

Università degli Studi di Palermo
Dipartimento di Energia, ingegneria dell'Informazione e modelli
Matematici (DEIM)

Task 48 

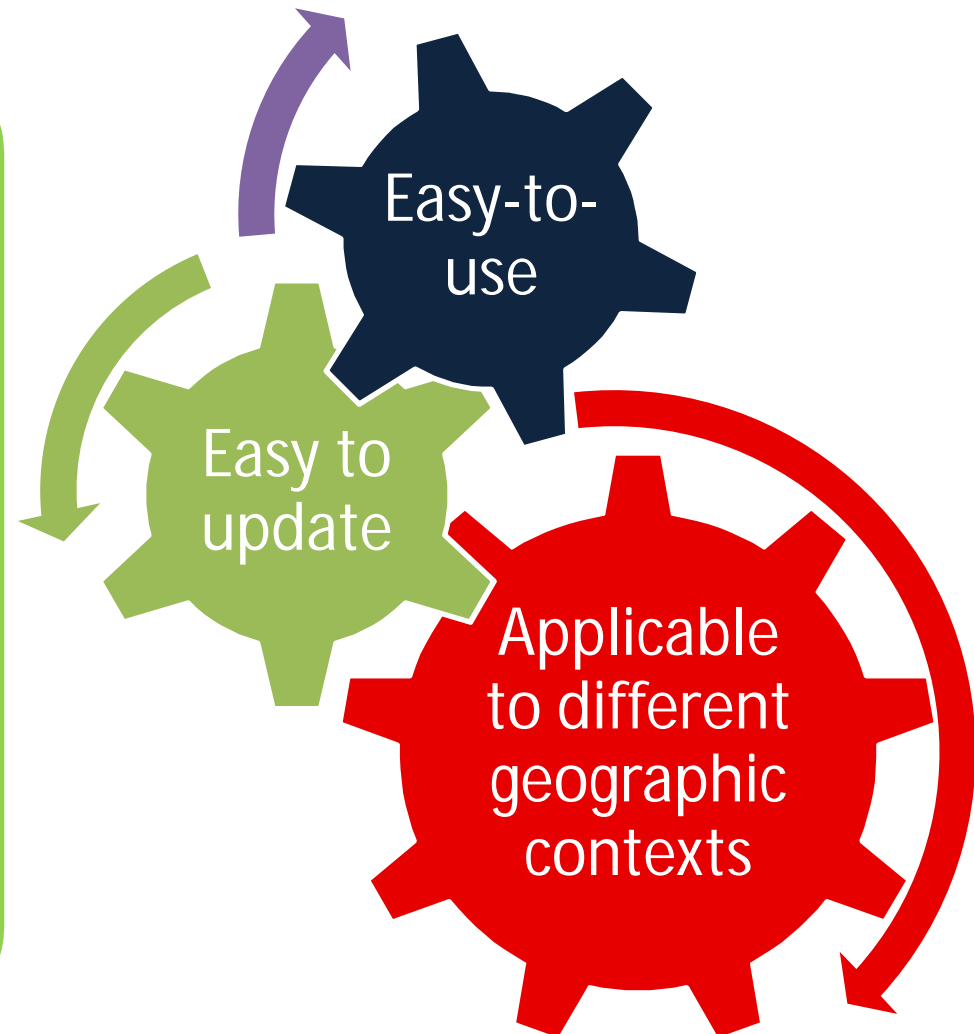
Quality assurance and support measures for Solar Cooling

Template of the LCA method tool

Prof. Marco Beccali

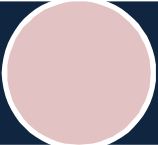



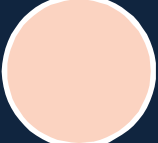
TEMPLATE OF LCA METHOD TOOL

**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**



TEMPLATE OF LCA METHOD TOOL

The tool will allow to calculate:

-  **Global Warming Potential (GWP)**
-  **Primary Energy Consumption (PE)**
-  **Energy Payback Time (EPT)**
-  **GWP Payback Time (GWP-PT)**
-  **Energy Return Ratio (ERR)**

TEMPLATE OF LCA METHOD TOOL

- The tool will be developed in **XLS format**

- Structure of the tool:
 - ✓ Step 1 components and energy sources check;
 - ✓ Step 2 data input;
 - ✓ Step 3 calculation of energy and environmental impacts;
 - ✓ Step 4 calculation of indexes (EPT, GWP-PT, ERR).

TEMPLATE OF LCA METHOD TOOL

First step: check of components and energy sources



A list of possible components of the system and of energy sources consumed during its operation will be showed.



The user will select components and energy sources that are part of the examined system.

!!! Up today, not all the eco-profiles of components not available.

TEMPLATE OF LCA METHOD TOOL

SOLAR HEATING AND COOLING SYSTEM

SOLAR AIR-CONDITIONING SYSTEM

Is this component part of the system?

COMPONENT	YES	NO
Absorption chiller	X	
Adsorption chiller		X
Conventional chiller		X
Gas boiler	X	
Solar thermal collectors	X	
...		

COMPONENT	YES	NO
Solar thermal collectors		X
Desiccant wheel	X	
Heat recovery wheel		X
Damper register	X	
Humidifier	X	
...		

TEMPLATE OF LCA METHOD TOOL

SOLAR HEATING AND COOLING SYSTEM

SOLAR AIR-CONDITIONING SYSTEM

Is this energy source consumed by the system during the operation step?

ENERGY SOURCE	YES	NO
Electricity Italy	X	
Electricity Germany		X
...		
Natural gas	X	

ENERGY SOURCE	YES	NO
Electricity Italy	X	
Electricity Germany		X
...		
Natural gas	X	

TEMPLATE OF LCA METHOD TOOL

Second step: data input

- A list of the components selected in the previous step will be showed.
- The user will insert the **figures** for each component/energy source.

SOLAR HEATING AND COOLING SYSTEM

COMPONENT/ENERGY SOURCE	Metrics	Quantity
Absorption chiller	kW	12
Gas boiler	kW	20
Solar thermal collectors	m ²	35
...		
Electricity Italy	kWh/year	2,434
Natural gas	kWh/year	12,794

TEMPLATE OF LCA METHOD TOOL

Third step: calculation energy and environmental impacts

i.e. Global Warming Potential calculation

The tool will show:

- the unitary impact for each component/energy source;

COMPONENT/ENERGY SOURCE	Metrics	Impact
Absorption chiller	kgCO _{2eq} /kW	105.00
Gas boiler	kgCO _{2eq} /kW	39.20
Solar thermal collectors	kgCO _{2eq} /m ²	101.20
...		
Electricity Italy	kgCO _{2eq} /kWh	0.716
Natural gas	kgCO _{2eq} /kWh	0.26

TEMPLATE OF LCA METHOD TOOL

Third step: energy and environmental impacts calculation

Global Warming Potential calculation

The tool will show:

- the total impact for each component/energy source

COMPONENT/ENERGY SOURCE	Metrics	Impact
Absorption chiller	kgCO _{2eq}	1,260
Gas boiler	kgCO _{2eq}	784
Solar thermal collectors	kgCO _{2eq}	3,542
...		
Electricity Italy	kgCO _{2eq}	1,743
Natural gas	kgCO _{2eq}	3,326

TEMPLATE OF LCA METHOD TOOL

Third step: energy and environmental impacts calculation

Global Warming Potential calculation

The tool will show:

- the total impact of the examined system

GWP of the innovative system ($GWP_{\text{innovative}}$)

COMPONENT/ENERGY SOURCE	Metrics	Impact
Absorption chiller	kgCO _{2eq}	1,260
Gas boiler	kgCO _{2eq}	784
Solar thermal collectors	kgCO _{2eq}	3,542
...		
Electricity Italy	kgCO _{2eq}	1,743
Natural gas	kgCO _{2eq}	3,326
TOTAL IMPACT	kgCO_{2eq}	10,713

TEMPLATE OF LCA METHOD TOOL

IN ADDITION:

THE TOOL WILL SHOW THE IMPACTS FOR EACH LIFE-CYCLE STEP OF THE SYSTEM (PRODUCTION, OPERATION, END-OF-LIFE).

PRODUCTION STEP	Metrics	Impact
Absorption chiller	kgCO _{2eq}	1,251
Gas boiler	kgCO _{2eq}	750
Solar thermal collectors	kgCO _{2eq}	3,244
TOTAL IMPACT	kgCO_{2eq}	5,245

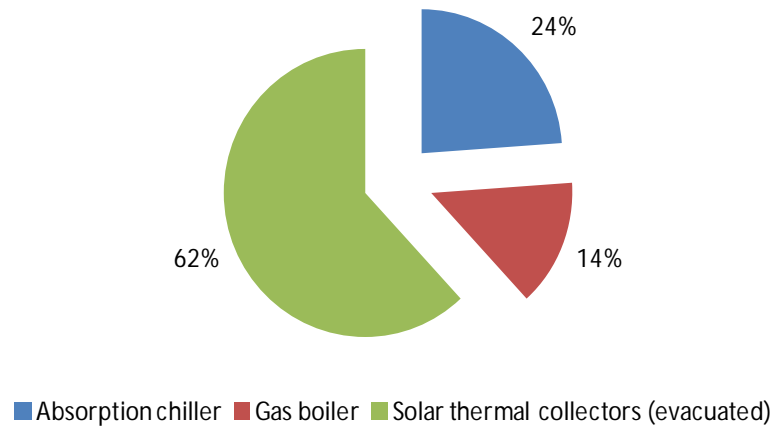
OPERATION STEP	Metrics	Impact
Electricity Italy	kgCO _{2eq}	1,743
Natural gas	kgCO _{2eq}	3,326
TOTAL IMPACT	kgCO_{2eq}	5,069

END-OF-LIFE STEP	Metrics	Impact
Absorption chiller	kgCO _{2eq}	9
Gas boiler	kgCO _{2eq}	34
Solar thermal collectors	kgCO _{2eq}	298
TOTAL IMPACT	kgCO_{2eq}	341

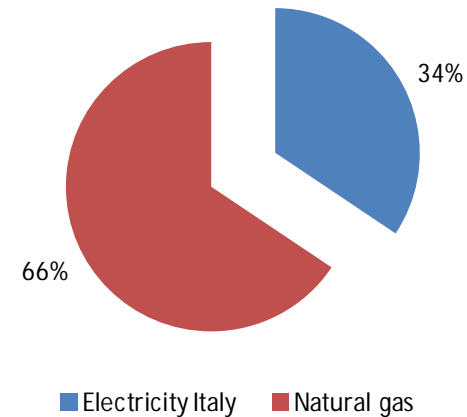
TEMPLATE OF LCA METHOD TOOL

IMPACTS FOR EACH LIFE-CYCLE STEP

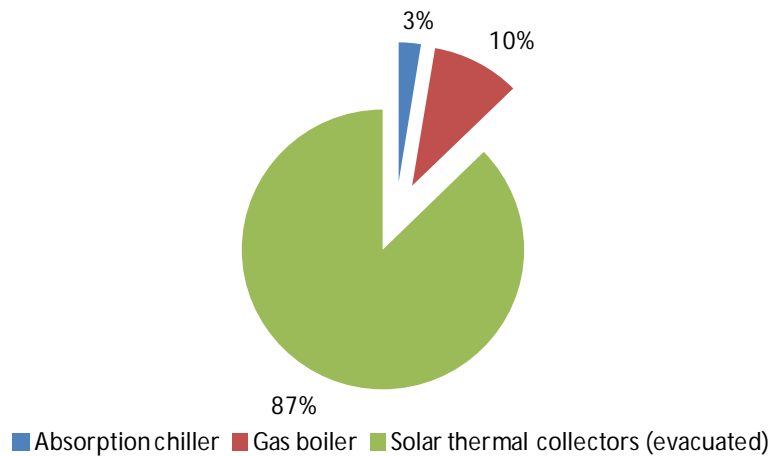
Production step



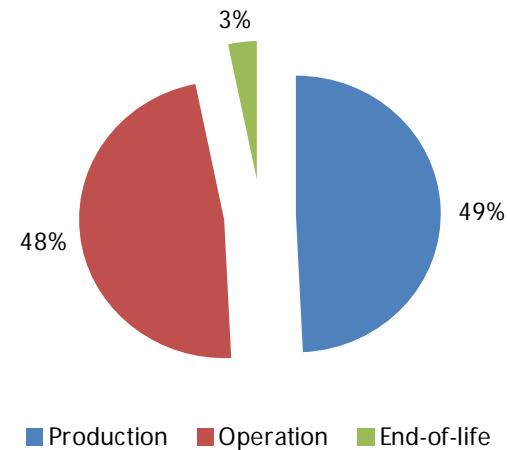
Operation step



End-of-life step



Life cycle impact



TEMPLATE OF LCA METHOD TOOL

IN ADDITION THE TOOL WILL CALCULATE:

- The impacts of a **reference system** (for example: the GWP of the conventional system ($GWP_{\text{reference}}$));
The input of components and energy sources will be similar to the one for innovative systems.
- The **net yearly impact savings** due the use of the innovative system instead of the conventional one (for example: Net yearly GWP avoided emissions (GWP_{year})).

TEMPLATE OF LCA METHOD TOOL

Fourth step: calculation of indicators

i.e. : GWP Payback Time

$$\frac{(\text{GWP}_{\text{innovative}} - \text{GWP}_{\text{reference}})}{\text{EM}_{\text{year}}}$$

GWP of the innovative system (except the use phase) (kgCO_{2eq})

GWP of the reference system (except for the use phase) (kgCO_{2eq})

Net yearly GWP emission savings due the use of the innovative system (kgCO_{2eq}/year)

TEMPLATE OF LCA METHOD TOOL

Fourth step: indices calculation

GWP Payback Time

$$\frac{(GWP_{\text{innovative}} - GWP_{\text{reference}})}{EM_{\text{year}}}$$

Value automatically inserted

Value automatically inserted

Value automatically inserted

TEMPLATE OF LCA METHOD TOOL

**The same calculations can be made
for the other indicators**

**Parametric/Sensitivity analyses can
be done very easily (i.e. changing
components sizes, energy source,
country of installation)**

TEMPLATE OF LCA METHOD TOOL

**!!! WARNING
TO DEVELOP THE TOOL WE NEED THE ECO-
PROFILE OF SOME COMPONENTS**

SOLAR HEATING AND COOLING SYSTEM

- Absorption chiller (**Available**)
- Adsorption chiller (**Available**)
- Solar collectors (**Available**)
- Heat storage (**Available**)
- Cooling Tower/Heat Rejection (**Available**)
- Gas boiler (**Available**)
- Glycol (**Available**)
- Piping+insulation (**Available**)
- Pumps (**Available**)
- Conventional chiller (**Available**)

SOLAR AIR-CONDITIONING SYSTEM

- Solar thermal collectors (**Available**)
- Desiccant wheel (**Not available**)
- Housing (**Not available**)
- Heat recovery wheel (**Not available**)
- Damper register (**Not available**)
- Filter (**Not available**)
- Fan+motor (**Not available**)
- Humidifier (**Not available**)
- Switch box (**Not available**)
- Compression chiller (**Not available**)
- Gas boiler (**Available**)

TEMPLATE OF LCA METHOD TOOL

A possible interaction with activity B4 regarding calculation of energy consumption figures could be discussed

Thank you for your attention