m_i \times EF_x) / m_{\text{product}}) \times \text{functional unit}$

Calculation $CO_2 \text{ emission} = ((14729.4 \times 0.819)/12703.56) \times 1$
 $= 0.9496 \text{ kg CO}_2$

$CH_4 \text{ emission} = ((14729.4 \times 0.00112)/12703.56) \times 1$
 $= 1.3 \times 10^{-3} \text{ kg CH}_4$

$N_2O \text{ emission} = ((14729.4 \times 0.00105)/12703.56) \times 1$
 $= 1.22 \times 10^{-3} \text{ kg N}_2\text{O}$

C.2.1.2 *Emission from Water Input*

Emission factor for water: $EF_{CO_2} = 0.00226 \text{ kg CO}_2/\text{ kg water}$

$EF_{NO_x} = 0.0051 \text{ kg NO}_x/\text{ kg water}$

$EF_{SO_x} = 0.0147 \text{ kg SO}_x/\text{ kg water}$

$EF_{NMVOC} = 0.001 \text{ kg NMVOC}/\text{ kg water}$

From equation $((m_i \times EF_x) / m_{\text{product}}) \times \text{functional unit}$

Calculation $CO_2 \text{ emission} = ((6260.22 \times 0.00226)/12703.56) \times 1$

$$= 1.11 \times 10^{-3} \text{ kg CO}_2$$

$$\begin{aligned} \text{NO}_x \text{ emission} &= ((6260.22 \times 0.0051)/12703.56) \times 1 \\ &= 2.51 \times 10^{-3} \text{ kg NO}_x \end{aligned}$$

$$\begin{aligned} \text{SO}_x \text{ emission} &= ((6260.22 \times 0.0147)/12703.56) \times 1 \\ &= 7.24 \times 10^{-3} \text{ kg SO}_x \end{aligned}$$

$$\begin{aligned} \text{NMVOC emission} &= ((6260.22 \times 0.001)/12703.56) \times 1 \\ &= 4.93 \times 10^{-4} \text{ kg NMVOC} \end{aligned}$$

C.2.2 Emission from Energy Calculation

This step will calculate emission of pollutant from fuel combustion per functional unit in the process. In this case bituminous coal is use as a fuel in every unit that required.

Emission factor for bituminous coal: $EF_{\text{CO}_2} = 93.28 \text{ kg CO}_2/\text{MMBtu}$

$EF_{\text{CH}_4} = 0.01 \text{ kg CH}_4/\text{MMBtu}$

$EF_{\text{N}_2\text{O}} = 0.0015 \text{ kg N}_2\text{O}/\text{MMBtu}$

From equation $((E_i \times EF_x) / m_{\text{product}}) \times \text{functional unit}$

$$\begin{aligned} \text{Calculation CO}_2 \text{ emission} &= ((25.60 \times 93.28)/12703.56) \times 1 \\ &= 0.188 \text{ kg CO}_2 \end{aligned}$$

$$\begin{aligned} \text{CH}_4 \text{ emission} &= ((25.60 \times 0.01)/12703.56) \times 1 \\ &= 2.02 \times 10^{-5} \text{ kg CH}_4 \end{aligned}$$

$$\begin{aligned} \text{N}_2\text{O emission} &= ((25.60 \times 0.0015)/12703.56) \times 1 \\ &= 3.02 \times 10^{-6} \text{ kg N}_2\text{O} \end{aligned}$$

C.2.3 Emission from Utility Calculation

Utility use in this process contain of electricity, steam as hot utility and cooling water as cold utility

C.2.3.1 *Emission from Electricity*

Emission factor for electricity: $EF_{CO_2} = 0.583 \text{ kg CO}_2/\text{kWh}$

$$EF_{CH_4} = 2.0 \times 10^{-5} \text{ kg CH}_4/\text{kWh}$$

$$EF_{N_2O} = 5.0 \times 10^{-6} \text{ kg N}_2\text{O}/\text{kWh}$$

From equation $((\text{kWh} \times EF_x) / m_{\text{product}}) \times \text{functional unit}$

$$\begin{aligned} \text{Calculation CO}_2 \text{ emission} &= ((117.562 \times 0.583)/12703.56) \times 1 \\ &= 5.4 \times 10^{-3} \text{ CO}_2 \end{aligned}$$

$$\begin{aligned} \text{CH}_4 \text{ emission} &= ((117.562 \times (2.0 \times 10^{-5}))/12703.56) \times 1 \\ &= 1.85 \times 10^{-7} \text{ kg CH}_4 \end{aligned}$$

$$\begin{aligned} \text{N}_2\text{O emission} &= ((117.562 \times (5.0 \times 10^{-6}))/12703.56) \times 1 \\ &= 4.63 \times 10^{-8} \text{ kg N}_2\text{O} \end{aligned}$$

C.2.3.2 *Emission from Steam*

Emission factor for steam: $EF_{CO_2} = 88.18 \text{ kg CO}_2/\text{MMBtu}$

$$EF_{CH_4} = 0.008169 \text{ kg CH}_4/\text{MMBtu}$$

$$EF_{N_2O} = 0.000603 \text{ kg N}_2\text{O}/\text{MMBtu}$$

From equation $((E_{\text{steam}} \times EF_x) / m_{\text{product}}) \times \text{functional unit}$

$$\begin{aligned} \text{Calculation CO}_2 \text{ emission} &= ((179.52 \times 88.18)/12703.56) \times 1 \\ &= 1.25 \text{ kg CO}_2 \end{aligned}$$

$$\begin{aligned} \text{CH}_4 \text{ emission} &= ((179.52 \times 0.008169)/12703.56) \times 1 \\ &= 1.16 \times 10^{-4} \text{ kg CH}_4 \end{aligned}$$

$$\begin{aligned} \text{N}_2\text{O emission} &= ((179.52 \times 0.000603)/12703.56) \times 1 \\ &= 8.5 \times 10^{-6} \text{ kg N}_2\text{O} \end{aligned}$$

C.2.3.3 Emission from Cooling Water

Emission factor for CW at 30 °C: $\text{EF}_{\text{CO}_2} = 0.59 \text{ kg CO}_2/\text{ton CW}$

$$\text{EF}_{\text{CH}_4} = 0.000056 \text{ kg CH}_4/\text{ton CW}$$

$$\text{EF}_{\text{N}_2\text{O}} = 0.000001 \text{ kg N}_2\text{O}/\text{ton CW}$$

From equation $((m_{\text{cw}} \times \text{EF}_x) / m_{\text{product}}) \times \text{functional unit}$

$$\begin{aligned} \text{Calculation CO}_2 \text{ emission} &= ((2979.82 \times 0.59)/12703.56) \times 1 \\ &= 0.14 \text{ kg CO}_2 \end{aligned}$$

$$\begin{aligned} \text{CH}_4 \text{ emission} &= ((2979.82 \times 0.000056)/12703.56) \times 1 \\ &= 1.31 \times 10^{-5} \text{ kg CH}_4 \end{aligned}$$

$$\begin{aligned} \text{N}_2\text{O emission} &= (2979.82 \times 0.000001)/12703.56 \times 1 \\ &= 2.34 \times 10^{-7} \text{ kg N}_2\text{O} \end{aligned}$$

C.3 Energy and Fuel Consumption Calculation

C.3.1 Total Energy Consumption

From Table B2 in Appendix B there are nine equipments in the process that consumes energy. These nine equipments are E1, E2, E3, RefE3, R1, T1, T2, T1reboiler and T2reboiler

$$\begin{aligned} \text{Calculation } E_{\text{total}} &= \sum \text{energy in the process} \\ &= 26.68 + 0.23 + 4.92 + 4.92 + 23.23 + 3.16 \\ &\quad + 133.59 + 0.41 + 29.28 \\ &= 226.43 \text{ GJ} \end{aligned}$$

C.3.2 Energy Consumption for Product

$$\begin{aligned} \text{Calculation } E_{\text{product}} &= E_{\text{total}}/m_{\text{product}} \\ &= 226.43 / 12703.56 \\ &= 0.018 \text{ GJ} \end{aligned}$$

C.3.3 Percentage Energy from Renewable

No renewable energy use in this process

C.3.4 Fuel Consumption

From fuel consumption = Energy from coal/ Heating value

$$\begin{aligned} \text{Calculation Heating value for bituminous coal} &= 0.030145 \text{ GJ/kg} \\ &= 27.03/0.030145 \\ &= 896.67 \text{ kg of bituminous coal} \end{aligned}$$

C.4 Carbon Footprint

Since there is no direct emission of greenhouse gas from the process all the greenhouse gas used to calculate in this step will come from indirect source only.

C.4.1 Greenhouse Gas Conversion

Global warming potential for greenhouse gas:

$$\text{GWP}_{\text{CH}_4} = 21 \text{CO}_2\text{eq/kg CH}_4$$

$$\text{GWP}_{\text{N}_2\text{O}} = 310 \text{CO}_2\text{eq/kg CH}_4$$

Calculation CO_2 equivalent = $m_{\text{GHG}} \times \text{GWP}$

For raw material input to process

$$\begin{aligned} \text{CO}_2\text{e of CH}_4 \text{ from raw material} &= 1.3 \times 10^{-3} \times 21 \\ &= 0.027 \text{ kg CO}_2\text{e}_q \end{aligned}$$

$$\begin{aligned} \text{CO}_2\text{e of N}_2\text{O from raw material} &= 1.22 \times 10^{-3} \times 310 \\ &= 0.378 \text{ kg CO}_2\text{e}_q \end{aligned}$$

For utility usage

-Steam

$$\begin{aligned} \text{CO}_2\text{e of CH}_4 \text{ from unit E1} \\ &= 1.62 \times 10^{-5} \text{ kg CH}_4 \times 21 \text{ kg CO}_2\text{e}_q/\text{kg CH}_4 \\ &= 3.41 \times 10^{-4} \text{ kg CO}_2\text{e}_q \end{aligned}$$

$$\begin{aligned} \text{CO}_2\text{e of N}_2\text{O from unit E1} \\ &= 1.2 \times 10^{-6} \text{ kg N}_2\text{O} \times 310 \text{ kg CO}_2\text{e}_q/\text{kg N}_2\text{O} \\ &= 3.72 \times 10^{-4} \text{ kg CO}_2\text{e}_q \end{aligned}$$

$$\begin{aligned} \text{CO}_2\text{e of CH}_4 \text{ from unit T1}_{\text{reboiler}} \\ &= 8.14 \times 10^{-5} \text{ kg CH}_4 \times 21 \text{ kg CO}_2\text{e}_q/\text{kg CH}_4 \\ &= 1.71 \times 10^{-3} \text{ kg CO}_2\text{e}_q \end{aligned}$$

$$\begin{aligned} \text{CO}_2\text{e of N}_2\text{O from unit T1}_{\text{reboiler}} \\ &= 6.00 \times 10^{-6} \text{ kg N}_2\text{O} \times 310 \text{ kg CO}_2\text{e}_q/\text{kg N}_2\text{O} \\ &= 1.86 \times 10^{-3} \text{ kg CO}_2\text{e}_q \end{aligned}$$

$$\begin{aligned} \text{CO}_2\text{e of CH}_4 \text{ from unit T2}_{\text{reboiler}} \\ &= 1.78 \times 10^{-5} \text{ kg CH}_4 \times 21 \text{ kg CO}_2\text{e}_q/\text{kg CH}_4 \\ &= 3.74 \times 10^{-4} \text{ kg CO}_2\text{e}_q \end{aligned}$$

$$\begin{aligned}
 & \text{CO}_2\text{e of N}_2\text{O from unit T2}_{\text{reboiler}} \\
 &= 1.32 \times 10^{-6} \text{ kg N}_2\text{O} \times 310 \text{ kgCO}_2\text{eq/kg N}_2\text{O} \\
 &= 4.08 \times 10^{-4} \text{ kg CO}_2\text{eq}
 \end{aligned}$$

-Electricity

$$\begin{aligned}
 & \text{CO}_2\text{e of CH}_4 \text{ from unit C1} \\
 &= 1.82 \times 10^{-7} \text{ kg CH}_4 \times 21 \text{ kgCO}_2\text{eq/kg CH}_4 \\
 &= 3.82 \times 10^{-6} \text{ kg CO}_2\text{eq}
 \end{aligned}$$

$$\begin{aligned}
 & \text{CO}_2\text{e of N}_2\text{O from unit C1} \\
 &= 4.52 \times 10^{-8} \text{ kg N}_2\text{O} \times 310 \text{ kgCO}_2\text{eq/kg N}_2\text{O} \\
 &= 1.4 \times 10^{-5} \text{ kg CO}_2\text{eq}
 \end{aligned}$$

-Cooling water

$$\begin{aligned}
 & \text{CO}_2\text{e of CH}_4 \text{ from unit E3} \\
 &= 3.47 \times 10^{-8} \text{ kg CH}_4 \times 21 \text{ kg CO}_2\text{eq/kgCH}_4 \\
 &= 7.29 \times 10^{-6} \text{ kg CO}_2\text{eq}
 \end{aligned}$$

$$\begin{aligned}
 & \text{CO}_2\text{e of N}_2\text{O from unit E3} \\
 &= 6.19 \times 10^{-9} \text{ kg N}_2\text{O} \times 310 \text{ kg CO}_2\text{eq/kg N}_2\text{O} \\
 &= 1.92 \times 10^{-6} \text{ kg CO}_2\text{eq}
 \end{aligned}$$

$$\begin{aligned}
 & \text{CO}_2\text{e of CH}_4 \text{ from unit Ref-E3} \\
 &= 3.47 \times 10^{-8} \text{ kg CH}_4 \times 21 \text{ kg CO}_2\text{eq/kgCH}_4 \\
 &= 7.29 \times 10^{-6} \text{ kg CO}_2\text{eq}
 \end{aligned}$$

$$\begin{aligned}
 & \text{CO}_2\text{e of N}_2\text{O from unit Ref-E3} \\
 &= 6.19 \times 10^{-9} \text{ kg N}_2\text{O} \times 310 \text{ kg CO}_2\text{eq/kg N}_2\text{O} \\
 &= 1.92 \times 10^{-6} \text{ kg CO}_2\text{eq}
 \end{aligned}$$

$$\begin{aligned}
& \text{CO}_2\text{e of CH}_4 \text{ from unit F2} \\
& = 1.15 \times 10^{-6} \text{ kg CH}_4 \times 21 \text{ kg CO}_2\text{eq/kg CH}_4 \\
& = 2.42 \times 10^{-5} \text{ kg CO}_2\text{eq}
\end{aligned}$$

$$\begin{aligned}
& \text{CO}_2\text{e of N}_2\text{O from unit F2} \\
& = 2.06 \times 10^{-8} \text{ kg N}_2\text{O} \times 310 \text{ kg CO}_2\text{eq/kg N}_2\text{O} \\
& = 6.39 \times 10^{-6} \text{ kg CO}_2\text{eq}
\end{aligned}$$

$$\begin{aligned}
& \text{CO}_2\text{e of CH}_4 \text{ from unit T1}_{\text{condenser}} \\
& = 9.18 \times 10^{-6} \text{ kg CH}_4 \times 21 \text{ kg CO}_2\text{eq/kg CH}_4 \\
& = 1.93 \times 10^{-4} \text{ kg CO}_2\text{eq}
\end{aligned}$$

$$\begin{aligned}
& \text{CO}_2\text{e of N}_2\text{O from unit T1}_{\text{condenser}} \\
& = 1.64 \times 10^{-7} \text{ kg N}_2\text{O} \times 310 \text{ kg CO}_2\text{eq/kg N}_2\text{O} \\
& = 5.08 \times 10^{-5} \text{ kg CO}_2\text{eq}
\end{aligned}$$

$$\begin{aligned}
& \text{CO}_2\text{e of CH}_4 \text{ from unit T2}_{\text{condenser}} \\
& = 2.03 \times 10^{-6} \text{ kg CH}_4 \times 21 \text{ kg CO}_2\text{eq/kg CH}_4 \\
& = 4.26 \times 10^{-5} \text{ kg CO}_2\text{eq}
\end{aligned}$$

$$\begin{aligned}
& \text{CO}_2\text{e of N}_2\text{O from unit T2}_{\text{condenser}} \\
& = 3.63 \times 10^{-8} \text{ kg N}_2\text{O} \times 310 \text{ kg CO}_2\text{eq/kg N}_2\text{O} \\
& = 1.13 \times 10^{-5} \text{ kg CO}_2\text{eq}
\end{aligned}$$

$$\begin{aligned}
& \text{CO}_2\text{e of CH}_4 \text{ from unit SC1} \\
& = 2.66 \times 10^{-8} \text{ kg CH}_4 \times 21 \text{ kg CO}_2\text{eq/kg CH}_4 \\
& = 5.59 \times 10^{-5} \text{ kg CO}_2\text{eq}
\end{aligned}$$

$$\begin{aligned}
& \text{CO}_2\text{e of N}_2\text{O from unit SC1} \\
& = 4.75 \times 10^{-10} \text{ kg N}_2\text{O} \times 310 \text{ kg CO}_2\text{eq/kg N}_2\text{O} \\
& = 1.47 \times 10^{-7} \text{ kg CO}_2\text{eq}
\end{aligned}$$

CO₂e of CH₄ from unit SC2

$$= 3.95 \times 10^{-7} \text{ kg CH}_4 \times 21 \text{ kg CO}_2\text{eq/kg CH}_4$$

$$= 8.29 \times 10^{-6} \text{ kg CO}_2\text{eq}$$

CO₂e of N₂O from unit SC2

$$= 7.05 \times 10^{-9} \text{ kg N}_2\text{O} \times 310 \text{ kg CO}_2\text{eq/kg N}_2\text{O}$$

$$= 2.19 \times 10^{-6} \text{ kg CO}_2\text{eq}$$

-For energy usage

CO₂e of CH₄ from unit E2

$$= 1.73 \times 10^{-7} \text{ kg CH}_4 \times 21 \text{ kg CO}_2\text{eq/kg CH}_4$$

$$= 3.63 \times 10^{-6} \text{ kg CO}_2\text{eq}$$

CO₂e of N₂O from unit E2

$$= 2.60 \times 10^{-8} \text{ kg N}_2\text{O} \times 310 \text{ kg CO}_2\text{eq/kg N}_2\text{O}$$

$$= 8.04 \times 10^{-6} \text{ kg CO}_2\text{eq}$$

CO₂e of CH₄ from unit R1

$$= 1.73 \times 10^{-5} \text{ kg CH}_4 \times 21 \text{ kg CO}_2\text{eq/kg CH}_4$$

$$= 3.63 \times 10^{-4} \text{ kg CO}_2\text{eq}$$

CO₂e of N₂O from unit R1

$$= 2.6 \times 10^{-6} \text{ kg N}_2\text{O} \times 310 \text{ kg CO}_2\text{eq/kg N}_2\text{O}$$

$$= 8.04 \times 10^{-4} \text{ kg CO}_2\text{eq}$$

CO₂e of CH₄ from unit T1

$$= 2.36 \times 10^{-6} \text{ kg CH}_4 \times 21 \text{ kg CO}_2\text{eq/kg CH}_4$$

$$= 4.96 \times 10^{-5} \text{ kg CO}_2\text{eq}$$

CO₂e of N₂O from unit T1

$$= 3.54 \times 10^{-7} \text{ kg N}_2\text{O} \times 310 \text{ kg CO}_2\text{eq/kg N}_2\text{O}$$

$$= 1.1 \times 10^{-4} \text{ kg CO}_2\text{eq}$$

$$\begin{aligned}
 &\text{CO}_2\text{e of CH}_4 \text{ from unit T2} \\
 &= 3.03 \times 10^{-7} \text{ kg CH}_4 \times 21 \text{ kg CO}_2\text{eq/kg CH}_4 \\
 &= 6.36 \times 10^{-6} \text{ kg CO}_2\text{eq}
 \end{aligned}$$

$$\begin{aligned}
 &\text{CO}_2\text{e of N}_2\text{O from unit T2} \\
 &= 4.55 \times 10^{-8} \text{ kg N}_2\text{O} \times 310 \text{ kg CO}_2\text{eq/kg N}_2\text{O} \\
 &= 1.41 \times 10^{-5} \text{ kg CO}_2\text{eq}
 \end{aligned}$$

C.4.2 Carbon Footprint

From Carbon footprint = $\sum \text{CO}_2\text{eq.}$ in each activity

Calculation CO₂ from raw material = 0.951 + 0.027 + 0.38 = 1.36

$$\begin{aligned}
 \text{CO}_2 \text{ from unit F2} &= 0.012 + (2.42 \times 10^{-5}) + (6.39 \times 10^{-6}) \\
 &= 0.0122 \text{ kg CO}_2\text{eq}
 \end{aligned}$$

$$\begin{aligned}
 \text{CO}_2 \text{ from unit E1} &= 0.175 + (3.41 \times 10^{-4}) + (3.72 \times 10^{-4}) \\
 &= 0.1757 \text{ kg CO}_2\text{eq}
 \end{aligned}$$

$$\begin{aligned}
 \text{CO}_2 \text{ from unit E2} &= (1.61 \times 10^{-3}) + (3.63 \times 10^{-6}) + \\
 &\quad (8.04 \times 10^{-6}) \\
 &= 1.62 \times 10^{-3} \text{ kg CO}_2\text{eq}
 \end{aligned}$$

$$\begin{aligned}
 \text{CO}_2 \text{ from unit E3} &= (3.65 \times 10^{-3}) + (7.29 \times 10^{-6}) + \\
 &\quad (1.92 \times 10^{-6}) \\
 &= 3.66 \times 10^{-3} \text{ kg CO}_2\text{eq}
 \end{aligned}$$

$$\begin{aligned}
 \text{CO}_2 \text{ from unit ref-E3} &= (3.65 \times 10^{-3}) + (7.29 \times 10^{-6}) + \\
 &\quad (1.92 \times 10^{-6}) \\
 &= 3.66 \times 10^{-3} \text{ kg CO}_2\text{eq}
 \end{aligned}$$

$$\begin{aligned}\text{CO}_2 \text{ from unit R1} &= 0.161 + (3.63 \times 10^{-4}) + (8.04 \times 10^{-4}) \\ &= 0.163 \text{ kg CO}_2\text{eq}\end{aligned}$$

$$\begin{aligned}\text{CO}_2 \text{ from unit SC1} &= (2.80 \times 10^{-4}) + (5.59 \times 10^{-7}) + \\ &\quad (1.47 \times 10^{-7}) \\ &= 2.81 \times 10^{-4} \text{ kg CO}_2\text{eq}\end{aligned}$$

$$\begin{aligned}\text{CO}_2 \text{ from unit SC2} &= (4.16 \times 10^{-3}) + (8.29 \times 10^{-6}) + \\ &\quad (2.19 \times 10^{-6}) \\ &= 4.17 \times 10^{-3} \text{ kg CO}_2\text{eq}\end{aligned}$$

$$\begin{aligned}\text{CO}_2 \text{ from unit T1} &= 0.022 + (4.96 \times 10^{-5}) + (1.1 \times 10^{-4}) \\ &= 0.022 \text{ kg CO}_2\text{eq}\end{aligned}$$

$$\begin{aligned}\text{CO}_2 \text{ from unit T2} &= (2.82 \times 10^{-3}) + (6.36 \times 10^{-6}) + \\ &\quad (1.41 \times 10^{-5}) \\ &= 2.84 \times 10^{-3} \text{ kg CO}_2\text{eq}\end{aligned}$$

$$\begin{aligned}\text{CO}_2 \text{ from unit T1}_{\text{con}} &= 0.097 + (1.93 \times 10^{-4}) + (5.1 \times 10^{-5}) \\ &= 0.097 \text{ kg CO}_2\text{eq}\end{aligned}$$

$$\begin{aligned}\text{CO}_2 \text{ from unit T2}_{\text{con}} &= 0.021 + (4.26 \times 10^{-5}) + (1.1 \times 10^{-5}) \\ &= 0.0215 \text{ kg CO}_2\text{eq}\end{aligned}$$

$$\begin{aligned}\text{CO}_2 \text{ from unit T1}_{\text{reb}} &= 0.878 + (1.71 \times 10^{-3}) + (1.9 \times 10^{-3}) \\ &= 0.881 \text{ kg CO}_2\text{eq}\end{aligned}$$

$$\begin{aligned}\text{CO}_2 \text{ from unit T2}_{\text{reb}} &= 0.192 + (3.74 \times 10^{-4}) + (4.1 \times 10^{-4}) \\ &= 0.193 \text{ kg CO}_2\text{eq}\end{aligned}$$

C.5 Impact Assessment

C.5.1 Global Warming

Calculation Greenhouse gases from this process are CO₂, CH₄ and N₂O

Gas	GWP ₁₀₀ (kg of CO ₂ e/kg GHG)
CO ₂	1
CH ₄	21
N ₂ O	310

$$\begin{aligned}
 \text{Global warming} &= \sum m_i \times \text{GWP}_i \\
 &= 0.951 + 0.188 + 1.39 + (1.3 \times 10^{-3} \times 21) + \\
 &\quad (2.02 \times 10^{-5} \times 21) + (1.29 \times 10^{-4} \times 21) + \\
 &\quad (1.22 \times 10^{-3} \times 310) + (3.02 \times 10^{-6} \times 310) \\
 &\quad + (8.8 \times 10^{-6} \times 21) \\
 &= 2.94 \text{ kg of CO}_2\text{eq.}
 \end{aligned}$$

C.5.2 Ozone Depletion

Calculation Ozone depletion substance from this process is only volatile organic compound

Substance	ODP (kg CFC-11e/kg substance)
NMVOG	0.005

$$\begin{aligned}
 \text{Ozone depletion} &= \sum m_i \times \text{ODP}_i \\
 &= 5.7 \times 10^{-4} \times 0.005 \\
 &= 2.85 \times 10^{-6} \text{ kg CFC-11eq}
 \end{aligned}$$

C.5.3 Acidification

Calculation Acidify substances from this process are NO_x, SO_x and N₂O

Gas	AP (kg of SO ₂ e/kg substance)
NO _x	0.7
SO _x	1
N ₂ O	0.7

$$\begin{aligned}
 \text{Acidification} &= \sum m_i \times AP_i \\
 &= (8.37 \times 10^{-3} \times 1) + (2.91 \times 10^{-3} \times 0.7) + \\
 &\quad (1.22 \times 10^{-3} \times 0.7) + (3.02 \times 10^{-6} \times 0.7) \\
 &\quad + (8.8 \times 10^{-6} \times 0.7) \\
 &= 0.011269 \text{ kg of SO}_2\text{eq}
 \end{aligned}$$

C.5.4 Eutrophication

Calculation Nutrient substance from this process is only NO_x

Substance	ODP (kg PO ₄ e/kg substance)
NO _x	0.13

$$\begin{aligned}
 \text{Eutrophication} &= \sum m_i \times EP_i \\
 &= (2.91 \times 10^{-3}) \times 0.13 \\
 &= 3.78 \times 10^{-4} \text{ kg PO}_4\text{eq}
 \end{aligned}$$

C.5.5 Photochemical Oxidation Formation

Calculation Photochemical oxidation substances from this process are CH₄ and NMVOC

Substance	POCP (kg C ₂ H ₄ e/kg substance)
CH ₄	0.0065
NMVOC	0.416

$$\begin{aligned}
 \text{Photochemical oxidation formation} &= \sum m_i \times \text{POCP}_i \\
 &= (1.3 \times 10^{-3} \times 0.0065) + \\
 &\quad (2.02 \times 10^{-5} \times 0.0065) + \\
 &\quad (1.29 \times 10^{-4} \times 0.0065) + \\
 &\quad (5.7 \times 10^{-4} \times 0.416) \\
 &= 0.000378 \text{ kg C}_2\text{H}_4\text{eq}
 \end{aligned}$$

C.5.6 Human Toxicity

Because the calculation for this impact category base on the emission of toxic substance into urban air, since there is no any toxic substance emit to urban air in this case so Human toxicity for this process is equal to 0.

C.5.7 Aquatic Toxicity

Calculation Toxic substances emit to fresh water from this process are ethanol, acetic acid and butyl alcohol.

Substance	ATP (kg 1,4-Dichlorobenzene-equi./kg substance)
Ethanol	0.00056
Acetic acid	0.045
Butyl alcohol	0.0073

$$\begin{aligned}
 \text{Aquatic toxicity} &= \sum m_i \times \text{ATP}_i \\
 &= (183.08 \times 0.00056) + (370.76 \times 0.045) + \\
 &\quad (131.02 \times 0.0073) \\
 &= 17.74 \text{ kg 1,4-DB-eq}
 \end{aligned}$$

C.5.8 Terrestrial Toxicity

Calculation Toxic substances emit to soil from this process are ethanol, acetaldehyde and ethyl acetate.

Substance	TTP (kg 1,4-Dichlorobenzene-equi./kg substance)
Ethanol	9.46×10^{-7}
Acetaldehyde	2.08×10^{-4}
Ethyl acetate	4.99×10^{-5}

$$\begin{aligned}
 \text{Terrestrial toxicity} &= \sum m_i \times \text{TTP}_i \\
 &= (762.54 \times 9.46 \times 10^{-7}) + (10.91 \times 2.08 \times 10^{-4}) + \\
 &\quad (231.2 \times 4.99 \times 10^{-5}) \\
 &= 0.01452 \text{ kg 1,4-DB-eq}
 \end{aligned}$$

Appendix D LCSoft source code

Worksheet "Input Data"

```
Dim CList As Range
```

```
Dim wsI As Worksheet
```

```
.....
```

```
Private Sub cmdDefProd_Click()
```

```
    Sheets("Product and Functional Unit").Activate
```

```
End Sub
```

```
.....
```

```
Private Sub cmdOK_Click()
```

```
Dim n As Byte
```

```
n = Sheets.Count
```

```
Select Case True
```

```
    Case Sheets("Input Data").TextBox1.Value = ""
```

```
        MsgBox "Please input renewable energy"
```

```
    Case Sheets("Input Data").Range("F11").Value = ""
```

```
        MsgBox "Please specify fuel type"
```

```
    Case Sheets("Input Data").Range("G11").Value = ""
```

```
        MsgBox "Please specify energy used"
```

```
    Case Sheets("Utility Entry").Cells(3, 2).Value = ""
```

```
        MsgBox "Hot/Cold Utility not specify yet"
```

```
    Case Sheets("Utility Entry").Cells(3, 5).Value = ""
```

```
        MsgBox "Hot/Cold Utility not specify yet"
```

```
    Case Sheets("Define Stream").Cells(3, 2).Value = ""
```

```
        MsgBox "Input streams are not define"
```

```
    Case Sheets("Define Stream").Cells(3, 3).Value = ""
```

```
        MsgBox "Output streams are not define"
```

```
    Case n < 12
```

```
        MsgBox "Please import stream/equipment table"
```

```
        Sheets("Main Menu").cmdRawmat.Enabled = False
```

```
    Case Else
```

```
        Sheets("Main Menu").Activate
```

```
        Sheets("Main Menu").cmdRawmat.Enabled = True
    End Select
```

```
End Sub
```

```
Private Sub CommandButton1_Click()
```

```
    Call InputCtrl.ImpStr
    Call InputCtrl.renameStr
```

```
    If Not ActiveSheet.Name = "Input Data" Then
        ConfirmStrTable.Show
    End If
```

```
End Sub
```

```
Private Sub CommandButton2_Click()
```

```
    Call InputCtrl.ImpEqui
    Call InputCtrl.renameEqui
```

```
    If Not ActiveSheet.Name = "Input Data" Then
        ConfirmEquTable.Show
    End If
```

```
End Sub
```

```
Private Sub CommandButton3_Click()
```

```
    Sheets("Define Stream").Activate
```

```
End Sub
```

```
Private Sub cmdFuelType_Click()
```

```
    FuelType.Show
```

```
End Sub
```

```
Private Sub CommandButton4_Click()
```

```
    UtilInput.Show
```

```
End Sub
```

```
Private Sub CommandButton5_Click()
```

```
    Sheets("Main Menu").Activate
```

```
End Sub
```

```
Private Sub Worksheet_Activate()
```

```
    Set wsI = Sheets("UtilEF")
```

```
    For Each CList In wsI.Range("CountryList")
```

```
        With Sheets("Input Data").cboCountry
```

```
            .AddItem CList.Value
```

```
        End With
```

```
    Next CList
```

```
    If Sheets.Count < 22 Then
```

```
        Sheets("Input Data").cmdDefProd.Enabled = False
```

```
    Else
```

```
        Sheets("Input Data").cmdDefProd.Enabled = True
```

```
    End If
```

```
End Sub
```

Worksheet “Main Menu”

```
Private Sub cmdCarbFP_Click()
```

```
    Sheets("Carbon Footprint").Activate
```

```
End Sub
```

```
Private Sub cmdInput_Click()
```

```
    Sheets("Input Data").Activate
```

```
End Sub
```

```
Private Sub cmdLCIA_Click()
```

```
    Call ImpactAssessment.AP  
    Call ImpactAssessment.ATP  
    Call ImpactAssessment.EP  
    Call ImpactAssessment.GWP  
    Call ImpactAssessment.HTP  
    Call ImpactAssessment.ODP  
    Call ImpactAssessment.POCP  
    Call ImpactAssessment.TTP  
    Sheets("LCIA Results").Activate  
    Call ImpactAssessment.AddChrtIA
```

```
End Sub
```

```
Private Sub cmdRawmat_Click()
```

```
    Call ReadImport.ReadInSt  
    Call ReadImport.ReadOtSISSt  
    Call ReadImport.ReadOtASSt  
    Call ReadImport.ReadOtWSt  
    Sheets("Inventory Data").Activate
```

```
End Sub
```

```
Private Sub cmdSeeResults_Click()
```

```
    GoResults.Show
```

```
End Sub
```

```
Private Sub Worksheet_Activate()
```

```
    If Sheets.Count < 22 Then
```

```
        Sheets("Main Menu").cmdRawmat.Enabled = False
```

```
        Sheets("Main Menu").cmdCarbFP.Enabled = False
```

```
    Else
```

```
        Sheets("Main Menu").cmdRawmat.Enabled = True
```

```
        Sheets("Main Menu").cmdCarbFP.Enabled = True
```

```
    End If
```

```
    Select Case True
```

```
        Case Sheets("Inventory Data").Cells(4, 12).Value = ""
```

```
            Sheets("Main Menu").cmdLCIA.Enabled = False
```

```
        Case Not Sheets("Inventory Data").Cells(4, 12).Value = ""
```

```
            Sheets("Main Menu").cmdLCIA.Enabled = True
```

```
    End Select
```

```
End Sub
```

Worksheet "Product and Functional Unit"

```
Dim z As Byte
```

```
Private Sub cboChemName_Change()
```

```
    Sheets("Product and Functional Unit").Cells(3, 2).Value = Sheets("Product and Functional  
Unit").cboChemName.Value
```

```
End Sub
```

```
.....  
Private Sub cmdAddByProd_Click()
```

```
    AddByProduct.Show
```

```
End Sub
```

```
.....  
Private Sub CommandButton1_Click()
```

```
    Sheets("Input Data").Activate
```

```
End Sub
```

```
.....  
Private Sub Worksheet_Activate()
```

```
    With Sheets("Product and Functional Unit").cboChemName  
        .Clear
```

```
    End With
```

```
    For z = 10 To Sheets("Stream Table").Range("D" & Rows.Count).End(xlUp).Row
```

```
        With Sheets("Product and Functional Unit").cboChemName
```

```
            .AddItem Sheets("Stream Table").Cells(z, 4).Value
```

```
        End With
```

```
    Next z
```

```
End Sub  
.....
```

Worksheet “Define Stream”

```
Private Sub CommandButton1_Click()
```

```
    Worksheets("Input Data").Activate
```

```
End Sub
```

Worksheet “Utility Entry”

```
Private Sub cmdAddMore_Click()
```

```
    UtilInput.Show
```

```
End Sub
```

```
Private Sub cmdDone_Click()
```

```
    Sheets("Input Data").Activate
```

```
End Sub
```

Worksheet “Inventory Data”

```
Private Sub cmdCal_Click()
```

```
    Sheets("Inventory Data").Range("SubstInvent").ClearContents
```

```
    Call CalInvent.CalRawMat
```

```
    Call CalInvent.CalEng
```

```
    Call CalInvent.CalElect
```

```
    Call CalInvent.CalHU
```

```
    Call CalInvent.CalCU
```

```
    Call CalInvent.EnConsm
```

```
    Call CalInvent.EnProCon
```

```
    Call CalInvent.FuelConsm
```

```
    Call CalInvent.MassAllocate
```

```
    Sheets("Inventory Data").Activate
```

```
End Sub
```

```
Private Sub cmdGoMain_Click()
```

```
    Sheets("Main Menu").Activate
```

```
End Sub
```

Worksheet "Carbon Footprint"

```
Private Sub cmdCalCarFP_Click()
```

```
Application.ScreenUpdating = False
```

```
    Call CarbFP.CalCFP
```

```
    Call CarbFP.MassAllocate
```

```
    Sheets("Carbon Footprint Results").Activate
```

```
    Call CarbFP.AddChrt
```

```
    Sheets("Carbon Footprint").Activate
```

```
Application.ScreenUpdating = True
```

```
End Sub
```

```
Private Sub cmdGoMain_Click()
```

```
    Sheets("Main Menu").Activate
```

```
End Sub
```

```
Private Sub cmdReadEquipment_Click()
```

```
    Call CarbFP.ReadUnit
```

```
    Sheets("Carbon Footprint").cmdReadEquipment.Enabled = False
```

```
End Sub
```

```
Private Sub cmdSpecEnCall_Click()
```

```
    SpecEn.Show
```

```
End Sub
```

Worksheet “Carbon Footprint Results”

```
Private Sub cmdGoMain_Click()
```

```
    Sheets("Main Menu").Activate
```

```
End Sub
```

Worksheet “LCIA Results”

```
Private Sub CommandButton1_Click()
```

```
    Sheets("Main Menu").Activate
```

```
End Sub
```

User form “AddByProduct”

```
Private Const FIRST_ROW = 3
```

```
Private Const FIRST_COL = 6
```

```
Private nLastRow As Integer
```

```
Dim y As Byte
```

```
Private Sub cmdAdd_Click()
```

```
    SaveForm
```

```
    Unload Me
```

```
End Sub
```

```
Private Sub cmdCalcel_Click()
```

```
    Unload Me
```

```
End Sub
```

```
Private Sub UserForm_Initialize()
```

```
    For y = 10 To Sheets("Stream Table").Range("D" & Rows.Count).End(xlUp).Row  
        With AddByProduct.cboByName  
            .AddItem Sheets("Stream Table").Cells(y, 4).Value  
        End With  
    Next y  
    getLastrow
```

```
End Sub
```

```
.....  
Function getLastrow()
```

```
    nLastRow = FIRST_ROW  
    j = FIRST_COL  
    Do While Cells(nLastRow, j).Value <> ""  
        nLastRow = nLastRow + 1  
    Loop  
    Cells(nLastRow, FIRST_COL).Activate
```

```
End Function
```

```
.....  
Private Sub SaveForm()
```

```
    If ActiveSheet.Name <> "Product and Functional Unit" Then Worksheets("Product and Functional  
Unit").Activate  
    If ActiveCell.Row <> nLastRow Then getLastrow  
  
    If Not cboByName.Value = "" Then  
        ActiveCell.Value = cboByName.Value  
    End If
```

```
End Sub
```

```
.....
```


User form “ConfirmEquTable”

```
Private Sub cmdNo_Click()
```

```
    Sheets("Equipment Table").Delete
```

```
    Sheets("Input Data").Activate
```

```
    Unload ConfirmEquTable
```

```
End Sub
```

```
Private Sub cmdOK_Click()
```

```
    Sheets("Input Data").Activate
```

```
    Unload ConfirmEquTable
```

```
End Sub
```

User form “ConfirmStrTable”

```
Private Sub cmdNo_Click()
```

```
    Sheets("Stream Table").Delete
```

```
    Sheets("Input Data").Activate
```

```
    Unload ConfirmStrTable
```

```
End Sub
```

```
Private Sub cmdOK_Click()
```

```
    Sheets("Input Data").Activate
```

```
    Unload ConfirmStrTable
```

```
End Sub
```

User form “FuelType”

```
Private Sub cboFuel_Click()

Dim FList As Range
Dim ws As Worksheet
Set ws = Worksheets("EngEF")

Select Case True
    Case cboFuel.Value = "Coal"
        cboType.Clear
        For Each FList In ws.Range("Coallist")
            With Me.cboType
                .AddItem FList.Value
            End With
        Next FList
    Case cboFuel.Value = "Petroleum fuel"
        cboType.Clear
        For Each FList In ws.Range("PetroList")
            With Me.cboType
                .AddItem FList.Value
            End With
        Next FList
    Case cboFuel.Value = "Natural gas"
        cboType.Clear
        For Each FList In ws.Range("NatList")
            With Me.cboType
                .AddItem FList.Value
            End With
        Next FList
    Case cboFuel.Value = "Other fuel"
        cboType.Clear
        For Each FList In ws.Range("OList")
            With Me.cboType
                .AddItem FList.Value
            End With
        Next FList
End Select

End Sub
```

```
Private Sub cmdCancel_Click()
```

```
    Unload FuelType
```

```
End Sub
```

```
.....  
Private Sub cmdOK_Click()
```

```
    Select Case True
```

```
        Case cboFuel.Value = ""
```

```
            MsgBox "Type of fuel must be specified"
```

```
        Case cboType.Value = ""
```

```
            MsgBox "Type of fuel must be specify"
```

```
        Case txtEn.Value = ""
```

```
            MsgBox "Energy must be specified"
```

```
        Case Else
```

```
            Unload FuelType
```

```
    End Select
```

```
    If Not cboFuel.Value = "" And Not cboType.Value = "" And Not txtEn.Value = "" Then
```

```
        With Worksheets("Input Data")
```

```
            .Cells(11, 6).Value = cboFuel.Value
```

```
            .Cells(11, 7).Value = cboType.Value
```

```
            .Cells(11, 8).Value = txtEn.Value
```

```
        End With
```

```
    End If
```

```
End Sub
```

```
.....  
Private Sub UserForm_Initialize()
```

```
    cboFuel.List = Array("Coal", "Petroleum fuel", "Natural gas", "Other fuel")
```

```
End Sub
```

```
.....
```

User form “GoResults”

```
Private Sub cmdCancel_Click()
```

```
    Unload Me
```

```
End Sub
```

```
Private Sub cmdGO_Click()
```

```
    If opbCarbFP.Value = True Then
```

```
        Sheets("Carbon Footprint Results").Activate
```

```
    ElseIf opbLCIARes.Value = True Then
```

```
        Sheets("LCIA Results").Activate
```

```
    End If
```

```
    Unload Me
```

```
End Sub
```

User form “SpecEn”

```
Dim p As Integer
```

```
Dim q As Integer
```

```
Dim y As Integer
```

```
Dim x As Integer
```

```
Dim z As Integer
```

```
Dim iMatch As Range
```

```
Private Sub cboAct_Change()
```

```
    If SpecEn.cboAct.Value = "Heating" Then
```

```
        SpecEn.cboEnS.Clear
```

```
        For x = 3 To Sheets("UtilEF").Range("F" & Rows.Count).End(xlUp).Row
```

```
            With SpecEn.cboEnS
```

```
                .AddItem Sheets("UtilEF").Cells(x, 6).Value
```

```
            End With
```

```
        Next x
```

```

ElseIf SpecEn.cboAct.Value = "Cooling" Then
    SpecEn.cboEnS.Clear
    For z = 3 To Sheets("UtilEF").Range("K" & Rows.Count).End(xlUp).Row
        With SpecEn.cboEnS
            .AddItem Sheets("UtilEF").Cells(z, 11).Value
        End With
    Next z
ElseIf SpecEn.cboAct.Value = "Fuel combustion" Then
    SpecEn.cboEnS.Clear
    With SpecEn.cboEnS
        .AddItem "Fuel"
    End With
ElseIf SpecEn.cboAct.Value = "Electric usage" Then
    SpecEn.cboEnS.Clear
    With SpecEn.cboEnS
        .AddItem "Electricity"
    End With
End If

End Sub
.....

Private Sub cmdAdd_Click()

    With Sheets("Carbon Footprint")

        Set iMatch = Cells.Find(What:=SpecEn.cboUnit.Value, After:=ActiveCell, LookIn:=xlValues,
LookAt:=xlPart, SearchOrder:=xlByRows, SearchDirection:=xlNext, MatchCase:=False,
SearchFormat:=False)

        End With

        iMatch.Select
        ActiveCell.Offset(0, 4).Value = SpecEn.cboEnS.Value
        ActiveCell.Offset(0, 3).Value = SpecEn.cboAct.Value

        p = Sheets("Carbon Footprint").Range("B" & Rows.Count).End(xlUp).Row
        q = Sheets("Carbon Footprint").Range("E" & Rows.Count).End(xlUp).Row

```

```
If p = q Then
    SpecEn.cmdDone.Enabled = True
Else
    SpecEn.cmdDone.Enabled = False
End If

End Sub

.....

Private Sub cmdCancel_Click()

    Unload Me

End Sub

.....

Private Sub cmdDone_Click()

    Unload Me

End Sub

.....

Private Sub UserForm_Initialize()

    For y = 6 To Sheets("Carbon Footprint").Range("B" & Rows.Count).End(xlUp).Row
        With SpecEn.cboUnit
            .AddItem Sheets("Carbon Footprint").Cells(y, 2).Value
        End With
    Next y

    With SpecEn.cboAct
        .AddItem "Cooling"
        .AddItem "Heating"
        .AddItem "Fuel combustion"
        .AddItem "Electric usage"
    End With

End Sub
```

User form “UtilInput”

```
Private Const FIRST_ROW = 3
```

```
Private Const FIRST_COL = 2
```

```
Private nLastRow As Integer
```

```
.....
```

```
Private Sub CommandButton1_Click()
```

```
    SaveForm
```

```
End Sub
```

```
.....
```

```
Private Sub CommandButton3_Click()
```

```
    Unload UtilInput
```

```
End Sub
```

```
.....
```

```
Private Sub UserForm_Initialize()
```

```
    ComboBox1.List = Array("Steam")
```

```
    ComboBox2.List = Array("Cooling water from absorbtion chiller using natural gas", "Cooling  
water from engine-driven chiller using natural gas")
```

```
    Worksheets("Utility Entry").Activate
```

```
    getLastrow
```

```
End Sub
```

```
.....
```

```
Function getLastrow()
```

```
    nLastRow = FIRST_ROW
```

```
    j = FIRST_COL
```

```
    Do While Cells(nLastRow, j).Value <> ""
```

```
        nLastRow = nLastRow + 1
```

```
    Loop
```

```
    Cells(nLastRow, FIRST_COL).Activate
```

```
End Function
```

```
Private Sub SaveForm()
```

```
    If ActiveSheet.Name <> "Utility Entry" Then Worksheets("Utility Entry").Activate
```

```
    If ActiveCell.Row <> nLastRow Then getLastrow
```

```
    Select Case True
```

```
        Case ComboBox1.Value = ""
```

```
            MsgBox "Hot utility must be specified"
```

```
        Case TextBox1.Value = ""
```

```
            MsgBox "Energy from hot utility must be specified"
```

```
        Case ComboBox2.Value = ""
```

```
            MsgBox "Cold utility must be specified"
```

```
        Case TextBox2.Value = ""
```

```
            MsgBox "Quantity of cold utility must be specified"
```

```
        Case Else
```

```
            Unload UtilInput
```

```
    End Select
```

```
    If Not ComboBox1.Value = "" Then
```

```
        ActiveCell.Value = ComboBox1.Value
```

```
    End If
```

```
    If Not ComboBox2.Value = "" Then
```

```
        ActiveCell.Offset(0, 3).Value = ComboBox2.Value
```

```
    End If
```

```
    If Not TextBox1.Value = "" Then
```

```
        ActiveCell.Offset(0, 1).Value = TextBox1.Value
```

```
    End If
```

```
    If Not TextBox2.Value = "" Then
```

```
        ActiveCell.Offset(0, 4).Value = TextBox2.Value
```

```
    End If
```

```
End Sub
```

CallInvent Module

Dim BMatch As Range

Dim CMatch As Range

Dim DMatch As Range

Dim EMatch As Range

Dim FMatch As Range

Dim GMatch As Range

Dim Prng As Range

Dim Prng2 As Range

Dim Pst As Range

Dim Pst2 As Range

Dim PName As String

Dim i As Byte

Dim j As Byte

Dim k As Byte

Dim n As Byte

Dim o As Byte

Dim p As Byte

Dim q As Byte

Dim r As Byte

Dim s As Byte

Dim SS As Byte

Dim t As Byte

Dim Prow As Byte

Dim Prow2 As Byte

Dim Pcol As Byte

Dim Pcol2 As Byte

Dim l As Long

Dim rng As Range

Dim e As Single

Dim Elect As Single

Dim x As Single

Dim x2 As Single

Dim x3 As Single

Dim x4 As Single

Dim x5 As Single

Dim m As Single

Dim EF As Single

```

Dim uEF As Single
Dim eEF As Single
Dim hu As Single
Dim hEF As Single
Dim cu As Single
Dim cEF As Single
Dim Eren As Single
Dim Etot As Single
Dim Pm As Single
Dim Pm2 As Single
Dim EFuel As Single
Dim HV As Single
Dim EConv As Single

```

```

Sub CalRawMat()

```

```

    For i = 4 To Sheets("Inventory Data").Range("A" & Rows.Count).End(xlUp).Row

```

```

        Sheets("RawEF").Activate
        Cells(1, 1).Select

```

```

        With Sheets("RawEF")

```

```

            Set BMatch = Cells.Find(What:=Worksheets("Inventory Data").Cells(i, 1).Value,
After:=ActiveCell, LookIn:=xlValues, LookAt:=xlPart, SearchOrder:=xlByRows,
SearchDirection:=xlNext, MatchCase:=False, SearchFormat:=False)

```

```

        End With

```

```

        If BMatch Is Nothing Then

```

```

            Beep

```

```

        Else

```

```

            BMatch.Select

```

```

        End If

```

```

        m = Sheets("Inventory Data").Cells(i, 2).Value

```

```

        For j = 1 To 13

```

```

    EF = ActiveCell.Offset(0, j).Value
    x = EF * m
    Sheets("Inventory Data").Cells(3, 12).Offset(j, 0).Value = Sheets("Inventory Data").Cells(3,
12).Offset(j, 0).Value + x

```

```

Next j

```

```

Next i

```

```

End Sub

```

```

Sub CalEng()

```

```

    Sheets("EngEF").Activate
    Cells(1, 1).Select

```

```

    With Sheets("EngEF")

```

```

        Set CMatch = Cells.Find(What:=Worksheets("Input Data").Cells(11, 7).Value,
After:=ActiveCell, LookIn:=xlValues, LookAt:=xlPart, SearchOrder:=xlByRows,
SearchDirection:=xlNext, MatchCase:=False, SearchFormat:=False)

```

```

    End With

```

```

    CMatch.Select

```

```

    e = Sheets("Input Data").Cells(11, 8).Value * 0.947086

```

```

    eEF = ActiveCell.Offset(0, 1).Value

```

```

    x2 = e * eEF

```

```

    Sheets("Inventory Data").Cells(5, 13).Value = x2

```

```

    Select Case True

```

```

        Case Sheets("Input Data").Cells(11, 6).Value = "Coal"

```

```

            x2 = e * Sheets("EngEF").Cells(48, 3).Value

```

```

            Sheets("Inventory Data").Cells(6, 13).Value = x2

```

```

            x2 = e * Sheets("EngEF").Cells(48, 5).Value

```

```

            Sheets("Inventory Data").Cells(9, 13).Value = x2

```

```

        Case Sheets("Input Data").Cells(11, 6).Value = "Petroleum fuel"

```

```

    x2 = e * Sheets("EngEF").Cells(49, 3).Value
    Sheets("Inventory Data").Cells(6, 13).Value = x2
    x2 = e * Sheets("EngEF").Cells(49, 5).Value
    Sheets("Inventory Data").Cells(9, 13).Value = x2
Case Sheets("Input Data").Cells(11, 6).Value = "Natural gas"
    x2 = e * Sheets("EngEF").Cells(50, 3).Value
    Sheets("Inventory Data").Cells(6, 13).Value = x2
    x2 = e * Sheets("EngEF").Cells(50, 5).Value
    Sheets("Inventory Data").Cells(9, 13).Value = x2
Case Sheets("Input Data").Cells(11, 6).Value = "Wood"
    x2 = e * Sheets("EngEF").Cells(49, 3).Value
    Sheets("Inventory Data").Cells(6, 13).Value = x2
    x2 = e * Sheets("EngEF").Cells(49, 5).Value
    Sheets("Inventory Data").Cells(9, 13).Value = x2
End Select

```

```
End Sub
```

```
Sub CalElect()
```

```
    For k = 1 To 3
```

```

        Sheets("Equipment Table").Activate
        l = Sheets("Equipment Table").UsedRange.Columns.Count
        Elect = Application.Sum(Range(Cells(16, 6), Cells(16, l)))

```

```

        Sheets("UtilEF").Activate
        With Sheets("UtilEF")

```

```

            Set DMatch = Cells.Find(What:=Sheets("Input Data").cboCountry.Value, After:=ActiveCell,
            LookIn:=xlValues, LookAt:=xlPart, SearchOrder:=xlByRows, SearchDirection:=xlNext,
            MatchCase:=False, SearchFormat:=False)

```

```
        End With
```

```

        If DMatch Is Nothing Then
            Beep

```

```

Else
    DMatch.Select
End If

uEF = ActiveCell.Offset(0, k).Value
x3 = uEF * Elect

If k = 1 Then
    Sheets("Inventory Data").Cells(5, 14).Value = x3
ElseIf k = 2 Then
    Sheets("Inventory Data").Cells(6, 14).Value = x3
ElseIf k = 3 Then
    Sheets("Inventory Data").Cells(9, 14).Value = x3
End If

Next k

End Sub
.....
Sub CalHU()

For n = 3 To Sheets("Utility Entry").Range("B" & Rows.Count).End(xlUp).Row

    Sheets("UtilEF").Activate
    Cells(1, 1).Select
    With Sheets("UtilEF")

        Set EMatch = Cells.Find(What:=Sheets("Utility Entry").Cells(n, 2).Value, After:=ActiveCell,
LookIn:=xlValues, LookAt:=xlPart, SearchOrder:=xlByRows, SearchDirection:=xlNext,
MatchCase:=False, SearchFormat:=False)

    End With

    If EMatch Is Nothing Then
        Beep
    Else
        EMatch.Select
    End If

```

```

hu = Sheets("Utility Entry").Cells(n, 3).Value * 0.947086

For o = 1 To 3

    hEF = ActiveCell.Offset(0, o).Value
    x4 = hu * hEF

    If o = 1 Then
        Sheets("Inventory Data").Cells(5, 14).Value = Sheets("Inventory Data").Cells(5, 14).Value
+ x4
    ElseIf o = 2 Then
        Sheets("Inventory Data").Cells(6, 14).Value = Sheets("Inventory Data").Cells(6, 14).Value
+ x4
    ElseIf o = 3 Then
        Sheets("Inventory Data").Cells(9, 14).Value = Sheets("Inventory Data").Cells(9, 14).Value
+ x4
    End If

Next o

Next n

End Sub
.....
Sub CalCU()

For q = 3 To Sheets("Utility Entry").Range("E" & Rows.Count).End(xlUp).Row

    Sheets("UtilEF").Activate
    Cells(1, 1).Select
    With Sheets("UtilEF")

        Set FMatch = Cells.Find(What:=Sheets("Utility Entry").Cells(q, 5).Value, After:=ActiveCell,
LookIn:=xlValues, LookAt:=xlPart, SearchOrder:=xlByRows, SearchDirection:=xlNext,
MatchCase:=False, SearchFormat:=False)

    End With

```

```

If FMatch Is Nothing Then
    Beep
Else
    FMatch.Select
End If

cu = Sheets("Utility Entry").Cells(q, 6).Value

For p = 1 To 3

    cEF = ActiveCell.Offset(0, p).Value
    x5 = cu * cEF
    If p = 1 Then
        Sheets("Inventory Data").Cells(5, 14).Value = Sheets("Inventory Data").Cells(5, 14).Value
+ x5
    ElseIf p = 2 Then
        Sheets("Inventory Data").Cells(6, 14).Value = Sheets("Inventory Data").Cells(6, 14).Value
+ x5
    ElseIf p = 3 Then
        Sheets("Inventory Data").Cells(9, 14).Value = Sheets("Inventory Data").Cells(9, 14).Value
+ x5
    End If

Next p

Next q

End Sub
-----
Sub EnConsmpt()

Sheets("Inventory Data").Cells(20, 12).ClearContents

For r = 6 To Sheets("Equipment Table").UsedRange.Columns.Count

    If Sheets("Equipment Table").Cells(10, r).Value > 0 Then

```

```

        Sheets("Inventory Data").Cells(20, 12).Value = Sheets("Inventory Data").Cells(20, 12).Value
+ Sheets("Equipment Table").Cells(10, r).Value
    End If

```

```

    If Sheets("Equipment Table").Cells(24, r).Value > 0 Then
        Sheets("Inventory Data").Cells(20, 12).Value = Sheets("Inventory Data").Cells(20, 12).Value
+ Sheets("Equipment Table").Cells(24, r).Value
    End If

```

```

Next r

```

```

Etot = Sheets("Inventory Data").Cells(20, 12).Value
Eren = Sheets("Input Data").TextBox1.Value
Sheets("Inventory Data").Cells(22, 12).NumberFormat = "0.00%"
Sheets("Inventory Data").Cells(22, 12).Value = Eren / Etot

```

```

End Sub

```

```

Sub EnProCon()

```

```

    PName = Sheets("Product and Functional Unit").Cells(3, 2).Value
    Sheets("Inventory Data").Cells(25, 11).Value = PName

```

```

    Sheets("CalSt").Cells.Clear
    s = 0

```

```

    For t = 3 To Sheets("Define Stream").Range("F" & Rows.Count).End(xlUp).Row

```

```

        Worksheets("Stream Table").Activate
        Cells(1, 2).Select
        With Sheets("Stream Table")

```

```

            Set ProMatch = Columns.Find(What:=Sheets("Define Stream").Cells(t, 6).Value,
After:=ActiveCell, LookIn:=xlValues, LookAt:=xlPart, SearchOrder:=xlByRows,
SearchDirection:=xlNext, MatchCase:=False, SearchFormat:=False)

```

```

        End With

```



```

ProMatch.Select
ActiveCell.EntireColumn.Copy
s = s + 1

If s = 1 Then
    ActiveSheet.Paste Destination:=Worksheets("CalSt").Columns(1)
ElseIf s > 1 Then
    ActiveSheet.Paste Destination:=Worksheets("CalSt").Columns(s)
End If

Next t

LCol = Sheets("CalSt").UsedRange.Columns.Count

For u = 10 To Sheets("CalSt").Range("B" & Rows.Count).End(xlUp).Row

    Set wsCurr5 = Worksheets("CalSt")
    Set rStartCell5 = wsCurr5.Cells(u, 1)
    Set mrnge5 = wsCurr5.Range(rStartCell5, rStartCell5.End(xlToRight))

    m5 = Application.WorksheetFunction.Sum(mrnge5)
    Sheets("CalSt").Cells(u, LCol + 1).Value = m5

Next u

Sheets("Stream Table").Activate
Cells(1, 1).Select

With Sheets("Stream Table")

    Set ProNameMatch = Cells.Find(What:=Worksheets("Product and Functional Unit").Cells(3,
2).Value, After:=ActiveCell, LookIn:=xlValues, LookAt:=xlPart, SearchOrder:=xlByRows,
SearchDirection:=xlNext, MatchCase:=False, SearchFormat:=False)

End With

ProNameMatch.Select
ProRow = ActiveCell.Row

```

```
Etot = Sheets("Inventory Data").Cells(20, 12).Value
```

```
If LCol > 1 Then
```

```
    Pm = Sheets("CalSt").Cells(ProRow, LCol + 1).Value
```

```
ElseIf LCol = 1 Then
```

```
    Pm = Sheets("CalSt").Cells(ProRow, LCol).Value
```

```
End If
```

```
Sheets("Inventory Data").Cells(25, 12).Value = (Etot / Pm) * Sheets("Product and Functional Unit").Cells(3, 3).Value
```

```
For s = 3 To Sheets("Product and Functional Unit").Range("F" & Rows.Count).End(xlUp).Row
```

```
    Sheets("Stream Table").Activate
```

```
    Cells(1, 1).Select
```

```
    With Sheets("Stream Table")
```

```
        Set Pmg2 = Cells.Find(What:=Worksheets("Product and Functional Unit").Cells(s, 6).Value,
        After:=ActiveCell, LookIn:=xlValues, LookAt:=xlPart, SearchOrder:=xlByRows,
        SearchDirection:=xlNext, MatchCase:=False, SearchFormat:=False)
```

```
    End With
```

```
If Pmg2 Is Nothing Then
```

```
    Beep
```

```
Else
```

```
    Pmg2.Select
```

```
End If
```

```
Prow2 = ActiveCell.Row
```

```
For t = 3 To Sheets("Define Stream").Range("F" & Rows.Count).End(xlUp).Row
```

```
    Sheets("Stream Table").Activate
```

```
    Cells(1, 1).Select
```

```
    With Sheets("Stream Table")
```

```

        Set Pst2 = Cells.Find(What:=Worksheets("Define Stream").Cells(t, 6).Value,
After:=ActiveCell, LookIn:=xlValues, LookAt:=xlPart, SearchOrder:=xlByRows,
SearchDirection:=xlNext, MatchCase:=False, SearchFormat:=False)

    End With

    If Pst2 Is Nothing Then
        Beep
    Else
        Pst2.Select
    End If

    Pcol2 = ActiveCell.Column
    Pm2 = Sheets("Stream Table").Cells(Prow2, Pcol2).Value
    Etot = Sheets("Inventory Data").Cells(20, 12).Value
    Sheets("Inventory Data").Cells(s + 24, 12).Value = Etot / Pm2
    Sheets("Inventory Data").Cells(s + 24, 11).Value = Sheets("Product and Functional
Unit").Cells(s, 6).Value
    Next t
Next s

End Sub
-----
Sub FuelConsm()

    EConv = 238845.896627
    EFuel = Sheets("Input Data").Cells(11, 8).Value

    Sheets("Heating Value").Activate
    Cells(1, 1).Select

    With Sheets("Heating Value")

        Set GMatch = Cells.Find(What:=Worksheets("Input Data").Cells(11, 7).Value,
After:=ActiveCell, LookIn:=xlValues, LookAt:=xlPart, SearchOrder:=xlByRows,
SearchDirection:=xlNext, MatchCase:=False, SearchFormat:=False)

    End With

```

```
If GMatch Is Nothing Then
```

```
    Beep
```

```
Else
```

```
    GMatch.Select
```

```
End If
```

```
HV = ActiveCell.Offset(0, 1).Value
```

```
Sheets("Inventory Data").Cells(18, 12).Value = (EFuel * EConv) / HV
```

```
If ActiveCell.Offset(0, 2).Value = "kcal/kg" Then
```

```
    Sheets("Inventory Data").Cells(18, 13).Value = "kg"
```

```
ElseIf ActiveCell.Offset(0, 2).Value = "kcal/m3" Then
```

```
    Sheets("Inventory Data").Cells(18, 13).Value = "m3"
```

```
    SS = Worksheets("Inventory Data").Cells(18, 13).Characters.Count
```

```
    Sheets("Inventory Data").Cells(18, 13).Characters(SS, 1).Font.Superscript = True
```

```
End If
```

```
End Sub
```

```
.....
```

```
Sub MassAllocate()
```

```
    Dim ProRow As Long
```

```
    Dim ProCol As Long
```

```
    Dim ProNameMatch As Range
```

```
    Dim ProStMatch As Range
```

```
    Dim ProMatch As Range
```

```
    Dim s As Byte
```

```
    Dim t As Byte
```

```
    Dim u As Byte
```

```
    Dim wsCurr5 As Worksheet
```

```
    Dim rStartCell5 As Range
```

```
    Dim mrange5 As Range
```

```
    Dim m5 As Single
```

```
    Dim ProMt看 As Single
```

```
    Dim LCol As Byte
```

```
    Dim Sstrng As Range
```

```
Sheets("CalSt").Cells.Clear
```

```
s = 0
```

```
For t = 3 To Sheets("Define Stream").Range("F" & Rows.Count).End(xlUp).Row
```

```
    Worksheets("Stream Table").Activate
```

```
    Cells(1, 2).Select
```

```
    With Sheets("Stream Table")
```

```
        Set ProMatch = Columns.Find(What:=Sheets("Define Stream").Cells(t, 6).Value,
After:=ActiveCell, LookIn:=xlValues, LookAt:=xlPart, SearchOrder:=xlByRows,
SearchDirection:=xlNext, MatchCase:=False, SearchFormat:=False)
```

```
    End With
```

```
    ProMatch.Select
```

```
    ActiveCell.EntireColumn.Copy
```

```
    s = s + 1
```

```
    If s = 1 Then
```

```
        ActiveSheet.Paste Destination:=Worksheets("CalSt").Columns(1)
```

```
    ElseIf s > 1 Then
```

```
        ActiveSheet.Paste Destination:=Worksheets("CalSt").Columns(s)
```

```
    End If
```

```
Next t
```

```
LCol = Sheets("CalSt").UsedRange.Columns.Count
```

```
For u = 10 To Sheets("CalSt").Range("B" & Rows.Count).End(xlUp).Row
```

```
    Set wsCurr5 = Worksheets("CalSt")
```

```
    Set rStartCell5 = wsCurr5.Cells(u, 1)
```

```
    Set mrnge5 = wsCurr5.Range(rStartCell5, rStartCell5.End(xlToRight))
```

```
    m5 = Application.WorksheetFunction.Sum(mrnge5)
```

```
    Sheets("CalSt").Cells(u, LCol + 1).Value = m5
```

```
Next u

Sheets("Stream Table").Activate
Cells(1, 1).Select

With Sheets("Stream Table")

    Set ProNameMatch = Cells.Find(What:=Worksheets("Product and Functional Unit").Cells(3,
2).Value, After:=ActiveCell, LookIn:=xlValues, LookAt:=xlPart, SearchOrder:=xlByRows,
SearchDirection:=xlNext, MatchCase:=False, SearchFormat:=False)

End With

ProNameMatch.Select
ProRow = ActiveCell.Row

If LCol > 1 Then
    ProMtot = Sheets("CalSt").Cells(ProRow, LCol + 1).Value
ElseIf LCol = 1 Then
    ProMtot = Sheets("CalSt").Cells(ProRow, LCol).Value
End If

For Each Sstrng In Sheets("Inventory Data").Range("SubstInvent")
    Sstrng.Value = (Sstrng.Value / ProMtot) * Sheets("Product and Functional Unit").Cells(3,
3).Value
Next Sstrng

End Sub
```

CarbFP Module

Dim a As Integer

Dim b As Integer

Dim c As Integer

Dim d As Integer

Dim e As Integer

Dim f As Integer

Dim g As Integer

Dim h As Integer

Dim i As Integer

Dim j As Integer

Dim n As Integer

Dim m As Single

Dim m1 As Single

Dim m2 As Single

Dim m3 As Single

Dim o As Single

Dim o1 As Single

Dim o2 As Single

Dim p As Single

Dim p1 As Single

Dim p2 As Single

Dim q As Single

Dim q1 As Single

Dim q2 As Single

Dim r As Single

Dim r1 As Single

Dim r2 As Single

Dim Match As Range

Dim Match1 As Range

Dim Match2 As Range

Dim Match3 As Range

```
Sub ReadUnit()
```

```
g = Sheets("Equipment Table").UsedRange.Columns.Count
```

```
For a = 6 To Sheets("Equipment Table").UsedRange.Columns.Count
```

```
Sheets("Equipment Table").Activate
```

```
Sheets("Equipment Table").Cells(3, a).Select
```

```
Sheets("Carbon Footprint").Cells(a, 2).Value = ActiveCell.Value
```

```
Sheets("Carbon Footprint").Cells(a, 3).Value = ActiveCell.Offset(1, 0).Value
```

```
Sheets("Carbon Footprint").Cells(a, 4).Value = ActiveCell.Offset(7, 0).Value
```

```
Next a
```

```
For f = 6 To Sheets("Equipment Table").UsedRange.Columns.Count
```

```
Sheets("Equipment Table").Activate
```

```
Sheets("Equipment Table").Cells(23, f).Select
```

```
If ActiveCell.Value = 0 Then
```

```
Else
```

```
g = g + 1
```

```
Sheets("Carbon Footprint").Cells(g, 2).Value = ActiveCell.Offset(-20, 0).Value &
```

```
"Condenser"
```

```
Sheets("Carbon Footprint").Cells(g, 3).Value = "Condenser"
```

```
Sheets("Carbon Footprint").Cells(g, 4).Value = ActiveCell.Value
```

```
End If
```

```
Next f
```

```
i = Sheets("Carbon Footprint").UsedRange.Rows.Count
```

```
For h = 6 To Sheets("Equipment Table").UsedRange.Columns.Count
```

```
Sheets("Equipment Table").Activate
```

```
Sheets("Equipment Table").Cells(24, h).Select
```

```
If ActiveCell.Value = 0 Then
```

```
Else
```

```
i = i + 2
```



```

        Sheets("Carbon Footprint").Cells(i, 2).Value = ActiveCell.Offset(-21, 0).Value & "Reboiler"
        Sheets("Carbon Footprint").Cells(i, 3).Value = "Reboiler"
        Sheets("Carbon Footprint").Cells(i, 4).Value = ActiveCell.Value
    End If
Next h

e = Sheets("Carbon Footprint").UsedRange.Rows.Count

For d = 6 To Sheets("Equipment Table").UsedRange.Columns.Count
    Sheets("Equipment Table").Activate
    Sheets("Equipment Table").Cells(16, d).Select
    If ActiveCell.Value = 0 Then

    Else
        e = e + 2
        Sheets("Carbon Footprint").Cells(e, 2).Value = ActiveCell.Offset(-13, 0).Value
        Sheets("Carbon Footprint").Cells(e, 3).Value = ActiveCell.Offset(-12, 0).Value
        Sheets("Carbon Footprint").Cells(e, 4).Value = ActiveCell.Value
    End If
Next d

For c = Sheets("Carbon Footprint").Cells(Rows.Count, 4).End(xlUp).Row To 6 Step -1
    Sheets("Carbon Footprint").Activate
    If Cells(c, 4) = "" Then
        Rows(c).Delete
    End If
Next c

End Sub

```

```

Sub CalCFP()

For j = 6 To Sheets("Carbon Footprint").Range("B" & Rows.Count).End(xlUp).Row
    Sheets("Carbon Footprint").Cells(j, 2).Copy
    Sheets("Carbon Footprint Results").Cells(j + 1, 2).PasteSpecial xlPasteValues
Next j

m = Sheets("Inventory Data").Cells(5, 12).Value

```

```

m1 = Sheets("Inventory Data").Cells(6, 12).Value
m2 = Sheets("Inventory Data").Cells(9, 12).Value
m3 = Sheets("Inventory Data").Cells(11, 12).Value

```

```

Sheets("Carbon Footprint Results").Cells(6, 3).Value = m + (m1 * 21) + (m2 * 310)

```

```

For n = 6 To Sheets("Carbon Footprint").Range("B" & Rows.Count).End(xlUp).Row

```

```

If Sheets("Carbon Footprint").Cells(n, 5).Value = "Cooling" Then

```

```

    Sheets("UtilEF").Activate
    Cells(1, 1).Select
    With Sheets("UtilEF")

```

```

        Set Match = Cells.Find(What:=Worksheets("Carbon Footprint").Cells(n, 6).Value,
After:=ActiveCell, LookIn:=xlValues, LookAt:=xlPart, SearchOrder:=xlByRows,
SearchDirection:=xlNext, MatchCase:=False, SearchFormat:=False)

```

```

    End With

```

```

    Match.Select

```

```

        o = (Abs(Sheets("Carbon Footprint").Cells(n, 4).Value) * 15.97) * ActiveCell.Offset(0,
1).Value

```

```

        o1 = ((Abs(Sheets("Carbon Footprint").Cells(n, 4).Value) * 15.97) * ActiveCell.Offset(0,
2).Value) * 21

```

```

        o2 = ((Abs(Sheets("Carbon Footprint").Cells(n, 4).Value) * 15.97) * ActiveCell.Offset(0,
3).Value) * 310

```

```

    Sheets("Carbon Footprint Results").Cells(n + 1, 3).Value = o + o1 + o2

```

```

ElseIf Sheets("Carbon Footprint").Cells(n, 5).Value = "Heating" Then

```

```

    Sheets("UtilEF").Activate
    Cells(1, 1).Select
    With Sheets("UtilEF")

```

```

Set Match1 = Cells.Find(What:=Worksheets("Carbon Footprint").Cells(n, 6).Value,
After:=ActiveCell, LookIn:=xlValues, LookAt:=xlPart, SearchOrder:=xlByRows,
SearchDirection:=xlNext, MatchCase:=False, SearchFormat:=False)

```

```
End With
```

```
Match1.Select
```

```

p = (Abs(Sheets("Carbon Footprint").Cells(n, 4).Value) * 0.947086) * ActiveCell.Offset(0,
1).Value

```

```

p1 = ((Abs(Sheets("Carbon Footprint").Cells(n, 4).Value) * 0.947086) * ActiveCell.Offset(0,
2).Value) * 21

```

```

p2 = ((Abs(Sheets("Carbon Footprint").Cells(n, 4).Value) * 0.947086) * ActiveCell.Offset(0,
3).Value) * 310

```

```
Sheets("Carbon Footprint Results").Cells(n + 1, 3).Value = p + p1 + p2
```

```
Elseif Sheets("Carbon Footprint").Cells(n, 5).Value = "Fuel combustion" Then
```

```
Sheets("EngEF").Activate
```

```
Cells(1, 1).Select
```

```
With Sheets("EngEF")
```

```

Set Match2 = Cells.Find(What:=Worksheets("Input Data").Cells(11, 7).Value,
After:=ActiveCell, LookIn:=xlValues, LookAt:=xlPart, SearchOrder:=xlByRows,
SearchDirection:=xlNext, MatchCase:=False, SearchFormat:=False)

```

```
End With
```

```
Match2.Select
```

```

q = (Abs(Sheets("Carbon Footprint").Cells(n, 4).Value) * 0.947086) * ActiveCell.Offset(0,
1).Value

```

```
Select Case True
```

```
Case Sheets("Input Data").Cells(11, 6).Value = "Coal"
```

```

q1 = ((Abs(Sheets("Carbon Footprint").Cells(n, 4).Value) * 0.947086) *
Sheets("EngEF").Cells(48, 3).Value) * 21

```

```

        q2 = ((Abs(Sheets("Carbon Footprint").Cells(n, 4).Value) * 0.947086) *
Sheets("EngEF").Cells(48, 5).Value) * 310
        Case Sheets("Input Data").Cells(11, 6).Value = "Petroleum fuel"
            q1 = ((Abs(Sheets("Carbon Footprint").Cells(n, 4).Value) * 0.947086) *
Sheets("EngEF").Cells(49, 3).Value) * 21
            q2 = ((Abs(Sheets("Carbon Footprint").Cells(n, 4).Value) * 0.947086) *
Sheets("EngEF").Cells(49, 5).Value) * 310
            Case Sheets("Input Data").Cells(11, 6).Value = "Natural gas"
                q1 = ((Abs(Sheets("Carbon Footprint").Cells(n, 4).Value) * 0.947086) *
Sheets("EngEF").Cells(50, 3).Value) * 21
                q2 = ((Abs(Sheets("Carbon Footprint").Cells(n, 4).Value) * 0.947086) *
Sheets("EngEF").Cells(50, 5).Value) * 310
            End Select

        Sheets("Carbon Footprint Results").Cells(n + 1, 3).Value = q + q1 + q2

ElseIf Sheets("Carbon Footprint").Cells(n, 5).Value = "Electric usage" Then

    Sheets("UtilEF").Activate
    Cells(1, 1).Select
    With Sheets("UtilEF")

        Set Match3 = Cells.Find(What:=Sheets("Input Data").cboCountry.Value,
After:=ActiveCell, LookIn:=xlValues, LookAt:=xlPart, SearchOrder:=xlByRows,
SearchDirection:=xlNext, MatchCase:=False, SearchFormat:=False)

        End With

        Match3.Select

        r = Abs(Sheets("Carbon Footprint").Cells(n, 4).Value) * ActiveCell.Offset(0, 1).Value
        r1 = (Abs(Sheets("Carbon Footprint").Cells(n, 4).Value) * ActiveCell.Offset(0, 2).Value) * 21
        r2 = (Abs(Sheets("Carbon Footprint").Cells(n, 4).Value) * ActiveCell.Offset(0, 3).Value) *
310

        Sheets("Carbon Footprint Results").Cells(n + 1, 3).Value = r + r1 + r2

    End If

```

```

Next n

End Sub

-----

Sub AddChrt()

Dim k As Integer
Dim l As Integer
Dim rngY As Range
Dim rngX As Range
Dim z As ChartObject
Dim ValChart
Dim XVal

k = Sheets("Carbon Footprint Results").Range("B" & Rows.Count).End(xlUp).Row
l = Sheets("Carbon Footprint Results").Range("C" & Rows.Count).End(xlUp).Row

Set rngY = Sheets("Carbon Footprint Results").Cells(l, 3)
Set rngX = Sheets("Carbon Footprint Results").Cells(k, 2)

ValChart = Sheets("Carbon Footprint Results").Range(Cells(6, 3), rngY)
XVal = Sheets("Carbon Footprint Results").Range(Cells(6, 2), rngX)

Set z = Sheets("Carbon Footprint Results").ChartObjects.Add(375, 90, 750, 450)

With z
    .Chart.ChartType = xlColumnClustered
    .Chart.SeriesCollection.NewSeries
    .Chart.SeriesCollection(1).XValues = XVal
    .Chart.SeriesCollection(1).Values = ValChart
    .Chart.SeriesCollection(1).Name = "CO2 eq."
    .Chart.ChartTitle.Caption = "Carbon Footprint Results"
    .Chart.Axes(xlCategory, xlPrimary).HasTitle = True
    .Chart.Axes(xlCategory, xlPrimary).AxisTitle.Caption = "Activity/Unit operation"
    .Chart.Axes(xlCategory, xlPrimary).AxisTitle.Font.Size = 14
    .Chart.Axes(xlCategory, xlPrimary).AxisTitle.Font.Bold = True
    .Chart.Axes(xlValue, xlPrimary).HasTitle = True

```

```

        .Chart.Axes(xlValue, xlPrimary).AxisTitle.Caption = "Kilograms CO2 equivalent"
        .Chart.Axes(xlValue, xlPrimary).AxisTitle.Font.Size = 14
        .Chart.Axes(xlValue, xlPrimary).AxisTitle.Font.Bold = True
    End With

End Sub

-----
Sub MassAllocate()

    Dim ProRow As Long
    Dim ProCol As Long
    Dim ProNameMatch As Range
    Dim ProStMatch As Range
    Dim ProMatch As Range
    Dim s As Byte
    Dim t As Byte
    Dim u As Byte
    Dim Carbrng As Integer
    Dim wsCurr5 As Worksheet
    Dim rStartCell5 As Range
    Dim mrnge5 As Range
    Dim m5 As Single
    Dim ProMtot As Single
    Dim LCol As Byte
    Dim Sstrng As Range

    Sheets("CalSt").Cells.Clear
    s = 0

    For t = 3 To Sheets("Define Stream").Range("F" & Rows.Count).End(xlUp).Row

        Worksheets("Stream Table").Activate
        Cells(1, 2).Select
        With Sheets("Stream Table")

            Set ProMatch = Columns.Find(What:=Sheets("Define Stream").Cells(t, 6).Value,
            After:=ActiveCell, LookIn:=xlValues, LookAt:=xlPart, SearchOrder:=xlByRows,
            SearchDirection:=xlNext, MatchCase:=False, SearchFormat:=False)

```

End With

ProMatch.Select

ActiveCell.EntireColumn.Copy

s = s + 1

If s = 1 Then

 ActiveSheet.Paste Destination:=Worksheets("CalSt").Columns(1)

ElseIf s > 1 Then

 ActiveSheet.Paste Destination:=Worksheets("CalSt").Columns(s)

End If

Next t

LCol = Sheets("CalSt").UsedRange.Columns.Count

For u = 10 To Sheets("CalSt").Range("B" & Rows.Count).End(xlUp).Row

 Set wsCurr5 = Worksheets("CalSt")

 Set rStartCell5 = wsCurr5.Cells(u, 1)

 Set mrnge5 = wsCurr5.Range(rStartCell5, rStartCell5.End(xlToRight))

 m5 = Application.WorksheetFunction.Sum(mrnge5)

 Sheets("CalSt").Cells(u, LCol + 1).Value = m5

Next u

Sheets("Stream Table").Activate

Cells(1, 1).Select

With Sheets("Stream Table")

 Set ProNameMatch = Cells.Find(What:=Worksheets("Product and Functional Unit").Cells(3, 2).Value, After:=ActiveCell, LookIn:=xlValues, LookAt:=xlPart, SearchOrder:=xlByRows, SearchDirection:=xlNext, MatchCase:=False, SearchFormat:=False)

End With

```

ProNameMatch.Select
ProRow = ActiveCell.Row

If LCol > 1 Then
    ProMtot = Sheets("CalSt").Cells(ProRow, LCol + 1).Value
ElseIf LCol = 1 Then
    ProMtot = Sheets("CalSt").Cells(ProRow, LCol).Value
End If

For Carbrng = 7 To Sheets("Carbon Footprint Results").Range("C" &
Rows.Count).End(xlUp).Row

    Sheets("Carbon Footprint Results").Cells(Carbrng, 3).Value = (Sheets("Carbon Footprint
Results").Cells(Carbrng, 3).Value / ProMtot) * Sheets("Product and Functional Unit").Cells(3,
3).Value

Next Carbrng

End Sub

```

ImpactAssessment Module

```

Sub GWP()
Dim GMatch As Range
Dim GMatch1 As Range
Dim GMatch2 As Range
Dim GMatch3 As Range
Dim GMatch4 As Range
Dim mCH4 As Single
Dim mN2O As Single
Dim mHFC As Single
Dim mCO2 As Single
Dim mi As Single
Dim GW As Single
Dim GWPi As Single
Dim GWCO2 As Single

```



```

Dim GWCH4 As Single
Dim GWN2O As Single
Dim GWHFC As Single
Dim GWPCO2 As Single
Dim GWPCH4 As Single
Dim GWPN2O As Single
Dim GWP HFC As Single
Dim a As Integer
Dim b As Integer

```

```

mCO2 = Application.WorksheetFunction.Sum(Sheets("Inventory Data").Range("CO2rng"))
mCH4 = Application.WorksheetFunction.Sum(Sheets("Inventory Data").Range("CH4rng"))
mN2O = Application.WorksheetFunction.Sum(Sheets("Inventory Data").Range("N2Orng"))
mHFC = Application.WorksheetFunction.Sum(Sheets("Inventory Data").Range("HFCrng"))

```

```

Sheets("GWP100").Activate
Cells(1, 1).Select
With Sheets("GWP100").Columns("B")

```

```

    Set GMatch1 = Cells.Find(What:="Carbon dioxide", After:=ActiveCell, LookIn:=xlValues,
LookAt:=xlWhole, SearchOrder:=xlByRows, SearchDirection:=xlNext, MatchCase:=False,
SearchFormat:=False)

```

```

    Set GMatch2 = Cells.Find(What:="Methane", After:=ActiveCell, LookIn:=xlValues,
LookAt:=xlWhole, SearchOrder:=xlByRows, SearchDirection:=xlNext, MatchCase:=False,
SearchFormat:=False)

```

```

    Set GMatch3 = Cells.Find(What:="Nitrous oxide", After:=ActiveCell, LookIn:=xlValues,
LookAt:=xlWhole, SearchOrder:=xlByRows, SearchDirection:=xlNext, MatchCase:=False,
SearchFormat:=False)

```

```

    Set GMatch4 = Cells.Find(What:="HFC-134a", After:=ActiveCell, LookIn:=xlValues,
LookAt:=xlPart, SearchOrder:=xlByRows, SearchDirection:=xlNext, MatchCase:=False,
SearchFormat:=False)

```

```

End With

```

```

GWPCO2 = GMatch1.Offset(0, 2).Value
GW PCH4 = GMatch2.Offset(0, 2).Value
GWPN2O = GMatch3.Offset(0, 2).Value
GW P HFC = GMatch4.Offset(0, 2).Value

```

GWCO2 = mCO2 * GWPCO2

GWCH4 = mCH4 * GWPCH4

GWN2O = mN2O * GWPN2O

GWHFC = mHFC * GWPFC

Sheets("LCIA Results").Cells(5, 3).Value = GWCO2 + GWCH4 + GWN2O + GWHFC

For a = 6 To Sheets("Inventory Data").Range("F" & Rows.Count).End(xlUp).Row

Sheets("GWP100").Activate

With Sheets("GWP100").Range("B:C")

Set GMatch = Cells.Find(What:=Worksheets("Inventory Data").Cells(a, 6).Value,
After:=ActiveCell, LookIn:=xlValues, LookAt:=xlWhole, SearchOrder:=xlByRows,
SearchDirection:=xlNext, MatchCase:=False, SearchFormat:=False)

End With

If GMatch Is Nothing Then

Beep

Else

GMatch.Select

b = ActiveCell.Row

mi = Worksheets("Inventory Data").Cells(a, 7).Value

GWPi = Sheets("GWP100").Cells(b, 4).Value

GW = mi * GWPi

Sheets("LCIA Results").Cells(5, 3).Value = Sheets("LCIA Results").Cells(5, 3).Value + GW

End If

Next a

End Sub

.....
Sub ODP()

Dim OMatch As Range

Dim OMatch1 As Range

Dim OMatch2 As Range

```

Dim mCFC As Single
Dim mNMVOC As Single
Dim mj As Single
Dim OD As Single
Dim ODPi As Single
Dim ODCFC As Single
Dim ODNMVOC As Single
Dim ODPCFC As Single
Dim ODPNMVOC As Single
Dim c As Integer
Dim d As Integer
Dim e As Integer
Dim f As Integer

    mCFC = Application.WorksheetFunction.Sum(Sheets("Inventory Data").Range("CFCrng"))
    mNMVOC = Application.WorksheetFunction.Sum(Sheets("Inventory
Data").Range("NMVOCrng"))

    Sheets("ODP").Activate
    Cells(1, 1).Select
    With Sheets("ODP").Range("B:C")

        Set OMatch = Cells.Find(What:="Trichlorofluoromethane"), After:=ActiveCell,
LookIn:=xlValues, LookAt:=xlWhole, SearchOrder:=xlByRows, SearchDirection:=xlNext,
MatchCase:=False, SearchFormat:=False)
        Set OMatch1 = Cells.Find(What:="Non-methane volatile organic compound"),
After:=ActiveCell, LookIn:=xlValues, LookAt:=xlWhole, SearchOrder:=xlByRows,
SearchDirection:=xlNext, MatchCase:=False, SearchFormat:=False)

    End With

    e = OMatch.Row
    f = OMatch1.Row
    ODPCFC = Sheets("ODP").Cells(e, 5).Value
    ODPNMVOC = Sheets("ODP").Cells(f, 5).Value

    ODCFC = mCFC * ODPCFC
    ODNMVOC = mNMVOC * ODPNMVOC

```

```

Sheets("LCIA Results").Cells(6, 3).Value = ODCFC + ODNMVOC

For c = 6 To Sheets("Inventory Data").Range("F" & Rows.Count).End(xlUp).Row

    Sheets("ODP").Activate
    With Sheets("ODP").Range("B:C")

        Set OMatch2 = Cells.Find(What:=Worksheets("Inventory Data").Cells(c, 6).Value,
After:=ActiveCell, LookIn:=xlValues, LookAt:=xlWhole, SearchOrder:=xlByRows,
SearchDirection:=xlNext, MatchCase:=False, SearchFormat:=False)

        End With

        If OMatch2 Is Nothing Then
            Beep
        Else
            OMatch2.Select
            d = ActiveCell.Row
            mj = Worksheets("Inventory Data").Cells(c, 7).Value
            ODPi = Sheets("ODP").Cells(d, 5).Value
            OD = mj * ODPi
            Sheets("LCIA Results").Cells(6, 3).Value = Sheets("LCIA Results").Cells(6, 3).Value + OD
        End If

    Next c

End Sub

.....
Sub AP()
Dim AMatch As Range
Dim AMatch1 As Range
Dim AMatch2 As Range
Dim AMatch3 As Range
Dim AMatch4 As Range
Dim AMatch5 As Range
Dim AMatch6 As Range
Dim mSOx As Single

```

Dim mN2O As Single
Dim mNOx As Single
Dim mHCl As Single
Dim mHF As Single
Dim mNH3 As Single
Dim mk As Single
Dim mk1 As Single
Dim mk2 As Single
Dim Acid As Single
Dim Acid1 As Single
Dim Acid2 As Single
Dim APi As Single
Dim AP1 As Single
Dim AP2 As Single
Dim ASOx As Single
Dim ANOx As Single
Dim AN2O As Single
Dim AHCl As Single
Dim AHF As Single
Dim ANH3 As Single
Dim APSOx As Single
Dim APNOx As Single
Dim APN2O As Single
Dim APHF As Single
Dim APHCl As Single
Dim APNH3 As Single
Dim g As Integer
Dim h As Integer
Dim h1 As Integer
Dim h2 As Integer
Dim i As Integer
Dim j As Integer
Dim k As Integer
Dim l As Integer
Dim m As Integer
Dim n As Integer

```

mSOx = Application.WorksheetFunction.Sum(Sheets("Inventory Data").Range("SOxrng"))
mNOx = Application.WorksheetFunction.Sum(Sheets("Inventory Data").Range("NOxrng"))
mN2O = Application.WorksheetFunction.Sum(Sheets("Inventory Data").Range("N2Orng"))
mHF = Application.WorksheetFunction.Sum(Sheets("Inventory Data").Range("HFrng"))
mHCl = Application.WorksheetFunction.Sum(Sheets("Inventory Data").Range("HClrng"))
mNH3 = Application.WorksheetFunction.Sum(Sheets("Inventory Data").Range("NH3rng"))

```

```

Sheets("AP").Activate
Cells(1, 1).Select
With Sheets("AP").Range("B:C")

```

```

    Set AMatch1 = Cells.Find(What:="Sulfur oxide", After:=ActiveCell, LookIn:=xlValues,
LookAt:=xlWhole, SearchOrder:=xlByRows, SearchDirection:=xlNext, MatchCase:=False,
SearchFormat:=False)

```

```

    Set AMatch2 = Cells.Find(What:="Nitrogen oxide", After:=ActiveCell, LookIn:=xlValues,
LookAt:=xlWhole, SearchOrder:=xlByRows, SearchDirection:=xlNext, MatchCase:=False,
SearchFormat:=False)

```

```

    Set AMatch3 = Cells.Find(What:="Nitrous oxide", After:=ActiveCell, LookIn:=xlValues,
LookAt:=xlWhole, SearchOrder:=xlByRows, SearchDirection:=xlNext, MatchCase:=False,
SearchFormat:=False)

```

```

    Set AMatch4 = Cells.Find(What:="Hydrofluoric", After:=ActiveCell, LookIn:=xlValues,
LookAt:=xlWhole, SearchOrder:=xlByRows, SearchDirection:=xlNext, MatchCase:=False,
SearchFormat:=False)

```

```

    Set AMatch5 = Cells.Find(What:="Hydrochloric", After:=ActiveCell, LookIn:=xlValues,
LookAt:=xlWhole, SearchOrder:=xlByRows, SearchDirection:=xlNext, MatchCase:=False,
SearchFormat:=False)

```

```

    Set AMatch6 = Cells.Find(What:="Ammonia", After:=ActiveCell, LookIn:=xlValues,
LookAt:=xlWhole, SearchOrder:=xlByRows, SearchDirection:=xlNext, MatchCase:=False,
SearchFormat:=False)

```

```

End With

```

```

i = AMatch1.Row
j = AMatch2.Row
k = AMatch3.Row
l = AMatch4.Row
m = AMatch5.Row
n = AMatch6.Row

```

```

APSOx = Sheets("AP").Cells(i, 4).Value
APNOx = Sheets("AP").Cells(j, 4).Value
APN2O = Sheets("AP").Cells(k, 4).Value
APHF = Sheets("AP").Cells(l, 4).Value
APHCl = Sheets("AP").Cells(m, 4).Value
APNH3 = Sheets("AP").Cells(n, 4).Value

```

```

ASOx = mSOx * APSOx
ANOx = mNOx * APNOx
AN2O = mN2O * APN2O
AHF = mHF * APHF
AHCl = mHCl * APHCl
ANH3 = mNH3 * APNH3

```

```

Sheets("LCIA Results").Cells(8, 3).Value = ASOx + ANOx + AN2O + AHF + AHCl + ANH3

```

```

For g = 6 To Sheets("Inventory Data").Range("D" & Rows.Count).End(xlUp).Row

```

```

    Sheets("AP").Activate
    With Sheets("AP").Range("B:C")

```

```

        Set AMatchA = Cells.Find(What:=Worksheets("Inventory Data").Cells(g, 6).Value,
After:=ActiveCell, LookIn:=xlValues, LookAt:=xlWhole, SearchOrder:=xlByRows,
SearchDirection:=xlNext, MatchCase:=False, SearchFormat:=False)

```

```

        Set AMatchS = Cells.Find(What:=Worksheets("Inventory Data").Cells(g, 4).Value,
After:=ActiveCell, LookIn:=xlValues, LookAt:=xlWhole, SearchOrder:=xlByRows,
SearchDirection:=xlNext, MatchCase:=False, SearchFormat:=False)

```

```

        Set AMatchW = Cells.Find(What:=Worksheets("Inventory Data").Cells(g, 8).Value,
After:=ActiveCell, LookIn:=xlValues, LookAt:=xlWhole, SearchOrder:=xlByRows,
SearchDirection:=xlNext, MatchCase:=False, SearchFormat:=False)

```

```

    End With

```

```

    If AMatchA Is Nothing Then

```

```

        Beep

```

```

    Else

```

```

        AMatchA.Select

```

```

    h = ActiveCell.Row
    mk = Worksheets("Inventory Data").Cells(g, 7).Value
    APi = Sheets("AP").Cells(h, 4).Value
    Acid = mk * APi
    Sheets("LCIA Results").Cells(8, 3).Value = Sheets("LCIA Results").Cells(8, 3).Value + Acid
End If

```

```

If AMatchS Is Nothing Then

```

```

    Beep

```

```

Else

```

```

    AMatchS.Select

```

```

    h1 = ActiveCell.Row

```

```

    mk1 = Worksheets("Inventory Data").Cells(g, 5).Value

```

```

    AP1 = Sheets("AP").Cells(h1, 4).Value

```

```

    Acid1 = mk1 * AP1

```

```

    Sheets("LCIA Results").Cells(8, 3).Value = Sheets("LCIA Results").Cells(8, 3).Value + Acid1

```

```

End If

```

```

If AMatchW Is Nothing Then

```

```

    Beep

```

```

Else

```

```

    AMatchW.Select

```

```

    h2 = ActiveCell.Row

```

```

    mk2 = Worksheets("Inventory Data").Cells(g, 9).Value

```

```

    AP2 = Sheets("AP").Cells(h2, 4).Value

```

```

    Acid2 = mk2 * AP2

```

```

    Sheets("LCIA Results").Cells(8, 3).Value = Sheets("LCIA Results").Cells(8, 3).Value + Acid2

```

```

End If

```

```

Next g

```

```

End Sub

```

```

.....
Sub POCP()

```

```

    Dim PMatch As Range

```

```

    Dim PMatch1 As Range

```

```

    Dim PMatch2 As Range

```

```

    Dim PMatch3 As Range

```


Dim mCH4 As Single

Dim mNMVOC As Single

Dim mCO As Single

Dim ml As Single

Dim POC As Single

Dim POCPi As Single

Dim POCCH4 As Single

Dim POCNMVOC As Single

Dim POCCO As Single

Dim POCPCH4 As Single

Dim POCPNMVOC As Single

Dim POCPCO As Single

Dim o As Integer

Dim p As Integer

Dim q As Integer

Dim r As Integer

Dim s As Integer

mCH4 = Application.WorksheetFunction.Sum(Sheets("Inventory Data").Range("CH4rng"))

mNMVOC = Application.WorksheetFunction.Sum(Sheets("Inventory Data").Range("NMVOCrng"))

mCO = Application.WorksheetFunction.Sum(Sheets("Inventory Data").Range("COrng"))

Sheets("POCP").Activate

Cells(1, 1).Select

With Sheets("POCP").Range("B:C")

Set PMatch1 = Cells.Find(What:="Methane"), After:=ActiveCell, LookIn:=xlValues, LookAt:=xlWhole, SearchOrder:=xlByRows, SearchDirection:=xlNext, MatchCase:=False, SearchFormat:=False)

Set PMatch2 = Cells.Find(What:="Non-methane volatile organic compound"), After:=ActiveCell, LookIn:=xlValues, LookAt:=xlWhole, SearchOrder:=xlByRows, SearchDirection:=xlNext, MatchCase:=False, SearchFormat:=False)

Set PMatch3 = Cells.Find(What:="Carbonmonoxide"), After:=ActiveCell, LookIn:=xlValues, LookAt:=xlWhole, SearchOrder:=xlByRows, SearchDirection:=xlNext, MatchCase:=False, SearchFormat:=False)

End With

```

q = PMatch1.Row
r = PMatch2.Row
s = PMatch3.Row
POCPCH4 = Sheets("POCP").Cells(q, 4).Value
POCPNMVOC = Sheets("POCP").Cells(r, 4).Value
POCPCO = Sheets("POCP").Cells(s, 4).Value

POCCH4 = mCH4 * POCPCH4
POCNMVOC = mNMVOC * POCPNMVOC
POCCO = mCO * POCPCO

Sheets("LCIA Results").Cells(7, 3).Value = POCCH4 + POCNMVOC + POCCO

For o = 6 To Sheets("Inventory Data").Range("F" & Rows.Count).End(xlUp).Row

    Sheets("POCP").Activate
    With Sheets("POCP").Range("B:C")

        Set PMatch = Cells.Find(What:=Worksheets("Inventory Data").Cells(o, 6).Value,
After:=ActiveCell, LookIn:=xlValues, LookAt:=xlWhole, SearchOrder:=xlByRows,
SearchDirection:=xlNext, MatchCase:=False, SearchFormat:=False)

        End With

        If PMatch Is Nothing Then
            Beep
        Else
            PMatch.Select
            p = ActiveCell.Row
            ml = Worksheets("Inventory Data").Cells(o, 7).Value
            POCPi = Sheets("POCP").Cells(p, 4).Value
            POC = ml * POCPi
            Sheets("LCIA Results").Cells(7, 3).Value = Sheets("LCIA Results").Cells(7, 3).Value + POC
        End If
    Next o

End Sub

```

```

Sub EP()
Dim EMatch As Range
Dim EMatch1 As Range
Dim EMatch2 As Range
Dim mNOx As Single
Dim mNH3 As Single
Dim mn As Single
Dim Eutro As Single
Dim EPi As Single
Dim ENOx As Single
Dim ENH3 As Single
Dim EPNOx As Single
Dim EPNH3 As Single
Dim t As Integer
Dim u As Integer
Dim v As Integer
Dim w As Integer

mNOx = Application.WorksheetFunction.Sum(Sheets("Inventory Data").Range("NOxrng"))
mNH3 = Application.WorksheetFunction.Sum(Sheets("Inventory Data").Range("NH3rng"))

Sheets("EP").Activate
Cells(1, 1).Select
With Sheets("EP").Range("B:C")

    Set EMatch1 = Cells.Find(What:="Nitrogen oxide", After:=ActiveCell, LookIn:=xlValues,
LookAt:=xlWhole, SearchOrder:=xlByRows, SearchDirection:=xlNext, MatchCase:=False,
SearchFormat:=False)

    Set EMatch2 = Cells.Find(What:="Ammonia"), After:=ActiveCell, LookIn:=xlValues,
LookAt:=xlWhole, SearchOrder:=xlByRows, SearchDirection:=xlNext, MatchCase:=False,
SearchFormat:=False)

End With

v = EMatch1.Row
w = EMatch2.Row
EPNOx = Sheets("EP").Cells(v, 4).Value

```

```
EPNH3 = Sheets("EP").Cells(w, 4).Value
```

```
ENOX = mNOx * EPNOx
```

```
ENH3 = mNH3 * EPNH3
```

```
Sheets("LCIA Results").Cells(9, 3).Value = ENOX + ENH3
```

```
For t = 6 To Sheets("Inventory Data").Range("F" & Rows.Count).End(xlUp).Row
```

```
    Sheets("EP").Activate
```

```
    With Sheets("EP").Range("B:C")
```

```
        Set EMatch = Cells.Find(What:=Worksheets("Inventory Data").Cells(t, 6).Value,
        After:=ActiveCell, LookIn:=xlValues, LookAt:=xlWhole, SearchOrder:=xlByRows,
        SearchDirection:=xlNext, MatchCase:=False, SearchFormat:=False)
```

```
    End With
```

```
    If EMatch Is Nothing Then
```

```
        Beep
```

```
    Else
```

```
        EMatch.Select
```

```
        u = ActiveCell.Row
```

```
        mn = Worksheets("Inventory Data").Cells(t, 7).Value
```

```
        EPi = Sheets("EP").Cells(u, 4).Value
```

```
        Eutro = mn * EPi
```

```
        Sheets("LCIA Results").Cells(9, 3).Value = Sheets("LCIA Results").Cells(9, 3).Value + Eutro
```

```
    End If
```

```
Next t
```

```
End Sub
```

```
Sub HTP()
```

```
Dim HuTox As Single
```

```
Dim mHT As Single
```

```
Dim HTPi As Single
```

```
Dim HTMatch As Range
```

```
Dim x As Integer
```

```
Dim y As Integer
```

```
For x = 6 To Sheets("Inventory Data").Range("F" & Rows.Count).End(xlUp).Row
```

```
    Sheets("Toxicity Indicator").Activate
```

```
    With Sheets("Toxicity Indicator").Range("B:C")
```

```
        Set HTMatch = Cells.Find(What:=Worksheets("Inventory Data").Cells(x, 6).Value,
```

```
        After:=ActiveCell, LookIn:=xlValues, LookAt:=xlWhole, SearchOrder:=xlByRows,
```

```
        SearchDirection:=xlNext, MatchCase:=False, SearchFormat:=False)
```

```
    End With
```

```
    If HTMatch Is Nothing Then
```

```
        Beep
```

```
    Else
```

```
        HTMatch.Select
```

```
        y = ActiveCell.Row
```

```
        mHT = Worksheets("Inventory Data").Cells(x, 7).Value
```

```
        HTPi = Sheets("Toxicity Indicator").Cells(y, 6).Value
```

```
        HuTox = mHT * HTPi
```

```
        Sheets("LCIA Results").Cells(10, 3).Value = Sheets("LCIA Results").Cells(10, 3).Value +
```

```
        HuTox
```

```
    End If
```

```
Next x
```

```
End Sub
```

```
.....
```

```
Sub ATP()
```

```
Dim AqTox As Single
```

```
Dim mAT As Single
```

```
Dim ATPi As Single
```

```
Dim ATMatch As Range
```

```
Dim xl As Integer
```

```
Dim yl As Integer
```

```

Sheets("LCIA Results").Cells(11, 3).Clear
For x1 = 6 To Sheets("Inventory Data").Range("H" & Rows.Count).End(xlUp).Row

    Sheets("Toxicity Indicator").Activate
    With Sheets("Toxicity Indicator").Range("B:C")

        Set ATMatch = Cells.Find(What:=Worksheets("Inventory Data").Cells(x1, 8).Value,
        After:=ActiveCell, LookIn:=xlValues, LookAt:=xlWhole, SearchOrder:=xlByRows,
        SearchDirection:=xlNext, MatchCase:=False, SearchFormat:=False)

        End With

        If ATMatch Is Nothing Then
            Beep
        Else
            ATMatch.Select
            y1 = ActiveCell.Row
            mAT = Worksheets("Inventory Data").Cells(x1, 9).Value
            ATPi = Sheets("Toxicity Indicator").Cells(y1, 4).Value
            AqTox = mAT * ATPi
            Sheets("LCIA Results").Cells(11, 3).Value = Sheets("LCIA Results").Cells(11, 3).Value +
AqTox
        End If

    Next x1

End Sub

-----
Sub TTP()
Dim TTox As Single
Dim mTT As Single
Dim TTPi As Single
Dim TTMatch As Range
Dim x2 As Integer
Dim y2 As Integer

    Sheets("LCIA Results").Cells(12, 3).Clear
    For x2 = 6 To Sheets("Inventory Data").Range("D" & Rows.Count).End(xlUp).Row

```

```

Sheets("Toxicity Indicator").Activate
With Sheets("Toxicity Indicator").Range("B:C")

    Set TTMatch = Cells.Find(What:=Worksheets("Inventory Data").Cells(x2, 4).Value,
After:=ActiveCell, LookIn:=xlValues, LookAt:=xlWhole, SearchOrder:=xlByRows,
SearchDirection:=xlNext, MatchCase:=False, SearchFormat:=False)

End With

If TTMatch Is Nothing Then
    Beep
Else
    TTMatch.Select
    y2 = ActiveCell.Row
    mTT = Worksheets("Inventory Data").Cells(x2, 5).Value
    TTpi = Sheets("Toxicity Indicator").Cells(y2, 5).Value
    TTox = mTT * TTpi
    Sheets("LCIA Results").Cells(12, 3).Value = Sheets("LCIA Results").Cells(12, 3).Value +
TTox
End If

Next x2

End Sub

```

```

Sub AddChrtIA()
Dim k As Integer
Dim l As Integer
Dim rngY As Range
Dim rngX As Range
Dim z As ChartObject
Dim ValChart
Dim XVal

k = Sheets("LCIA Results").Range("B" & Rows.Count).End(xlUp).Row
l = Sheets("LCIA Results").Range("C" & Rows.Count).End(xlUp).Row

```

```

Set rngY = Sheets("LCIA Results").Cells(l, 3)
Set rngX = Sheets("LCIA Results").Cells(k, 2)

ValChart = Sheets("LCIA Results").Range(Cells(5, 3), rngY)
XVal = Sheets("LCIA Results").Range(Cells(5, 2), rngX)

Set z = Sheets("LCIA Results").ChartObjects.Add(375, 90, 750, 450)

With z
    .Chart.ChartType = xlColumnClustered
    .Chart.SeriesCollection.NewSeries
    .Chart.SeriesCollection(1).XValues = XVal
    .Chart.SeriesCollection(1).Values = ValChart
    .Chart.SeriesCollection(1).Name = ""
    .Chart.ChartTitle.Caption = "Impact Assessment Results"
    .Chart.Axes(xlCategory, xlPrimary).HasTitle = True
    .Chart.Axes(xlCategory, xlPrimary).AxisTitle.Caption = "Impact Categories"
    .Chart.Axes(xlCategory, xlPrimary).AxisTitle.Font.Size = 14
    .Chart.Axes(xlCategory, xlPrimary).AxisTitle.Font.Bold = True
    .Chart.Axes(xlValue, xlPrimary).HasTitle = True
    .Chart.Axes(xlValue, xlPrimary).AxisTitle.Caption = ""
End With

End Sub

```

InputCtrl Module

```

Sub ImpEqui()

On Error GoTo ErrorHandler
Dim newsheet As Worksheet
Dim shname2 As String
    shname2 = Application.GetOpenFilename
    Sheets.Add Type:=shname2
ErrorHandler:
Resume Next

End Sub

```

```
Sub ImpStr()
```

```
On Error GoTo ErrorHandler
```

```
Dim newsheet As Worksheet
```

```
Dim shname1 As String
```

```
    shname1 = Application.GetOpenFilename
```

```
    Sheets.Add Type:=shname1
```

```
ErrorHandler:
```

```
Resume Next
```

```
End Sub
```

```
Sub renameEqui()
```

```
    If Not ActiveSheet.Name = "Input Data" Then
```

```
        ActiveSheet.Name = "Equipment Table"
```

```
    End If
```

```
End Sub
```

```
Sub renameStr()
```

```
    If Not ActiveSheet.Name = "Input Data" Then
```

```
        ActiveSheet.Name = "Stream Table"
```

```
    End If
```

```
End Sub
```

ReadImport Module

Dim AMatch As Range

Dim OtSIMatch As Range

Dim OtAMatch As Range

Dim OtWMatch As Range

Dim i As Byte

Dim j As Byte

Dim k As Byte

Dim l As Byte

Dim n As Byte

Dim o As Byte

Dim p As Byte

Dim q As Byte

Dim r As Byte

Dim s As Byte

Dim t As Byte

Dim u As Byte

Dim m As Single

Dim m2 As Single

Dim m3 As Single

Dim m4 As Single

Dim wsCurr As Worksheet

Dim rStartCell As Range

Dim mrnge As Range

Dim wsCurr2 As Worksheet

Dim rStartCell2 As Range

Dim mrnge2 As Range

Dim wsCurr3 As Worksheet

Dim rStartCell3 As Range

Dim mrnge3 As Range

Dim wsCurr4 As Worksheet

Dim rStartCell4 As Range

Dim mrnge4 As Range

```
Sub ReadInSt()
```

```
Sheets("CalSt").Cells.Clear
```

```
j = 1
```

```
Sheets("Stream Table").Activate
```

```
Sheets("Stream Table").Range("D10:D50").Select
```

```
Selection.Copy
```

```
Sheets("Inventory Data").Range("InChName").PasteSpecial Paste:=xlPasteValues,
```

```
Operation:=xlNone, SkipBlanks _
```

```
:=True, Transpose:=False
```

```
Sheets("Inventory Data").Range("OutSoilChName").PasteSpecial Paste:=xlPasteValues,
```

```
Operation:=xlNone, SkipBlanks _
```

```
:=True, Transpose:=False
```

```
Sheets("Inventory Data").Range("OutAirChName").PasteSpecial Paste:=xlPasteValues,
```

```
Operation:=xlNone, SkipBlanks _
```

```
:=True, Transpose:=False
```

```
Sheets("Inventory Data").Range("OutWaterChName").PasteSpecial Paste:=xlPasteValues,
```

```
Operation:=xlNone, SkipBlanks _
```

```
:=True, Transpose:=False
```

```
For i = 3 To Sheets("Define Stream").Range("B" & Rows.Count).End(xlUp).Row
```

```
    Worksheets("Stream Table").Activate
```

```
    Cells(1, 2).Select
```

```
    With Sheets("Stream Table")
```

```
        Set AMatch = Columns.Find(What:=Sheets("Define Stream").Cells(i, 2).Value,
```

```
        After:=ActiveCell, LookIn:=xlValues, LookAt:=xlPart, SearchOrder:=xlByRows,
```

```
        SearchDirection:=xlNext, MatchCase:=False, SearchFormat:=False)
```

```
    End With
```

```
    AMatch.Select
```

```
    ActiveCell.EntireColumn.Copy
```

```
    j = j + 1
```

```
    If j = 2 Then
```

```

        ActiveSheet.Paste Destination:=Worksheets("CalSt").Columns(2)
    ElseIf j > 2 Then
        ActiveSheet.Paste Destination:=Worksheets("CalSt").Columns(j)
    End If

Next i

For k = 10 To Sheets("CalSt").Range("B" & Rows.Count).End(xlUp).Row

    Set wsCurr = Worksheets("CalSt")
    Set rStartCell = wsCurr.Cells(k, 2)
    Set mrnge = wsCurr.Range(rStartCell, rStartCell.End(xlToRight))

    m = Application.WorksheetFunction.Sum(mrnge)
    Sheets("Inventory Data").Cells((k - 6), 2).Value = m

Next k

End Sub

```

```

Sub ReadOtSISt()

Sheets("CalSt").Cells.Clear
l = 1

For o = 3 To Sheets("Define Stream").Range("C" & Rows.Count).End(xlUp).Row

    Worksheets("Stream Table").Activate
    Cells(1, 2).Select
    With Sheets("Stream Table")

        Set OtSIMatch = Columns.Find(What:=Sheets("Define Stream").Cells(o, 3).Value,
After:=ActiveCell, LookIn:=xlValues, LookAt:=xlPart, SearchOrder:=xlByRows,
SearchDirection:=xlNext, MatchCase:=False, SearchFormat:=False)

    End With

```

```

OtSIMatch.Select
ActiveCell.EntireColumn.Copy
l = l + 1

If l = 2 Then
    ActiveSheet.Paste Destination:=Worksheets("CalSt").Columns(2)
ElseIf l > 2 Then
    ActiveSheet.Paste Destination:=Worksheets("CalSt").Columns(l)
End If

Next o

For n = 10 To Sheets("CalSt").Range("B" & Rows.Count).End(xlUp).Row

    Set wsCurr2 = Worksheets("CalSt")
    Set rStartCell2 = wsCurr2.Cells(n, 2)
    Set mrnge2 = wsCurr2.Range(rStartCell2, rStartCell2.End(xlToRight))

    m2 = Application.WorksheetFunction.Sum(mrnge2)
    Sheets("Inventory Data").Cells((n - 4), 5).Value = m2

Next n

End Sub
.....
Sub ReadOtASt()

Sheets("CalSt").Cells.Clear
p = 1

For q = 3 To Sheets("Define Stream").Range("D" & Rows.Count).End(xlUp).Row

    Worksheets("Stream Table").Activate
    Cells(1, 2).Select
    With Sheets("Stream Table")

```

```

    Set OtAMatch = Columns.Find(What:=Sheets("Define Stream").Cells(q, 4).Value,
After:=ActiveCell, LookIn:=xlValues, LookAt:=xlPart, SearchOrder:=xlByRows,
SearchDirection:=xlNext, MatchCase:=False, SearchFormat:=False)

```

```

End With

```

```

OtAMatch.Select
ActiveCell.EntireColumn.Copy
p = p + 1

```

```

If p = 2 Then

```

```

    ActiveSheet.Paste Destination:=Worksheets("CalSt").Columns(2)

```

```

ElseIf p > 2 Then

```

```

    ActiveSheet.Paste Destination:=Worksheets("CalSt").Columns(p)

```

```

End If

```

```

Next q

```

```

For r = 10 To Sheets("CalSt").Range("B" & Rows.Count).End(xlUp).Row

```

```

    Set wsCurr3 = Worksheets("CalSt")

```

```

    Set rStartCell3 = wsCurr3.Cells(r, 2)

```

```

    Set mrnge3 = wsCurr3.Range(rStartCell3, rStartCell3.End(xlToRight))

```

```

    m3 = Application.WorksheetFunction.Sum(mrnge3)

```

```

    Sheets("Inventory Data").Cells((r - 4), 7).Value = m3

```

```

Next r

```

```

End Sub

```

```

Sub ReadOtWSt()

```

```

Sheets("CalSt").Cells.Clear

```

```

s = 1

```

```

For t = 3 To Sheets("Define Stream").Range("E" & Rows.Count).End(xlUp).Row

    Worksheets("Stream Table").Activate
    Cells(1, 2).Select
    With Sheets("Stream Table")

        Set OtWMatch = Columns.Find(What:=Sheets("Define Stream").Cells(t, 5).Value,
After:=ActiveCell, LookIn:=xlValues, LookAt:=xlPart, SearchOrder:=xlByRows,
SearchDirection:=xlNext, MatchCase:=False, SearchFormat:=False)

        End With

        OtWMatch.Select
        ActiveCell.EntireColumn.Copy
        s = s + 1

        If s = 2 Then
            ActiveSheet.Paste Destination:=Worksheets("CalSt").Columns(2)
        ElseIf s > 2 Then
            ActiveSheet.Paste Destination:=Worksheets("CalSt").Columns(s)
        End If

    Next t

For u = 10 To Sheets("CalSt").Range("B" & Rows.Count).End(xlUp).Row

    Set wsCurr4 = Worksheets("CalSt")
    Set rStartCell4 = wsCurr4.Cells(u, 2)
    Set mrnge4 = wsCurr4.Range(rStartCell4, rStartCell4.End(xlToRight))

    m4 = Application.WorksheetFunction.Sum(mrnge4)
    Sheets("Inventory Data").Cells((u - 4), 9).Value = m4

Next u

End Sub

```

CURRICULUM VITAE

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Presentations:

1. Sarayut, P., Pomthong, M., Kitipat, S. and Rafiqul, G. (2012, April 24) Development of software for life cycle assessment. Paper presented at the 3rd Research Symposium on Petrochemical and Materials Technology and the 18th PPC Symposium on Petroleum, Petrochemicals, and Polymers, Bangkok, Thailand.