

**UNIVERSITÀ DEGLI STUDI DI PALERMO
DIPARTIMENTO DI ENERGIA, INGEGNERIA DELL'INFORMAZIONE E MODELLI
MATEMATICI (DEIM)**

Task 48

Quality assurance and support measures for Solar Cooling

LCA method tool (A2/B3 Activities)

Marco Beccali

LCA METHOD TOOL

MAIN GOAL:
TO DEVELOP A TOOL FOR ASSESSING THE ENERGY AND ENVIRONMENTAL IMPACTS OF SOLAR HEATING AND COOLING AND SOLAR AIR-CONDITIONING SYSTEMS FOLLOWING A LIFE-CYCLE APPROACH

The tool is in XLS format.

LCA METHOD TOOL

Sheet “Index”: It contains a list of the worksheets

Tool LCA draft [modalità compatibilità] - Microsoft Excel uso non commerciale

Home Inserisci Layout di pagina Formule Dati Revisione Visualizza Sviluppo

Calibri 11 A A Testo a capo Generale % 000,00,00 Formattazione condizionale Formatta come tabella Stili cella Inserisci Elimina Formato Celle Somma automatica Riempimento Ordina Trova e e filtra Cancella Modifica

G47 ffx A B C D E F G H I J K

1 SHC SOLAR HEATING & COOLING PROGRAMME INTERNATIONAL ENERGY AGENCY

2 Task 48 Quality Assurance & Support Measures for Solar Cooling Systems

3 LCA METHOD TOOL

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Sheet	Description	Go to the sheet
1	SHC system	Click here
2	Conventional system	Click here
3	Specific impacts SHC system	Click here
4	Specific impacts conventional system	Click here
5	Total impacts SHC system	Click here
6	Total impacts conventional system	Click here
7	Impacts comparison	Click here
8	Payback indices	Click here

11 Key

12 = Input data

13 = Information data

14 = Output data

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SHC SOLAR HEATING & COOLING PROGRAMME INTERNATIONAL ENERGY AGENCY

Task 48

UNIVERSITÀ DEGLI STUDI DI PALERMO

IVARCO BECCARI – Kingston, Canada

12.05.2013

Click on the button to display the worksheet.

LCA METHOD TOOL

Sheet “Index”: It contains a list of the worksheets

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SHC SOLAR HEATING & COOLING PROGRAMME INTERNATIONAL ENERGY AGENCY

Task 48

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IVARCO BECCARI – KINGSTON, Canada

12.05.2013

Click on the symbol to display a brief description of the worksheet.

LCA METHOD TOOL

Sheet “Index”: It contains a list of the worksheets

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Calibri 11 A A Testo a capo Generale % 000,00,00 Formattazione condizionale Formatta come tabella Stili cella Inserisci Elimina Formato Celle Somma automatica Riempimento Ordina Trova e Cancella Cella Modifica

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SHC
SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

LCA METHOD TOOL

Task 48 ☀

Quality Assurance & Support
Measures for Solar Cooling Systems

Sheet	Description	Go to the sheet
1	SHC system	Click here
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7	Impacts comparison	Click here
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Key

- = Input data
- = Information data
- = Output data

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Task 48 ☀

UNIVERSITÀ DEGLI STUDI DI PALERMO

MARCO BECCALI – Kingston, Canada

12.05.2013

LCA METHOD TOOL

Sheet No.1: SHC system

Tool LCA draft [modalità compatibilità] - Microsoft Excel uso non commerciale

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Times New Rom 11 A A Testo a capo Unisci e centra Generale % 000 00 00 00 Formattazione condizionale Formatta come tabella Stili cella Inserisci Elimina Formato Celle Somma automatica Riempimento Ordina e filtra Cancella Trova e seleziona Modifica

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SHC
SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

LCA METHOD TOOL

Task 48 ☀

Quality Assurance & Support
Measures for Solar Cooling Systems

COMPONENTS OF THE SHC SYSTEM

	U.M.	QUANTITY
Absorption chiller (12 kW)	unit	
Absorption chiller (19 kW)	unit	
Adsorption chiller (8 kW)	unit	
Ammonia	kg	
Auxiliary gas boiler (10 kW)	unit	
Auxiliary conventional chiller (10 kW)	unit	
Cooling tower (35 kW)	unit	
Evacuated tube collector	m ²	
Flat plate collector	m ²	
Glycol	l	
Heat storage (2000 l)	unit	
Heat rejection system	unit	
Pipes	m	
Pump (40 W)	unit	
Water	kg	

ENERGY SOURCES

	U.M.	QUANTITY
Electricity	kWh	
Natural gas	kWh	

OTHER INFORMATION

	U.M.	QUANTITY
Useful life of the system	year	

The user has to insert input data related to components that constitute the system.

...energy consumption during the operation step...

...and useful life of the system.

LCA METHOD TOOL

Sheet No.1: SHC system

ENERGY SOURCES	U.M.	QUANTITY
Electricity	kWh	
Electricity, low voltage, Sweden (excluding import) Electricity, low voltage, Switzerland (excluding import) Electricity, low voltage, United Kingdom (excluding import) Electricity, low voltage, Austria (including import) Electricity, low voltage, Belgium (including import) Electricity, low voltage, Bulgaria (including import) Electricity, low voltage, Croatia (including import) Electricity, low voltage, Czech Republic (including import)	MJ	



The user have to select the electricity mix and insert input data related on the electricity consumption during the operation of the SHC system.

ENERGY SOURCES	U.M.	QUANTITY
Electricity	kWh	
Natural gas	MJ	



The user have to select the boiler and insert input data related on the natural gas consumption during the operation of the SHC system.

LCA METHOD TOOL

Sheet No.1: SHC system

Calcolo LCA [modalità compatibilità] - Microsoft Excel uso non commerciale

ABC Controllo Ricerca Thesaurus Traduci ortografia Nuovo commento Elimina Precedente Successivo Mostra/Nascondi commento Mostra tutti i commenti Mostra input penna Proteggi e condividi cartella di lavoro Proteggi cartella di lavoro Condividi Consenti agli utenti la modifica degli intervalli Revisioni Revisioni

G16 A B C D E F G H

An example...

COMPONENTS OF THE SHC SYSTEM		U.M.	QUANTITY
Absorption chiller (12 kW)		unit	1
Absorption chiller (19 kW)		unit	0
Adsorption chiller (8 kW)		unit	0
Ammonia		kg	15
Auxiliary gas boiler (10 kW)		unit	1
Auxiliary conventional chiller (10 kW)		unit	0
Cooling tower (35 kW)		unit	1
Evacuated tube collector		m ²	35
Flat plate collector		m ²	0
Glycol		l	0
Heat storage (2000 l)		unit	1
Heat rejection system		unit	0
Pipes		m	0
Pump (40 W)		unit	6
Water		kg	10

ENERGY SOURCES		U.M.	QUANTITY
Electricity		kWh	24725
Natural gas		kWh	16500

OTHER INFORMATION		U.M.	QUANTITY
Useful life of the system		year	25

Index SHC system Conventional system Specific impacts SHC system Specific impacts conven. system

LCA METHOD TOOL

Sheet No.1: SHC system

Calcolo LCA [modalità compatibilità] - Microsoft Excel uso non commerciale

ABC Controllo ortografia Ricerche Thesaurus Traduci Nuovo commento Elimina Precedente Successivo Mostra/Nascondi commento Mostra tutti i commenti Mostra input penna Proteggi foglio Proteggi cartella di lavoro Condividi cartella di lavoro Proteggi e condividi cartella di lavoro Consenti agli utenti la modifica degli intervalli Revisioni Commenti Revisioni Strumenti di correzione G16 f:

COMPONENTS OF THE SHC SYSTEM		U.M.	QUANTITY
Heat storage (2000 l)	unit	1	
Heat rejection system	unit	0	
Pipes	m ²	0	
Pump (40 W)	l	0	
Water	unit	1	
	unit	0	
	m ²	15	
	l	0	
	unit	0	
	m ²	0	
	l	1	
	unit	35	
	m ²	0	
	l	0	
	unit	0	
	m ²	0	
	l	0	
	unit	6	
	kg	10	

!!! WARNING:
Using multiple units to reach a total size related to a single component can reduce the reliability of results (240 W ≠ 6 x 40 W).

An example...

ENERGY SOURCES		U.M.	QUANTITY
Electricity	kWh	24725	
Natural gas	kWh	16500	

OTHER INFORMATION		U.M.	QUANTITY
Useful life of the system	year	25	

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LCA METHOD TOOL

Sheet No.1: SHC system

Calcolo LCA [modalità compatibilità] - Microsoft Excel uso non commerciale

ABC Controllo Ricerche Thesaurus Traduci ortografia Nuovo commento Elimina Precedente Successivo Mostra/Nascondi commento Mostra tutti i commenti Mostra input penna Proteggi e condividi cartella di lavoro Proteggi cartella di lavoro Condividi cartella di lavoro Consenti agli utenti la modifica degli intervalli Revisioni Revisioni

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9
10 COMPONENTS OF THE SHC SYSTEM U.M. QUANTITY
11 Absorber 1
12 Pump (40 W) unit 0
13 Water kg 6
14
15
16
17
18
19
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21
22
23
24
25
26
27 ENERGY SOURCES U.M. QUANTITY
28 Electricity kWh 24725
29 Natural gas kWh 16500
30
31 OTHER INFORMATION U.M. QUANTITY
32 Useful life of the system year 25
33

An example...

!!! WARNING
Up today any eco-profile of components of solar air-conditioning system are available. My proposal: to cancel this part

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LCA METHOD TOOL

Sheet No.2: Conventional system

The components common to both systems (pumps, pipes, etc.) have not to be included in the analysis.

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Solar Heating & Cooling Systems

COMPONENTS OF THE SHC SYSTEM	U.M.	QUANTITY
Gas boiler	unit	
Conventional chiller	unit	
Electric installation (PV system)	unit	
Photovoltaic panel, a-Si	m ²	
Photovoltaic panel, CdTe	m ²	
Photovoltaic panel, CIS	m ²	
Photovoltaic panel, multi-Si	m ²	
Photovoltaic panel, ribbon-Si	m ²	
Photovoltaic panel, single-Si	m ²	
Inverter 500 W	unit	
Inverter 2500 W	unit	
Inverter 500 kW	unit	
...		

ENERGY SOURCES	U.M.	QUANTITY
Electricity, low voltage, Italy (including import)	kWh	
Natural gas, burned in boiler modulating, <100 kW, Europe	kWh	

The user has to insert input data related to the components that constitute the system...

...and energy consumption during the operation step.

SHC system Conventional system Specific impacts SHC system Specific impacts conven. system Total

Pronto

SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

DEPARTMENT OF
ENERGETICS SCIENCES
DI PALERMO

12.05.2013

LCA METHOD TOOL

Sheet No.2: Conventional system

ENERGY SOURCES	U.M.	QUANTITY
Electricity	kWh	
Electricity, low voltage, Sweden (excluding import) Electricity, low voltage, Switzerland (excluding import) Electricity, low voltage, United Kingdom (excluding import) Electricity, low voltage, Austria (including import) Electricity, low voltage, Belgium (including import) Electricity, low voltage, Bulgaria (including import) Electricity, low voltage, Croatia (including import) Electricity, low voltage, Czech Republic (including import)	MJ	

The user have to select the electricity mix and insert input data related on the electricity consumption during the operation of the conventional system.

ENERGY SOURCES	U.M.	QUANTITY
Electricity	kWh	
Natural gas	MJ	

Natural gas, burned in boiler atmospheric burner non-modulating, <100 kW, Europe
Natural gas, burned in boiler atmospheric low-NOx non-modulating, <100 kW, Europe
Natural gas, burned in boiler condensing modulating, <100 kW, Europe
Natural gas, burned in boiler condensing modulating, >100 kW, Europe
Natural gas, burned in boiler atm. low-NOx condensing non-modulating, <100 kW, Europe
Natural gas, burned in boiler fan burner low-NOx condensing non-modulating, <100 kW, Europe
Natural gas, burned in boiler fan burner non-modulating, <100 kW, Europe
Natural gas, burned in boiler modulating, <100 kW, Europe

The user have to select the boiler and insert input data related on the natural gas consumption during the operation of the conventional system.

LCA METHOD TOOL

Sheet No.2: Conventional system

An example...

COMPONENTS OF THE SHC SYSTEM		U.M.	QUANTITY
Gas boiler (10 kW)		unit	1
Conventional chiller (10 kW)		unit	1
Electric installation (PV system)		unit	
Photovoltaic panel, a-Si		m ²	
Photovoltaic panel, CdTe		m ²	
Photovoltaic panel, CIS		m ²	
Photovoltaic panel, multi-Si		m ²	
Photovoltaic panel, ribbon-Si		m ²	
Photovoltaic panel, single-Si		m ²	
Inverter 500 W		unit	
Inverter 2500 W		unit	
Inverter 500 kW		unit	
...			

ENERGY SOURCES		U.M.	QUANTITY
Electricity, low voltage, Italy (including import)		kWh	49875
Natural gas, burned in boiler modulating, <100 kW, Europe		kWh	68850

LCA METHOD TOOL

Sheet No.3: Specific impacts for SHC system

Calcolo LCA [modalità compatibilità] - Microsoft Excel uso non commerciale						
A15	f(x)	Ammonia				
		GER		GWP		
COMPONENTS	MANUFACTURING STEP	END-OF-LIFE STEP	U.M.	MANUFACTURING STEP	END-OF-LIFE STEP	U.M.
Absorption chiller (12 kW)	26055,37	3,127	MJ/unit	1376,15	12,553	kgCO _{2eq} /unit
Absorption chiller (19 kW)	42850,54	4,690	MJ/unit	1995,87	18,83	kgCO _{2eq} /unit
Adsorption chiller (8 kW)			MJ/unit			kgCO _{2eq} /unit
Ammonia	41,95	0	MJ/kg	2,096	0	kgCO _{2eq} /kg
Auxiliary gas boiler (10 kW)	6781,86	61,511	MJ/unit	363,67	12,039	kgCO _{2eq} /unit
Auxiliary conventional chiller (10 kW)	8131,09	7,833	MJ/unit	1656,87	25,826	kgCO _{2eq} /unit
Cooling tower (35 kW)	2950,69	0	MJ/unit	151,35	0	kgCO _{2eq} /unit
Evacuated tube collector	1579,69	12,982	MJ/m ²	86,52	3,931	kgCO _{2eq} /m ²
Flat plate collector			MJ/m ²			kgCO _{2eq} /m ²
Glycol			MJ/l			kgCO _{2eq} /l
Heat storage (2000 l)	14811,72	21,316	MJ/unit	777,54	12,712	kgCO _{2eq} /unit
Heat rejection system			MJ/unit			kgCO _{2eq} /unit
Pipes			MJ/m			kgCO _{2eq} /m
Pump (40 W)	118,17	0,374	MJ/unit	6,871	0,084	kgCO _{2eq} /unit
Water	0,019	0	MJ/kg	7,94E-04	0	kgCO _{2eq} /kg
		GER		GWP		
ENERGY SOURCES	QUANTITY	U.M.	QUANTITY	U.M.		
Electricity						

LCA METHOD TOOL

Sheet No.3: Specific impacts for SHC system

The screenshot shows a Microsoft Excel spreadsheet titled "Calcolo LCA [modalità compatibilità] - Microsoft Excel". The table is organized into columns: ENERGY SOURCES, QUANTITY (GER), U.M., QUANTITY (GWP), and U.M. The rows list various electricity sources from different countries, each with its quantity and unit of measurement. A callout bubble highlights the text "49 eco-profiles of electricity for 25 localities.".

ENERGY SOURCES	QUANTITY	U.M.	QUANTITY	U.M.
			GER	GWP
Electricity, low voltage, Europe	12,288	MJ/kWh	0,561	kg CO _{2eq} /kWh
Electricity, low voltage, Austria (excluding import)	8,065	MJ/kWh	0,354	kg CO _{2eq} /kWh
Electricity, low voltage, Belgium (excluding import)	12,512	MJ/kWh	0,363	kg CO _{2eq} /kWh
Electricity, low voltage, Bulgaria (excluding import)	15,523	MJ/kWh	0,786	kg CO _{2eq} /kWh
Electricity, low voltage, Croatia (excluding import)	10,837	MJ/kWh	0,421	kg CO _{2eq} /kWh
Electricity, low voltage, Czech Republic (excluding import)	13,190	MJ/kWh	0,882	kg CO _{2eq} /kWh
Electricity, low voltage, Denmark (excluding import)	10,735	MJ/kWh	0,691	kg CO _{2eq} /kWh
Electricity, low voltage, Finland (excluding import)	12,490	MJ/kWh	0,434	kg CO _{2eq} /kWh
Electricity, low voltage, France (excluding import)	13,627	MJ/kWh	0,105	kg CO _{2eq} /kWh
Electricity, low voltage, Germany (excluding import)	12,662	MJ/kWh	0,744	kg CO _{2eq} /kWh
Electricity, low voltage, Greece (excluding import)	18,658	MJ/kWh	1,175	kg CO _{2eq} /kWh
Electricity, low voltage, Hungary (excluding import)	17,051	MJ/kWh	0,829	kg CO _{2eq} /kWh
Electricity, low voltage, Ireland (excluding import)	13,059	MJ/kWh	0,897	kg CO _{2eq} /kWh
Electricity, low voltage, Italy (excluding import)	10,705	MJ/kWh	0,716	kg CO _{2eq} /kWh
Electricity, low voltage, Luxembourg (excluding import)	10,816	MJ/kWh	0,599	kg CO _{2eq} /kWh
Electricity, low voltage, Netherlands (excluding import)	11,845	MJ/kWh	0,742	kg CO _{2eq} /kWh
Electricity, low voltage, Poland (excluding import)	16,050	MJ/kWh	1,365	kg CO _{2eq} /kWh
Electricity, low voltage, Portugal (excluding import)	11,519	MJ/kWh	0,711	kg CO _{2eq} /kWh
Electricity, low voltage, Romania (excluding import)	12,420	MJ/kWh	0,803	kg CO _{2eq} /kWh
Electricity, low voltage, Slovakia (excluding import)	12,809	MJ/kWh	0,411	kg CO _{2eq} /kWh
Electricity, low voltage, Slovenia (excluding import)	10,385	MJ/kWh	0,557	kg CO _{2eq} /kWh

LCA METHOD TOOL

Sheet No.3: Specific impacts for SHC system

Calcolo LCA [modalità compatibilità] - Microsoft Excel uso non commerciale						
A15	f(x)	Ammonia				
	A	B	C	D	E	F
73	Electricity, low voltage, Romania (including import)	12,499	MJ/kWh	0,806	kg CO _{2eq} /kWh	
74	Electricity, low voltage, Slovakia (including import)	11,932	MJ/kWh	0,502	kg CO _{2eq} /kWh	
75	Electricity, low voltage, Slovenia (including import)	9,950	MJ/kWh	0,485	kg CO _{2eq} /kWh	
76	Electricity, low voltage, Spain (including import)	12,208	MJ/kWh	0,593	kg CO _{2eq} /kWh	
77	Electricity, low voltage, Sweden (including import)	10,655	MJ/kWh	0,101	kg CO _{2eq} /kWh	
78	Electricity, low voltage, Switzerland (including import)	10,983	MJ/kWh	0,148	kg CO _{2eq} /kWh	
79	Electricity, low voltage, United Kingdom (including import)	12,410	MJ/kWh	0,684	kg CO _{2eq} /kWh	
80	Natural gas					
81	Natural gas, burned in boiler atmosferic low-NOx condensing non-modulating, <100 kW, Europe	4,609	MJ/kWh	0,269	kg CO _{2eq} /kWh	
82	Natural gas, burned in boiler atmosferic burner non-modulating, <100 kW, Europe	4,443	MJ/kWh	0,262	kg CO _{2eq} /kWh	
83	Natural gas, burned in boiler condensing modulating, <100 kW, Europe	4,482	MJ/kWh	0,263	kg CO _{2eq} /kWh	
84	Natural gas, burned in boiler condensing modulating, >100 kW, Europe	4,304	MJ/kWh	0,245	kg CO _{2eq} /kWh	
85	Natural gas, burned in boiler fan burner low-Nox non-modulating, <100 kW, Europe	4,737	MJ/kWh	0,275	kg CO _{2eq} /kWh	
86	Natural gas, burned in boiler fan burner non-modulating, <100 kW, Europe	4,482	MJ/kWh	0,263	kg CO _{2eq} /kWh	
87	Natural gas, burned in boiler modulating, <100 kW, Europe	4,482	MJ/kWh	0,263	kg CO _{2eq} /kWh	
88	Natural gas, burned in boiler modulating, >100 kW, Europe	4,304	MJ/kWh	0,245	kg CO _{2eq} /kWh	
89	Natural gas, burned in industrial furnace, >100 kW, Europe	4,304	MJ/kWh	0,245	kg CO _{2eq} /kWh	
90	Natural gas, burned in industrial furnace low-NOx, >100 kW, Europe	4,444	MJ/kWh	0,251	kg CO _{2eq} /kWh	
91						
92						
93						
94						
95						
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97						

10 eco-profiles of
natural gas for the
European context.

LCA METHOD TOOL

Sheet No.4: Specific impacts for conventional system

Tool LCA draft [modalità compatibilità] - Microsoft Excel uso non commerciale						
ABC		Commenti		Revisioni		
Controllo ortografia	Ricerca Thesaurus Traduci	Modifica commento	Elimina Precedente Successivo	Mostra/Nascondi commento	Mostra tutti i commenti	Mostra input penna
Strumenti di correzione				Proteggi foglio	Proteggi cartella di lavoro	Condividi cartella di lavoro
					Consenti agli utenti la modifica degli intervalli	Revisioni
A11	f.x	COMPONENTS	B	C	D	E
1			Task 48			
2		SOLAR HEATING & COOLING PROGRAMME		Quality Assurance & Support		
3		INTERNATIONAL ENERGY AGENCY		Measures for Solar Cooling Systems		
4						
10			GER		GWP	
11	COMPONENTS		MANUFACTURING STEP	END-OF-LIFE STEP	U.M.	MANUFACTURING STEP
12	Gas boiler (10 kW)		6781,86	61,51	MJ/unit	363,67
13	Conventional chiller (10 kW)		8131,09	7,83	MJ/unit	1656,87
14	Electric installation (PV system)				MJ/unit	
15	Photovoltaic panel, a-Si				MJ/m ²	
16	Photovoltaic panel, CdTe				MJ/m ²	
28			GER		GWP	
29	ENERGY SOURCES		QUANTITY	U.M.	QUANTITY	U.M.
30	Electricity					
31	Electricity, low voltage, Europe		12,288	MJ/kWh	0,561	kg CO _{2eq} /kWh
32	Electricity, low voltage, Austria (excluding import)		8,065	MJ/kWh	0,354	kg CO _{2eq} /kWh
33	Electricity, low voltage, Belgium (excluding import)		12,512	MJ/kWh	0,363	kg CO _{2eq} /kWh
80	Natural gas					
81	Natural gas, burned in boiler atmosferic low-NOx condensing non-modulating, <100 kW, Europe		4,609	MJ/kWh	0,269	kg CO _{2eq} /kWh
82	Natural gas, burned in boiler atmosferic burner non-modulating, <100 kW, Europe		4,443	MJ/kWh	0,262	kg CO _{2eq} /kWh
83	Natural gas, burned in boiler condensing modulating, <100 kW, Europe		4,482	MJ/kWh	0,263	kg CO _{2eq} /kWh
84	Natural gas, burned in boiler condensing modulating, >100 kW, Europe		4,304	MJ/kWh	0,245	kg CO _{2eq} /kWh
85	Natural gas, burned in boiler fan burner low-Nox non-modulating, <100 kW, Europe		4,737	MJ/kWh	0,275	kg CO _{2eq} /kWh
86	Natural gas, burned in boiler fan burner non-modulating, <100 kW, Europe		4,482	MJ/kWh	0,263	kg CO _{2eq} /kWh

LCA METHOD TOOL

Sheet No.5: Total impacts for SHC system

The screenshot shows a Microsoft Excel-like spreadsheet titled "LCA METHOD TOOL". The title bar includes the SHC logo and "SOLAR HEATING & COOLING PROGRAMME INTERNATIONAL ENERGY AGENCY". The main content area displays a table with the following columns: "COMPONENTS OF THE SHC SYSTEM", "GER (MJ)", "Manufacturing", "Operation", "End-of-Life", and "Total". The "Total" column is highlighted with a red border and has a blue arrow pointing to it from the text "The tool shows: 1) The total impact for each component/energy source;". The table lists various components and their energy requirements:

COMPONENTS OF THE SHC SYSTEM	GER (MJ)	Manufacturing	Operation	End-of-Life	Total
Absorption chiller (12 kW)	26055,37	-	3,13	26058,50	
Absorption chiller (19 kW)	0,00	-	0,00	0,00	
Adsorption chiller (8 kW)	0,00	-	0,00	0,00	
Ammonia	629,25	-	0,00	629,25	
Auxiliary gas boiler (10 kW)	6781,86	-	61,51	6843,37	
Auxiliary conventional chiller (10 kW)	0,00	-	0,00	0,00	
Cooling tower (35 kW)	2950,69	-	0,00	2950,69	
Evacuated tube collector	55289,15	-	454,30	55743,45	
Flat plate collector	0,00	-	0,00	0,00	
Glycol	0,00	-	0,00	0,00	
Heat storage (2000 l)	14811,72	-	21,31	14833,03	
Heat rejection system	0,00	-	0,00	0,00	
Pipes	0,00	-	0,00	0,00	
Pump (40 W)	709,02	-	2,22	711,24	
Water	0,19	-	0,00	0,19	
Electricity	-	264681,13	-	264681,13	
Natural gas	-	73953,00	-	73953,00	
Total	107227,25	338634,13	542,47	446403,85	

The tool shows:

- 1) The total impact for each component/energy source;

LCA METHOD TOOL

Sheet No.5: Total impacts for SHC system

The screenshot shows a Microsoft Excel-like spreadsheet titled "LCA METHOD TOOL". The title bar includes the "SHC SOLAR HEATING & COOLING PROGRAMME INTERNATIONAL ENERGY AGENCY" logo and the text "Task Quality Ass. Measures for S". The main content is a table with the following columns:

COMPONENTS OF THE SHC SYSTEM	GER (MJ)			Total
	Manufacturing	Operation	End-of-Life	
Absorption chiller (12 kW)	26055,37	-	3,13	26058,50
Absorption chiller (19 kW)	0,00	-	0,00	0,00
Adsorption chiller (8 kW)	0,00	-	0,00	0,00
Ammonia	629,25	-	0,00	629,25
Auxiliary gas boiler (10 kW)	6781,86	-	61,51	6843,37
Auxiliary conventional chiller (10 kW)	0,00	-	0,00	0,00
Cooling tower (35 kW)	2950,69	-	0,00	2950,69
Evacuated tube collector	55289,15	-	454,30	55743,45
Flat plate collector	0,00	-	0,00	0,00
Glycol	0,00	-	0,00	0,00
Heat storage (2000 l)	14811,72	-	21,31	14833,03
Heat rejection system	0,00	-	0,00	0,00
Pipes	0,00	-	0,00	0,00
Pump (40 W)	709,02	-	2,22	711,24
Water	0,19	-	0,00	0,19
Electricity	-	264681,13	-	264681,13
Natural gas	-	73953,00	-	73953,00
Total	107227,25	338634,13	542,47	446403,85

The tool shows:

- 1) The total impact for each component/energy source;**
- 2) The impact for the manufacturing and end-of-life of each component of the system;**

LCA METHOD TOOL

Sheet No.5: Total impacts for SHC system

GER (MJ)				
COMPONENTS OF THE SHC SYSTEM	Manufacturing	Operation	End-of-Life	Total
Absorption chiller (12 kW)	26055,37	-	3,13	26058,50
Absorption chiller (19 kW)	0,00	-	0,00	0,00
Adsorption chiller (8 kW)	0,00	-	0,00	0,00
Ammonia	629,25	-	0,00	629,25
Auxiliary gas boiler (10 kW)	6781,86	-	61,51	6843,37
Auxiliary conventional chiller (10 kW)	0,00	-	0,00	0,00
Cooling tower (35 kW)	2950,69	-	0,00	2950,69
Evacuated tube collector	55289,15	-	454,30	55743,45
Flat plate collector	0,00	-	0,00	0,00
Glycol	0,00	-	0,00	0,00
Heat storage (2000 l)	14811,72	-	21,31	14833,03
Heat rejection system	0,00	-	0,00	0,00
Pipes	0,00	-	0,00	0,00
Pump (40 W)	709,02	-	2,22	711,24
Water	0,19	-	0,00	0,19
Electricity	-	264681,13		264681,13
Natural gas	73052,00			73953,00
Total	107227,25	338634,13	542,47	446403,85

The tool shows:

- 1) The total impact for each component/energy source;**
- 2) The impact for the manufacturing and end-of-life of each component of the system;**
- 3) The total impact for each life-cycle step (manufacturing, operation, end-of-life);**

LCA METHOD TOOL

Sheet No.5: Total impacts for SHC system

COMPONENTS OF THE SHC SYSTEM	GER (MJ)			
	Manufacturing	Operation	End-of-Life	Total
Absorption chiller (12 kW)	26055,37	-	3,13	26058,50
Absorption chiller (19 kW)	0,00	-	0,00	0,00
Adsorption chiller (8 kW)	0,00	-	0,00	0,00
Ammonia	629,25	-	0,00	629,25
Auxiliary gas boiler (10 kW)	6781,86	-	61,51	6843,37
Auxiliary conventional chiller (10 kW)	0,00	-	0,00	0,00
Cooling tower (35 kW)	2950,69	-	0,00	2950,69
Evacuated tube collector	55289,15	-	454,30	55743,45
Flat plate collector	0,00	-	0,00	0,00
Glycol	0,00	-	0,00	0,00
Heat storage (2000 l)	14811,72	-	21,31	14833,03
Heat rejection system	0,00	-	0,00	0,00
Pipes	0,00	-	0,00	0,00
Pump (40 W)	709,02	-	2,22	711,24
Water	0,19	-	0,00	0,19
Electricity	-	264681,13	-	264681,13
Natural gas	-	73953,00	-	73953,00
Total	107227,25	338634,13	542,47	446403,85

The tool shows:

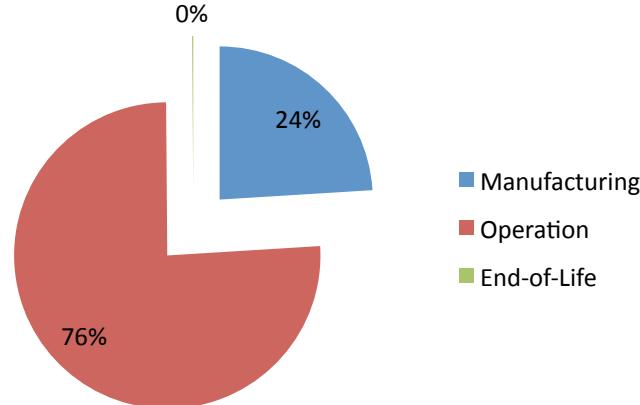
- 1) The total impact for each component/energy source;**
- 2) The impact for the manufacturing and end-of-life of each component of the system;**
- 3) The total impact for each life-cycle step (manufacturing, operation, end-of-life);**
- 4) The total impact for the life-cycle of the SHC system.**

LCA METHOD TOOL

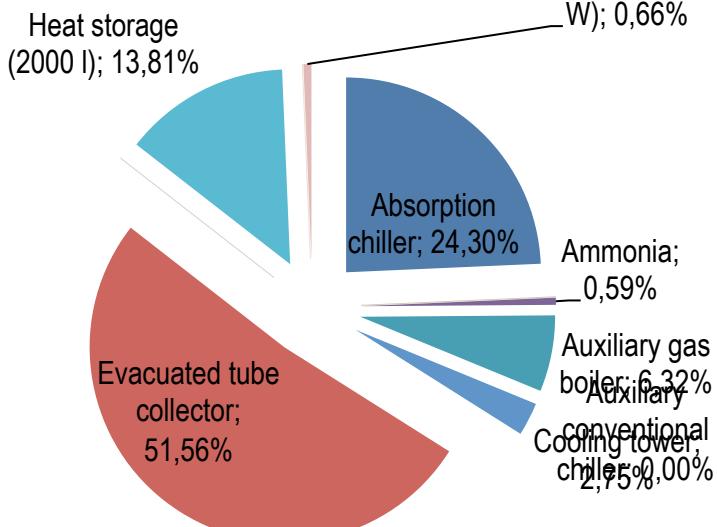
Sheet No.5: Total impacts for SHC system

A picture of results...

Life cycle impacts – GER (%)



Manufacturing step - GER (%)

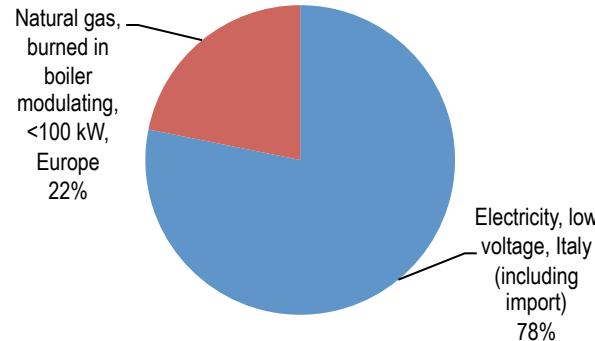


LCA METHOD TOOL

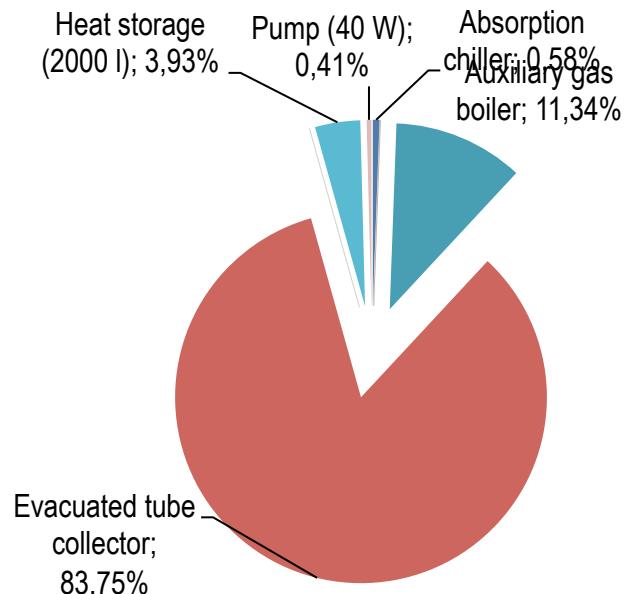
Sheet No.5: Total impacts for SHC system

A picture of results...

Operation step - GER (%)



End-of-life step - GER (%)



LCA METHOD TOOL

Sheet No.6: Total impacts for conventional system

In a similar way to the SHC system, the tool shows the impacts for conventional system:

- 1)The total impact for each component/energy source;**
- 2) The impact for the manufacturing and end-of-life of each component of the system;**
- 3) The total impact for each life-cycle step (manufacturing, operation, end-of-life);**
- 4) The total impact for the life-cycle of the SHC system;**
- 5) A picture of results.**

LCA METHOD TOOL

Sheet No.7: Impacts comparison

Tool LCA draft [modalità compatibilità] - Microsoft Excel uso non commerciale

Home Inserisci Layout di pagina Formule Dati Revisione Visualizza Sviluppo

Calibri 11 Testo a capo Generale

Appunti Carattere Allineamento Numeri

Incolla Formattazione condizionale Formatta Stili

Incolla Formattazione come tabella Stili cella

Appunti Inserisci Elimina Formato Celle

Σ Somma automatica Riempimento Ordina e filtra Trova e seleziona Modifica

N9

1 SHC SOLAR HEATING & COOLING PROGRAMME INTERNATIONAL ENERGY AGENCY

2 LCA METHOD TOOL

3 Task 48 ☀

4 Quality Assurance & Support

5 Measures for Solar Cooling Systems

6

7

8

9

10 System GER (MJ) GWP (kg CO₂,r.)

11 Manufacturing Operation End-of-Life Total Manufacturing Operation End-of-Life Total

12 SHC system 107227,25 338634,13 542,47 446403,85 5769,49 22042,60 175,33 27987,42

13 Conventional system 14912,95 842497,58 69,34 857479,87 2020,54 53818,05 37,86 55876,45

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400000
300000
200000
100000
0

107227,25 14912,95 338634,13 842497,58 542,47 69,34

Manufacturing Operation End-of-life

■ SHC system ■ Conventional system

GWP

60000
50000
40000
30000
20000
10000
0

5769,49 2020,54 22042,60 53818,05 175,33 37,86

Manufacturing Operation End-of-life

■ SHC system ■ Conventional system

Total impacts SHC system Total impacts convent. system Impacts comparison Payback indices

12.05.2013

LCA METHOD TOOL

Sheet No.8: Payback indices

Calcolo LCA [modalità compatibilità] - Microsoft Excel uso non commerciale

A B C D E F G H I J K L

INTERNATIONAL ENERGY AGENCY

Energy Payback Time=(GER _{SHC-system} -GER _{Conventional-system})/E _{year}		
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 production and disposal. The harvest energy is considered as net of the energy expenditure for the system use.		
GER _{SHC-system}	=	107769,72 MJ
GER _{Conventional-system}	=	14982,29 MJ
E _{year}	=	20154,538 MJ/year
Energy Payback Time =		4,60379841 year

GWP Payback Time=(GWP _{SHC-system} -GWP _{Conventional-system})/GWP _{year}		
GWP Payback Time is defined as the time during which the avoided GWP impact due to the use of the SHC system is equal to GWP impact caused during its production and disposal		
GWP _{SHC-system}	=	5944,82 kgCO _{2eq}
GWP _{Conventional-system}	=	2058,40 kgCO _{2eq}
GWP _{year}	=	1271,018 kgCO _{2eq} /year
GWP Payback Time =		3,057720614 year

Energy Return Ratio=E _{overall} /GER _{SHC-system}		
Energy Return Ratio represents how many times the energy saving overcomes the global energy consumption due to the SHC system.		
GER _{SHC-system}	=	107769,72 MJ
E _{overall}	=	503863,45 MJ
Energy Return Ratio =		4,675371245

Total impacts SHC system Total impacts convent. system Impacts comparison Payback indices

LCA METHOD TOOL

Sheet No.8: Payback indices

Calcolo LCA [modalità compatibilità] - Microsoft Excel uso non commerciale

Home Inserisci Layout di pagina Formule Dati Revisione Visualizza Sviluppo

Incolla Appunti Arial Narrow 12 Carattere Allineamento Testo a capo Unisci e centra Generale Numeri Formattazione condizionale Formatta come tabella Stili cella Inserisci Elimina Formato Celle Somma automatica Riempimento Cancella Ordina e filtra Trova e seleziona Modifica

D31 fx

A	B	C	D	E	F	G	H	I	J	K	L
7	INTERNATIONAL ENERGY AGENCY										
8											
9											
10	Energy Payback Time=(GER_{SHC-system}-GER_{Conventional-system})/E_{year}										
11	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 production and disposal. The harvest energy is considered as net of the energy expenditure for the system use.										
12	GER _{SHC-system}	=	107769,72	MJ							
13	GER _{Conventional-system}	=	14982,29	MJ							
14	E _{year}	=	20154,538	MJ/year							
15	Energy Payback Time =		4,60379841	year							
16	GWP Payback Time=(GWP_{SHC-system}-GWP_{Conventional-system})/GWP_{year}										
17	GWP Payback Time is defined as the time during which the avoided GWP impact due to the use of the SHC system is equal to GWP impact caused during its production and disposal										
18	GWP _{SHC-system}	=	5944,82	kgCO _{2eq}							
19	GWP _{Conventional-system}	=	2058,40	kgCO _{2eq}							
20	GWP _{year}	=	1271,018	kgCO _{2eq} /year							
21	GWP Payback Time =		3,057720614	year							
22	Energy Return Ratio=E_{overall}/GER_{SHC-system}										
23	Energy Return Ratio represents how many times the energy saving overcomes the global energy consumption due to the SHC system.										
24	GER _{SHC-system}	=	107769,72	MJ							
25	E _{overall}	=	503863,45	MJ							
26	Energy Return Ratio =		4,675371245								
27	Click on the symbol to display a brief description of the value.										
28											
29											
	Total impacts SHC system	Total impacts convent. system	Impacts comparison	Payback indices							

LCA METHOD TOOL

Sheet No.8: Payback indices

Calcolo LCA [modalità compatibilità] - Microsoft Excel uso non commerciale

A B C D E F G H I J K L

INTERNATIONAL ENERGY AGENCY

Energy Payback Time=(GER _{SHC-system} -GER _{Conventional-system})/E _{year}			
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 production and disposal. The harvest energy is considered as net of the energy expenditure for			
GER _{SHC-system} = Primary energy consumed during LCA phases of SHC system except for the operation phase			
GER _{Conventional-system}	=	72	MJ
E _{year}	=	29	MJ
		638	MJ/year
Energy Payback Time =		4,60379841	year

GWP Payback Time=(GWP _{SHC-system} -GWP _{Conventional-system})/GWP _{year}	
GWP Payback Time is defined as the time during which the avoided GWP impact due to the use of the SHC system is equal to GWP impact caused during its production and disposal	
GWP _{SHC-system} = 5944,82 kgCO _{2eq}	
GWP _{Conventional-system} = 2058,40 kgCO _{2eq}	
GWP _{year} = 1271,018 kgCO _{2eq/year}	
GWP Payback Time = 3,057720614 year	

Energy Return Ratio=E _{overall} /GER _{SHC-system}	
Energy Return Ratio represents how many times the energy saving overcomes the global energy consumption due to the SHC system.	
GER _{SHC-system} = 107769,72 MJ	
E _{overall} = 503863,45 MJ	
Energy Return Ratio = 4,675371245	

Total impacts SHC system Total impacts convent. system Impacts comparison Payback indices

LCA METHOD TOOL

Sheet No.8: Payback indices

The screenshot shows a Microsoft Excel spreadsheet titled "Calcolo LCA [modalità compatibilità] - Microsoft Excel us". The spreadsheet contains two main sections: "Energy Payback Time" and "Energy Return Ratio".

Energy Payback Time:

$$\text{Energy Payback Time} = (\text{GER}_{\text{SHC-system}} - \text{GER}_{\text{Conventional-system}}) / E_{\text{year}}$$

(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 production and disposal. The harvest energy is considered as net of the energy expenditure for the system use.)

$\text{GER}_{\text{SHC-system}}$	=	107769,72	MJ
$\text{GER}_{\text{Conventional-system}}$	=	14982,29	MJ
E_{year}	=	20154,538	MJ/year
Energy Payback Time =		4,60379841	year

Energy Return Ratio:

$$\text{Energy Return Ratio} = E_{\text{overall}} / \text{GER}_{\text{SHC-system}}$$

(Energy Return Ratio represents how many times the energy saving overcomes the global energy consumption due to the SHC system.)

$\text{GER}_{\text{SHC-system}}$	=	107769,72	MJ
E_{overall}	=	503863,45	MJ
Energy Return Ratio =		4,675371245	

The tool allows to calculate:

- 1) The Net yearly primary energy saving due to the use of the SHC system;

LCA METHOD TOOL

Sheet No.8: Payback indices

The screenshot shows a Microsoft Excel spreadsheet titled "Calcolo LCA [modalità compatibilità] - Microsoft Excel us". The spreadsheet contains several sections related to energy payback and return ratios:

- Energy Payback Time:**
$$\text{Energy Payback Time} = (\text{GER}_{\text{SHC-system}} - \text{GER}_{\text{Conventional-system}}) / E_{\text{year}}$$

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 production and disposal. The harvest energy is considered as net of the energy expenditure for the system use.

$\text{GER}_{\text{SHC-system}}$	=	107769,72	MJ
$\text{GER}_{\text{Conventional-system}}$	=	14982,29	MJ
E_{year}	=	20154,538	MJ/year
Energy Payback Time =		4,60379841	year
- GWP Payback Time:**
$$\text{GWP Payback Time} = \frac{\text{GWP}_{\text{SHC-system}}}{(\text{GWP}_{\text{SHC-system}} - \text{GWP}_{\text{Conventional-system}})} \cdot \text{GWP}_{\text{year}}$$

GWP Payback Time represents the time during which the SHC system must work to harvest as much primary energy as it requires for its production and disposal. The harvest energy is considered as net of the energy expenditure for the system use.
- Energy Return Ratio:**
$$\text{Energy Return Ratio} = E_{\text{overall}} / \text{GER}_{\text{SHC-system}}$$

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

$\text{GER}_{\text{SHC-system}}$	=	107769,72	MJ
E_{overall}	=	503863,45	MJ
Energy Return Ratio =		4,675371245	

The tool allows to calculate:

1) The Net yearly primary energy saving due to the use of the SHC system;

2) The net primary energy saving during the overall life-time of SHC system.

LCA METHOD TOOL

Sheet No.8: Payback indexes

The tool allows to calculate:

- 1) The Net yearly primary energy saving due to the use of the SHC system;
- 2) The net primary energy saving during the overall life-time of SHC system.
- 3) The net yearly avoided GWP impact due to the use of the SHC system.

The screenshot shows a Microsoft Excel window titled "Fattibilità compatibilità - Microsoft Excel uso non commerciale". The ribbon is visible at the top, showing tabs like "Home", "Sviluppo", etc. The main area contains a table with the following data:

GWP Payback Time = $(GWP_{SHC\text{-}system} - GWP_{Conventional\text{-}system}) / GWP_{year}$		
$GWP_{SHC\text{-}system}$	=	5944,82 kgCO _{2eq}
$GWP_{Conventional\text{-}system}$	=	2058,40 kgCO _{2eq}
GWP_{year}	=	1271,018 kgCO _{2eq/year}
GWP Payback Time =		3,057720614 year

A red oval highlights the values for $GWP_{SHC\text{-}system}$, $GWP_{Conventional\text{-}system}$, and GWP_{year} . A green arrow points from the value 1271,018 in the third row to the formula in the first row. In the bottom left corner of the Excel window, there are two rows of data:

E _{overall}	=	503863,45 MJ
Energy Return Ratio	=	4,675371245

The status bar at the bottom of the Excel window shows tabs: "Total impacts SHC system", "Total impacts convent. system", "Impacts comparison", "Payback indices", and "Impacts comparison".

LCA METHOD TOOL

The tool will be completed
within October 2014.

LCA METHOD TOOL

Thank you for your attention

