IMPROVED MOBILE AIR CONDITIONING-GREENHOUSE GAS-LIFE CYCLE CLIMATE PERFORMANCE (IMAC-GHG-LCCP) TOOL –

USER'S GUIDE AND MANUAL



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<u>About</u>

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Software maintained and distributed by:

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Introduction

Life Cycle Climate Performance (LCCP) is a metric to estimate greenhouse gas (GHG) emissions throughout the lifecycle of a refrigerant gas, including emissions from manufacturing and end-of-life recycling. This tool was developed to measure the LCCP of Mobile Air Conditioning (MAC) system refrigerant after the U.S. Environmental Protection Agency (EPA) started providing incentives in the Greenhouse Gas Emissions Rule of 2009. The tool is an adaptation and improvement of the Excel-based GREEN-MAC-LCCP (Global Refrigerants Energy & Environmental-MAC-LCCP) with a focus on simplicity and ease-of-use.

This concept was first applied in the late 1990's by Oak Ridge National Laboratory (ORNL) and General Motors (GM) for the evaluation of alternative refrigerant options for R134a. ORNL originally proposed a metric called Total Equivalent Warming Impact (TEWI) in 1997. This metric can be used to estimate how a MAC system is contributing to global warming.

In 2017, Optimized Thermal Systems, Inc. (OTS) was contracted by the Society of Automotive Engineers (SAE)¹ to develop the next generation of the model originally developed at GM.

This document is designed to guide the user through the program and complete a successful simulation.

¹ SAE does not endorse or authorize the **IMAC-GHG-LCCP software**.

Installation and Setup

1. Hardware & Software Requirements

The hardware requirements for the installation of this software are as follows:

- Dual Core Intel/AMD Processor 2.0 GHz, 4GB RAM, 1GB Disk space
- Monitor resolution of 1366 x 768 or higher

The software requirements for the installation of this software are as follows:

- Microsoft Windows Operating System (Windows 7, 8.1, 10)
- Microsoft Office 2007-2016

2. Installation

The LCCP package will be delivered as a .zip folder. To install and run the LCCP package it needs to be unzipped and extracted into the desired folder.

Directions are as follows:

- 1. Download the .zip file in any desired folder from the email.
- 2. Extract the .zip file by right-clicking on the folder and selecting *"Extract All"* as shown in *Figure 1.*



Figure 1. Extracting the package from the .zip file

3. From the pop-up screen, extract the package into the desired path and folder as shown in *Figure 2*.

		\times
~	Extract Compressed (Zipped) Folders	
	Select a Destination and Extract Files	
-	Files will be extracted to this folder:	
	C:\Users\IMAC-GHG-LCCP-1_0_2_4-20190509\ Browse	
	Show ovtracted files when complete	
	Show extracted mes when complete	
8		
	Extract Cance	el

Figure 2. Selecting the path and folder for the package to be extracted

4. Once the package is extracted in the desired folder, the application can be accessed from it anytime the user wishes to run the program. Open the folder containing the tool, which will have the same name as the .zip file, and double click the *"LCCP2017"* icon to run the application as shown in *Figures 3 and 4*.

Name	Date modified	Туре	Size
IMAC-GHG-LCCP-1_0_2_4-20190509	7/8/2019 12:30 PM	File folder	

Figure 3. Opening the folder which contains the application

Name	Date modified	Туре	Size
My LCCP Project	6/25/2019 11:20 A	File folder	
E LCCP2017	6/4/2019 10:04 AM	Application	2,515 KB
System.Net.Http.dll	6/4/2019 10:04 AM	Application extens	177 KB
ZedGraph.dll	6/4/2019 10:04 AM	Application extens	300 KB

Fiaure 4.	Runnina	the	application
rigare n	nannig	cric	application

5. On opening the application, click "*Enter*" to start the simulation or click "*About LCCP*" to learn more about it. A picture of the start-up screen is shown in *Figure 5*.



Figure 5. Starting the program

On selecting "*Enter*" the program will start, and the user will have to go through nine different input screens before the simulation can be run. All previous screens are saved automatically when the user moves onto the next screen. The simulation results are obtained as an Excel file which opens automatically after simulations are run. The directions to open the results file at a later stage can be obtained in the *Viewing Results* section or by clicking <u>here</u>.

Input Screen Walkthrough

This section is a walkthrough for each of the input screens for the IMAC-GHG-LCCP simulation tool. All screens have pre-defined data loaded in the input boxes. Instructions on how to load pre-defined data to complete some input screens are provided in their respective sections.

1. System Selection

The program begins with the Systems Selection screen shown in Figure 6. The user can choose to evaluate six unique systems simultaneously. There are four pre-defined refrigerants supported along with a user-defined refrigerant option.

The available pre-defined refrigerants are:

- I. R-134a
- II. R-1234yf
- III. R-744
- IV. R-152a

The screen includes the following inputs:

- I. Project name
- II. Number of systems
- III. Name of all systems
- IV. Type of refrigerant to be compared with an option of a user defined refrigerant

The available refrigerants and the input boxes can be seen in *Figure 6*.

🖳 System Selection				-		×
System Set-up						
Project Name	ProjectName Test					
# of Systems	1	~				
	Name		Refrigerant	t		
System 1	Sys1		R134a		\sim	
System 2	Sys2		R134a R1234yf			
System 3	Sys3		R744 R152a			
System 4	Sys4		User-Defir R1348	ned	_	
System 5	Sys5		R134a		\sim	
System 6	Sys6		R134a		\sim	
		Load Pr	oject	(ЭК	

Figure 6. Selecting the system

On this screen, the user can also load a project that was previously developed by following the steps shown below:

1. Click on the *"Load Project"* button as seen in *Figure 6* to open the folder that has all previously saved projects. Select the required project that is required as shown in *Figure 7.*

Name	Date modified	Туре	Size
LCCP_20190604130832_ProjectName1	6/4/2019 1:08 PM	Microsoft Excel W	70 KB
LCCP_20190605101344_ProjectName2	6/5/2019 10:13 AM	Microsoft Excel W	88 KB
LCCP_20190606092204_ProjectName Test	6/6/2019 1:47 PM	Microsoft Excel W	72 KB

Figure 7. Loading a project file

2. Select the project that is to be worked on and let it load. The program will then refill all input boxes with the project data. *Figure 8* shows the completed screen after loading the project. Once complete, the screen will show a message *"Project loading complete"*.

🖳 System Selection		_		×
System Set-up				
Project Name	ProjectName Test			
# of Systems	2 ~			
	Name	Refrigerant		
System 1	Sys1	R134a	~	
System 2	Sys2	R1234yf	~	
System 3	Sys3	R134a	\sim	
System 4	Sys4	R134a	\sim	
System 5	Sys5	R134a	\sim	
System 6	Sys6	R134a	\sim	
	Project	loading complete.		
	Lo	ad Project	ок	

Figure 8. Loading of a previous project

2. <u>Refrigerant Data</u>

The Refrigerant Data screen shows the refrigerant characteristics for each system. The refrigerants come with pre-loaded data unless the user-defined refrigerant is selected.

Figure 9 shows the parameters that the user needs to provide if pre-defined refrigerants are used. They are:

- I. Option of adding a recycle for refrigerant during servicing. Default: Yes
- II. J2727 Leakage rate (g/y)

iner reengerant wate				
	Sys1	Sys2		
efrigerant	R134a	R1234yf		
WP	1430	4		
Formyl fluoride - HC(O)F	0.065	0.065		
Carbonyl fluoride - C(O)F2	0.0325	0.0325		
Trifluoroacetyl fluoride -CF3-C(O)F	0.13	1		
Total GWP due to ADP	1.5925	3.3325		
CO2-Eq. emissions for virgin refrigerant	8	8		
CO2-Eq. emissions for recycled refrigerant	2.1	2.1		
CO2-Eq. fugitive emissions of gases from manufacture	0	0		
CO2-Eq. due to refrigerant leakage during transport	0.429	0.429		
CO2-Eq. due to fuel consumption during transport	0	0		
Atmospheric Reaction Byproducts	1.59	3.33		
Refrigerant Recycling During Servicing	Yes ~	Yes 🗸		
J2727 Leakage Rate [gly]	10	10		

Figure 9. Providing data for pre-defined refrigerant

The user needs to define many more parameters if user-defined refrigerant is selected. They are listed below, and an example can also be seen in *Figure 10*.

Data to be entered if using user defined refrigerant:

- I. GWP (Global Warming Potential)
- II. Formyl fluoride-HC(O)F
- III. Carbonyl fluoride-C(O)F2
- IV. Trifluoroacetyl fluoride-CF3-C(O)F
- V. CO₂-Eq. emissions for virgin refrigerant (g)
- VI. CO₂-Eq. emissions for recycled refrigerant (g)
- VII. CO₂-Eq. fugitive emissions of gases from manufacture (g)
- VIII. CO₂-Eq. due to refrigerant leakage during transport (g)
- IX. CO₂-Eq. due to fuel consumption during transport (g)
- X. Refrigerant Recycling During Servicing (Y/N)
- XI. J2727 Leakage rate (g/y)

	Sys1	Sys2	Sys3
Refrigerant	R134a	R1234vf	User-Defined
GWP	1430	4	10
Formvl fluoride - HC(O)F	0.065	0.065	0.065
Carbonyl fluoride - C(0)F2	0.0325	0.0325	0.035
Trifluoroacetyl fluoride -CF3-C(O)F	0.13	1	3
Total GWP due to ADP	1.5925	3.3325	7.335
CO2-Eq. emissions for virgin refrigerant	8	8	8
CO2-Eq. emissions for recycled refrigerant	2.1	2.1	10
CO2-Eq. fugitive emissions of gases from manufacture	0	0	0
CO2-Eq. due to refrigerant leakage during transport	0.429	0.429	0.05
CO2-Eq. due to fuel consumption during transport	0	0	2
Atmospheric Reaction Byproducts	1.59	3.33	7.34
Refrigerant Recycling During Servicing	Yes 🗸	Yes 🗸 🗸	Yes v
J2727 Leakage Rate [g/y]	10	10	20

Figure 10. Providing data for a user-defined refrigerant

3. Parameter Selection

The Parameter Selection screen allows the user to select cities for evaluation, select the vehicle details, and modify the default vehicle servicing leakage rates. The city selection determines the weather bin data used to estimate the vehicle emissions. Cities from all around the world are available for comparison. The cities are categorized based on their region.

All vehicle data is pre-loaded, but the user can make modifications.

Data to be entered on this screen:

- I. City Selection
- II. Vehicle type
 - i. Large
 - ii. Mid-Size
 - iii. Small
 - iv. Truck
 - v. Dual-AC
- III. Pulley ratio
- IV. Incremental Engine Efficiency (%)
- V. Fuel type
 - i. Diesel
 - ii. Gasoline
 - iii. Ethanol
 - iv. Methanol
- VI. Transmission type
 - i. 6 speed auto
- VII. Leakage rates
 - i. Estimated loss before service is required (g)
 - ii. Leaks from professional service (g/service)
 - iii. Leaks from DIY service (g/service)
 - iv. %DIY service

The user has the option to choose the type of vehicle type for each system. Each system uses the same refrigerant and the same vehicle in all selected cities to generate results.

Note: The leakage rates vary by region.

The procedure to complete this input screen is as follows:

1. Select the region that needs to be compared from the drop-down menu and select the country and city as shown in *Figure 11*. To add the cities to the simulation, select all the cities needed and click *"Add Selected Cities"*.

🥶 Parameter Selection		_		×
Fuel Data				
City Selection				
Region North and Central A V Selected Cities				
Country Europe North and Central Amer				
City South America Southwest Pacific				
Remove				
Add Selected Cities Remove All				
	Back	N	lext	

Figure 11. Choosing cities for comparison

- 2. After selecting all cities in Step 1 and as shown in *Figure 11*, the screen will update to show more input boxes to choose the type of vehicle and fuel for each system from drop-down menus. A representation of the completed screen can be seen in *Figure 12*.
- 3. Adjust all parameters for the vehicle type and leakage rates for all systems in use and press *"Next"* to advance to the next screen.

Parameter Se	election				- 🗆 🗙
Fuel Data					
City Selectio	n		System Inputs		
Region	Asia ~	Selected Cities	Sys1 Sys2		
Country City	Japan ✓ All Kagoshima Nagoya Sapporo Tokyo Add Selected Cities	Bangalore Jaipur Kolkata Mumbai New.Delhi Birmingham Kagoshima Nagoya Sapporo Tokyo Wake	Vehicle Vehicle Type Put Large 1.6 Mid-size Small Truck Dual-AC 6 Leakage Rates by Region Region Estimated Loss Befor Service Is Required (g Leaks from Profession Loss (g/service) Leaks from DIY Servic Loss (g/service) % DIY service	Increm Engine Efficier Markensission apd autc v North and Cent e)) nal Service 2 2	ral America > 50
				Back	Next

Figure 12. Choosing type of vehicle and assigning parameters

Similarly, some cities can be removed by selecting the cities that were added and clicking on *"Remove"*. If the user desires to restart the selection of cities, the user can select the *"Remove All"* option. The *"Remove All"* option gives an output such as that obtained in *Figure 13*.

The system and vehicle inputs are not cleared, but cities need to be selected again and vehicle parameters can be assigned again as can be seen in *Figure 13*.

	- 🗆 🗙
Fuel Data	
City Selection	System Inputs
Region Selected Cities Country City	Sys1 Sys2 Vehicle Vehicle Type Pulley Ratio Efficiency (%) Large Vehicle Type 1.6 40 Fuel Transmission
Add Selected Cities	Gasoline 6 spd autc Leakage Rates by Region Region North and Central America
	Estimated Loss Before 50 Service Is Required (g) Leaks from Professional Service 25 Loss (g/service)
	Leaks from DIY Service 30 Loss (g/service)
	% DIY service 20
	Back Next

Figure 13. Removing all selected cities

4. Vehicle Usage Parameters

The Vehicle Usage Parameters screen allows the user to modify the assumed vehicle population and vehicle usage details of each selected city. Each city has pre-loaded default values. The values are applied for all systems. *Figure 14* shows the input screen.

Input data:

- I. Driving distance (km/year)
- II. Driving time (s/year)
- III. Vehicle Lifetime (years)
- IV. % manual air conditioners
- V. % automatic air conditioners
- VI. Amount of time the AC stays on based on the ambient temperature (°C)

🖳 Vehicle Usage Parameter	s		_		×
Vehicle Usage Parame	eters				
City		Phoenix		~	
Driving Distance	e (km/yr)	20050			
Driving Time (se	ec/yr)	1537200			
Vehicle Lifetime	(years)	9			
% Manual		65			
% Automatic		35			
	Ambient (°	C) % AC On			
Manual	1-10	37			
	11-20	48			
	21-30	100			
	31-40	100			
	>40	100			
Automatic	1-10	100			
	11-20	100			
	21-30	100			
	31-40	100			
	>40	100			
		Back	N	lext	

Figure 14. Setting vehicle usage parameters

5. <u>Component Mass Input</u>

The Component Mass Input screen allows the user to load and modify the total mass and distribution of the components and materials of the MAC system. All formulas are hard coded. All components are set to be made of standard materials; the total percentage of materials for each component must add to 100%. User-input is allowed, but a standard dataset is available which can be loaded manually. Every system can have unique mass-component values.

Input data (in kg):

- I. Refrigerant Charge
- II. Lubricant
- III. Piping/Hoses
- IV. Sensors
- V. Condenser
- VI. Receiver/Accumulator
- VII. Evaporator
- VIII. Expansion Device
 - IX. Chillers
 - X. Water Plumbing

The standard dataset can be loaded by following the steps below:

1. Click on the *"Load Data"* button on the screen to open the folder in which the component data is stored as shown in *Figure 15*.

Component Mass Input						×
Sys1 Sys2						
A/C Component CO2-Equivalent Emissions	Refrigerant					
 Refrigerant 		Mass (kg)	% of mass	Energy (MJ)	CO2-Eq (kg)	
 Lubricant 	Original Refrigerant Charge	0			0	
O Compressor						
O Piping/Hoses						
Sensors						
 Condenser 						
 Receiver/Accumulator 						
 Evaporator 						
Expansion Device						
O Fasteners						
O Chillers						
O water Plumbing						
		Loa	d Data	Back	Next	

Figure 15. Loading the pre-defined data

2. Select the file, "Component Mass Data" and click "Open" as shown in Figure 16. The data will be filled in all sections automatically and the process is completed when the screen shows "Input loading complete" at the bottom. A representation is shown in Figure 17.

Name	Date modified	Туре	Size
😰 Component Mass Data	6/4/2019 10:04 AM	Microsoft	38 KB
File name: Component Mass Data		ExcelDoct	ument(.xlsx) ~
		Oper	Cancel

Figure 16. Selecting standard dataset for component mass values

🛃 Component Mass Input					- 0	×
Svs1 Svs2						
A/C Component CO2-Equivalent Emissions	Refrigerant					
Refrigerant Lubricant Compressor Piping/Hoses Sensors Condenser Receiver/Accumulator Evaporator Expansion Device Fasteners Chillers Water Plumbing	Original Refrigerant Charge	Mass (kg) 0.6	% of mass	Energy (MJ)	CO2-Eq (kg)	
		Input loa	ding complete ad Data	Back	Next	

Figure 17. Assigning component mass values

6. Fan Power Input

The Fan Power Input screen allows the user to modify assumptions for the power consumption of the cooling fan at a range of ambient temperatures and vehicle speeds. All systems come with pre-loaded default values but can be modified as required. Each system can have its own values.

Input data is specified for the following Ambient Temperatures:

- I. 15°C
- II. 25°C
- III. 35°C
- IV. 45°C

🖳 Fan Power Input \times Sys1 Sys2 Ambient / Vehicle Speed Inputs Ambient Vehicle Speed Fan Power (W) 15°C <10km/h 100 10-50km/h 100 50-100km/h 0 >100km/h 0 25°C <10km/h 150 10-50km/h 150 50-100km/h 0 >100km/h 0 35°C <10km/h 150 10-50km/h 150 50-100km/h 50 >100km/h 50 45°C <10km/h 150 10-50km/h 150 50-100km/h 50 >100km/h 50 Back Next

Figure 18 shows the default values available for each ambient temperature.

Figure 18. Assigning power values for the fan based on ambient temperature

7. AC System Mechanism

The A/C System Question screen allows the user to specify whether the MAC system is belt-driven or electrically driven. This determines what inputs are required for the Capacity and Power Input screen.

Specify if the system will be:

- I. Belt-driven
- II. Electrically-driven

The same driving mechanism is used for all systems. *Figure 19* shows the available options.

💀 A/C	System Question		_		×
I	How is the A/C system	n driven?			
	Belt-driven		Electrically-d	riven	

Figure 19. Choosing a mechanism

8. <u>Capacity / Power Input</u>

The Capacity and Power Input screen asks the user to enter cooling capacity and power consumption of the MAC system of a range of ambient conditions and compressor RPMs / vehicle speeds. All input values are in kW. The data is entered based on the ambient temperature and percentage of relative humidity.

The belt-driven mechanism uses compressor speed for calculations and the electrically-driven mechanism uses vehicle speed. All speeds are to be measured at the following conditions:

Compressor speeds required for belt-driven mechanisms:

- I. 900 RPM [+15K]
- II. 900 RPM
- III. 1800 RPM
- IV. 2500 RPM
- V. 4000 RPM

Vehicle speeds required for belt-driven mechanisms:

- I. 10 km/hr [+15K]
- II. 10 km/hr
- III. 30 km/hr
- IV. 60 km/hr
- V. 100 km/hr

All data is calculated on the following temperature parameters:

- I. 15°C x 80% RH [10°C control]
- II. 15°C x 80% RH [3°C control]
- III. 25°C x 80% RH [10°C control]
- IV. 25°C x 80% RH [3°C control]
- V. 25°C x 50% RH [10°C control]
- VI. 25°C x 50% RH [3°C control]
- VII. 35°C
- VIII. 45°C

Figures 20 and 21 give a representation of capacity input screens for the belt-driven and the electrically-driven mechanisms, and *Figures 22 and 23* give a representation of power input screens for the belt-driven and the electrically-driven mechanisms and highlight all the speeds and temperature parameters mentioned above.

Default data is available and can be loaded from a file. Belt-driven and the electrically-driven systems have different files and different values associated with them. User input and modification is allowed, but the user needs to input values that correspond to the speeds and temperature conditions mentioned above.

The default data can be loaded by following the steps below:

1. Click on *"Load Data"* on the screen to open the folder in which the capacity/power data is stored. *Figures 20 and 21* show the capacity input screens for the belt-driven and the electrically-driven mechanisms respectively. *Figures 22 and 23* show the power input screens for the belt-driven and the electrically-driven mechanisms respectively.

						Load condit	on from J2765						
s1 Sys2													
pacity Power													
Ambient	Component	900 RPM [+15K]	900 RPM	1800 RPM	2500 RPM	4000 RPM	Ambient	Component	900 RPM [+15K]	900 RPM	1800 RPM	2500 RPM	4000 RPM
15°C x 80% RH	Evaporator #1	0	0	0	0	0	25°C x 50% RH	Evaporator #1	0	0	0	0	0
[10°C control]	Evaporator #2	0	0	0	0	0	[10°C control]	Evaporator #2	0	0	0	0	0
	Chiller #1	0	0	0	0	0		Chiller #1	0	0	0	0	0
	Chiller #2	0	0	0	0	0		Chiller #2	0	0	0	0	0
15°C x 80% RH	Evaporator #1	0	0	0	0	0	25°C x 50% RH	Evaporator #1	0	0	0	0	0
[3*C control]	Evaporator #2	0	0	0	0	0	[3*C control]	Evaporator #2	0	0	0	0	0
	Chiller #1	0	0	0	0	0		Chiller #1	0	0	0	0	0
	Chiller #2	0	0	0	0	0		Chiller #2	0	0	0	0	0
25°C x 80% RH	Evaporator #1	0	0	0	0	0	35°C	Evaporator #1	0	0	0	0	0
[10°C control]	Evaporator #2	0	0	0	0	0		Evaporator #2	0	0	0	0	0
	Chiller #1	0	0	0	0	0		Chiller #1	0	0	0	0	0
	Chiller #2	0	0	0	0	0		Chiller #2	0	0	0	0	0
25°C x 80% RH	Evaporator #1	0	0	0	0	0	45°C	Evaporator #1	0	0	0	0	0
[3*C control]	Evaporator #2	0	0	0	0	0		Evaporator #2	0	0	0	0	0
	Chiller #1	0	0	0	0	0		Chiller #1	0	0	0	0	0
	Chiller #2	0	0	0	0	0		Chiller #2	0	0	0	0	0

Figure 20. Capacity input screen for Belt-Driven mechanism

						Load condit	ion from J2765						
s1 Sys2													
pacity Power													
								_					
mbient	Component	10 km/hr [+15K]	10 km/hr	30 km/hr	60 km/hr	100 km/hr	Ambient	Component	10 km/hr [+15K]	10 km/hr	30 km/hr	60 km/hr	100 km/hr
5°C x 80% RH	Evaporator #1	0	0	0	0	0	25°C x 50% RH	Evaporator #1	0	0	0	0	0
[lortros] 0*0	Evaporator #2	0	0	0	0	0	[10°C control]	Evaporator #2	0	0	0	0	0
	Chiller #1	0	0	0	0	0		Chiller ≢1	0	0	0	0	0
	Chiller #2	0	0	0	0	0		Chiller #2	0	0	0	0	0
15°C x 80% RH	Evaporator #1	0	0	0	0	0	25°C x 50% RH	Evaporator #1	0	0	0	0	0
3°C control]	Evaporator #2	0	0	0	0	0	[3*C control]	Evaporator #2	0	0	0	0	0
	Chiller #1	0	0	0	0	0		Chiller #1	0	0	0	0	0
	Chiller #2	0	0	0	0	0		Chiller #2	0	0	0	0	0
25°C x 80% RH	Evaporator #1	0	0	0	0	0	35°C	Evaporator #1	0	0	0	0	0
10°C control]	Evaporator #2	0	0	0	0	0		Evaporator #2	0	0	0	0	0
	Chiller #1	0	0	0	0	0		Chiller #1	0	0	0	0	0
	Chiller #2	0	0	0	0	0		Chiller #2	0	0	0	0	0
25°C x 80% RH	Evaporator #1	0	0	0	0	0	45°C	Evaporator #1	0	0	0	0	0
3°C control]	Evaporator #2	0	0	0	0	0		Evaporator #2	0	0	0	0	0
	Chiller #1	0	0	0	0	0		Chiller #1	0	0	0	0	0
	Chiller #2	0	0	0	0	0		Chiller #2	0	0	0	0	0



4000 RPI 0 0
0 0
0 0
0 0
4000 RP1 0 0
4000 RPI 0 0
0
0
0
0
0
0
0
0
0
0
0
0



10 km/hr [+15K]	10 km/hr	30 km/hr		Load condit	ion from J2765						
10 km/hr [+15K]	10 km/hr	30 km/hr									
10 km/hr [+15K]	10 km/hr	30 km/br									
10 km/hr [+15K]	10 km/hr	30 km/hr									
10 km/hr [+15K]	10 km/hr	30 km/hr									
10 km/hr [+15K]	10 km/hr	30 km/hr									
0		Se istere	60 km/hr	100 km/hr	Ambient	Component	10 km/hr [+15K]	10 km/hr	30 km/hr	60 km/hr	100 km/hr
0	0	0	0	0	25°C x 50% RH	Compressor	0	0	0	0	0
0	0	0	0	0	[10°C control]	Coolant Pump	0	0	0	0	0
0	0	0	0	0		Electrical Heater	0	0	0	0	0
0	0	0	0	0	25°C x 50% RH	Compressor	0	0	0	0	0
0	0	0	0	0	[3*C control]	Coolant Pump	0	0	0	0	0
0	0	0	0	0		Electrical Heater	0	0	0	0	0
0	0	0	0	0	35*C	Compressor	0	0	0	0	0
0	0	0	0	0		Coolant Pump	0	0	0	0	0
0	0	0	0	0		Electrical Heater	0	0	0	0	0
0	0	0	0	0	45°C	Compressor	0	0	0	0	0
0	0	0	0	0		Coolant Pump	0	0	0	0	0
0	0	0	0	0		Electrical Heater	0	0	0	0	0
	0 0 0 0 0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0 0 0 0 0 0 10°C control] 0 0 0 0 0 25°C x50% RH 25°C x50% RH 0 0 0 0 0 25°C x50% RH 35°C 0 0 0 0 0 35°C 35°C 0 0 0 0 0 0 35°C	0 0 0 0 0 [10°C control] Coolant Pump 0 0 0 0 0 25°C x 50% RH Compressor 0 0 0 0 0 18°C control] Coolant Pump 0 0 0 0 0 18°C control] Coolant Pump 0 0 0 0 0 18°C control] Coolant Pump 0 0 0 0 0 25°C x 50% RH Compressor 0 0 0 0 0 18°C control] Electrical Heater 0 0 0 0 0 25°C Compressor Coolant Pump 0 0 0 0 0 Coolant Pump 0 0 0 0 0 Coolant Pump 0 0 0 0 Coolant Pump Electrical Heater 0 0 0 0 0 Coolant Pump Electrical Heater	0 0 0 0 0 0 0 10°C controll Coolant Pump 0 0 0 0 0 0 0 Electrical Heater 0 0 0 0 0 0 25°C x 50% RH Compressor 0 0 0 0 0 0 13°C controll Colant Pump 0 0 0 0 0 0 13°C Controll Colant Pump 0 0 0 0 0 0 3°C Compressor 0 0 0 0 0 0 Colant Pump 0 0 0 0 0 0 Colant Pump 0 0 0 0 0 0 Electrical Heater 0 0 0 0 0 0 Colant Pump 0 0 0 0 0 0 Colant Pump 0 0 0 0	0 0 0 0 0 [10°C control] Coolant Pump 0 0 0 <td>0 0</td> <td>0 0</td>	0 0	0 0

Figure 23. Power input screen for an Electrically-Driven mechanism

2. Select the file, "Belt Driven-Capacity and Power Data" for the belt-driven mechanism or the "Electrically Driven-Capacity and Power Data" for the electrically-driven mechanism and click "Open" to load the data as shown in Figure 24.

Note: The program opens the "*Capacity Data*" sub-folder in the "*My LCCP Project*" main folder by default. User will have to navigate to their desired file/folder.

Name	Date modified	Туре	Size
😰 Belt Driven-Capacity and Power Data	6/4/2019 10:04 AM	Microsoft Excel W	41 KB
Electrically Driven-Capacity and Power D	6/4/2019 10:04 AM	Microsoft Excel W	41 KB
Eile name:		Even De ev	mant(slav)
			iment(.xisx) ~
		Oper	Cancel

Figure 24. Selecting data for type of AC mechanism

Figure 25 and *Figure 26* show capacity data samples for belt-driven and electrically-driven mechanisms respectively and *Figure 27* and *Figure 28* show power data samples for the belt driven and electrically-driven mechanisms respectively.

						Load condit	ion from J2765						
1 Sys2													
acity Power													
Ambient	Component	900 RPM [+15K]	900 RPM	1800 RPM	2500 RPM	4000 RPM	Ambient	Component	900 RPM [+15K]	900 RPM	1800 RPM	2500 RPM	4000 RP
15°C x 80% RH	Evaporator #1	0.7808	0.7808	0.9923	1.085	1.112	25°C x 50% RH	Evaporator #1	2.183	2.177	2.246	2.312	2.362
10°C control]	Evaporator #2	0	0	0	0	0	[10°C control]	Evaporator #2	0	0	0	0	0
	Chiller #1	0	0	0	0	0		Chiller #1	0	0	0	0	0
	Chiller #2	0	0	0	0	0		Chiller #2	0	0	0	0	0
15°C x 80% RH	Evaporator #1	1.96	1.997	2.224	2.347	2.3	25°C x 50% RH	Evaporator #1	2.833	3.135	3.535	3.654	3.385
3°C control]	Evaporator #2	0	0	0	0	0	[3°C control]	Evaporator #2	0	0	0	0	0
	Chiller #1	0	0	0	0	0		Chiller #1	0	0	0	0	0
	Chiller #2	0	0	0	0	0		Chiller #2	0	0	0	0	0
25°C x 80% RH	Evaporator #1	3.3	3.735	3.846	3.697	3.748	35°C	Evaporator #1	3.439	3.937	5.366	5.914	6.313
10°C control]	Evaporator #2	0	0	0	0	0		Evaporator #2	0	0	0	0	0
	Chiller #1	0	0	0	0	0		Chiller #1	0	0	0	0	0
	Chiller #2	0	0	0	0	0		Chiller #2	0	0	0	0	0
25°C x 80% RH	Evaporator #1	3.3	3.735	4.845	4.898	4.795	45°C	Evaporator #1	2.7512	3.1496	4.2928	4.7312	5.0504
3°C control]	Evaporator #2	0	0	0	0	0		Evaporator #2	0	0	0	0	0
	Chiller #1	0	0	0	0	0		Chiller #1	0	0	0	0	0
	Chiller #2	0	0	0	0	0		Chiller #2	0	0	0	0	0

Figure 25. Capacity data for a belt-driven AC system

art													-
							ion from 12765						
e1						Load condit	1011 11011 32/65						
51													
and the last													
pacity Power													
Imbient	Component	10 km/hr	10 km/br	20 km/br	60 km/br	100 km/br	Ambient	Component	10 km/hr	10 km/br	20 km/br	60 km/br	100 km/br
Ambrent	Component	[+15K]	TO KIN/III	30 100	OV KITI/TI		Ambient	Component	[+15K]	IV KIIVIII	30 100	OO KIIWIII	TOO KIIMII
15°C x 80% RH	Evaporator #1	0.7808	0.7808	0.9923	1.085	1.112	25°C x 50% RH	Evaporator #1	2.183	2.177	2.246	2.312	2.362
10°C control]	Evaporator #2	0	0	0	0	0	[10°C control]	Evaporator #2	0	0	0	0	0
	Chiller #1	0	0	0	0	0		Chiller #1	0	0	0	0	0
	Chiller #2	0	0	0	0	0		Chiller #2	0	0	0	0	0
15°C x 80% RH	Evaporator #1	1.96	1.997	2.224	2.347	2.3	25°C x 50% RH	Evaporator #1	2.833	3.135	3.535	3.654	3.385
3°C control]	Evaporator #2	0	0	0	0	0	[3°C control]	Evaporator #2	0	0	0	0	0
	Chiller #1	0	0	0	0	0		Chiller #1	0	0	0	0	0
	Chiller #2	0	0	0	0	0		Chiller #2	0	0	0	0	0
25°C x 80% RH	Evaporator #1	3.3	3.735	3.846	3.697	3.748	35°C	Evaporator #1	3.439	3.937	5.366	5.914	6.313
10°C control]	Evaporator #2	0	0	0	0	0		Evaporator #2	0	0	0	0	0
	Chiller #1	0	0	0	0	0		Chiller #1	0	0	0	0	0
	Chiller #2	0	0	0	0	0		Chiller #2	0	0	0	0	0
25°C x 80% RH	Evaporator #1	3.3	3.735	4.845	4.898	4.795	45°C	Evaporator #1	2.7512	3.1496	4.2928	4.7312	5.0504
3°C control]	Evaporator #2	0	0	0	0	0		Evaporator #2	0	0	0	0	0
	Chiller #1	0	0	0	0	0		Chiller #1	0	0	0	0	0
	Chiller #2	0	0	0	0	0		Chiller #2	0	0	0	0	0

Figure 26. Capacity data for an electrically-driven AC system

Sys2	Ambient Component 900 RPM [+15K] 900 RPM 1800 RPM 2500 RPM 2500 RPM 4000 RPM 4000 RPM 2500 RPM 400 RPM 2500 RPM 25'C x 50% RH 000 RPM 25'C x 50% RH 900 RPM 25'C x 50% RH 200 RPM 25'C x 50% RH 900 RPM 25'C x 50% RH 900 RPM 25'C x 50% RH 200 RPM 25'C 200 RPH 25'C x 80% RH 200 RPM 20 1500 RPM 25'C 200 RPH 25'C x 80% RH 200 RPM 20 200 RPM 20 200 RPM 20 200 RPM 25'C 200 RPH 25'C x 80% RH 200 RPM 20 200 RPM 20 200 RPM 20 200 RPM 25'C 200 RPH 25'C 200 RPH 20'C 200 RPH 200 RPH 200 RPM 20'C 200 RPH 20'C 20'C 200 RPH 20'C 20'C 20'	Load condition from J2765													
Sys2 Actr Component (+15K) 900 RPM (+15K) 900 RPM (400 RPM (-15K) 900 RPM (400 RPM (-15K) 900 RPM (400 RPM (-15K) 900 RP	I Sys2 mblent Component 900 RPM [+15K] 900 RPM 1800 RPM 2500 RPM 4000 RPM Component 900 RPM [+15K] 900 RPM 1800 RPM 2500 RPM 4000 RPM 2500 RPM 000 RPM 900 RPM 1800 RPM 2500 RPM 4000 RPM 250 C x 50% RH Component 900 RPM 1800 RPM 2500 RPM 250 C x 50% RH Component 900 RPM 1800 RPM 2500 RPM 250 C x 50% RH Component 900 RPM 1800 RPM 2500 RPM 250 C x 50% RH Compressor 0.537145240 0.555656513 0.716 10°C control Coolant Pump 0 <						L	oad conditio	on from J2765						
Libert Component 900 RPM [+15K] 900 RPM 1800 RPM 2500 RPM 4000 RPM Comonant Component 900 RPM 1800 RPM 2500 RPM 4000 RPM C's 80% RH Component 0.146904985 0.111542857 0.193581740 0.265410956 0.393767705 0.26501466786 0.37312242 0.565886513 0.710111468 1.0290425 C's 80% RH Compressor 0.146904985 0.111542857 0.599040970 0.661126760 0.989767705 0.26501466786 0.37312424 0.565886513 0.710111468 1.0290425 C's 80% RH Compressor 0.514841082 0.509040970 0.661126760 0.94002654 10° 0<	pacity Power Nublent Component 900 RPM (r15K) 900 RPM 1800 RPM 2500 RPM 4000 RPM 2500 RPM 000 RPM 900 RPM 1800 RPM 2500 RPM 10°C control Coolant Pump 0 0 0 0 25°C x 50% RH Component 900 RPM 1800 RPM 2500 RPM 10°C control Coolant Pump 0 0 0 0 25°C x 50% RH Compressor 0.51486178 0.374312242 0.565895613 0.716 10°C control Coolant Pump 0 0 0 0 0 25°C x 50% RH Compressor 0.97339731 0.661124542 1.510904891 1.300 3°C control Coolant Pump 0	ys2													
Next Component 900 RPM [+15K] 900 RPM 1800 RPM 2500 RPM 4000 RPM *Cx 80% RH Compressor 0.1469049856 0.111542857 0.193581740 0.265410958 0.393767705 0.556146676 0.374312242 0.555885613 0.7160111486 1.0296425 1.0200 RPM 1800 RPM 2500 RPM 4000 RPM *Cx 80% RH Compressor 0.1469049856 0.111542857 0.193581740 0.265410958 0.393767705 0.556146676 0.374312242 0.555885613 0.7160111486 1.0296425 1.0200 RPM 25°C x 50% RH Compressor 0.5514841082 0.30464627 0.509040970 0.6611267600 0.948062564 10°C controll Coolant Pump 0	Power Ambient Component 900 RPM (+15K) 900 RPM 1800 RPM 2500 RPM 4000 RPM 2500 RPM														
blent Component 900 RPM [+15K] 900 RPM 900 RPM 1800 RPM 2500 RPM 900 RPM 4000 RPM [+15K] 900 RPM [+15K] 900 RPM 900 RPM 1800 RPM 2500 RPM 4000 RPM 'C x 80% RH Compressor 0.146904985 0.111542877 0.193581740 0.2654109586 0.393767705 25'C x 50% RH Compressor 0.666146678 0.374312242 0.565885613 0.7160111486 1.0296425 ''C x 60% RH Compressor 0.51481082 0.30846427 0.509040970 0.661126760 0.948062654 25'C x 50% RH Compressor 0.22739731 0.6611434542 1.15109084 1.38403067 1.846866 C control Colant Pump 0	Imberi Component 900 RPM 1800 RPM 2500 RPM 4000 RPM Component 900 RPM 900 RPM 1800 RPM 2500 RPM 15'C X 80% RH Compressor 0.145904985 0.111542857 0.193581740 0.265419958 0.393767705 0.556146678 0.374312242 0.556885613 0.716 10''C control] Coolant Pump 0	Power													
bleff Component 900 RPM [+15K]	Number Component 900 RPM [+15]														
**Cx 80% RH Compressor 0.146904985 (0.111542857 0.193581740 0.265410958 0.393767705 25°C x 50% RH Compressor 0.656146678 (0.374312242 (0.565885613 0.716011148 1.0296425 1.0294252 **C control Coolant Pump 0	5*C x 80% RH Compressor 0.146904986 0.111542857 0.193581740 0.265410958 0.393767705 0	nt C	Component	900 RPM [+15K]	900 RPM	1800 RPM	2500 RPM	4000 RPM	Ambient	Component	900 RPM [+15K]	900 RPM	1800 RPM	2500 RPM	4000 RPM
*** Controll Coolant Pump 0 <td>Concentroling Condant Pump 0<td>80% RH C</td><td>Compressor</td><td>0.1469049858</td><td>0.1115428571</td><td>0.193581740</td><td>0.265410958</td><td>0.393767705</td><td>25°C x 50% RH</td><td>Compressor</td><td>0.6561466786</td><td>0.3743122420</td><td>0.565885613</td><td>0.7160111489</td><td>1.02964254</td></td>	Concentroling Condant Pump 0 <td>80% RH C</td> <td>Compressor</td> <td>0.1469049858</td> <td>0.1115428571</td> <td>0.193581740</td> <td>0.265410958</td> <td>0.393767705</td> <td>25°C x 50% RH</td> <td>Compressor</td> <td>0.6561466786</td> <td>0.3743122420</td> <td>0.565885613</td> <td>0.7160111489</td> <td>1.02964254</td>	80% RH C	Compressor	0.1469049858	0.1115428571	0.193581740	0.265410958	0.393767705	25°C x 50% RH	Compressor	0.6561466786	0.3743122420	0.565885613	0.7160111489	1.02964254
Electrical Heater 0	Electrical Heater 0	control] C	Coolant Pump	0	0	0	0	0	[10°C control]	Coolant Pump	0	0	0	0	0
Cx 80% RH Compressor 0.514841082/0.308464627 0.509040970 0.6611267605 0.94062654 2 ⁵ C x 50% RH Compressor 0.27393731 0.6611136542 1.15090891 1.380430672 1.8468666 C control Colant Pump 0 <td>5*C x 80% RH Compressor 0.514841082/ 0.308464627/ 0.509040970 0.6611267605 0.9480626540 25*C x 50% RH Compressor 0.927939731 0.6611134542 1.151090849[1.380 *C control] Coolant Pump 0</td> <td>E</td> <td>Electrical Heater</td> <td>0</td> <td>0</td> <td>0</td> <td>0</td> <td>0</td> <td></td> <td>Electrical Heater</td> <td>0</td> <td>0</td> <td>0</td> <td>0</td> <td>0</td>	5*C x 80% RH Compressor 0.514841082/ 0.308464627/ 0.509040970 0.6611267605 0.9480626540 25*C x 50% RH Compressor 0.927939731 0.6611134542 1.151090849[1.380 *C control] Coolant Pump 0	E	Electrical Heater	0	0	0	0	0		Electrical Heater	0	0	0	0	0
C control Condart Pump 0	**Controll Coolant Pump 0	80% RH C	Compressor	0.5148410822	0.308464627	0.5090409704	0.6611267605	0.9480626545	25°C x 50% RH	Compressor	0.9279397314	0.6611134542	1.1510908498	1.3804306762	1.84468664
Electrical Heater 0	Electrical Heater 0	ontrol] C	Coolant Pump	0	0	0	0	0	[3°C control]	Coolant Pump	0	0	0	0	0
*Cx 80% RH Compressor 0.973164258 0.690771222 1.056303213 1.1456461105 1.590156979 35°C Compressor 1.251000363 0.912398009 1.973519675 2.5017310 3.8307038 *C control Coolant Pump 0	***C x80% RH Compressor 9.973164258 0.690771222 1.056303213 1.1456461105 1.590156875 35°C Compressor 1.251000363 0.912396009 1.973519675 2.560 0	E	Electrical Heater	0	0	0	0	0		Electrical Heater	0	0	0	0	0
*** Controli Coolant Pump 0 <td>O°C Controll Coolant Pump 0</td> <td>80% RH C</td> <td>Compressor</td> <td>0.9731642583</td> <td>0.6907712224</td> <td>1.0563032134</td> <td>1.1456461109</td> <td>1.5901569792</td> <td>35°C</td> <td>Compressor</td> <td>1.251000363</td> <td>0.9123986095</td> <td>1.9735196763</td> <td>2.560173160</td> <td>3.8307038</td>	O°C Controll Coolant Pump 0	80% RH C	Compressor	0.9731642583	0.6907712224	1.0563032134	1.1456461109	1.5901569792	35°C	Compressor	1.251000363	0.9123986095	1.9735196763	2.560173160	3.8307038
Electrical Heater 0	Electrical Heater 0	control] C	Coolant Pump	0	0	0	0	0		Coolant Pump	0	0	0	0	0
*C x 80% RH Compressor 0.973164258 0.690771222 1.516431924 1.976594027 2.5013041210 Compressor 1.00800291 0.7299188874 1.578815741 2.404138528 3.0645631 C control Coolant Pump 0	*Cx 80% RH Compressor 0.973164258 0.690771222 1.516431924 1.976594027 2.5013041210 45°C Compressor 1.000800291 0.729918887 1.578815741 2.048 C control Coolant Pump 0	E	Electrical Heater	0	0	0	0	0		Electrical Heater	0	0	0	0	0
C control] Coolant Pump 0	**C control] Coolant Pump 0	80% RH C	Compressor	0.9731642583	0.6907712224	1.5164319248	1.9765940274	2.5013041210	45°C	Compressor	1.0008002910	0.7299188876	1.5788157410	2.048138528	3.06456310
Electrical Heater 0 0 0 0 0 0 Electrical Heater 0 0 0 0 0	Electrical Heater 0 0 0 0 0 Electrical Heater 0 0 0 0	ontrol] C	Coolant Pump	0	0	0	0	0		Coolant Pump	0	0	0	0	0
		E	Electrical Heater	0	0	0	0	0		Electrical Heater	0	0	0	0	0
		E	Electrical Heater	0	0	0	0	0		Electrical Heater	0	0	0	0	0

Figure 27. Power data for a belt-driven AC system

hart												_		×
					L	oad conditio	on from J2765							
ys1 Sys2														
apacity Power														
Ambient	Component	10 km/hr [+15K]	10 km/hr	30 km/hr	60 km/hr	100 km/hr	Ambient	Component	10 km/hr [+15K]	10 km/hr	30 km/hr	60 km/hr	100 km/hr	
15°C x 80% RH	Compressor	0.1469049858	0.1115428571	0.193581740	0.2654109589	0.393767705:	25°C x 50% RH	Compressor	0.656146678	0.374312242	0.565885613	0.7160111489	1.0296425	151
[10°C control]	Coolant Pump	0	0	0	0	0	[10°C control]	Coolant Pump	0	0	0	0	0	
	Electrical Heater	0	0	0	0	0		Electrical Heater	0	0	0	0	0	
15°C x 80% RH	15°C x 80% RH Compressor 0.514841082 (0.308464627) 0.509040970 (0.6611267605 0.9480626545 [25°C x 50% RH Compressor 0.927939731 (0.6611134542 1.151090849 (1.380430676 1.84461												1.8446866	185
[3°C control] Coolant Pump 0 0 0 0 0 0 [3°C control] Coolant Pump 0 0 0 0												0	0	
	Electrical Heater	0	0	0	0	0		Electrical Heater	0	0	0	0	0	
25°C x 80% RH	Compressor	0.9731642583	0.6907712224	1.0563032134	1.1456461109	1.5901569792	35°C	Compressor	1.251000363	0.912398609	1.973519676	2.560173160	3.8307038	134
[10°C control]	Coolant Pump	0	0	0	0	0		Coolant Pump	0	0	0	0	0	
	Electrical Heater	0	0	0	0	0		Electrical Heater	0	0	0	0	0	
25°C x 80% RH	Compressor	0.9731642583	0.6907712224	1.5164319248	1.9765940274	2.5013041210	45°C	Compressor	1.000800291	0.729918887	1.578815741	2.048138528	3.0645631	161
[3°C control]	Coolant Pump	0	0	0	0	0		Coolant Pump	0	0	0	0	0	
	Electrical Heater	0	0	0	0	0		Electrical Heater	0	0	0	0	0	
									Input lo	bading comple	te.			
									L	oad Data	Back	:	Next	

Figure 28. Power data for an electrically-driven AC system

There is also an option to check if the capacity and power data is being used as intended by selecting the *"Chart"* option at the top left corner of the screen. The drop-down menu has an option of *"Capacity Chart"* or a *"COP Chart"*. An illustration is shown in *Figure 29*. On selecting any one of these options, a graphical representation of the capacity and power parameters is shown.

Representations of the "Capacity Chart" is shown in Figure 30 and for the "COP Chart" is shown in Figure 31.

capacity cha	rt					Load condit	ion from J2765						
COP Chart													
pacity Power													
Imbient	Component	900 RPM [+15K]	900 RPM	1800 RPM	2500 RPM	4000 RPM	Ambient	Component	900 RPM [+15K]	900 RPM	1800 RPM	2500 RPM	4000 RPM
15°C x 80% RH	Evaporator #1	0.7808	0.7808	0.9923	1.085	1.112	25°C x 50% RH	Evaporator #1	2.183	2.177	2.246	2.312	2.362
[iortroo O*01	Evaporator #2	0	0	0	0	0	[10°C control]	Evaporator #2	0	0	0	0	0
	Chiller #1	0	0	0	0	0		Chiller #1	0	0	0	0	0
	Chiller #2	0	0	0	0	0		Chiller #2	0	0	0	0	0
5°C x 80% RH	Evaporator #1	1.96	1.997	2.224	2.347	23	25°C x 50% RH	Evaporator #1	2.833	3.135	3.535	3.654	3.385
C control]	Evaporator #2	0	0	0	0	0	[3*C control]	Evaporator #2	0	0	0	0	0
	Chiller #1	0	0	0	0	0		Chiller #1	0	0	0	0	0
	Chiller #2	0	0	0	0	0		Chiller #2	0	0	0	0	0
5°C x 80% RH	Evaporator #1	3.3	3.735	3.846	3.697	3.748	35°C	Evaporator #1	3.439	3.937	5.366	5.914	6.313
[iortroo O*01	Evaporator #2	0	0	0	0	0		Evaporator #2	0	0	0	0	0
	Chiller #1	0	0	0	0	0		Chiller #1	0	0	0	0	0
	Chiller #2	0	0	0	0	0		Chiller #2	0	0	0	0	0
5°C x 80% RH	Evaporator #1	3.3	3.735	4.845	4.898	4.795	45°C	Evaporator #1	2.7512	3.1496	4.2928	4.7312	5.0504
C control]	Evaporator #2	0	0	0	0	0		Evaporator #2	0	0	0	0	0
	Chiller #1	0	0	0	0	0		Chiller #1	0	0	0	0	0
	Chiller #2	0	0	0	0	0		Chiller #2	0	0	0	0	0

Figure 29. Viewing the Chart option



Figure 30. Representation of the Capacity Chart



Figure 31. Representation of the COP charts

9. Drive Cycle Input and Simulation Output

The Drive Cycle Input screen allows the user to see which drive cycle the software has automatically selected for use based on the selected cities.

The drive cycles available for use are:

- I. FTP
- II. SC03
- III. NEDC
- IV. India
- V. JC08
- VI. AC17

The drive cycles are shown in *Figure 32*.



Figure 32. Selecting drive cycles

The default drive cycle for US cities are FTP and SC03. There is an option to use the AC17 drive cycle for US-based cities. To use this cycle, click on the checkbox as shown in *Figure 33*. Choosing this option automatically unchecks the FTP and SC03 drive cycles. The change in drive cycle

selection can be seen in *Figures 32 and 33*. India, Europe and Japan have their own drive cycles viz. India, NEDC and JC08 respectively. All African, Australian and South American countries are assumed to be using NEDC.



Figure 33. Choosing AC17 drive cycle instead of the standard cycles for USA cities

The user has the option to upload a custom drive cycle. Two different user-defined cycles can be compared.

To choose a user defined option: (Steps are shown for one user-defined data. A repeat of the same steps can be used to fill the second user-defined data)

- 1. Check the *"User-defined 1"* button as seen in the red box in *Figure 34*.
- 2. Click on "Add/Remove Cities" as shown in Figure 34. From the pop-up screen, select the cities that the driving cycle will be used on. After selecting the cities, click "Add Selected Cities" and click "OK" to continue as shown in Figure 35.



Figure 34. Choosing a User-Defined driving cycle

Project Cities		Drive Cycle Cities	
Proenix Houston Boston Chicago	^	Phoenix Houston Boston Chicago	
Fargo WDC Los Angeles		Fargo WDC Los Angeles	
San.Francisco Sacramento San.Diego	~		
Add Selected C	ities	Remove	
17 e		Remove All	

Figure 35. Choosing cities to be included in the driving cycle

3. Select "Load User-Defined Data" to load the speeds (km/h) and Engine RPM data for the user defined cycle as shown in Figure 36. Open the path in which the data is saved, select the data and click "Open" to load it in the program. A representation of the file is shown in Figure 37.

Note: The program opens the "Engine RPM" sub-folder in the "My LCCP Project" main folder by default. User will have to navigate to their desired file/folder.



Figure 36. Loading User-defined data

Name	Date modified	Туре	Size
User-Defined Data	6/4/2019 10:04 AM	Microsoft Excel W	230 KB
File name: User-Defined Data		 ExcelDoct 	ument(.xlsx)
		Oper	n Cancel

Figure 37. Opening the file containing user-defined data

4. Once the loading is complete, the screen will display a message saying *"Drive cycle load complete"* as shown in *Figure 38*. The program inputs are complete, and calculations can now be run by selecting the *"Run Calculations"* button as highlighted below.



Figure 38. Complete drive cycle screen

The user can remove the selected cities in the user-defined section by clicking on "Add/Remove Cities" as shown in Figure 34. From the pop-up screen, select the cities that need to be removed. After selecting the cities, click "Remove All" and click "OK" to continue as shown in Figure 39. The same steps can be followed for removing single cities as well.

Phoenix Houston	^		
Boston Chicago Fargo			
WDC Los Angeles San Francisco Sacramento			
San.Diego	~		
Add Selected (Cities	Rem	ove

Figure 39. Removing cities from user-defined selection

After selecting the appropriate driving cycle, and clicking run calculations, the results are exported in an excel file which opens after the calculations run. A representation of the final screen can be seen in *Figure 40*. Refer to the *Viewing Results* section to learn how to open the output file at a later stage or be clicking <u>here</u>.



Figure 40. Final screen showing successful calculation

Viewing Results

The output file can be loaded at a later stage by following the steps shown below:

1. Open the folder in which the tool is saved and enter the folder "My LCCP Project" as shown in Figure 41.

Name	Date modified	Туре	Size
📙 My LCCP Project	6/10/2019 4:40 PM	File folder	
LCCP2017	6/4/2019 10:04 AM	Application	2,515 KB
System.Net.Http.dll	6/4/2019 10:04 AM	Application extens	177 KB
🗟 ZedGraph.dll	6/4/2019 10:04 AM	Application extens	300 KB



2. Open the folder *"Results"* to access the folder in which all the results are saved as shown in *Figure 42*.

Name	Date modified	Туре	Size
📙 Calculation	6/14/2019 11:00 A	File folder	
📕 Capacity Data	6/14/2019 12:03 PM	File folder	
📕 Component Mass Data	6/14/2019 12:07 PM	File folder	
📙 Engine RPM Data	6/4/2019 10:04 AM	File folder	
Projects	6/14/2019 12:09 PM	File folder	
Results	6/11/2019 3:03 PM	File folder	

Figure 42. Opening the folder containing all results

3. Find and open the excel-file that is desired. *Figure 43* shows a sample file name.

Name	Date modified	Туре	Size	
ICCP_20190604130832_ProjectName1_Results_132300	6/4/2019 1:29 PM	Microsoft Excel W		25 KB
LCCP_20190606140528_ProjectName Test_Results_140611	6/6/2019 2:06 PM	Microsoft Excel W		39 KB

Figure 43. Selecting the desired file

The results sheet consists of six sheets, viz. *Sheet 1, Chart 1, Chart 2, Chart 3, Weighted, Chart 4.* The contents of the sheets are briefly explained below:

I. A summary and comparison of all the systems that were used for evaluation across all cities is available in *Sheet 1*. A sample of the sheet is shown in *Figure 44*.

	А	В	с	D	E	F	G	н	1
1		Cities	Phoenix	Houston	Boston	Chicago	Fargo	WDC	Los.Angele
2	Sys1	Total Lifetime Equivalent Warming Impact (kg CO2)	8714	13340	15110	9092	8527	14930	26120
3		Total Lifetime Direct Contribution (kg CO2)	1307	1291	1143	1145	1015	1147	1158
4		Total Lifetime Indirect Contribution (kg CO2)	7407	12040	13970	7948	7512	13780	24960
5		Total Contribution per Lifetime Driving Distance (g CO2/km)	48.29	75.46	85.37	51.45	47.25	82.72	144.7
6		Total Annual Equivalent Warming Impact (kg CO2/year)	968.2	1482	1679	1010	947.4	1659	2902
7		Total Annual Direct Contribution (kg CO2/year)	145.2	143.5	127	127.2	112.8	127.5	128.7
8		Total Annual Indirect Contribution (kg CO2/year)	823	1338	1552	883.1	834.6	1531	2773
9		Direct Contribution Due to Refrigerant Leakage							
10		Lifetime Refrigerant Emissions due to Leakage (kg refrigerant)	0.913	0.9021	0.7985	0.7997	0.709	0.8013	0.809
11		GWP of Refrigerant (kg CO2/kg refrigerant)	1430	1430	1430	1430	1430	1430	1430
12		Lifetime Equivalent CO2 Emissions Due to Leakage (kg CO2)	1306	1290	1142	1144	1014	1146	1157
13		Direct Contribution Due to Atmospheric Breakdown Products							
14		Atmospheric Breakdown Due to Refrigerant Manufacture (kg CO2)	0.000477	0.000477	0.000477	0.000477	0.000477	0.000477	0.000477
15		Atmospheric Breakdown Due to Refrigerant Leakage (kg CO2)	1.452	1.434	1.27	1.272	1.127	1.274	1.286
16		Lifetime Contribution Due to Atmospheric Breakdown Products (kg CO2)	1.452	1.435	1.27	1.272	1.128	1.274	1.287
17		Indirect Contribution Due to A/C System Components							
18		Energy from Manufacturing of A/C System Components (MJ)	1751	1751	1751	1751	1751	1751	1751
19		Equaivalent CO2 from Manufacturing of A/C System Components (kg CO2)	100.1	100.1	100.1	100.1	100.1	100.1	100.1
20		Energy from End of Life Disposal of A/C System Components (MJ)	43.82	43.82	43.82	43.82	43.82	43.82	43.82
21		Equaivalent CO2 from End of Life Disposal of A/C System Components (kg CO2)	4.052	4.052	4.052	4.052	4.052	4.052	4.052
22		Total CO2 Equiv. Emissions for A/C System Components (kg CO2)	104.1	104.1	104.1	104.1	104.1	104.1	104.1
23		Indirect Contribution Due to A/C Power Consumption							
24		Total CO2 Equiv. Emissions Due to A/C Power Consumption (kg CO2)	6615	11270	13190	7171	6723	12990	24170
25		Indirect Contribution Due to Transportation Fuel Use							
26		System Total Weight (kg)	30.92	30.92	30.92	30.92	30.92	30.92	30.92
27		Incremental Fuel Use (Liters/kg/km)	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005
28		Lifetime Fuel Use (Liters)	279	273.2	273.6	273.2	279	279	279
29		Annual Fuel Use (Liters/yr)	31	30.36	30.4	30.36	31	31	31
30		Lifetime Transportation Fuel Use CO2 Emissions (kg)	675	661	662	661	675	675	675
31		Annual Transportation Fuel Use CO2 Emissions (kg/year)	75	73.5	73.6	73.5	75	75	75
32		Indirect Contribution Due to Recover/Recycle/Recharge Equipment							
33		Horse Power of Equipment	0.333	0.333	0.333	0.333	0.333	0.333	0.333
34		Time per Cycle (hours)	1	1	1	1	1	1	1
35		BTU per Cycle	9413	9413	9413	9413	9413	9413	9413
36		Weight of CO2/BTU (kg/BTU)	0.000196	0.000196	0.000196	0.000196	0.000196	0.000196	0.000196
37		Equipment CO2 per Cycle (kg/cycle)	1.848	1.848	1.848	1.848	1.848	1.848	1.848
38		Lifetime Equipment CO2 Emissions (kg CO2)	12.94	12.94	11.09	11.09	9.24	11.09	11.09
39	Sys2	Total Lifetime Equivalent Warming Impact (kg CO2)	9381	15290	17660	9984	9354	17500	31240
40		Total Lifetime Direct Contribution (kg CO2)	5.081	5.001	4.854	4.863	3.36	4.874	4.931
41		Total Lifetime Indirect Contribution (kg CO2)	9376	15280	17660	9979	9351	17500	31230
42		Total Contribution per Lifetime Driving Distance (g CO2/km)	51.99	86.51	99.79	56.5	51.84	96.99	173.1
43		Total Annual Equivalent Warming Impact (kg CO2/year)	1042	1699	1962	1109	1039	1945	3471
44		Total Annual Direct Contribution (kg CO2/year)	0.5645	0.5557	0.5393	0.5403	0.3733	0.5416	0.5479

Figure 44. Representation of the comparison sheet (Sheet 1)

 Chart 1 contains a bar graph marking the differences between the systems in terms of lifetime CO₂-eq emissions across all cities used for evaluation. A representation is shown in *Figure 45*.



Figure 45. Graph of cumulative CO_2 – equivalent emissions across all cities during the lifetime of the vehicle (Chart 1)



III. Annual CO₂-equivalent emissions for each system across all cities are available in *Chart 2*. A representation is shown in *Figure 46*.

Figure 46. Graph of annual CO_2 – equivalent emissions across all cities during the lifetime of the vehicle (Chart 2)



IV. *Chart 3* contains a bar graph comparison of CO₂-equivalent emissions for each system per kilometer, across all cities. A sample of the sheet is shown in *Figure 47*.

Figure 47. Graph of CO_2 – equivalent emissions across all cities per kilometer during the lifetime of the vehicle (Chart 3)

V. The *Weighted* tab gives a comparison of the amount of CO₂ emitted in all GREEN-MAC USA cities across all systems. If GREEN-MAC USA cities weren't selected for simulations, this screen would be blank. *Figure 48* shows a sample of a filled sheet.

	A	В	с	D	E	F	G	н	I.	J	K	L	М
	Indirect Contribution, Weighted (GREEN-MAC USA												
1	Cities)	Phoenix	Houston	Boston	Chicago	Fargo	WDC	Los Angeles	San Francisco	Sacramento	San Diego	Miami	Sum
2	Percent of total vehicles in these cities	4.5%	16.3%	13.2%	22.5%	4.5%	12.4%	5.0%	5.7%	5.0%	5.0%	5.8%	100%
3	Driving Distance (km/yr)	20,050	19,635	19,665	19,635	20,050	20,050	20,050	20,050	20,050	20,050	19,832	
4													
5	Annual MAC Operation Contribution (kg CO2/year)												
6	Sys1	734.9	1251.8	1465.4	796.8	747.0	1443.2	2685.2	1649.3	1516.7	2896.3	1421.9	
7	Sys2	954.5	1612.4	1875.9	1023.0	951.9	1856.7	3383.2	2116.5	1955.7	3641.5	1833.1	
12	8												
	Weighted MAC Operation Contribution per Mile (g												
13	CO2/mi)												Weighted Average
14	Sys1	2.65	16.72	15.83	14.69	2.70	14.36	10.77	7.54	6.09	11.62	6.69	109.67
15	i Sys2	3.45	21.54	20.26	18.86	3.44	18.48	13.58	9.68	7.85	14.61	8.63	140.36

Figure 48. Comparison of all GREEN-MAC USA cities

VI. *Chart 4* graphically compares all the systems for the GREEN-MAC USA cities with respect to the amount of CO₂-equivalent emissions per mile emitted. If GREEN-MAC USA cities weren't selected for simulations, this screen would be blank. *Figure 49* shows a sample of a filled sheet.



Figure 49. Graphical comparison of GREEN-MAC USA cities w.r.t emissions per mile