Task 53 - 7th Expert meeting in Messina

12-13 April 2016

Activities A5-1 and A5-2

LCA and techno-eco comparison between reference and new systems

Prof. Marco Beccali, Prof. Maurizio Cellura, Ing. Sonia Longo

University of Palermo – DEIM

Activity A5-1: Techno-economic analysis on comparison between thermal and PV existing solar cooling systems including as well LCA approach and Eco label sensibility.

!!! For developing the action, the contribution from all partners is needed. In detail, information and data on reference systems and existing thermal and PV solar cooling systems, as well as on storage systems, should be collected by partners and will be used to carry out the techno-economic and LCA analyses.

Techno-economic analysis

The analysis should be performed for all the systems examined in this action (systems installed in Palermo and Messina, system from TECSOL, etc.).

The analysis for the two systems installed in Palermo (Freescoo and Air handling unit desiccant cooling) will start in the next months, based on the technical and economic KPI identified in the Activity A5-2.

Activity A5-1: Techno-economic analysis on comparison between thermal and PV existing solar cooling systems including as well LCA approach and Eco label sensibility.

LCA analysis

Developed actions: UNIPA is carrying out the following LCA studies:

- FREESCOO: the LCA is completed
- Air Handling Unit Desiccant Cooling (AHU-DEC) equipped with a hybrid photovoltaic/thermal (PV/T) system: analysis of the manufacturing and end-of-life steps is completed.

  The assessment of the operational step is in progress.

Air handling unit desiccant cooling (AHU-DEC)

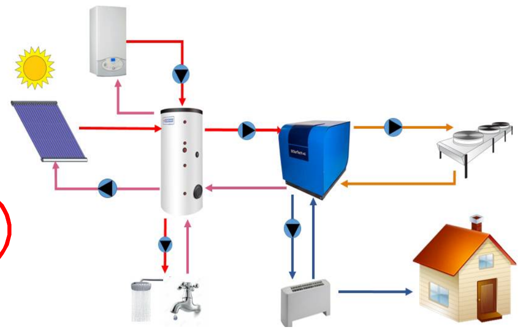
FREESCOO

Activity A5-1: Techno-economic analysis on comparison between thermal and PV existing solar cooling systems including as well LCA approach and Eco label sensibility.

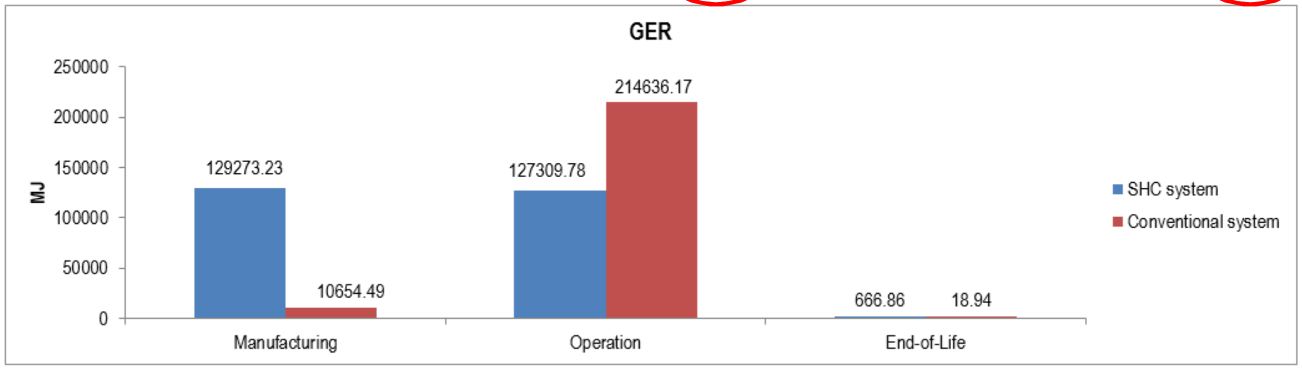
LCA analysis

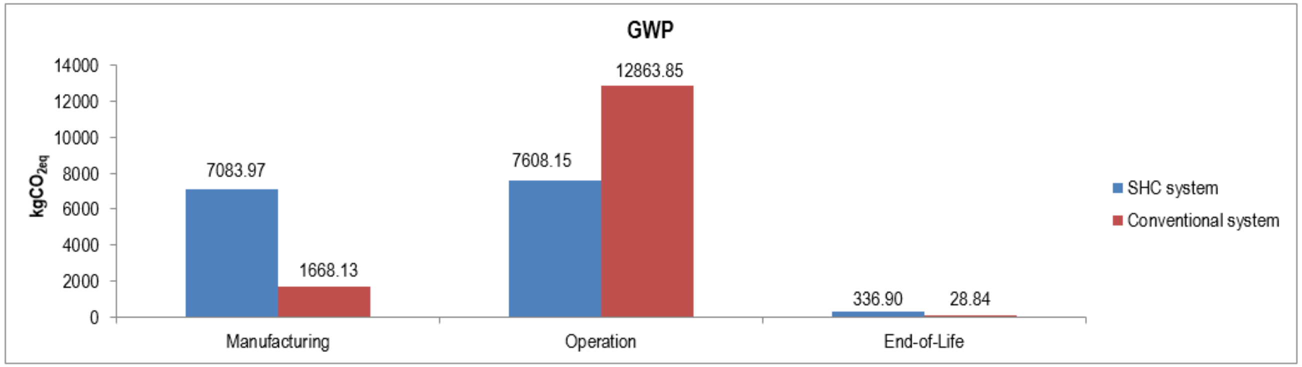
Developed actions: UNIPA is carrying out the following LCA studies:

- SHC system installed in Messina (adsorption chiller): the LCA is completed.



System	GLOBAL ENERGY REQUIREMENT (GER) (MJ)				GLOBAL WARMING POTENTIAL (GWP) (kg CO_{2eq})			
	Manufacturing	Operation	End-of-Life	Total	Manufacturing	Operation	End-of-Life	Total
SHC system	129273.23	127309.78	666.86	257249.87	7083.97	7608.15	336.90	15029.02
Conventional system	10654.49	214636.17	18.94	225309.60	1668.13	12863.85	28.84	14560.83





Energy Payback Time	=	13.66	year
GWP Payback Time	=	10.89	year
Energy Return Ratio	=	0.67	

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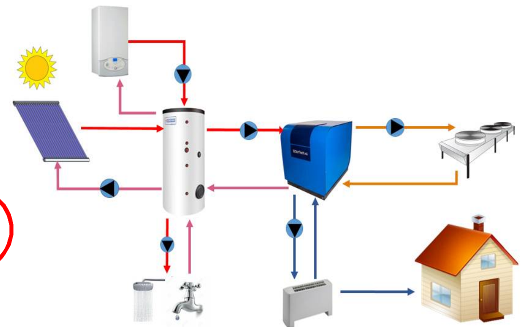
Task 53
NEW GENERATION
SOLAR COOLING & HEATING SYSTEMS

Activity A5-1: Techno-economic analysis on comparison between thermal and PV existing solar cooling systems including as well LCA approach and Eco label sensibility.

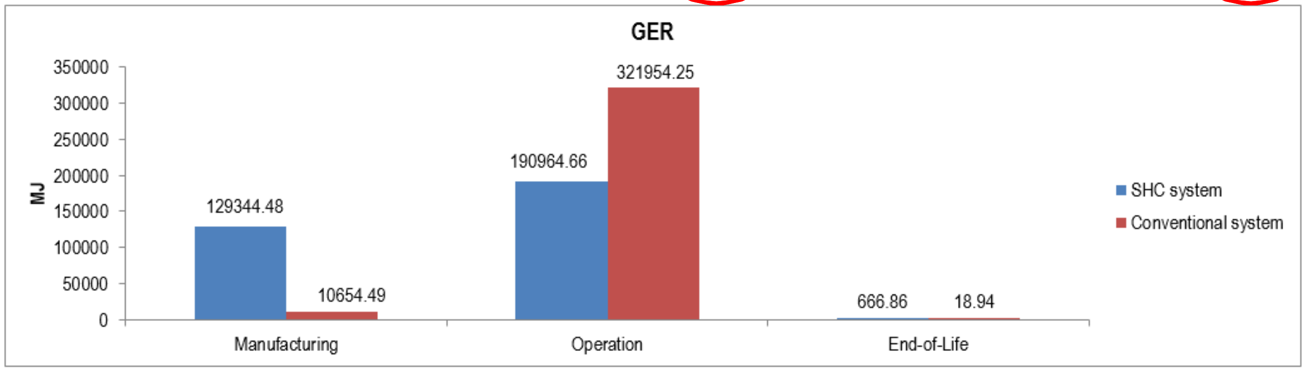
LCA analysis

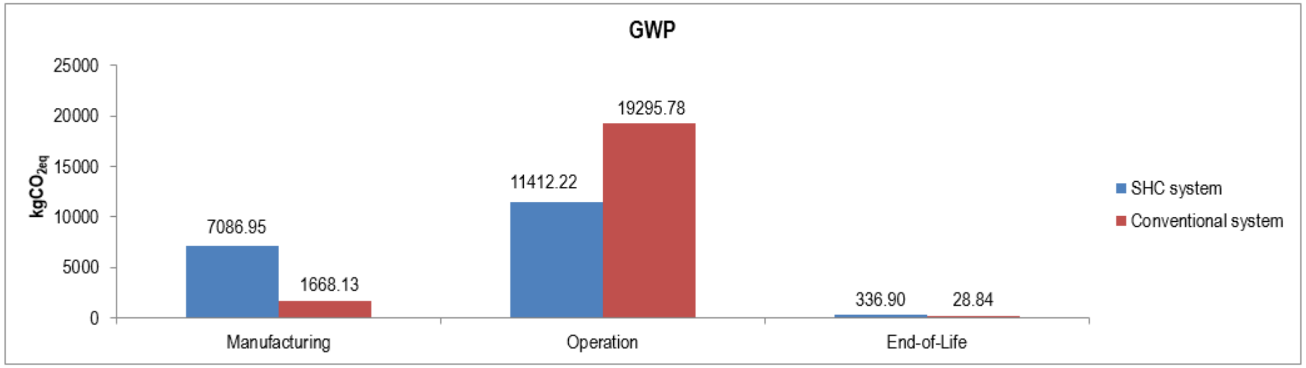
Developed actions: UNIPA is carrying out the following LCA studies:

- SHC system installed in Messina (adsorption chiller): the LCA is completed.



System	GLOBAL ENERGY REQUIREMENT (GER) (MJ)				GLOBAL WARMING POTENTIAL (GWP) (kg CO_{2eq})			
	Manufacturing	Operation	End-of-Life	Total	Manufacturing	Operation	End-of-Life	Total
SHC system	129344.48	190964.66	666.86	320976.00	7086.95	11412.22	336.90	18836.07
Conventional system	10654.49	321954.25	18.94	332627.68	1668.13	19295.78	28.84	20992.75





Energy Payback Time	=	13.66	year
GWP Payback Time	=	10.89	year
Energy Return Ratio	=	1.00	

Activity A5-1: Techno-economic analysis on comparison between thermal and PV existing solar cooling systems including as well LCA approach and Eco label sensibility.

Other potential LCA analyses

We are waiting for new contributions to perform the LCA

Activity A5-1: Techno-economic analysis on comparison between thermal and PV existing solar cooling systems including as well LCA approach and Eco label sensibility.

LCA analysis

Develop actions: UNIPA is carrying out literature review of LCA studies on thermal and PV existing solar cooling systems. The literature studies will be summarized by using a format already developed within Task 38.

Results: The literature review is in progress.

Literature review of LCA studies on thermal and PV existing solar cooling systems

12 literature studies

1. **Product**
2. **Authors and reference**
3. **Description of the product**
4. **Product characteristics**
5. **Metadata**
6. **Life Cycle Inventory**
7. **Product Eco-profile**
8. **Primary energy saving and avoided emissions**
9. **Payback indexes**

SHC SOLAR HEATING & COOLING PROGRAMME INTERNATIONAL ENERGY AGENCY

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Task 53 NEW GENERATION SOLAR COOLING & HEATING SYSTEMS

Activity A5-2: Definition of Key Performance Indicators (KPI) of the market available systems and possible characterization test method (permitting to lead to a quality labeling scheme for new generation solar cooling systems) as well as standards.

Energy indicators	Environmental indicators
Global Energy Requirement (MJ) Energy payback time (years) Energy return ratio (a-dimensional)	Global Warming Potential (kg CO_{2eq}) Acidification Potential (kg SO_{2eq}) Eutrophication Potential (kg $PO_4^{3-}{}_{eq}$) Ozone Depletion Potential (kg CFC-11_{eq}) Photochemical Ozone Creation Potential (kg C_2H_{4eq}) GWP payback time (years)
Economic indicators	**Technical indicators**
Money savings during the operation (€) Initial cost ratio Operation/maintenance costs ratio Payback period (years)	Useful life of the system (years) Thermal Performance Coefficient (COP_{th}) of the ab/adsorption machine Solar Electric Performance Coefficient ($COP_{Elec-sol}$) of the system Reliability of the system (%)
Social indicators	
Customer satisfaction (qualitative) Ease of use of the systems (qualitative)	

Activity A5-2: Definition of Key Performance Indicators (KPI) of the market available systems and possible characterization test method (permitting to lead to a quality labeling scheme for new generation solar cooling systems) as well as standards.

FORMAT FOR KEY Global Warming Potential

Key performance indicator name: Global Warming Potential (GWP)

Typology (economic, energy or environmental, social, technical): Environmental indicator

Type of assessment (qualitative or quantitative): Quantitative

Unit of measure (only for quantitative KPI): kg CO_{2eq}

Description: GWP is a measure of the relative, globally averaged, warming effect arising from the emissions of a particular greenhouse-gas. The GWP represents the time-integrated commitment to climate forcing from the instantaneous release of 1 kg of a trace gas expressed relative to that from 1 kg of carbon dioxide.

Performance target: % reduction of GWP during the life-cycle of the system (to be fixed case by case)

Measurement process: Life Cycle Assessment methodology

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Activity A5-2: Quality labeling scheme

QUALITY LABEL SCHEME Task 53
NEW GENERATION SOLAR COOLING & HEATING SYSTEMS

Picture of the system	The system
(insert a picture of the system)	(insert a brief description of the system)

Energy KPIs		Environmental KPIs	
GER (MJ):		GWP (kg $CO_{2,eq}$):	
EPT (years):		AP (kg $SO_{2,eq}$):	
ERR:		EP (kg $PO_4^{3-}{}_{eq}$):	
		ODP (kg CFC-11$_{eq}$):	
		POCP (kg $C_2H_{4,eq}$):	
		GWP-PT (year):	

Economic KPIs		Social KPIs	
MSDO (€):		CS:	
ICR (€):		EUS:	
OMC (€):			
PP (years):			

Technical KPIs	
ULS (years):	
COP_{th}:	
$COP_{Elec-sol}$:	
RS (%):	

Key of KPIs

Energy indicators: Global Energy Requirement (GER); Energy Payback Time (EPT); Energy Return Ratio (ERR);
Environmental indicators: Global Warming Potential (GWP); Acidification Potential (AP); Eutrophication Potential (EP); Ozone Depletion Potential (ODP); Photochemical Ozone Creation Potential (POCP); GWP Payback Time (GWP-PT);
Economic indicators: Money savings during the operation (MSDO); Initial cost ratio (ICR); Operation/maintenance costs ratio (OMC); Payback period (PP);
Social indicators: Customer satisfaction (CS); Ease of use of the system (EUS);
Technical indicators: Useful life of the system (ULS); Thermal performance coefficient of the ab/adsorption machine (COPth); Solar Electric Performance Coefficient of the system (COPElec-sol); Reliability of the system (RS).

Activity A5-2: Quality labeling scheme

QUALITY LABEL SCHEME	
Picture of the system	**The system**
(insert a picture of the system)	(insert a brief description of the system)

Energy KPIs		**Environmental KPIs**	
GER (MJ):		GWP (kg CO_{2eq}):	
EPT (years):		AP (kg SO_{2eq}):	
ERR:		EP (kg $PO_4^{3-}{}_{eq}$):	
		ODP (kg CFC-11_{eq}):	
		POCP (kg C_2H_{4eq}):	
		GWP-PT (year):	

Activity A5-2: Quality labeling scheme

Economic KPIs		Social KPIs	
MSDO (€):		CS:	
ICR (€):		EUS:	
OMC (€):			
PP (years):			

Technical KPIs	
ULS (years):	
COP_{th}:	
$COP_{Elec-sol}$:	
RS (%):	

Key of KPIs
Energy indicators: Global Energy Requirement (GER); Energy Payback Time (EPT); Energy Return Ratio (ERR); Environmental indicators: Global Warming Potential (GWP); Acidification Potential (AP); Eutrophication Potential (EP); Ozone Depletion Potential (ODP); Photochemical Ozone Creation Potential (POCP); GWP Payback Time (GWP-PT); Economic indicators: Money savings during the operation (MSDO); Initial cost ratio (ICR); Operation/maintenance costs ratio (OMC); Payback period (PP); Social indicators: Customer satisfaction (CS); Ease of use of the system (EUS); Technical indicators: Useful life of the system (ULS); Thermal performance coefficient of the ab/adsorption machine (COPth); Solar Electric Performance Coefficient of the system (COPElec-sol); Reliability of the system (RS).

Update of the LCA tool developed within Task 48

The LCA tool developed within Task 48 has been updated.

What is new?

-New design and functionality (non-editable equations, component selection from a drop down menu, enter new data, export in PDF of each page, etc.);

-Some new components have been added: 2 heat pumps (10 kW, 30 kW); 1 absorption chiller (100 kW) and air cooler;

-Comparing 4 different systems simultaneously: SHC, SHC equipped with PV, conventional, conventional equipped with PV.

The test of the tool is ongoing

Points for discussion

- Beta-testing by external users
- Intellectual property of the tool

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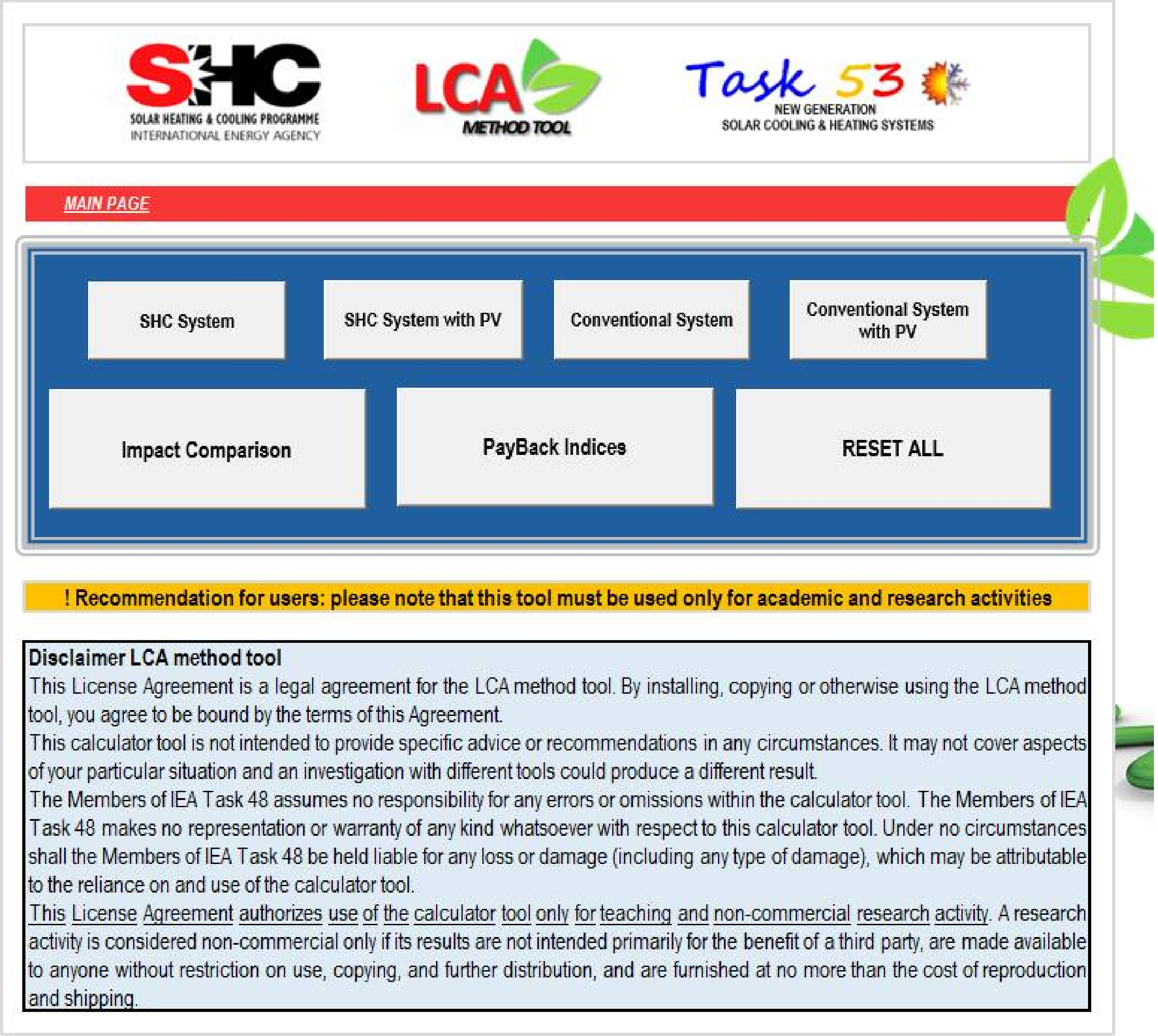
Task 53
NEW GENERATION
SOLAR COOLING & HEATING SYSTEMS

Update of the LCA tool developed within Task 48


SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY
LCA METHOD TOOL
Task 53 NEW GENERATION SOLAR COOLING & HEATING SYSTEMS
MAIN PAGE
SHC System
SHC System with PV
Conventional System
Conventional System with PV
Impact Comparison
PayBack Indices
RESET ALL
! Recommendation for users: please note that this tool must be used only for academic and research activities
Disclaimer LCA method tool
This License Agreement is a legal agreement for the LCA method tool. By installing, copying or otherwise using the LCA method tool, you agree to be bound by the terms of this Agreement.
This calculator tool is not intended to provide specific advice or recommendations in any circumstances. It may not cover aspects of your particular situation and an investigation with different tools could produce a different result.
The Members of IEA Task 48 assumes no responsibility for any errors or omissions within the calculator tool. The Members of IEA Task 48 makes no representation or warranty of any kind whatsoever with respect to this calculator tool. Under no circumstances shall the Members of IEA Task 48 be held liable for any loss or damage (including any type of damage), which may be attributable to the reliance on and use of the calculator tool.
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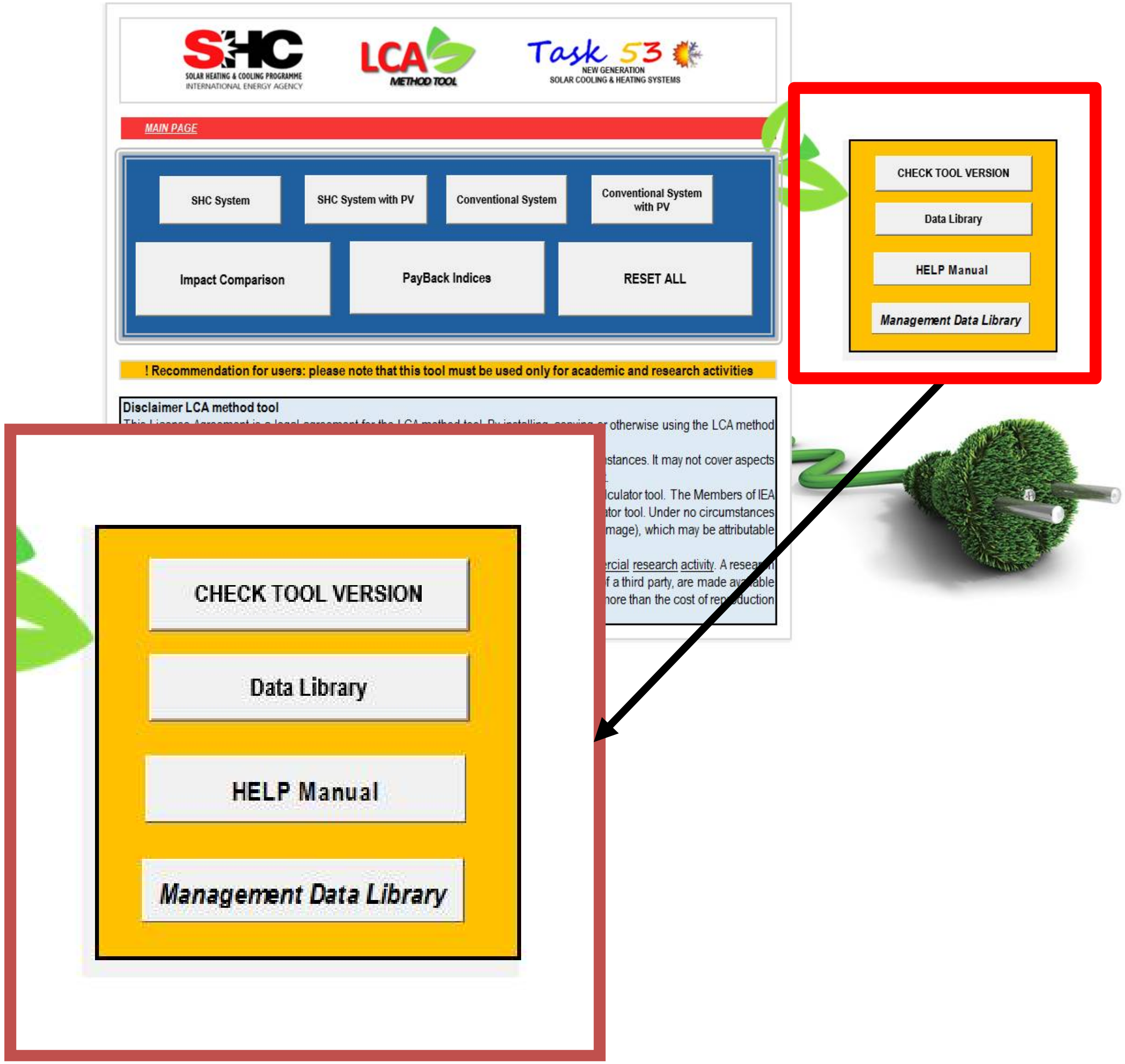
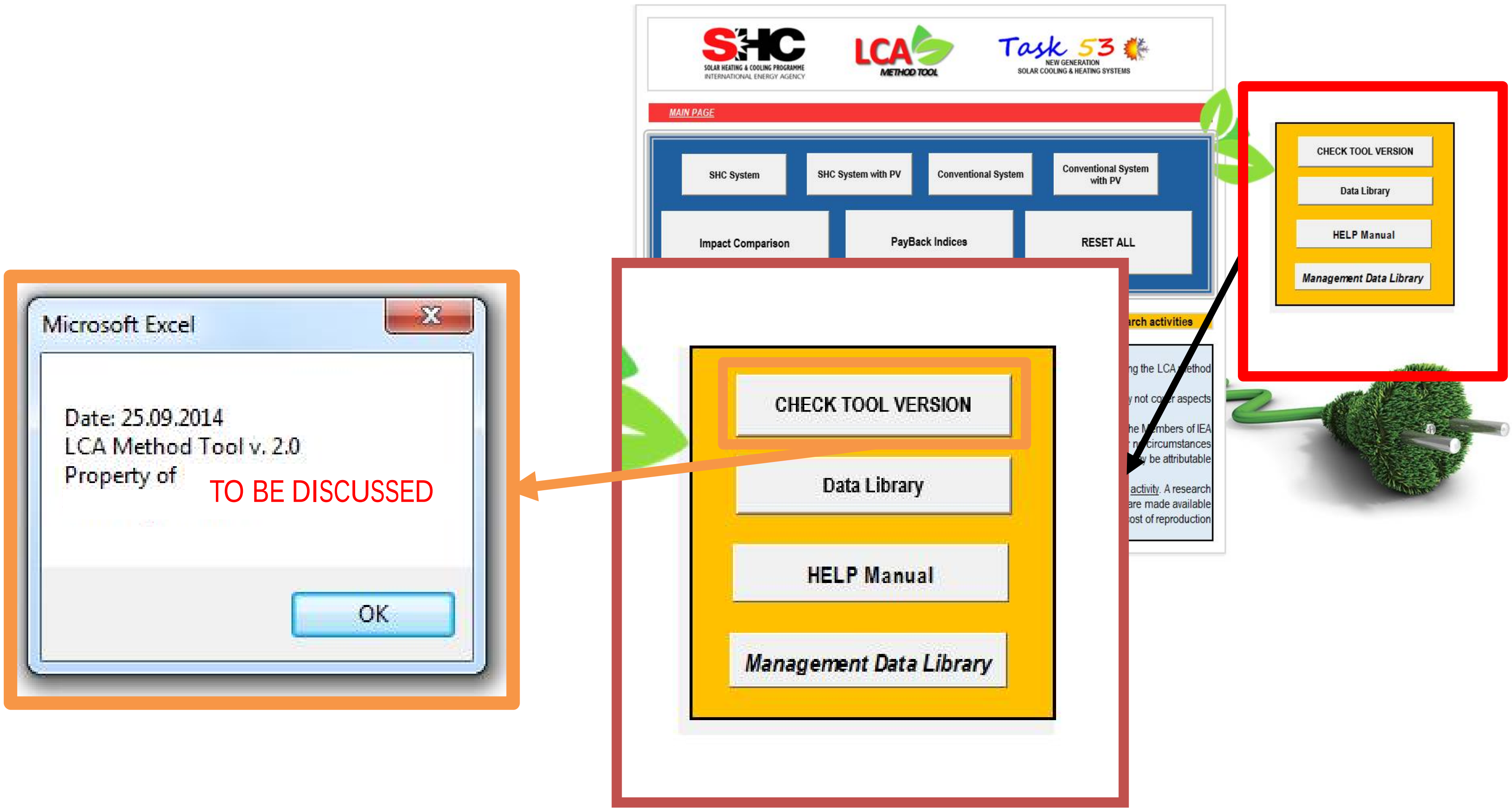
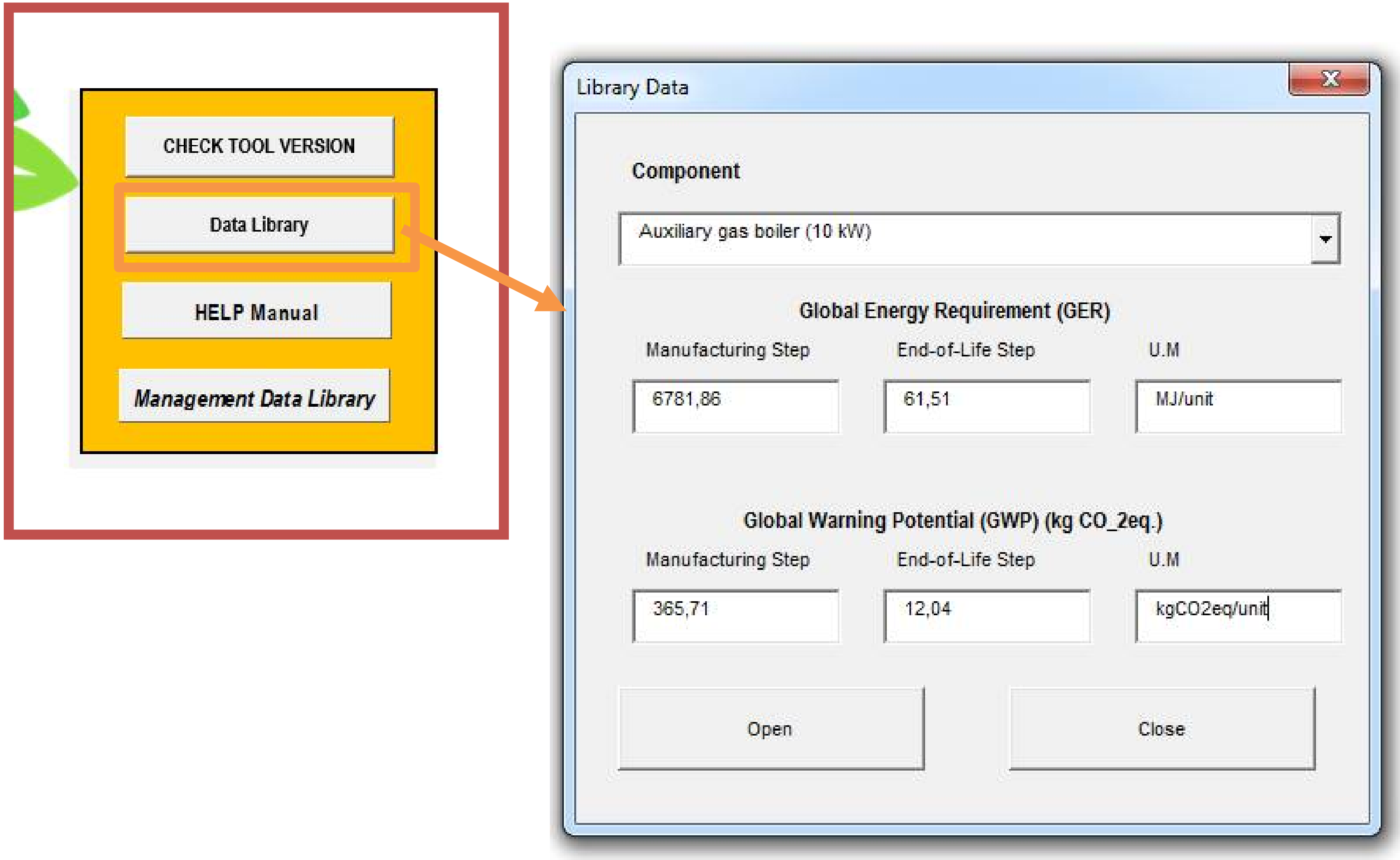
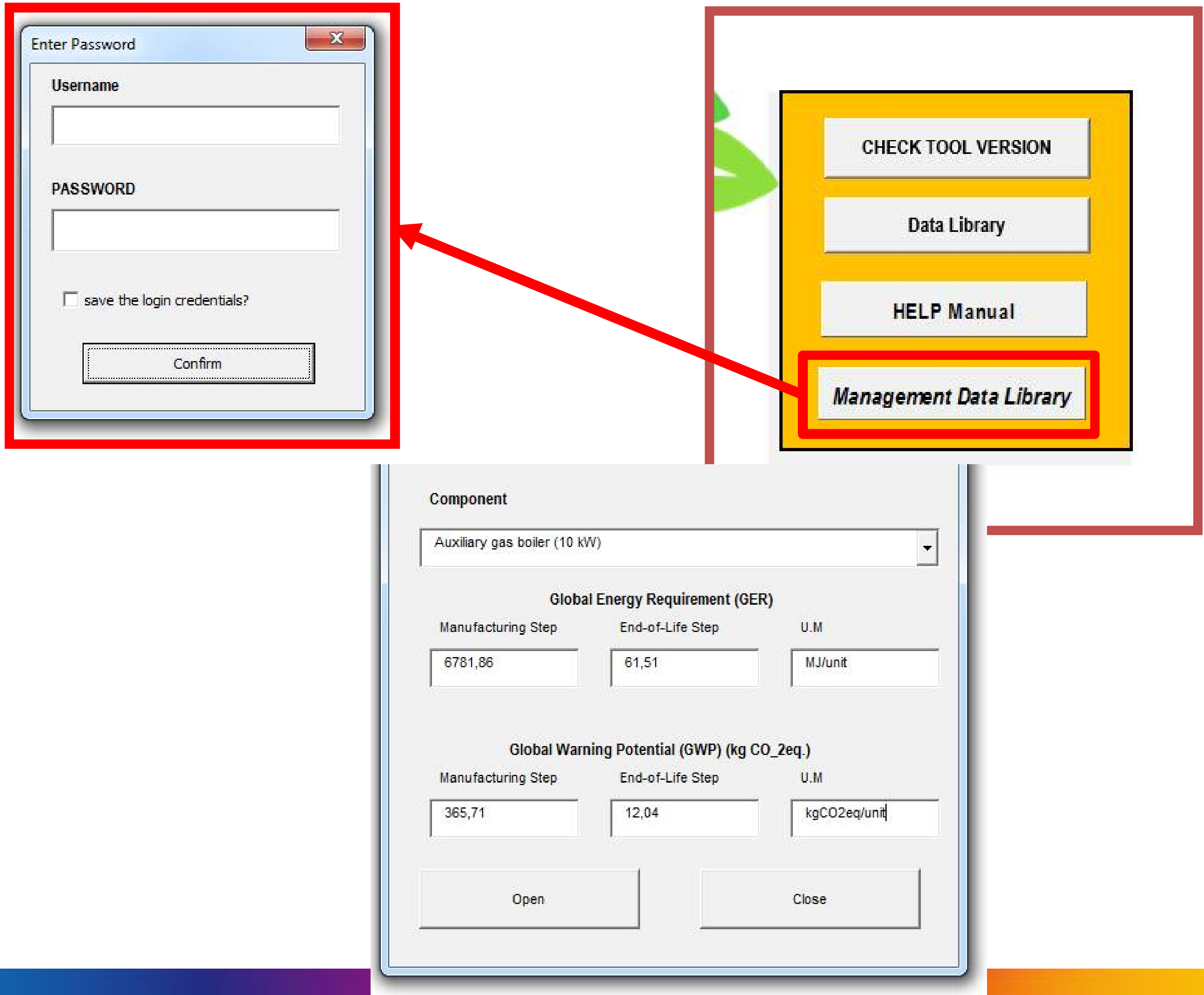

LCA METHOD TOOL
MAIN PAGE
SHC System
SHC System with PV
Conventional System
Conventional System with PV
Impact Comparison
PayBack Indices
RESET ALL
! Recommendation for users: please note that this tool must be used only for academic and research activities
Disclaimer LCA method tool
CHECK TOOL VERSION
Data Library
HELP Manual
Management Data Library


MAIN PAGE
SHC System
SHC System with PV
Conventional System
Conventional System with PV
Impact Comparison
PayBack Indices
RESET ALL
CHECK TOOL VERSION
Data Library
HELP Manual
Management Data Library
Microsoft Excel
Date: 25.09.2014
LCA Method Tool v. 2.0
Property of
TO BE DISCUSSED
OK


CHECK TOOL VERSION
Data Library
HELP Manual
Management Data Library
Library Data
Component
Auxiliary gas boiler (10 kW)
Global Energy Requirement (GER)
Manufacturing Step
End-of-Life Step
U.M
6781,86
61,51
MJ/unit
Global Warning Potential (GWP) (kg CO_2eq.)
Manufacturing Step
End-of-Life Step
U.M
365,71
12,04
kgCO2eq/unit
Open
Close


Enter Password
Username
PASSWORD
save the login credentials?
Confirm
CHECK TOOL VERSION
Data Library
HELP Manual
Management Data Library
Component
Auxiliary gas boiler (10 kW)
Global Energy Requirement (GER)
Manufacturing Step
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6781,86
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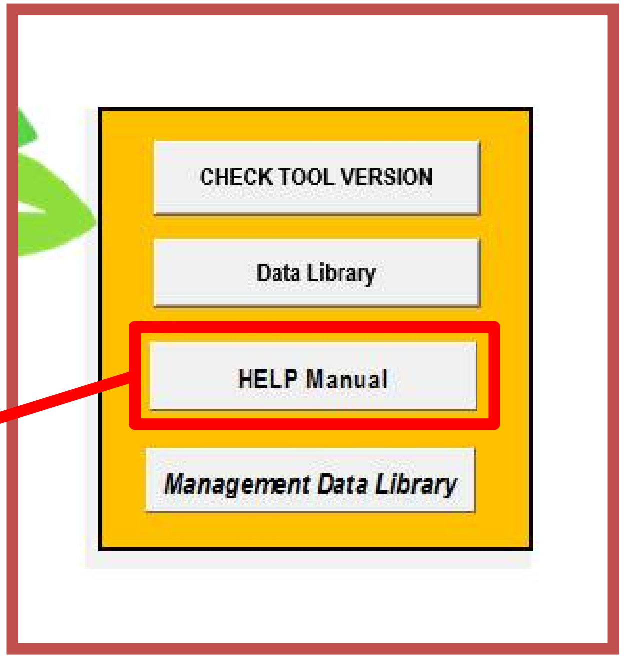
MJ/unit
Global Warning Potential (GWP) (kg CO_2eq.)
Manufacturing Step
End-of-Life Step
U.M
365,71
12,04
kgCO2eq/unit
Open
Close


CHECK TOOL VERSION
Data Library
HELP Manual
Management Data Library


LCA
METHOD TOOL
manual

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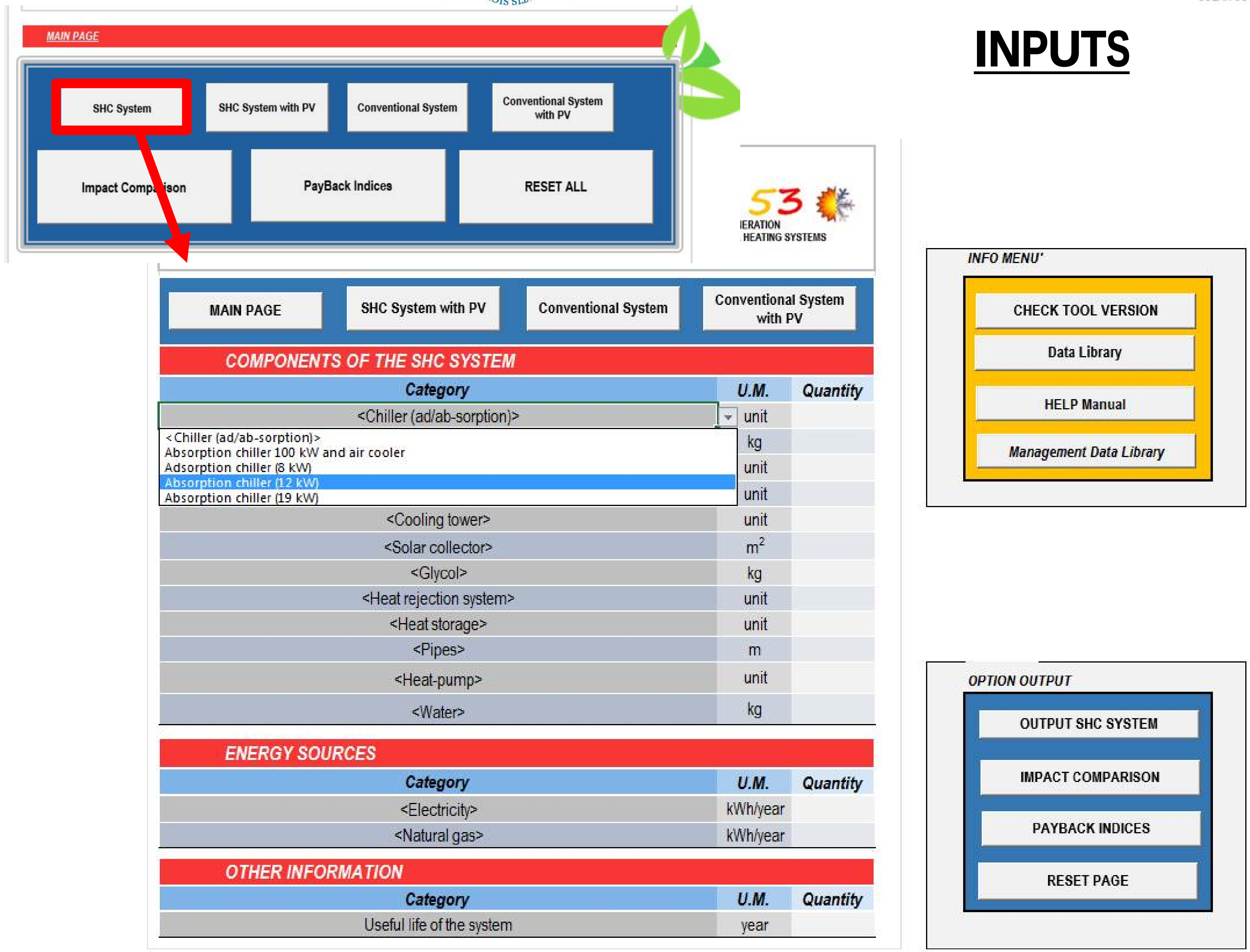
Task 53
NEW GENERATION
SOLAR COOLING & HEATING SYSTEMS

INPUTS



INPUTS

MAIN PAGE | SHC System with PV | Conventional System | Conventional System with PV

COMPONENTS OF THE SHC SYSTEM

Category	U.M.	Quantity	n° REPLACEMENT
Absorption chiller (12 kW)	unit	1.00	
Ammonia	kg	15.00	
Auxiliary conventional chiller (10 kW)	unit	1.00	
Auxiliary gas boiler (10 kW)	unit	1.00	
Cooling tower (32 kW)	unit	1.00	
Evacuated tube collector	m^2	35.00	
<Glycol>	kg		
<Heat rejection system>	unit		
Heat storage (2000 l)	unit	1.00	
Pipes (m)	m	60.00	
Pump (40 W)	unit	8.25	
Water	kg	10.00	

ENERGY SOURCES

Category	U.M.	Quantity
Electricity, low voltage, Italy (including import)	kWh/year	1,117.00
Natural gas, burned in boiler modulating, <100 kW, Europe	kWh/year	414.00

OTHER INFORMATION

Category	U.M.	Quantity
Useful life of the system	year	25.00

INPUTS

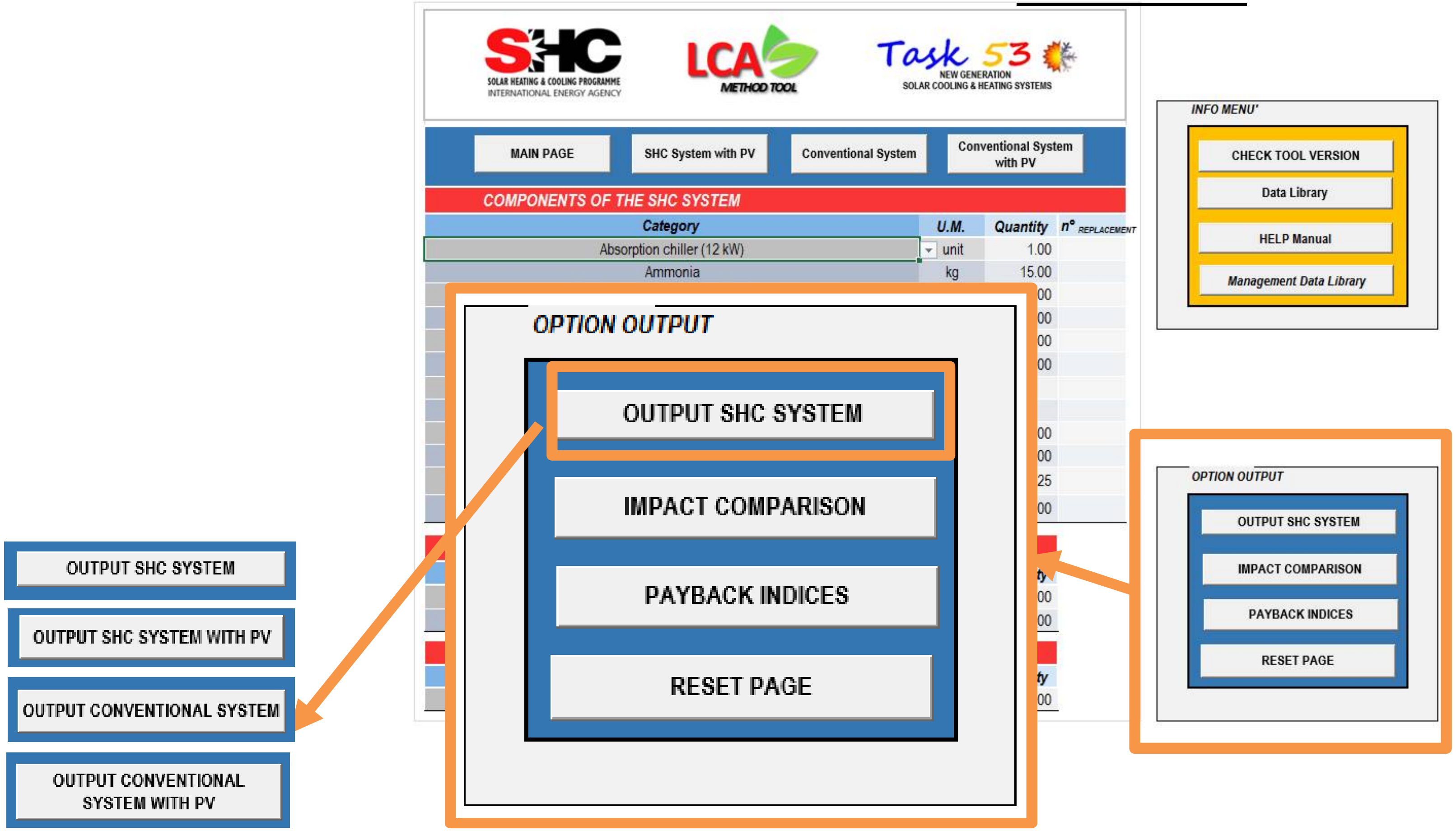
COMPONENTS OF THE SHC SYSTEM		
Category	***U.M.***	***Quantity***
<Chiller (ad/ab-sorption)>	unit	
<Ammonia>	kg	
<Auxiliary Conventional Chiller>	unit	
<Auxiliary Gas Boiler>	unit	
<Cooling tower>	unit	
<Solar collector>	m^2	
<Glycol>	kg	
<Heat rejection system>	unit	
<Heat storage>	unit	
<Pipes>	m	
<Heat-pump>	unit	
<Water>	kg	

COMPONENTS OF THE SHC SYSTEM WITH PV		
Category	***U.M.***	***Quantity***
<Chiller (ad/ab-sorption)>	unit	
<Ammonia>	kg	
<Auxiliary Conventional Chiller>	unit	
<Auxiliary Gas Boiler>	unit	
<Cooling tower>	unit	
<Solar collector>	m^2	
<Glycol>	kg	
<Heat rejection system>	unit	
<Heat storage>	unit	
<Pipes>	m	
<Heat-pump>	unit	
<Water>	kg	
<Battery>	kg	
<Electric installation>	unit	
<Inverter >	unit	
<Photovoltaic panel>	m^2	

COMPONENTS OF THE CONVENTIONAL SYSTEM		
Category	***U.M.***	***Quantity***
<Chiller (conventional)>	unit	
<Gas boiler >	unit	
<Pipes>	m^2	
<Pump>	unit	
<Heat-pump>	m^2	

COMPONENTS OF THE CONVENTIONAL SYSTEM WITH PV		
Category	***U.M.***	***Quantity***
<Battery>	kg	
<Chiller (conventional)>	unit	
<Electric installation>	unit	
<Gas boiler >	unit	
<Inverter >	unit	
<Photovoltaic panel>	m^2	
<Pipes>	m^2	
<Pump>	unit	
<Heat-pump>	m^2	

OUTPUTS

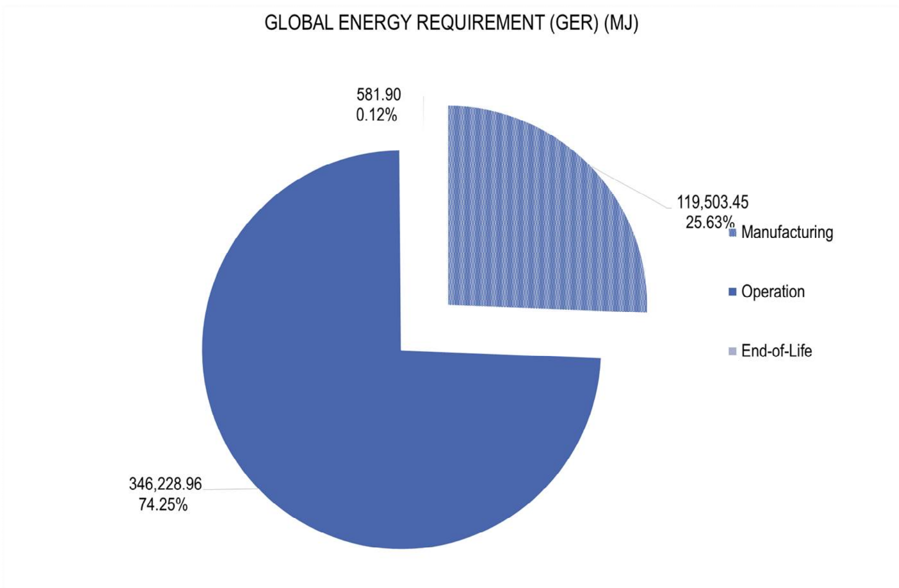

MAIN PAGE
SHC System with PV
Conventional System
Conventional System with PV
COMPONENTS OF THE SHC SYSTEM
Category
U.M.
Quantity
n° REPLACEMENT
Absorption chiller (12 kW)
unit
1.00
Ammonia
kg
15.00
INFO MENU'
CHECK TOOL VERSION
Data Library
HELP Manual
Management Data Library
OPTION OUTPUT
OUTPUT SHC SYSTEM
IMPACT COMPARISON
PAYBACK INDICES
RESET PAGE
OUTPUT SHC SYSTEM
OUTPUT SHC SYSTEM WITH PV
OUTPUT CONVENTIONAL SYSTEM
OUTPUT CONVENTIONAL SYSTEM WITH PV

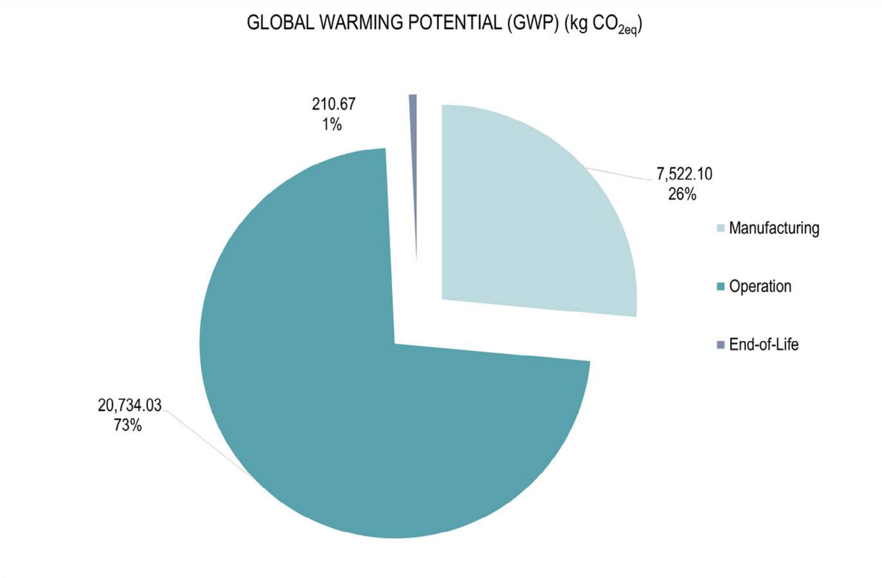
OUTPUTS

COMPONENTS OF THE SHC SYSTEM	GLOBAL ENERGY REQUIREMENT (GER) (MJ)				GLOBAL WARMING POTENTIAL (GWP) (kg $CO_{2,eq}$)			
	Manufacturing	Operation	End-of-Life	Total	Manufacturing	Operation	End-of-Life	Total
Absorption chiller (12 kW)	26,005.37		3.13	26,008.50	1,382.34		12.55	1,394.89
Ammonia	629.30			629.30	31.44			31.44
Auxiliary conventional chiller (10 kW)	8,131.10		7.83	8,138.93	1,550.46		25.82	1,576.28
Auxiliary gas boiler (10 kW)	6,781.86		61.51	6,843.37	365.71		12.04	377.75
Cooling tower (32 kW)	2,950.69		10.74	2,961.43	149.98		3.13	153.11
Evacuated tube collector	55,289.29		454.37	55,743.66	3,043.85		137.94	3,181.78
<Glycol>								
<Heat rejection system>								
Heat storage (2000 l)	14,811.72		21.32	14,833.04	783.31		12.71	796.02
Pipes (m)	3,928.98		19.92	3,948.90	157.98		5.82	163.80
Pump (40 W)	974.95		3.09	978.04	57.03		0.66	57.69
Electricity, low voltage, Italy (including import)		299,835.66		299,835.66		17,970.14		17,970.14
Natural gas, burned in boiler modulating, <100 kW, Europe		46,393.30		46,393.30		2,763.89		2,763.89
Totale	*119,503.45*	*346,228.96*	*581.90*	*466,314.31*	*7,522.10*	*20,734.03*	*210.67*	*28,466.80*

OUTPUTS

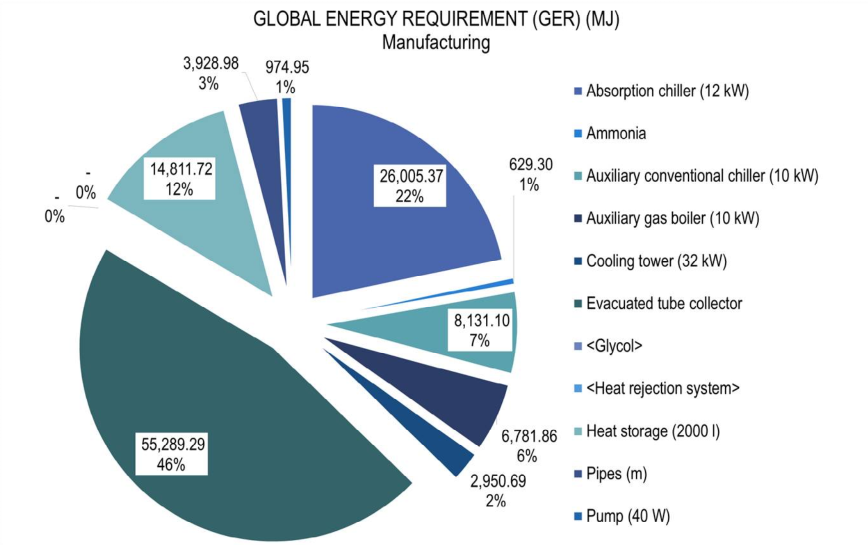
DOMINANCE ANALYSIS FOR THE LIFE CYCLE OF THE SHC SYSTEM

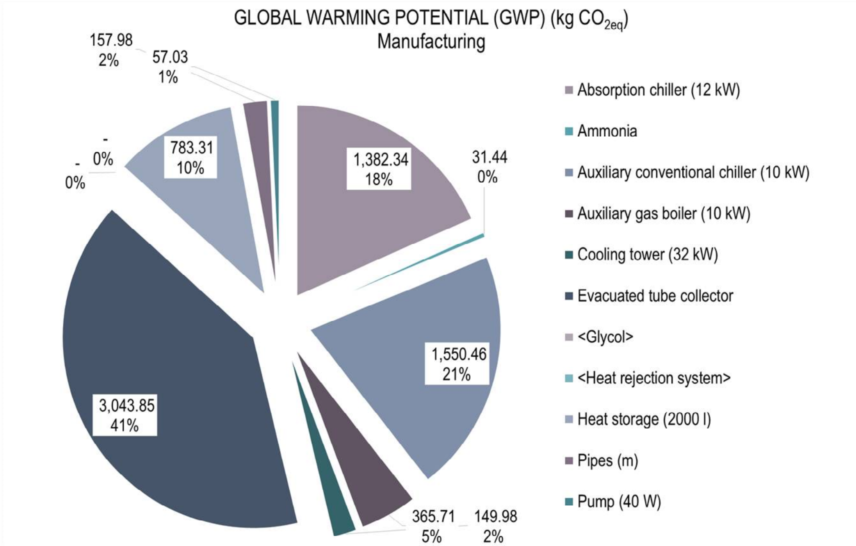




OUTPUTS

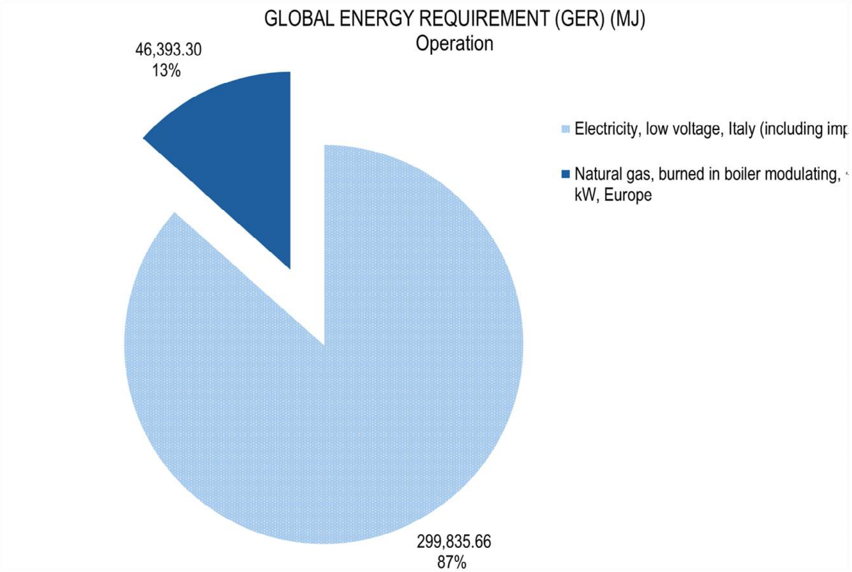
DOMINANCE ANALYSIS FOR THE MANUFACTURING OF THE SHC SYSTEM

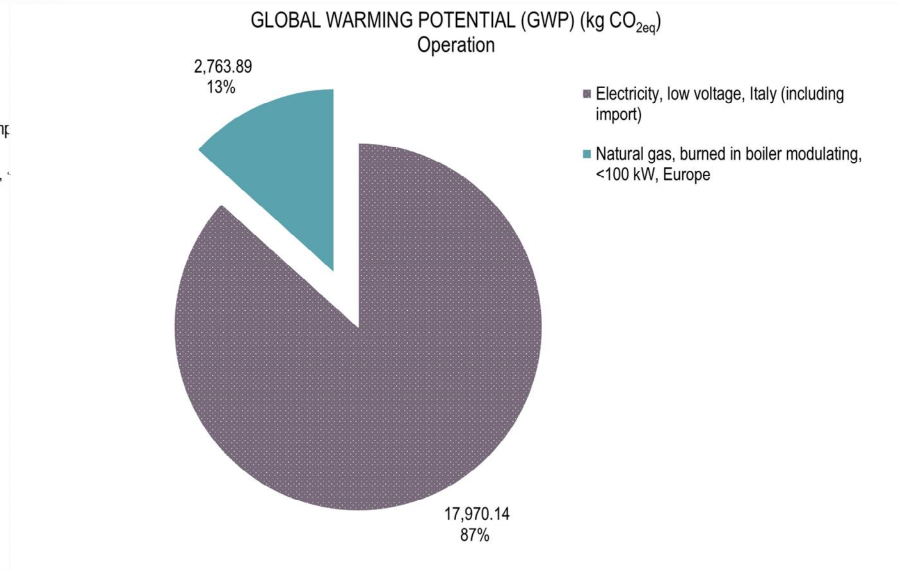




OUTPUTS

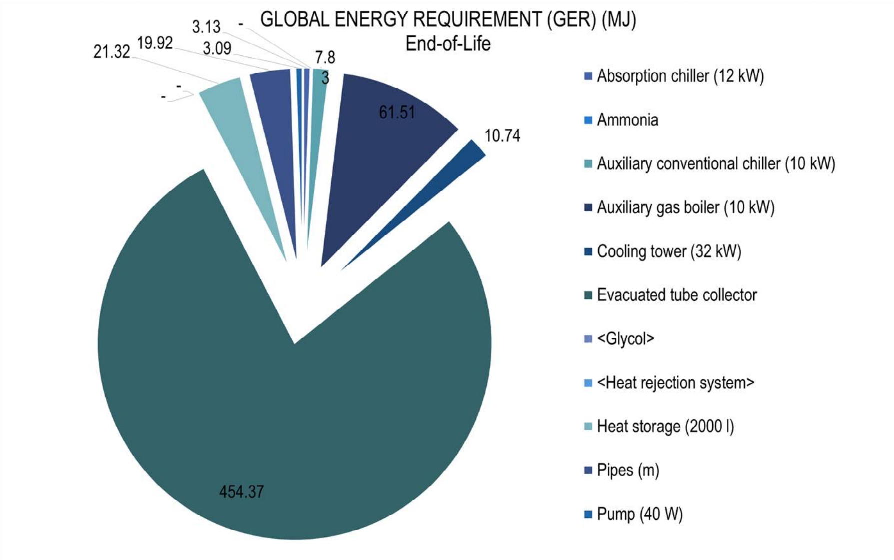
DOMINANCE ANALYSIS FOR THE OPERATION OF THE SHC SYSTEM

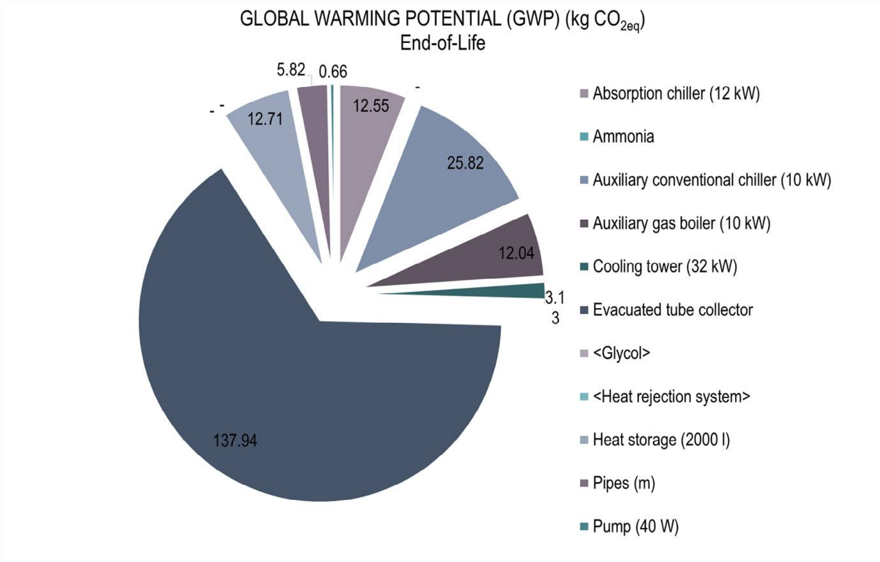




OUTPUTS

DOMINANCE ANALYSIS FOR THE END-OF-LIFE OF THE SHC SYSTEM



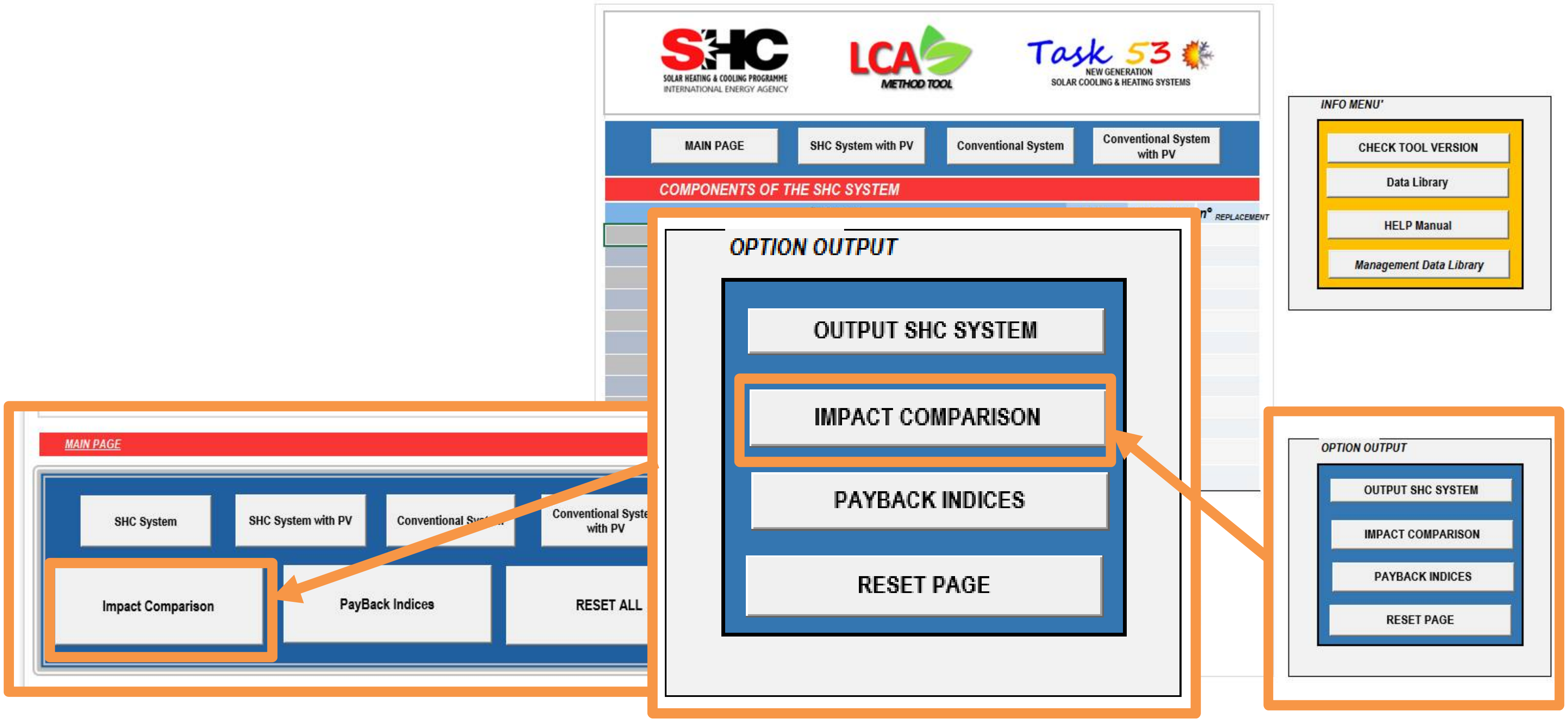


SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

UNIVERSITA' DEGLI STUDI DI PALERMO
DIPARTIMENTO DEIM

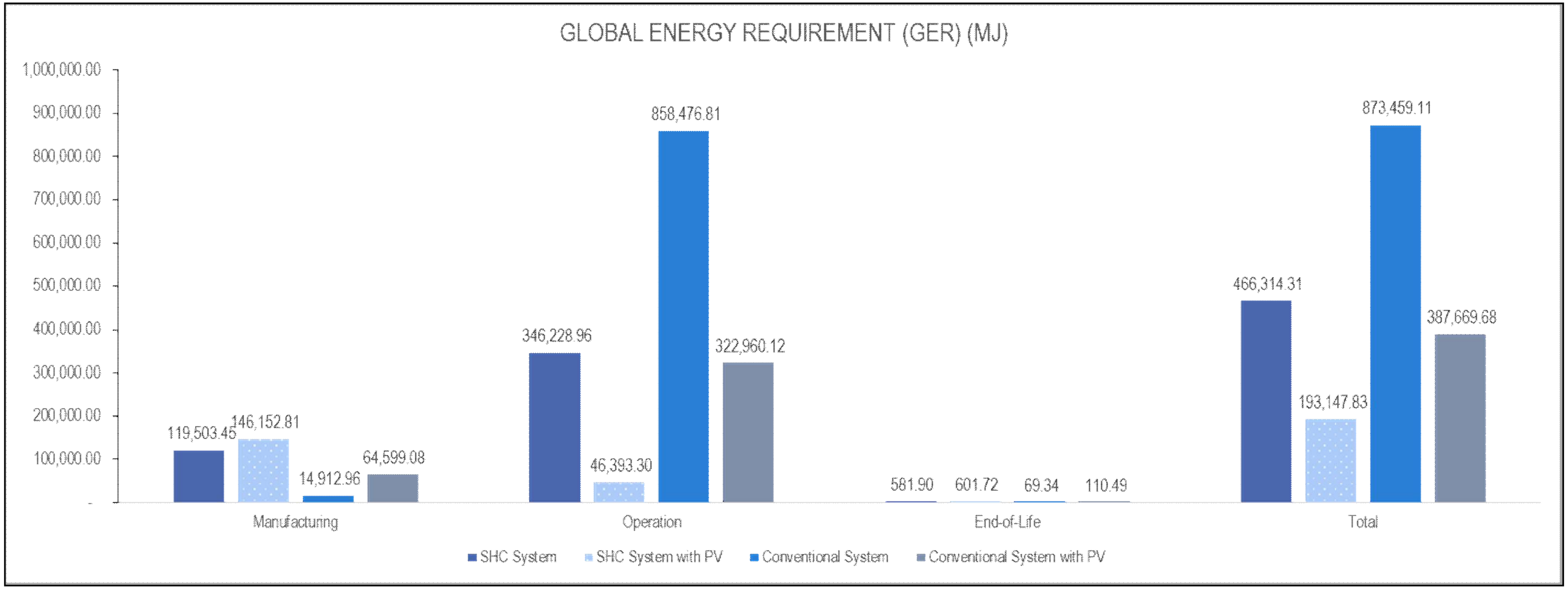
Task 53
NEW GENERATION
SOLAR COOLING & HEATING SYSTEMS

OUTPUTS



OUTPUTS

SYSTEM	GLOBAL ENERGY REQUIREMENT (GER) (MJ)				GLOBAL WARMING POTENTIAL (GWP) (kg CO_{2eq})			
	Manufacturing	Operation	End-of-Life	Total	Manufacturing	Operation	End-of-Life	Total
SHC System	119,503.45	346,228.96	581.90	466,314.31	7,522.10	20,734.03	210.67	28,466.80
SHC System with PV	146,152.81	46,393.30	601.72	193,147.83	8,870.42	2,763.89	276.36	11,910.67
Conventional System	14,912.96	858,476.81	69.34	873,459.11	1,916.17	51,335.67	37.86	53,289.70
Conventional System with PV	64,599.08	322,960.12	110.49	387,669.68	4,430.99	19,240.40	165.08	23,836.46



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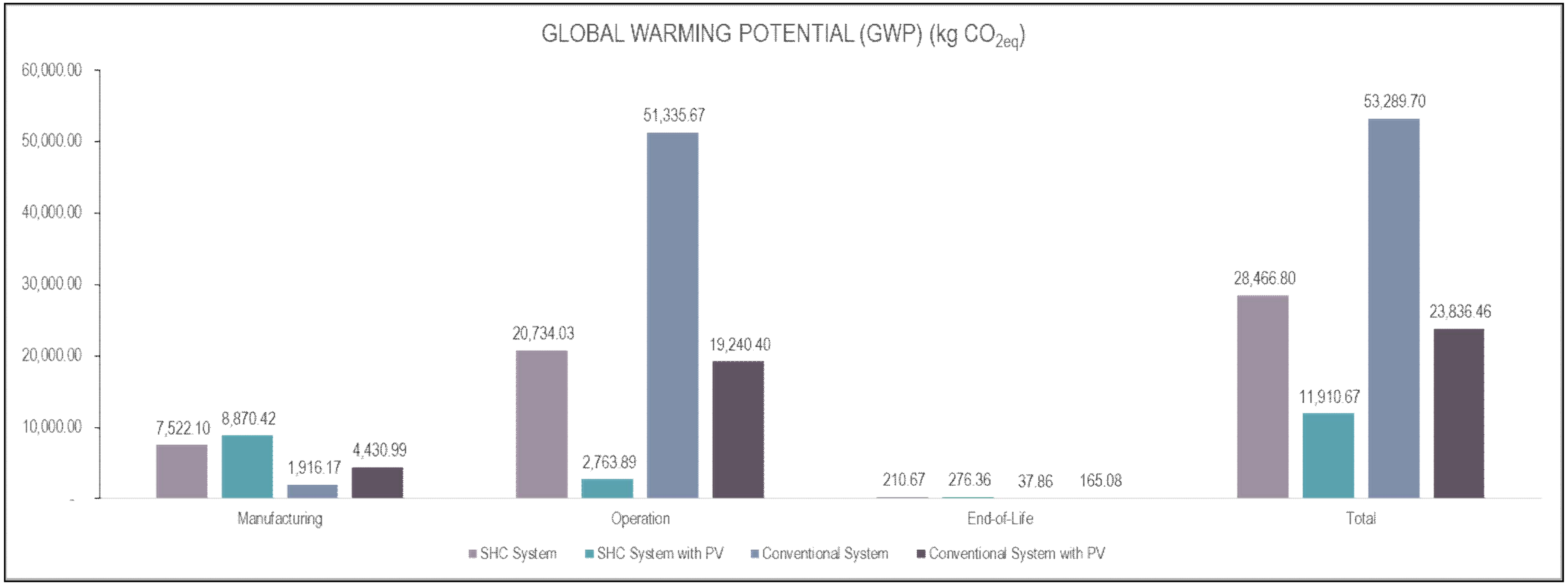
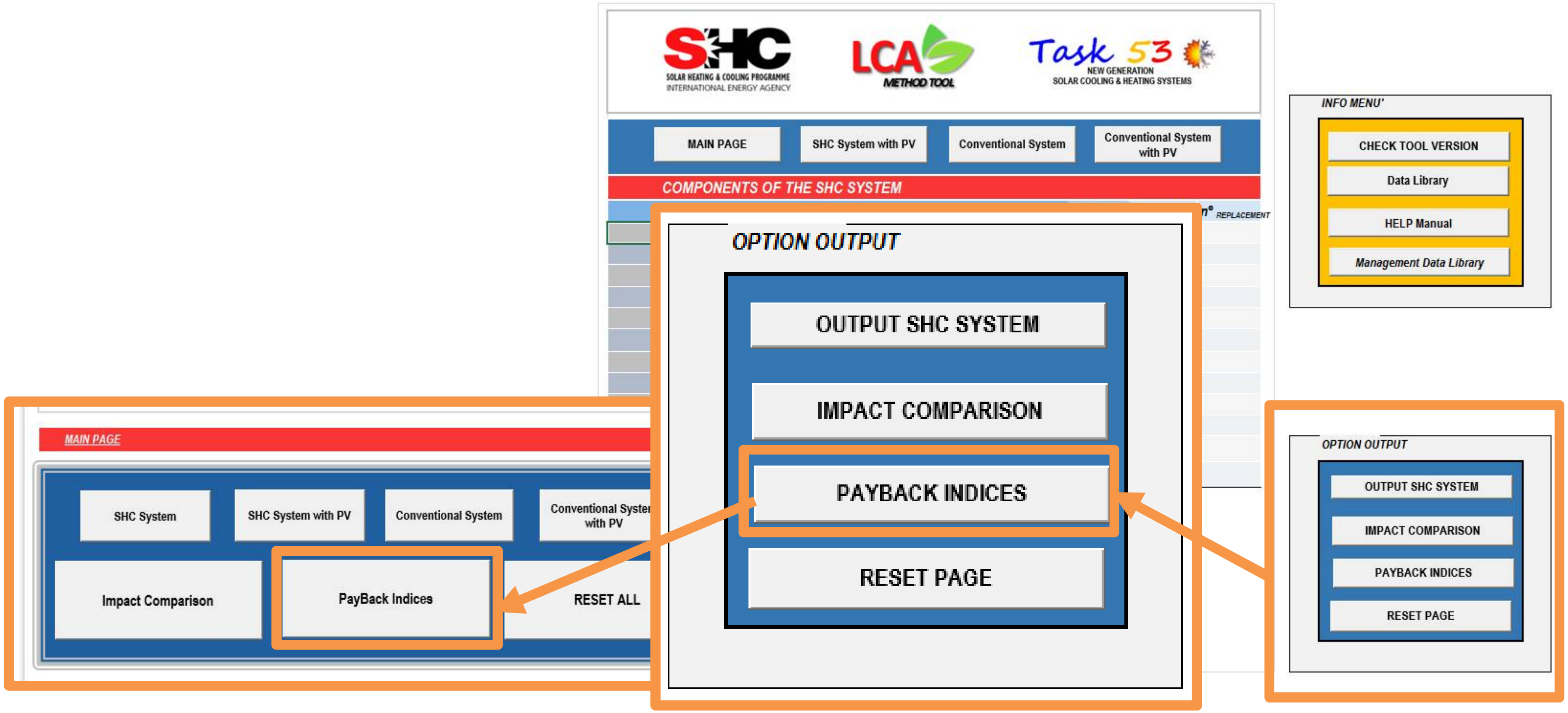


OUTPUTS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INTERNATIONAL ENERGY AGENCY
LCA
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OUTPUTS

Energy Payback Time

Energy Payback Time is defined as the time during which the SHC system must work to harvest as much primary energy as it requires for its manufacturing and end-of-life. The harvested energy is considered as net of the energy expenditure for the system use.

	Energy Payback Time	
	Conventional System	Conventional System with PV
	Energy Payback Time=$(GER_{j\text{-esimo,SHC-system}} - GER_{i\text{-esimo:Conventional-system}})/E_{year}$	
SHC System	5.13	- 59.50
SHC System with PV	4.06	7.42

Energy Return Ratio

Energy Return Ratio represents how many times the energy saving overcomes the global energy consumption due to the SHC system or the SHC system with PV.

	Energy Return Ratio	
	Conventional System	Conventional System with PV
	Energy Return Ratio $=E_{Overal,i\text{-esimo,SHC-system}}/GER_{j\text{-esimo,SHC-system}}$	
SHC System	4.27	- 0.19
SHC System with PV	5.53	1.88

GWP Payback Time

GWP Payback Time is defined as the time during which the avoided GWP impact due to the use of the SHC system or the SHC system with PV is equal to GWP impact caused during its manufacturing and end-of-life.

	GWP Payback Time	
	Conventional System	Conventional System with PV
	GWP Payback Time $=(GWP_{j\text{-esimo,SHC-system}} - GWP_{i\text{-esimo:Conventional-system}})/GWP_{year}$	
SHC System	4.72	- 52.50
SHC System with PV	3.70	6.90

Summary of Values

		Manufacturing and End-of-Life		*Operating Use*		
	SYSTEM	*GER*	*GWP*	*GER*	*GWP*	*years*
1	SHC System	120,085.35	7,732.77	346,228.96	20,734.03	25.00
2	SHC System with PV	146,754.53	9,146.78	46,393.30	2,763.89	25.00
3	Conventional System	14,982.30	1,954.03	858,476.81	51,335.67	25.00
4	Conventional System with PV	64,709.56	4,596.07	322,960.12	19,240.40	25.00

OUTPUTS

Open Info		
E_{year}	GWP_{year}	$E_{Overall}$

NOTE

	E_{year}	
	Conventional System	Conventional System with PV
SHC System	20,489.91	- 930.75
SHC System with PV	32,483.34	11,062.67

NOTE

	GWP_{year}	
	Conventional System	Conventional System with PV
SHC System	1,224.07	- 59.75
SHC System with PV	1,942.87	659.06

NOTE

	EOverall	
	Conventional System	Conventional System with PV
SHC System	512,247.85	- 23,268.85
SHC System with PV	812,083.51	276,566.82

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DIPARTIMENTO DEIM

THANK YOU FOR YOUR ATTENTION

Prof. Marco Beccali, Prof. Maurizio Cellura, Ing. Sonia Longo

Dipartimento di Energia, Ingegneria dell'Informazione e Modelli Matematici
Università degli Studi di Palermo
Viale delle Scienze Ed.9, 90128 Palermo, Italy