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1. Introduction

Note: Enabling macros

Tools 1 and 2 both use macros. It may be necessary to enable 'enable macros' when open excel for the sheets to function.

This can usually be achieved by changing the macro settings in the Microsoft 'Trust Centre'. (File > Options > Trust Centre)

Alternatively download the Tool files to local folder, right-click on the file name, select 'Properties' and check the "Unlock" checkbox at the end (Security option).

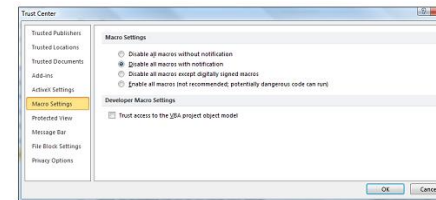
Microsoft support - enable macros

Change macro settings in the Trust Center

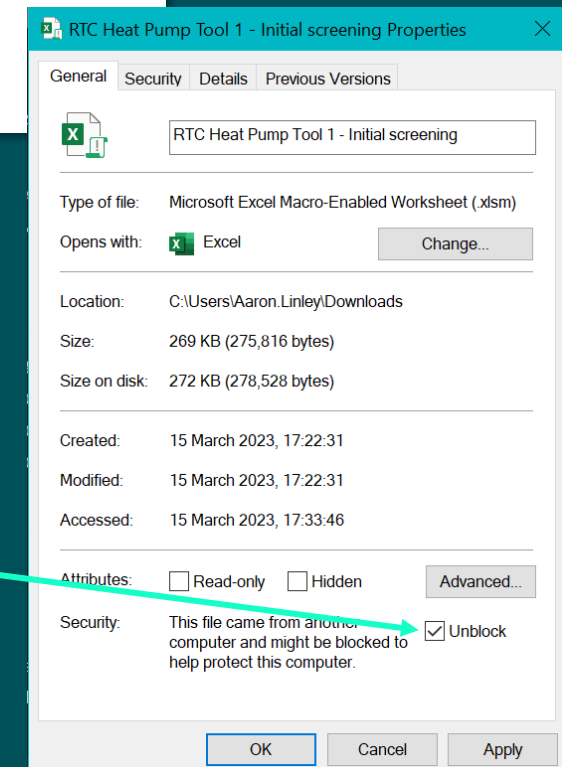
Macro settings are located in the Trust Center. However, if your device is managed by your work or school the system administrator might prevent anyone from changing settings.

Important: When you change your macro settings in the Trust Center, they are changed only for the Office program that you are currently using. The macro settings are not changed for all your Office programs.

1. Click the **File** tab.
2. Click **Options**.
3. Click **Trust Center**, and then click **Trust Center Settings**.
4. In the **Trust Center**, click **Macro Settings**.



5. Make the selections that you want, then click **OK**.



Failing that...

Refer to the following website:
<https://www.ablebits.com/office-addins-blog/enable-disable-macros-excel/#:~:text=Click%20the%20File%20tab%2C%20and%20then%20click%20Options%20at%20the,all%20macros%20and%20click%20OK.>

Go to the 'Trust Center Settings' as per image, then 'Trusted Locations'

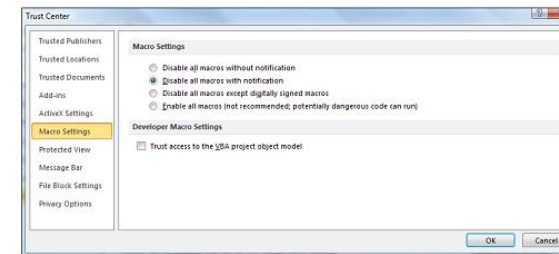
Click 'Add new location...' and add the location where the file is placed

Change macro settings in the Trust Center

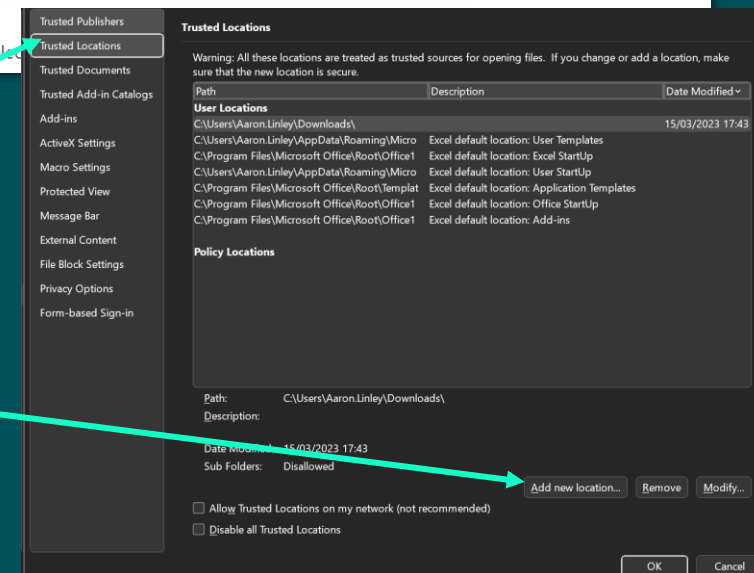
Macro settings are located in the Trust Center. However, if your device is managed by your work or school the system administrator might prevent anyone from changing settings.

Important: When you change your macro settings in the Trust Center, they are changed only for the Office program that you are currently using. The macro settings are not changed for all your Office programs.

1. Click the **File** tab.
2. Click **Options**.
3. Click **Trust Center**, and then click **Trust Center Settings**.
4. In the **Trust Center**, click **Macro Settings**.



5. Make the selection





1. Summary of tools

RTC Heat Pump project - 3 decision support tools

The RTC Heat Pump project has created **three** tools, designed to answer the common questions when considering the use of heat pumps:

1. Where might a heat pump be useful?
2. What technologies might be suitable?
3. Has a similar installation been done before?

Tool #1 Initial screening

4. Would it be commercially viable?
5. What can I do to improve the confidence in project viability before investing in detailed feasibility or design work?

Tool #2 High-level feasibility

6. Who can we work with and where?

Tool #3 Supplier database

Tool summary

Tool 1: Initial screening

Purpose: identification of heat pump opportunity(s)

Main user inputs:

- Industry
- Heat application
- Waste heat source



Tool 2: High-level feasibility

Purpose: initial technical and commercial viability assessment.

Main user inputs:

- Technical e.g. temps, flows, mediums, efficiencies.
- Commercial e.g. energy tariffs, grid factors and unit costs.



Tool 3: Supplier database

Purpose: provide details of relevant suppliers

User inputs:

- Country and technology of interest

Outputs:

- Short list of potential applications
- Case study links

- Technical parameters
- Costs and benefits
- Tailored implementation check list

- List of relevant suppliers
- Weblinks and contact details



Tool 1: Initial screening

Tool 1 user guide – general tool description

The initial screening tool is designed to help identify heat pump options based on only high-level information about candidate sites. This allows the user to focus down on the sites and technology options most worthy of further investigation.

The tool contains two databases, one of technology applications and the other of case studies. This tool filters these databases according to the user inputs to return potential applications and associated case studies relevant to the chosen sector and input parameters.

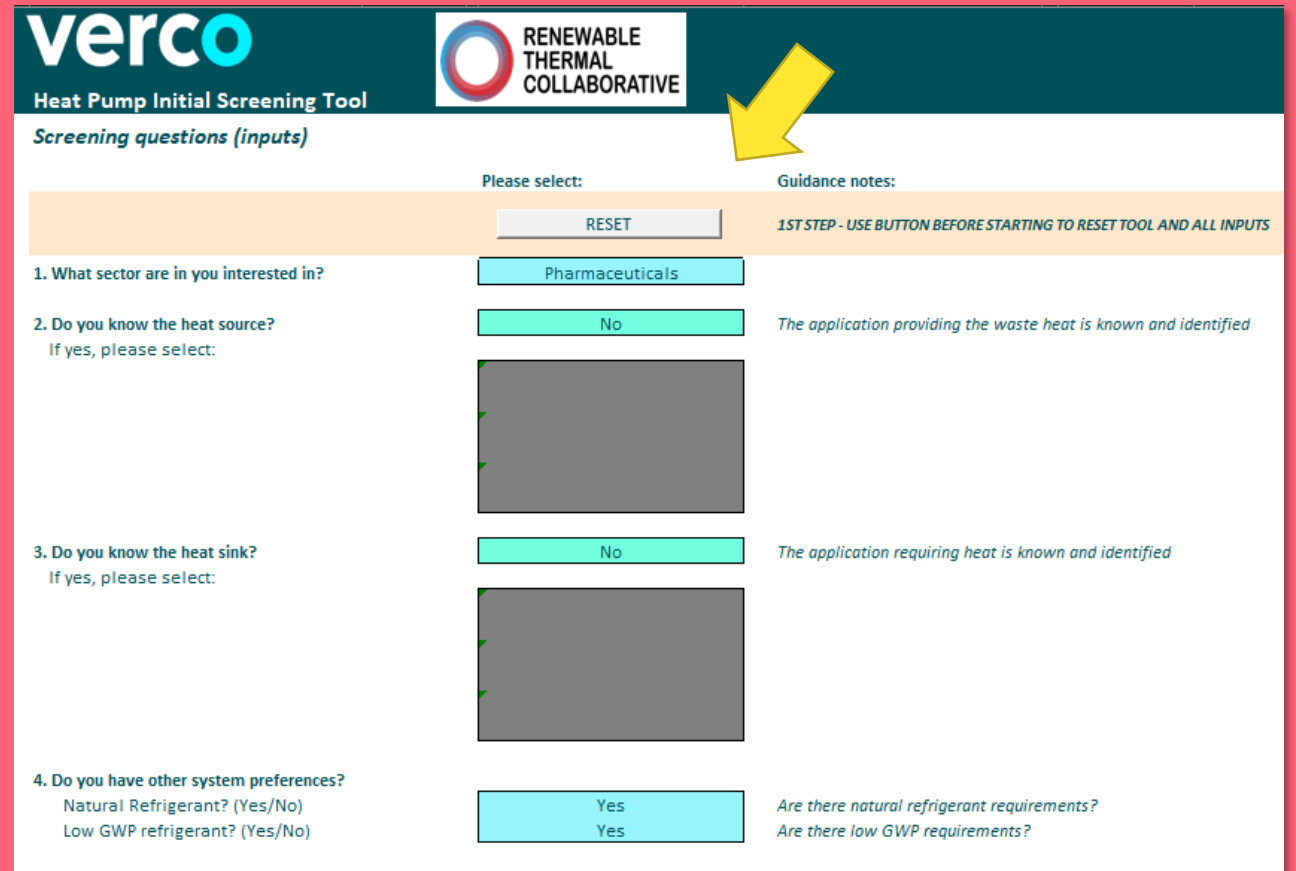
The tool can be used to explore options for single sites, or multiple sites with the same thermal processes.

Tool 1 user guide - inputs

First of all, press the **RESET** button to clear previous inputs.

This also resets some cells that can be overwritten.

The tool may not work correctly if this is not done.



The screenshot shows the 'verco' logo and 'RENEWABLE THERMAL COLLABORATIVE' header. The title is 'Heat Pump Initial Screening Tool'. Below it, the section is 'Screening questions (inputs)'. A yellow arrow points to a 'RESET' button under the heading 'Please select:'. To the right, under 'Guidance notes:', it says '1ST STEP - USE BUTTON BEFORE STARTING TO RESET TOOL AND ALL INPUTS'. The form contains four questions:

1. What sector are you interested in? (Selected: Pharmaceuticals)
2. Do you know the heat source? If yes, please select: (Selected: No). Guidance note: The application providing the waste heat is known and identified.
3. Do you know the heat sink? If yes, please select: (Selected: No). Guidance note: The application requiring heat is known and identified.
4. Do you have other system preferences? (Selected: Yes for both Natural Refrigerant and Low GWP refrigerant). Guidance notes: Are there natural refrigerant requirements? Are there low GWP requirements?

Tool 1 user guide - inputs (continued)

Answer questions 1 – 4.

If you can provide details of the heat source and sink, then the outputs will be more specific to your case.

The screenshot displays the 'verco' Heat Pump Initial Screening Tool interface. At the top, the 'verco' logo is on the left, and the 'RENEWABLE THERMAL COLLABORATIVE' logo is on the right. Below the logos, the title 'Heat Pump Initial Screening Tool' is centered. The main section is titled 'Inputs: Screening questions'. It features a 'Please select:' column with a 'RESET' button, and a 'Guidance notes:' column. The questions are numbered 1 through 4, with corresponding input fields and guidance notes.

	Please select:	Guidance notes:
1ST STEP - USE BUTTON BEFORE STARTING TO RESET TOOL AND ALL INPUTS		
1. What sector are you interested in?	Food and beverage	
2. Do you know the heat source?	Yes	The application providing the waste heat is known and identified
If yes, please select:		
Heat source	Process cooling	The application creating a waste heat stream
Source medium	Liquid	The medium of waste heat
Source minimum temp (degC)	5	The lowest temperature that the waste heat reaches; i.e. creates a lower boundary for the heat pump
Source maximum temp (degC)	40	The highest temperature boundary that the waste heat reaches; i.e. creates an upper boundary for the heat pump
3. Do you know the heat sink?	Yes	The application requiring heat is known and identified
If yes, please select:		
Heat sink	Preheating	The application requiring heat
Sink Medium	Liquid	The medium which provides the heating
Sink minimum temp (degC)	20	The lower temperature of heat required; i.e. creates a lower boundary for the heat pump
Sink maximum temp (degC)	100	The higher temperature of heat required; i.e. creates an upper boundary for the heat pump
4. Do you have other system preferences?		
Natural Refrigerant? (Yes/No)	Yes	Are there natural refrigerant requirements?
Low GWP refrigerant? (Yes/No)	Yes	Are there low GWP requirements?

Tool 1 user guide - reference sheets

All reference tabs are shown to the righthand side of the workbook.

These may be of interest in their own right. For example, the complete database of 200+ case studies can be viewed in reference tab 5

verco RENEWABLE THERMAL COLLABORATIVE											
Case study Database											
powered only for library											
ID	Industrial Sector	General Building Oper.	Continent	Country	Location	Source	Link	Year	HP Make	HP Model	Refrigerant
CS1	Chemical and petroleum	Plastic production	Europe	France	N/A	Annex 48	https://aemepump.eu/izv_deh	2015			R123 Eco
CS2	Chemical and petroleum	Extraction plant	Europe	Germany	Rahlingen Siersburg	Annex 48	https://aemepump.eu/izv_deh	2009			R407
CS3	Chemical and petroleum	Abrasives	Europe	Germany	Grafenbachheim	Annex 48	https://aemepump.eu/izv_deh	2001			na
CS4	Chemical and petroleum	Dry process of torrefied myro	Asia	Japan	Tochigi	Annex 48	https://aemepump.eu/izv_deh	2010	Mayekawa		R744 (CO2)
CS5	Chemical and petroleum	Distillation process of bioethan	Asia	Japan	Hokkaido	Annex 48	https://aemepump.eu/izv_deh	N/A			R245fa (CKD)
CS6	Chemical and petroleum	Dry laminating process	Asia	Japan	Saitama	Annex 48	https://aemepump.eu/izv_deh	2016			R744 (CO2)
CS7	Chemical and petroleum	Separation process, Separat	Europe	Netherlands	Gouda	Annex 48	https://aemepump.eu/izv_deh	1995			na
CS8	Textile, leather etc	Printing and dyeing	Europe	Germany	Mühlroff	Annex 48	https://aemepump.eu/izv_deh	2011			na
CS9	Textile, leather etc	Washing plant	Europe	Netherlands	Apeldoorn	Annex 48	https://aemepump.eu/izv_deh	1998			na
CS10	Other Manufacturing	Metal processing	Europe	Austria	Pyzdof	Annex 48	https://aemepump.eu/izv_deh	2009			R134a
CS11	Other Manufacturing	Electronics	Europe	Austria	Dautsch/Handberg	Annex 48	https://aemepump.eu/izv_deh	2005			na
CS12	Other Manufacturing	Automotive industry	Europe	Austria	Wetz	Annex 48	https://aemepump.eu/izv_deh	2012			na
CS13	Other Manufacturing	Construction industry	Europe	Austria	Vienna	Annex 48	https://aemepump.eu/izv_deh	2003			na
CS14	Other Manufacturing	washing metal items	Europe	Denmark	Bjerringbo	Annex 48	https://aemepump.eu/izv_deh	2011			R134a
CS15	Other Manufacturing	Automotive - Paint shop	Europe	Germany	Enden	Annex 48	https://aemepump.eu/izv_deh	2012			Fluid Xpro II
CS16	Other Manufacturing	Electronics - electrical drives	Europe	Germany	Bornhof	Annex 48	https://aemepump.eu/izv_deh	2001			na
CS17	Other Manufacturing	Glass	Europe	Germany	Wiemersdorf	Annex 48	https://aemepump.eu/izv_deh	2007			R404A
CS18	Other Manufacturing	Mechanical Engineering	Europe	Germany	Niederau/Grißborn	Annex 48	https://aemepump.eu/izv_deh	2012			na
CS19	Other Manufacturing	Metal processing - wires produ	Europe	Germany	Aachen	Annex 48	https://aemepump.eu/izv_deh	N/A			R134a
CS20	Other Manufacturing	Metal processing	Europe	Germany	Zerbst	Annex 48	https://aemepump.eu/izv_deh	2011			na
CS21	Other Manufacturing	Metal processing	Europe	Germany	Neustadt (Vred)	Annex 48	https://aemepump.eu/izv_deh	2011			na
CS22	Other Manufacturing	Plastic production	Europe	Germany	Burgthalach	Annex 48	https://aemepump.eu/izv_deh	2012			R134a
CS23	Other Manufacturing	Metal processing	Europe	Germany	Schwabsoch/Hall	Annex 48	https://aemepump.eu/izv_deh	2007			R404a
CS24	Other Manufacturing	Plastic production	Europe	Germany	Kaufbeuren	Annex 48	https://aemepump.eu/izv_deh	N/A			R134a
CS25	Other Manufacturing	Metal processing	Europe	Germany	Bargheide	Annex 48	https://aemepump.eu/izv_deh	N/A			R134a
CS26	Other Manufacturing	Machinery-dry process of trans	Asia	Japan	Tochigi	Annex 48	https://aemepump.eu/izv_deh	N/A			R134a
CS27	Other Manufacturing	Machinery-cleaning process	Asia	Japan	Nie	Annex 48	https://aemepump.eu/izv_deh	2013			R245fa (CKD)
CS28	Iron and steel non-ferrous met	Process heat for hardening pro	Europe	Switzerland	Egerkingen	Aramis	https://www.aramis.admin.ch/IL	2013	CTA AG		R134a
CS29	Other Manufacturing	Production	Europe	Switzerland	Gräsch	Aramis	https://www.aramis.admin.ch/IL	2010	SCH Frigo	SK 1805 WPC	R134a
CS30	Food and beverage	Meat processing	Europe	Austria	Hohenems	Annex 48	https://aemepump.eu/izv_deh	1996			R134a
CS31	Food and beverage	Brewery	Europe	Austria	Dornbirn	Annex 48	https://aemepump.eu/izv_deh	2005			R717 (NH3)
CS32	Food and beverage	Deep freeze food	Europe	Austria	Asten	Annex 48	https://aemepump.eu/izv_deh	2007			R403 (CO2 Kasko)
CS33	Food and beverage	Dairy, Drying as for milk powder	Europe	Denmark	Videbæk	Annex 48	https://aemepump.eu/izv_deh	2010			R717 and R718
CS34	Food and beverage	Dentifrices	Europe	France	Morot-sur-Loing	Annex 48	https://aemepump.eu/izv_deh	2017			na
CS35	Food and beverage	Slaughterhouse - Processing	Europe	France	Morfontaine/Meu	Annex 48	https://aemepump.eu/izv_deh	2011	ENGIE	Therme CO2 HHR 2 R744 (CO2)	na
CS36	Food and beverage	Manufacture of starch product	Europe	France	Bataillon	Annex 48	https://aemepump.eu/izv_deh	2016			na
CS37	Food and beverage	Chocolate manufact.	Europe	United Kingdom	Halifax, UK	Annex 48	https://aemepump.eu/izv_deh	2010			R717 (NH3)
CS38	Food and beverage	Malt production	Europe	Germany	Hamburg	Annex 48	https://aemepump.eu/izv_deh	2010			R717 (NH3)
CS39	Food and beverage		Europe			Annex 48					na
Introduction		Tool Page	Reference databases >	0. Dropdowns		1. Heat Source Details		2. Heat Sink Details		3. Tech Matrix	
								4. Refrigerant Details		5. Case Study Database	

Tool Navigation

Reference Tab	Description
Tool Page	User interface. Contains Inputs & Outputs.
0. Dropdowns	Reference page used to populate the 'Tool Page' and create dropdown lists.
1. Heat Source Details	Database of industries and their relevant heat sources. Includes heat source medium and temperature range.
2. Heat Sink Details	Database of industries and their relevant heat sinks. Includes heat sink medium and temperature range.
3. Tech Matrix	Database of heat pump technologies and their characteristics.
4. Refrigerant Details	Database of refrigerants and their properties.
5. Case Study Database	Detailed database of over 200 case studies.



Tool 2: High-level feasibility

Tool 2 user guide – general tool description

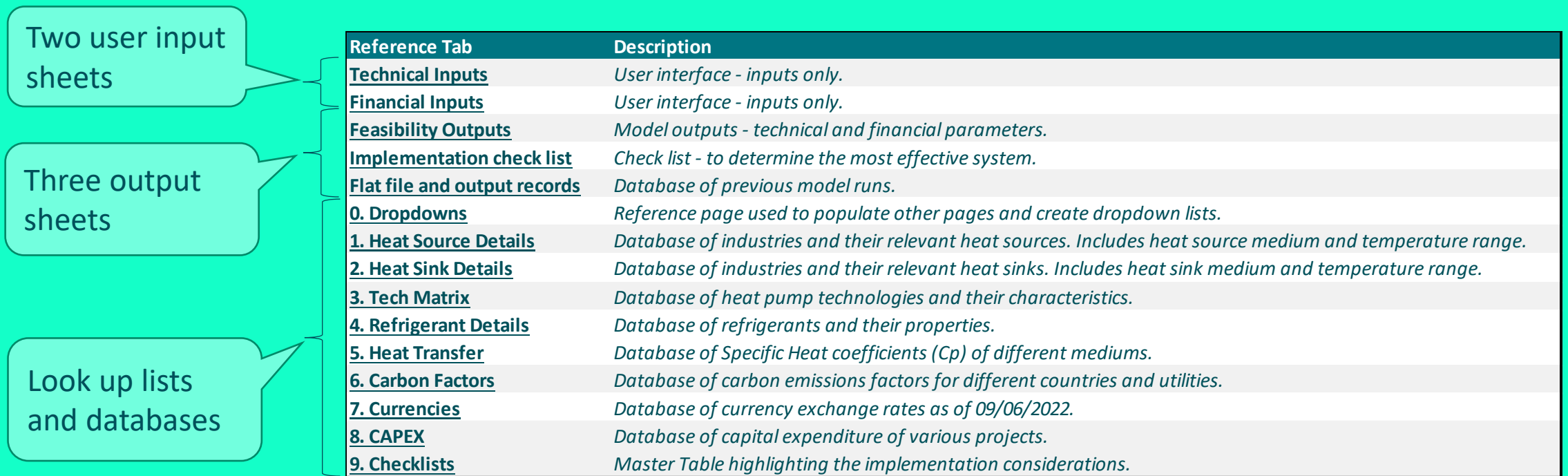
The high-level feasibility tool is designed to help with initial solution identification and feasibility at the preliminary stage of a heat pump project. The Tool helps to highlight the variables which effect the performance and output of heat pumps. It achieves this by modelling the operating conditions, distribution complexity, storage requirements / availability and financial variables.

The tool is designed to explore the feasibility of a single technology configuration and country location at a time.

It can used to consider the aggregate cost and benefits of multiple installations of the same type, but generally it is expected that the user will have a specific site in mind in order to input the required parameters and to obtain the most accurate results.

Tool 2 user guide – tool structure

The tool comprises two input sheets, three outputs sheets and further sheets with databases and references.



Tool 2 user guide - inputs

When starting, press the **RESET** button to clear previous inputs.

This also resets some cells that can be overwritten.

The tool may not work correctly if this is not done.

The input cells should be self-explanatory.



Guidance notes are shown in italics adjacent to all the input fields.

Active cells are colour-coded according to the formatting legend below.

Primary input - required
Primary input with pre-populated formula for guidance; can be overwritten
Calculation - read only
Output
Key output

Tool 2 user guide – calculation options

Row 72 of the Technical Input sheet allows the user the choice of **Basic** or **Advanced** calculation options.

If average sink flow rate and sink return temperature are known /can be estimated, then the Advanced method is recommended for more accurate results.

If information is lacking, then the Basic calculation option runs the model with more assumptions and fewer user inputs.

The screenshot displays a portion of a spreadsheet interface. A callout box labeled 'Calculation method selection' points to a dropdown menu in row 72, which is currently set to 'Advanced'. Below this, under the heading 'General performance parameters', there are three input fields: 'Annual electricity consumption (kWh)' with a value of 1,000,000, 'Annual Natural Gas consumption (kWh)' with a value of 5,000,000, and '% of heat used for current heating process' with a value of 80%.

Row	Calculation method?	Heat capacity calculation method	General performance parameters
70			
72		Advanced	
73			
74			
76			Annual electricity consumption (kWh)
77			Annual Natural Gas consumption (kWh)
78			% of heat used for current heating process
79			Current heat generation efficiency (%)
80			

Tool 2 user guide – quantitative outputs

The quantitative outputs are all shown on the 'Feasibility outputs' sheet, with further guidance notes where relevant.

Technical and financial outputs are shown on the same sheet.




Tool 2 user guide – project cash flows

The currency for the financial analysis is set in the 'general site parameters' section of the 'Technical Inputs' tab.

Project cashflows up to year 10 are shown in a table near the bottom of 'Feasibility outputs' tab. The cash flows are undiscounted.

What are your general site parameters?

Industry	Food and Beverage
Country	US Average
Currency	\$
Fuel Type	Natural Gas



Project cashflows - undiscounted and without inflation					
		Current	1	2	3
Opex	\$	0	-50,353	-50,353	-50,353
Natural Gas displaced	\$		-203,292	-203,292	-203,292
Electricity increase	\$		134,408	134,408	134,408
Maintenance	\$		36,298	36,298	36,298
Avoided OPEX	\$		-5,000	-5,000	-5,000
Cost of carbon displaced	\$		-12,767	-12,767	-12,767
Capex	\$	838,953	0	0	0
Heat Pump	\$	250,484	0	0	0
Distribution	\$	500,969	0	0	0
Storage	\$	112,500	0	0	0
Counter	\$	-25,000	0	0	0
Delayed	\$	0	0	0	0
Subsidy	\$	0	0	0	0
One-off subsidy	\$	0	0	0	0
Ongoing subsidy	\$	0	0	0	0
Net Savings	\$	838,953	-50,353	-50,353	-50,353
Cumulative Impact	\$	-838,953	-788,601	-738,248	-687,895

Tool 2 user guide – sensitivity table

At the bottom of 'Feasibility Outputs' tab there is a sensitivity analysis table showing how simple payback period varies due to changes in fuel and electricity prices.

Users enter percentage variations (relative to the previously-entered electricity and fuel prices) clicks the **REFRESH** button to populate the table with the respective payback periods.

This cell controls the formatting of the table. Payback periods under the threshold are shown in black

Sensitivity Analysis - Payback variation with electricity and fuel price

Payback threshold: years User enters the upper limit of acceptable payback for heat pump project

REFRESH


		Electricity price change (\$/kWh)						
		-30%	-20%	-10%	0%	10%	20%	60%
		0.18	0.20	0.23	0.25	0.28	0.30	0.40
Fuel price change (\$/kWh)	-50%	0.05	no payback	no payback	no payback	no payback	no payback	no payback
	-25%	0.08	17.7	24.1	36.7	55.9	no payback	no payback
	-10%	0.09	10.3	12.2	15.0	19.5	27.5	43.9
	0%	0.10	8.0	9.2	10.7	12.8	15.9	21.0
	10%	0.11	6.6	7.3	8.3	9.5	11.1	13.4
	25%	0.13	5.2	5.6	6.2	6.8	7.6	8.6
	50%	0.15	3.8	4.0	4.3	4.6	5.0	5.4


Tool 2 user guide – implementation check list

The 'implementation check list' sheet provides practical guidance to refine the initial feasibility and to progress the project concept towards detailed feasibility work.

The objective is to identify and consider all the key issues which may present barriers at the earliest stage possible, before significant time or resources have been spent.

The recommendations are tailored to the application in question, drawing from the full check list database contained in reference sheet 9. 'Checklists'.





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Implementation Check List

ID	Consideration category	Consideration summary	Detail
1	Technology selection	Additional electrical demand	Heat pumps based on mechanical compression have a significant electrical demand which will need to be supplied by the existing site infrastructure or be considered as part of the integration costs. Typically heat pumps with large installations higher voltage supplies may need to be considered
2	Technology selection	Back-up solution when heat pump is not available	On some sites, it is possible to install a heat pump, but not one that meets the demand (due to a limit on the available electricity supply). Other sites where heat is being used for space heating operation a high level of resilience is required. It is likely that a back-up solution is required at some time where either the heat source is not available or the heat pump is not operating. A system that uses another heat source as well is called a bivalent system. In most applications the existing heat / hot water system is not being replaced. A heat exchanger on the supply side of the heat pump is probably the easiest solution to consider if the existing plant has reached the end of its economic life
3	Technology selection	Is the use of natural refrigerants available?	Heat pumps based on mechanical compression will utilise a refrigerant. Natural refrigerants are available in the market

Tool 2 user guide – Flat file and output records

The 'Flat file and output records' sheet summarises all the input and output fields in one place for easy export.

There are unlocked columns (column G and to the right) for the user to paste the results of previous model runs alongside the 'live' model outputs for comparison.

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Heat Pump Export

Records of previous model runs

Input Name	Class1	Class2	Units	Value	Value
Industry	General Inputs			Food and Beverage	
Country	General Inputs			US Average	
Currency	General Inputs			\$	
Annual electricity consumption (kWh)	General Inputs		kWh	1,000,000	12,500,000
Current electricity cost (\$/kWh)	General Inputs		\$/kWh	0.190	0.250
Market based grid electricity factor (kgCO2e/kWh)	General Inputs		kgCO2e/kWh	0.0000	0.000
Fuel Type	General Inputs			Natural Gas	Natural Gas
Annual Natural Gas consumption (kWh)	General Inputs		kWh	5,000,000	6,000,000
Current Natural Gas cost (\$/kWh)	General Inputs		\$/kWh	0.600	0.600
Market based fuel factor (kgCO2e/kWh)	General Inputs		kgCO2e/kWh	0.183	0.183
Current heat generation efficiency (%)	General Inputs			80%	80%
Natural Refrigerant? (Yes/No)	General Inputs			No	
Low GWP refrigerant? (Yes/No)	General Inputs			No	
Application	Technical Inputs	Heat Source Input		Process cooling	
Application medium	Technical Inputs	Heat Source Input		Water	
Medium's specific heat capacity (kJ/kg.K)	Technical Inputs	Heat Source Input	kJ/kg.K	4.182	
Min temp - sense check only (degC)	Technical Inputs	Heat Source Input	°C	5	
Max temp - sense check only (degC)	Technical Inputs	Heat Source Input	°C	40	
Average source return temperature (degC)	Technical Inputs	Heat Source Input	°C	90	
Average source flow temperature (degC)	Technical Inputs	Heat Source Input	°C	70	
Heat availability / demand	Technical Inputs	Heat Source Input		Batch	

Records of previous model runs

Paste as values Column F into this table to record the results of different projects or scenarios

[insert project name] [insert project name] [insert project name]

12,500,000
0.250
0.000
Natural Gas
6,000,000



Tool 3: Supplier database

Tool 3 user guide - general tool description

Tool 3 is designed to help identify suitable manufacturers and suppliers that can deliver services in the following areas:

- 1) Equipment manufacturing
- 2) Design and engineering
- 3) Supply, installation, and commissioning
- 4) Ongoing operation and maintenance support


This tool filters by the country the project is based in and the technology of interest, providing contact details and website links for the most appropriate manufacturers and providers.

Tool 3 user guide - inputs

This tool requires two inputs in order to find appropriate manufacturers and suppliers:

- 1) The country the project is based in e.g. Thailand
- 2) The technology of interest e.g., mechanical compression

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Manufacturer & Supplier Identifier

Screening questions (inputs)

Country

Technology

Please select:

Thailand

Mechanical compression

Guidance notes:

Which country is the project based in?

Select the technology of interest


Manufacturers & Suppliers (output)**Contacts - Manufacturers & Suppliers (output)**

Tool 3 user guide - outputs

Using the inputs provided by the user the tool calculates the following outputs:

- 1) Table of suitable manufacturers & suppliers and their areas of operation, e.g. engineering design, ongoing support
- 2) Email contacts and website links to the manufacturers and suppliers identified

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Manufacturer & Supplier Identifier

Screening questions (inputs)

Country
Technology

Please select:

Thailand

Mechanical compression

Guidance notes:
Which country is the project based in?
Select the technology of interest

Manufacturers & Suppliers (output)

Manufacturer	Technology	Engineering design	Supply, install & commissioning	Ongoing support
GEA	Mechanical compressio	GEA	GEA	GEA
MAN	Mechanical compressio	MAN	MAN	MAN
Mayekawa	Mechanical compressio	0	0	Mayekawa
Rank	Mechanical compressio	Rank	Rank	0

Contacts - Manufacturers & Suppliers (output)

Manufacturer	Website	Email Contact
GEA	https://www.gea.com/en/products/refrigeration-heating/he	0
MAN	https://www.man-es.com/process-industry/campaigns/indu	james.pullen@man-es.com
Mayekawa	https://www.mayekawa.com/products/heat_pumps/	tony.bilham@mayekawa.uk
Rank	https://www.rank-orc.com/	jpmarti@rank-orc.com