PROCEEDINGS

12th Italian LCA Network Conference

Life Cycle Thinking in decision-making for sustainability: from public policies to private businesses

Messina
11-12th June 2018

Edited by: Giovanni Mondello, Marina Mistretta, Roberta Salomone
Arianna Dominici Loprieno, Sara Cortesi, Erika Mancuso

ENEA
Italian National Agency for New Technologies,
Energy and Sustainable Economic Development

Rete Italiana LCA

Life Cycle Thinking in decision-making for sustainability:
from public policies to private businesses

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Conference program

JUNE 11th, 2018 - Monday

08.30 - 09.00 **Registration to Italian LCA Network Conference**

09.00 - 09.30 **Italian LCA Network Conference - Opening ceremony**

Salvatore Cuzzocrea - *Rector of the University of Messina*
Augusto D'Amico - *Director of the Department of Economics*
Maurizio Cellura - *President of the Italian LCA Network*
Roberta Salomone - *Conference Chair*

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LCA, LOCAL GOVERNMENTS, AND CIRCULAR ECONOMY

Chairs: Maurizio Cellura – University of Palermo
Giuseppe Saija – University of Messina

EU Policies for ENERGY Research: the SET Plan and the new 2018-19 Horizon 2020 Work Program
Riccardo Basosi – *Italian Permanent Representative H2020 Energy EU Programme and MIUR Delegate in the SET Plan Steering Committee*

Life Cycle Assessment of electrochemical storage technologies
Marco Ferraro – *CNR-ITAE*

European Environmental Footprint methods: status update and future outlook
Michele Galatola – *European Commission - DG Environment - Sustainable Production, Products & Consumption*

The Accredia's experience in environmental conformity assessment, supporting LCA-based activities
Filippo Trifiletti – *General Director ACCREDIA*

11.00 - 11.30 Coffee break

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Marina Mistretta – Mediterranea University

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Grazia Barberio – *ENEA*

Life Cycle Analysis of an innovative component for the sustainability in the building sector
Maria Laura Parisi – *University of Siena*

Life Cycle Assessment of building end of life
Serena Giorgi – *Politecnico of Milano*

ELISA: A simplified tool for evaluating the Environmental Life-cycle Impacts of Solar Air-conditioning systems
Sonia Longo – *University of Palermo*

A comparative study between a Prefab building and a Standard building for the characterisation of production and construction stages
Mónica Alexandra Muñoz Veloza – *Politecnico of Torino*

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Roberta Salomone – University of Messina

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Nicoletta Patrizi – *University of Siena*

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Doriana Tedesco – University of Milan

Practitioner-related effects on LCA results: a case study on Energy and Carbon footprint of wine
Emanuele Bonamente – University of Perugia

Environmental impacts and economic costs of nectarine loss in Emilia-Romagna: a life cycle perspective
Fabio De Menna – University of Bologna

Grana Padano and Parmigiano Reggiano cheeses: preliminar results towards an environmental eco-label with Life DOP project
Daniela Lovarelli – University of Milan

Life Cycle studies in agrifood sector: focus on geographical location
Anna Mazzi – University of Padova

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Andrea Raggi – University "G. d'Annunzio"

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Luca Ciacci – University of Bologna

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Cristian Chiavetta – ENEA

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Andrea Fedele – University of Padova

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Serena Righi – University of Bologna

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Emanuela Viganò – CESI S.p.A.
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Anna Dalla Valle – Politecnico Milano

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Silvia Bobba – Politecnico Torino

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Gabriella Arcese – University of Bari "Aldo Moro"

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Marzia Traverso – RWTH Aachen University

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Serena Righi – University of Bologna

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Fulvio Ardente – European Commission - Joint Research Centre

Environmental comparison of two organic fraction of municipal solid waste liquid digestate's management modes
Federico Sisani – University of Perugia

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Laura Brenes-Peralta – University of Bologna/Researcher Instituto Tecnológico de Costa Rica

The way towards sustainable policies: combining LCA and LCC for construction waste management in the region of Flanders, Belgium
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LIFE CYCLE THINKING METHODS AND TOOLS

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Giuseppe Tassielli – University of Bari "Aldo Moro"

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Paola Masotti – University of Trento

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Rosa Di Capua – University of Bari "Aldo Moro"

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Jonathan Schmidt – RWTH Aachen University

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Michele Del Grosso – APTAR Italia SpA

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ROUND TABLE

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Bruno Notarnicola – University of Bari "Aldo Moro"

Methodological advancements and remaining challenges after 5 years of Environmental Footprint road field testing
Michele Galatola – European Commission - DG Environment - Sustainable Production, Products & Consumption

Life Cycle Thinking in the U.S. Public Policy
Sangwon Suh – University of California

Life cycle based environmental assessment of EU consumption
Serenella Sala – European Commission - Joint Research Centre - Directorate D – Sustainable Resources, Bio-Economy Unit (D1)

18.30 Bus transfer to Regional Museum

19.00 - 21.30 Guided tour of the regional Museum and Light Dinner

ELISA: A simplified tool for evaluating the Environmental Life-cycle Impacts of Solar Air-conditioning systems

Marco Beccali [1], Maurizio Cellura [1], Teresa Maria Gulotta[1], Sonia Longo [1], Marina Mistretta [2]

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Abstract

The paper presents ELISA, a simplified tool for estimating the Environmental Life-cycle Impacts of Solar Air-conditioning systems. The tool is designed to support researchers, designers and decision makers in a simplified evaluation of the life cycle energy and environmental potential benefits related to the installation of solar heating and cooling systems in substitution of conventional ones.
The tool was developed within the research activities of Task 53 "New Generation Solar Cooling & Heating Systems (PV or solar thermally driven systems)" of the International Energy Agency.

1. Introduction

The Solar Heating and Cooling (SHC) systems are of great interest in the reduction of the greenhouse gas emissions, particularly in sunny regions, due to the use of renewable energy resources for the buildings air-conditioning (Beccali et al., 2016). Good results in terms of electricity and natural gas savings can be achieved through an accurate design of the SHC systems, which takes into account climate characteristics and building loads during all the year (Beccali et al., 2014a).

Many researchers are contributing in the development of a competitive market for the SHC technologies by focusing on cost-effectiveness and high performance (Chang et al., 2009) in different geographic contexts. However, they often analyze only the SHC systems behavior during the operation stage, neglecting the energy and environmental aspects of the manufacturing and end-of-life of these technologies.

By extending the point of view to the whole life cycle, the benefits of using renewable energy during the operation of the SHC systems could be offset by the impacts of the other stages. For this reason, it is important to introduce the Life Cycle Assessment (LCA) (ISO 14040, 2006; ISO 14044, 2006) for assessing the energy and environmental performances of the systems during their life cycle. However, the development of a complete LCA for a complex system as the SHC can be difficult and time-consuming particularly for no-LCA experts, discouraging them in the inclusion of life-cycle considerations in the assessments.

In order to support the SHC experts in the development of simplified LCAs during the design phase of the SHC systems, the authors developed the tool ELISA. This tool can be used for estimating the environmental life-cycle impacts of solar air-conditioning systems. The tool, although simplified, can be used for understanding the potential energy and environmental benefits/impacts of the solar technologies in different geographic contexts with respect to conventional ones.

2. ELISA tool

ELISA is a tool for developing a simplified life cycle energy and environmental assessment of SHC systems and for comparing them with conventional ones. The tool, developed in Microsoft Excel (Microsoft Excel 2016, 2016), can be used for the comparison of four typologies of heating and cooling systems:

- SHC system;
- SHC system with photovoltaic panels (PVs);
- Conventional system;
- Conventional system with PVs.

The logo of ELISA is shown in Figure 1.

Figure 1: ELISA logo

The tool allows for calculating the following indices:

- Global warming potential (GWP) [kg of CO_{2eq}], calculated using the characterization factors of the “IPCC 2013 GWP 100 year” impact assessment method (IPCC, 2014);
- Global energy requirement (GER) [MJ], calculated using the impact assessment method “Cumulative Energy Demand” (Frischknecht et al., 2010);
- Energy payback time (E-PT) [years], defined as the time during which the SHC system (with or without PV) 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;

- GWP payback time (GWP-PT) [years], defined as the time during which the avoided GWP impact due to the use of the SHC system (with or without PV) is equal to the GWP impact caused during its manufacturing and end-of-life;
- Energy Return Ratio (ERR) that represents how many times the energy saving due to the use of the SHC system (with or without PV) overcomes its primary energy consumption during the life-cycle.

The main page of ELISA is shown in Figure 2.

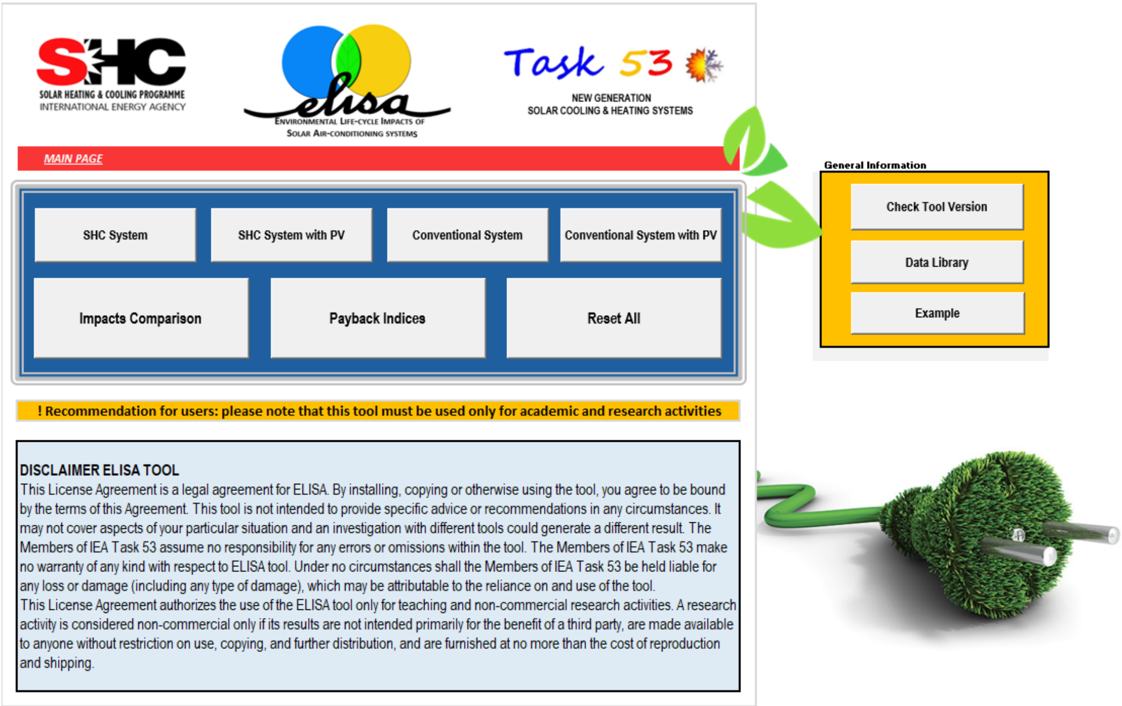

Figure 2: Main page of ELISA

From the main page, the user can access to the data library of the tool (Figure 3) that shows the specific energy and environmental impacts (Beccali et al., 2010 and 2014b; Cellura, 2014; Frischknecht et al., 2007; Longo et al., 2014; Majeau – Bettez et al., 2011; Mc Manus, 2012; Notter et al., 2010), in term of GER and GWP, of the components that are commonly part of a SHC or a conventional system (including the PV system) and of energy sources (electricity and natural gas).

3. Description of the Case study

To illustrate the features of ELISA a simple application is described in the following section, comparing four heating and cooling systems: a SHC system (without and with PV) and a conventional system (without and with PV). The systems are installed in Palermo (Italy) and have a useful life of 25 years.

The SHC system is composed of: an absorption chiller (12 kW); a field of evacuated solar tube collectors (35 m^2); a heat storage (2,000 l); a cooling tower (32 kW); an auxiliary gas boiler (10 kW); an auxiliary conventional chiller (10 kW); pipes (60 m); two pumps (80 W and 250 W); a solution of water and ammonia (15 kg of ammonia and 10 kg of water). The system consumes 1,117 kWh/year of electricity and 414 kWh/year of natural gas. The conventional system is constituted by a chiller of 10 kW and a gas boiler of 10 kW; it requires 1,995 kWh/year of electricity and 2,882 kWh/year of natural gas. In addition, the SHC system and the conventional system coupled with PV include: photovoltaic panels, inverter, electric installation and batteries. The PV system is sized as a stand-alone system with energy storage for supplying the electricity required from the SHC and conventional system during the useful life.

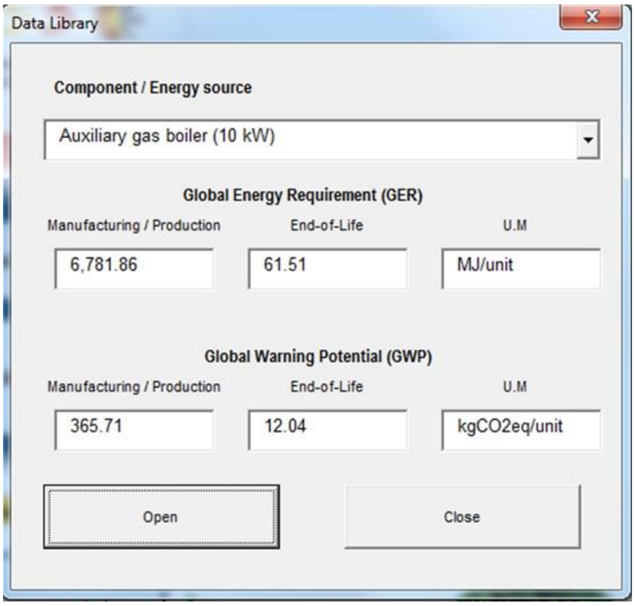

Figure 3: Data Library

3.1.1 Entering data in the input worksheet

ELISA contains four input worksheets, one for each system. Each input worksheet includes a list of the components of the analyzed system, of electricity mixes of 25 localities and of natural gas burned in 10 different systems in the European context. Figure 4 shows, as an example, the structure of the input worksheet for the SHC system.

In addition, ELISA allows for including the number of replacements of each component during the useful life of the system: e.g. the inverter used in the PV system has a useful life of 12.5 years, this means that it will be substituted one time during the 25 years.

3.1.2 Analysis of the results thought the output worksheets

The results are shown in three output worksheets:

The first one presents the GER and GWP results for each system both in table and graphs. In detail, the results in table shows: the total impact for each component/energy source; the impact of the manufacturing and end-of-life steps of each component of the system and the impact of the operation; the total impact of each life-cycle step (manufacturing, operation, end-of-life). The graphs allows for visualizing the contribution of the different life cycle steps to the total impact and the incidence of each component/energy source on the impact of manufacturing, operation and end-of-life. As an example, Figure 5 shows the incidence of each component of the SHC system to the impact on GER during the manufacturing step.

COMPONENTS OF THE SHC SYSTEM			
Category	**U.M.**	**Quantity**	**n° REPLACEMENT**
Ammonia	kg	15.00	
Auxiliary conventional chiller (10 kW)	unit	1.00	
Auxiliary gas boiler (10 kW)	unit	1.00	
Absorption chiller (12 kW)	unit	1.00	
Cooling tower (32 kW)	unit	1.00	
<Glycol>	kg		
<Heat rejection system>	unit		
Heat storage (2000 l)	unit	1.00	
<Heat-pump>	unit		
Pipes	m	60.00	
Pump (40 W)	unit	8.25	
Evacuated tube collector	m^2	35.00	
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 atmosferic low-NOx condensing non-modulating, <100 kW, Europe	kWh/year	414.00

Figure 4: Input worksheet of the SHC system

The second worksheet displays the comparison of the results for the different systems (both in table and graphs (Figure 6)).

The third worksheet shows the E-PT, GWP-PT and ERR indices (Figure 7). In detail, each box of Figure 7 indicates the value of the index calculated for the system of the j-th row if compared with the system of the i-th column.

The calculation of the above set of indices is useful to evaluate if the additional impacts usually caused during the production and end-of-life steps of a SHC system if compared with a conventional one are balanced by the energy saving and avoided emissions during its operation.
However, when the conventional system uses energy from renewable sources (e.g. electricity from PV), the impacts of the SHC system during the operation step can be higher than that of the conventional one. In this case, the SHC system has worse energy and environmental performances during the operation step and cannot balance the additional impacts caused during its production

and end-of-life. When this happens, E-PT, GWP-PT and ERR cannot be calculated.

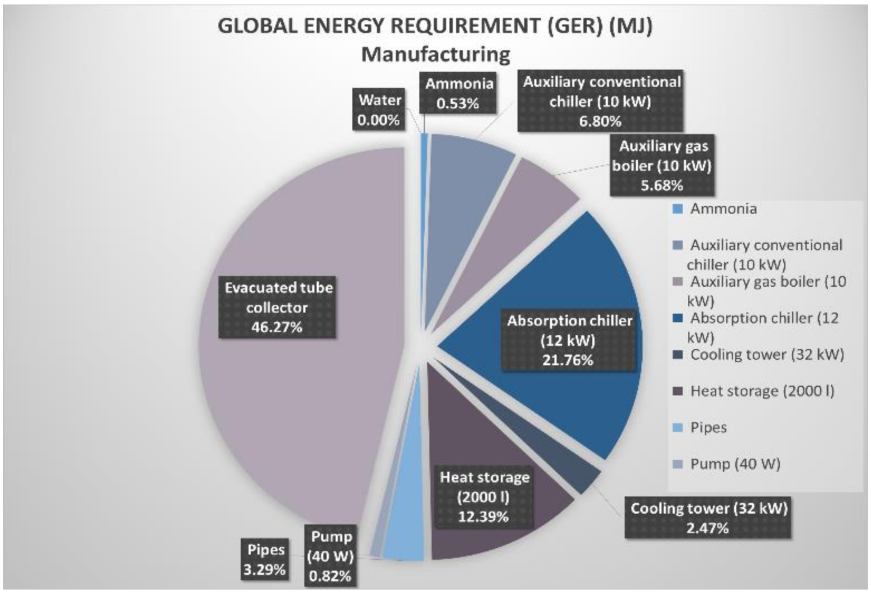

Figure 5: Manufacturing step: GER of the SHC system

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	119,503.54	347,549.01	581.90	467,634.46	7,522.10	20,795.83	210.67	28,528.60
SHC System with PV	176,582.25	47,713.35	3,847.30	228,142.90	10,490.07	2,825.69	558.08	13,873.83
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	112,435.80	322,960.12	5,507.97	440,903.89	7,009.47	19,240.40	582.56	26,832.43

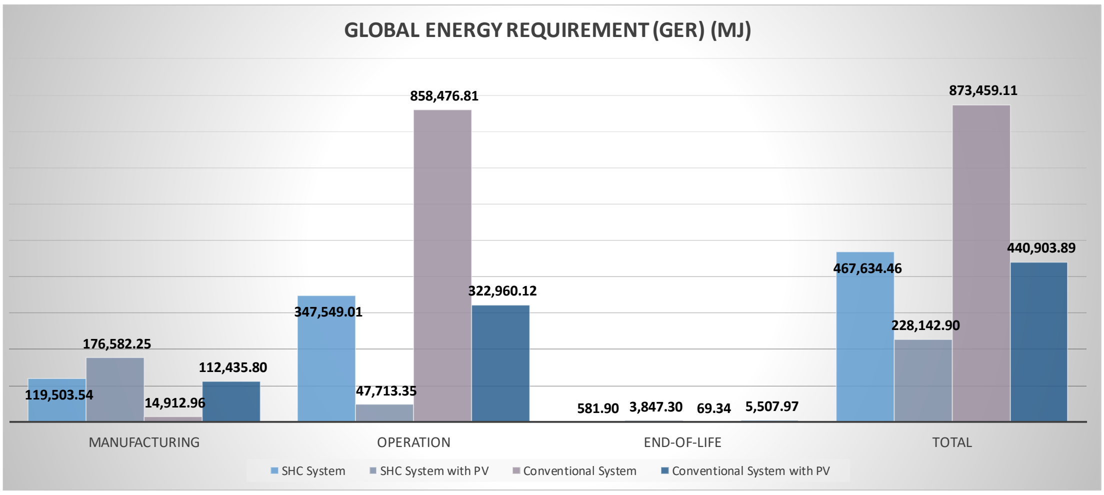

Figure 6: Impacts comparison worksheet

An analysis of the results indicates that the integration of the PV panels in the heating and cooling system can reduce the life-cycle impacts of about 50% for both the SHC and conventional system, although the impacts of the manufacturing and end-of-life steps increase. Comparing the results, it can be observed that, in the selected location, the use of the SHC system with PV allows for the reduction of the impacts of about 74% and 49% if compared with the conventional system without and with PV, respectively.

The analysis of the payback indices highlights that the benefits of using the SHC system with PV if compared with the respective conventional system allows for offsetting the energy and environmental costs due to the life-cycle of the solar system in about 5.5 years. The value of ERR indicates that the energy saved during the useful life of the SHC system with PV overcomes the global energy consumption due to its manufacture and end-of-life of about 4.5 times.

The SHC system has worse energy performances during the operation if compared with a conventional system with PV. In this case, the negative values obtained for the examined indices indicate that E-PT, GWP-PT and ERR cannot be calculated.

	$E\text{-}PT=(GER_{j\text{-}th,SHC\text{-}system} - GER_{i\text{-}th,Conventional\text{-}system})/E_{year}$	
	Conventional System	Conventional System with PV
SHC System	5.14	- 2.18
SHC System with PV	5.10	5.68

	$GWP\text{-}PT=(GWP_{j\text{-}th,SHC\text{-}system} - GWP_{i\text{-}th,Conventional\text{-}system})/GWP_{year}$	
	Conventional System	Conventional System with PV
SHC System	4.73	- 2.26
SHC System with PV	4.69	5.26

	$ERR=E_{Overall,j\text{-}th,SHC\text{-}system}/GER_{i\text{-}th,SHC\text{-}system}$	
	Conventional System	Conventional System with PV
SHC System	4.25	- 0.20
SHC System with PV	4.49	1.53

Figure 7: E-PT, GWP-PT and ERR

4. Conclusions

The paper describes ELISA, a useful tool for the evaluation of the potential benefits due to the installation of the SHC systems if compared with the conventional ones.

ELISA is a simplified tool that cannot be used for complete and accurate LCAs, but it gives a general overview and one order of magnitude of the energy and environmental impacts of the four typologies of systems presented above. In addition, the data library is limited and could be extended in the future with new data. However, ELISA is a user-friendly tool that can simplify the introduction of the life-cycle perspective in the selection of the most sustainable heating and cooling system is a specific geographic contexts.

Researchers, designers, and decision-makers can use ELISA to take environmentally sound considerations in the field of the SHC systems (PV or solar thermally driven systems).

ELISA can be downloaded for free from the website of Task 53 of the International Energy Agency (IEA): http://task53.iea-shc.org/.

6. Acknowledgements

ELISA was developed within the research activities of Task 53 "New Generation Solar Cooling & Heating Systems (PV or solar thermally driven systems)" of the International Energy Agency.

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