SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

Task 53 - 4th Expert meeting in Madrid

12-13 April 2016

Activities A5-1 and A5-2

LCA and techno-eco comparison between reference and new systems

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University of Palermo – DEIM

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Description of activity

A5: LCA and techno-eco comparison between reference and new systems

Subtask A – Activity A5 is focused on the **comparison between all the studied systems among Subtask A and the reference system** when accurate (same location and same boundary conditions). The comparison will be both on a **Life Cycle Analysis and on a techno-economical basis**. So as to properly compare solutions, adequate **key performance indicators** will be investigated and selected from literature and practical experience from Task experts as well as industry players. Some recommendations will be developed to go for **characterization test method** (permitting to lead to a **quality-labeling scheme** for new generation solar cooling systems) as well as standards.

Deliverables:

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

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

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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

To be carried out after the identification of the technical and economic KPI (Activity A5-2).

LCA analysis

Developed action: collection of contributions from the partners.

We sent a simplified sheet and a detailed sheet for data collection on thermal and PV existing solar cooling systems to all partners involved in the activities A1 and A2 (15.10.2015).

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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.

FORMAT for simplified data collection

Activity A5
LCA and techno-eco comparison between reference and new systems

Data collection for LCA analysis

Brief description of the system		
Site of installation		
List and characteristics of the components costituing the system		
Component	Quantity	Features

Useful life of the system [years]:
Electricity consumed by the system during the operational phase [kWh/year]:
Natural gas consumed by the system during the operational phase [kWh/year]:
Water consumed by the system during the operational phase [kg]:
Glycol consumed by the system during the operational phase [kg]:

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FORMAT for detailed data collection

Worksheet N.1: Product information

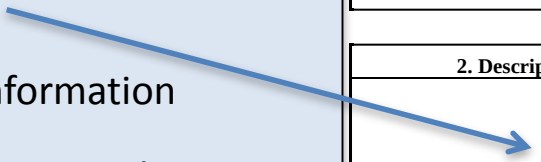
Worksheet N.2: Production process information

Worksheet N.3: Production process: input and output

Worksheet N.4: Installation

Worksheet N.5: Use and maintenance

Worksheet N.6: End-of-life



1. Commercial name of the product:
2. Description, as detailed as possible, of the product and of its function:
3. Description of the product charachteristics
Dimensions
Weight

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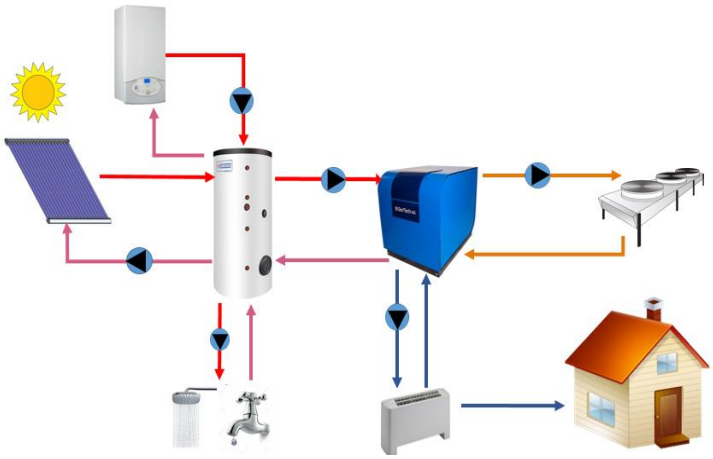
LCA analysis

Results: We received data from CNR-ITAE (Messina, Italy). The data elaboration is in progress by using the LCA tool developed within Task 48.



The application of the LCA tool (Task 48) is in progress

- Solar thermal collectors
- Gas boiler
- Hot water storage
- Adsorption chiller
- Dry cooler

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Other potential studies

Domestic Hot Water System supported by PV energy

We are waiting for the data from Pedro Vicente Quiles

COSSECO system

We are waiting for the LCA report from COSSECO

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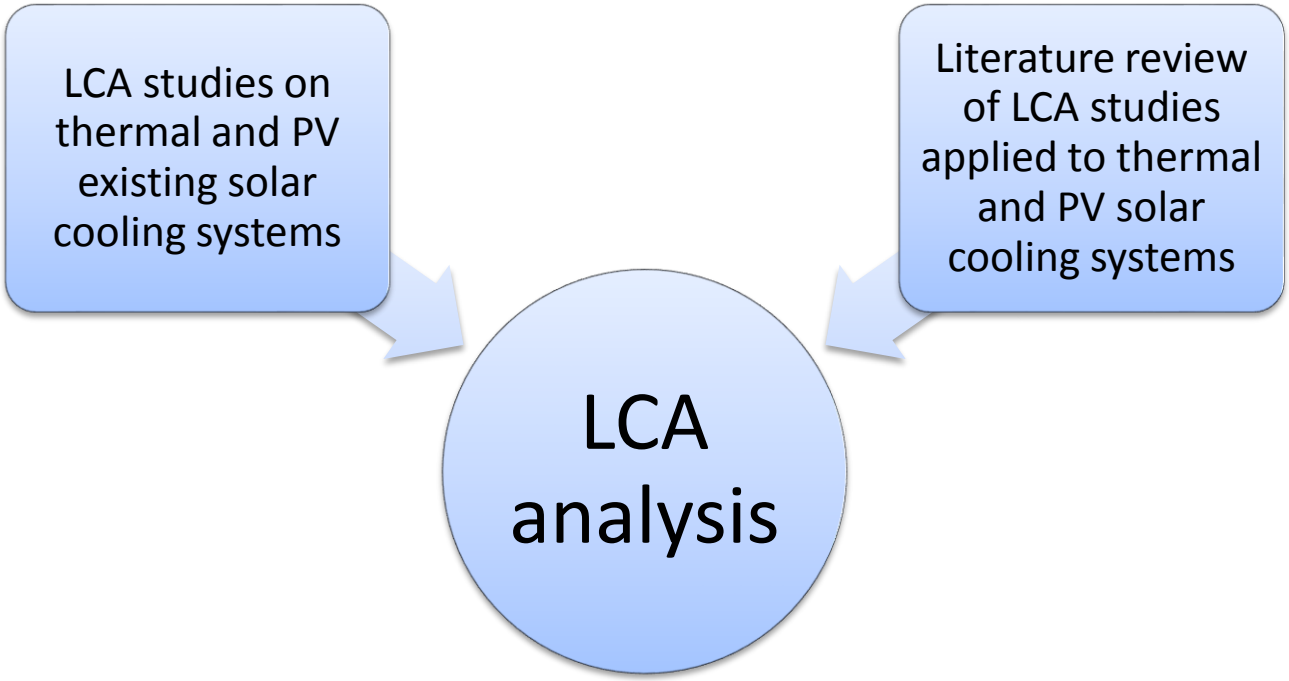
LCA analysis: UNIPA activities



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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 two LCA studies on the following solar cooling and heating system components installed on the terrace of UNIPA-DEIM: Air handling unit desiccant cooling (AHU-DEC) and FREESCOO.

Results:

- The assessment of energy and environmental impacts of manufacturing, operation and end-of-life steps of FREESCOO was completed.
- The assessment of energy and environmental impacts of manufacturing and end-of-life steps of the AHU-DEC was completed. The assessment of the operational step is in progress.

Air handling unit desiccant cooling (AHU-DEC)

FREESCOO

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LCA analysis AHU-DEC

The examined system is an Air Handling Unit Desiccant Cooling (AHU-DEC) equipped with a hybrid photovoltaic/thermal (PV/T) system.

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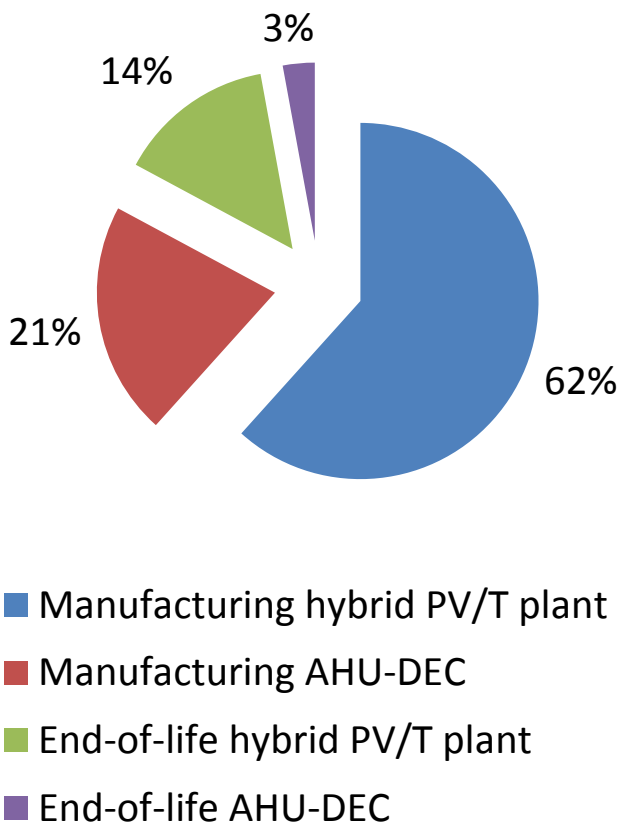
LCA analysis AHU-DEC



Component	NRE (MJ)	RE (MJ)	GER (MJ)
Hybrid PV/T plant			
Manufacturing	2.8E+05	4.3E+04	3.2E+05
End of life	5.9E+04	1.4E+04	7.4E+04
Sub-total (MJ)	**3.4E+05**	**5.8E+04**	**3.9E+05**
AHU-DEC			
Manufacturing	9.4E+04	1.4E+04	1.1E+05
End of life	1.4E+04	4.8E+02	1.5E+04
Sub-total (MJ)	**1.1E+05**	**1.5E+04**	**1.2E+05**
Total (MJ)	**4.5E+05**	**7.2E+04**	**5.2E+05**

Benefits arising from the recycling are not included

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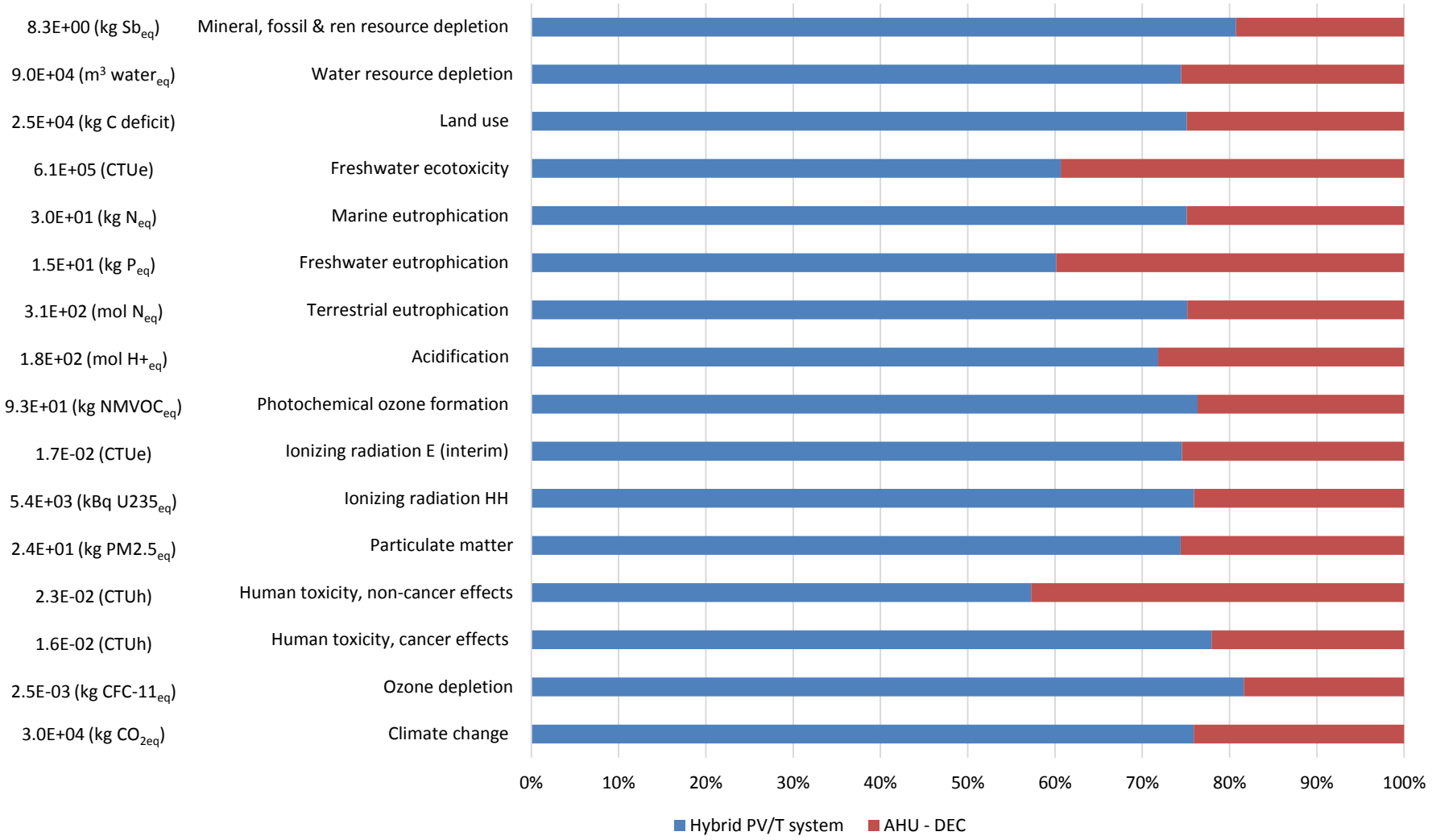

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LCA analysis FREESCOO

The examined system is FREESCOO, a compact solar air conditioner system designed for air-conditioning (heating in winter is also possible).

The system is composed by a solar photovoltaic/thermal air collector, two adsorption beds, an integrated cooling tower, two wet heat exchangers, fans, batteries and all other auxiliaries needed to perform the air handling process also in stand-alone operation. During winter, if solar radiation is available, warm air can be delivered to the building.

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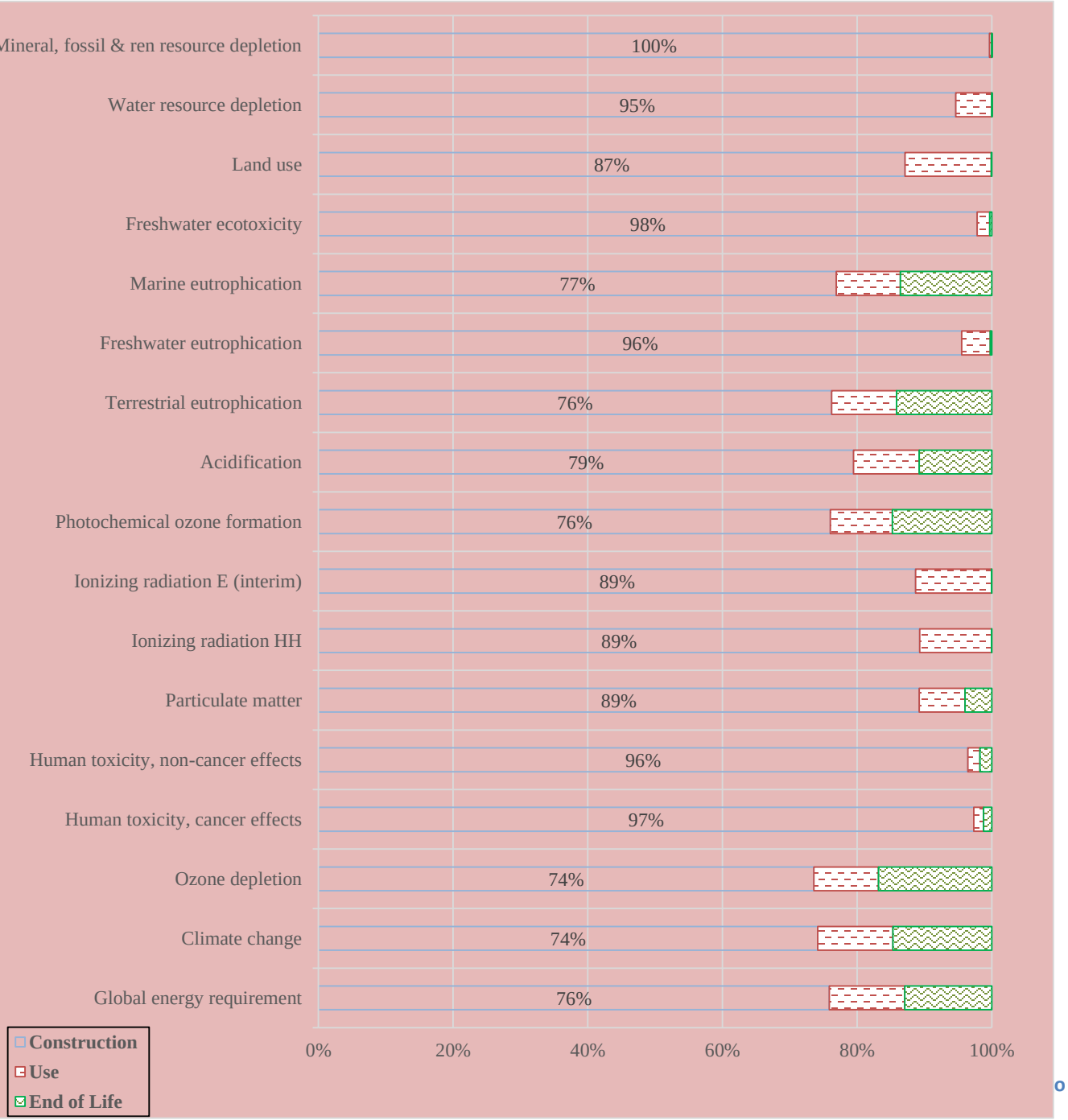
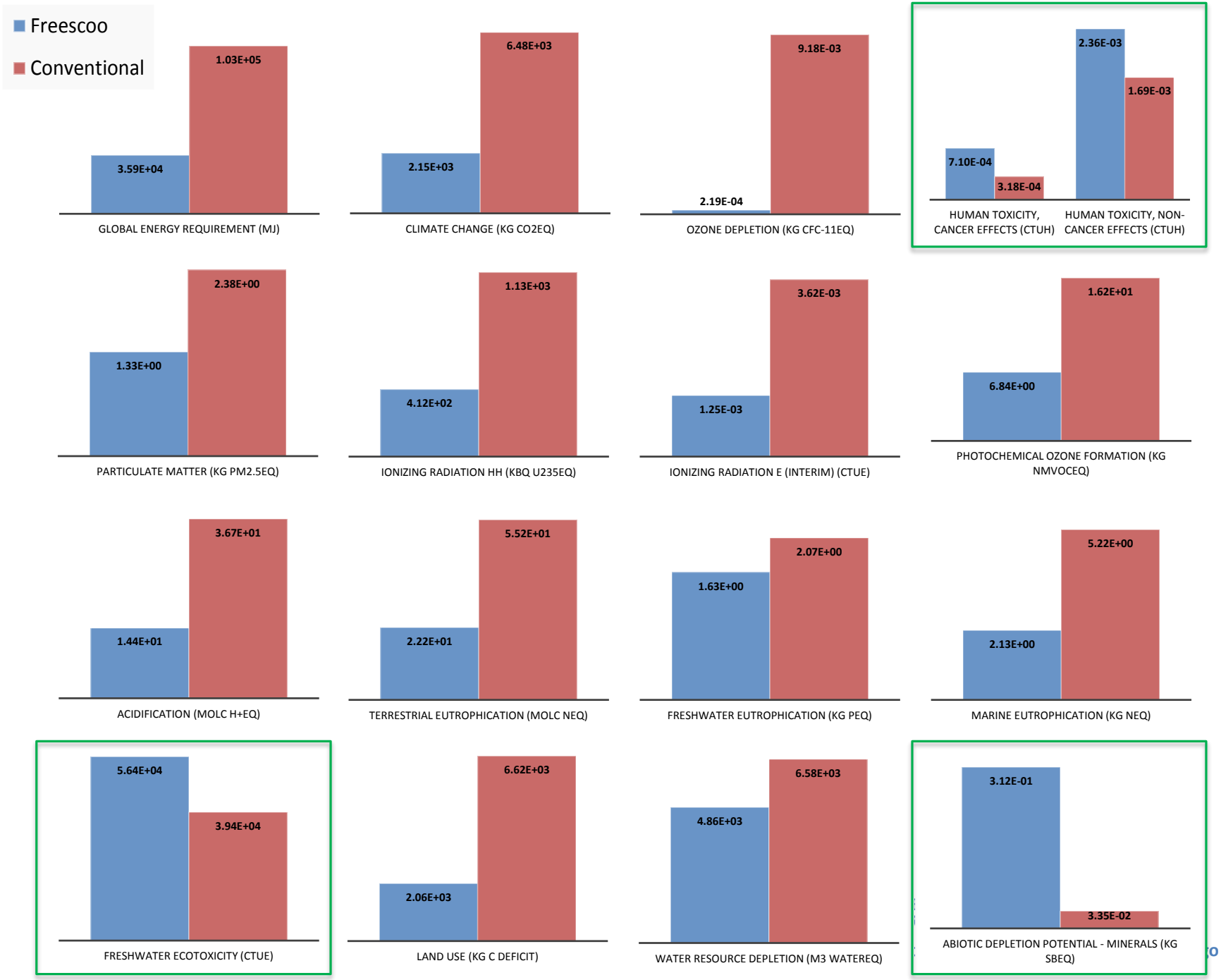
kg Sb_{eq}	3.12E-01	Mineral, fossil & ren resource depletion
m^3 $water_{eq}$	4.86E+03	Water resource depletion
kg C deficit	2.06E+03	Land use
CTUe	5.64E+04	Freshwater ecotoxicity
kg N_{eq}	2.13E+00	Marine eutrophication
kg P_{eq}	1.63E+00	Freshwater eutrophication
molc N_{eq}	2.22E+01	Terrestrial eutrophication
molc H^+_{eq}	1.44E+01	Acidification
kg $NMVOC_{eq}$	6.84E+00	Photochemical ozone formation
CTUe	1.25E-03	Ionizing radiation E (interim)
kBq $U235_{eq}$	4.12E+02	Ionizing radiation HH
kg $PM2.5_{eq}$	1.33E+00	Particulate matter
CTUh	2.36E-03	Human toxicity, non-cancer effects
CTUh	7.10E-04	Human toxicity, cancer effects
kg $CFC_{-11\ eq}$	2.19E-04	Ozone depletion
kg $CO_{2\ eq}$	2.15E+03	Climate change
MJ	3.59E+04	Global energy requirement




Freescoo
Conventional
1.03E+05
3.59E+04
GLOBAL ENERGY REQUIREMENT (MJ)
6.48E+03
2.15E+03
CLIMATE CHANGE (KG CO2EQ)
9.18E-03
2.19E-04
OZONE DEPLETION (KG CFC-11EQ)
2.36E-03
1.69E-03
7.10E-04
3.18E-04
HUMAN TOXICITY, CANCER EFFECTS (CTUH)
HUMAN TOXICITY, NON-CANCER EFFECTS (CTUH)
2.38E+00
1.33E+00
PARTICULATE MATTER (KG PM2.5EQ)
1.13E+03
4.12E+02
IONIZING RADIATION HH (KBQ U235EQ)
3.62E-03
1.25E-03
IONIZING RADIATION E (INTERIM) (CTUE)
1.62E+01
6.84E+00
PHOTOCHEMICAL OZONE FORMATION (KG NMVOCEQ)
3.67E+01
1.44E+01
ACIDIFICATION (MOLC H+EQ)
5.52E+01
2.22E+01
TERRESTRIAL EUTROPHICATION (MOLC NEQ)
2.07E+00
1.63E+00
FRESHWATER EUTROPHICATION (KG PEQ)
5.22E+00
2.13E+00
MARINE EUTROPHICATION (KG NEQ)
5.64E+04
3.94E+04
FRESHWATER ECOTOXICITY (CTUE)
6.62E+03
2.06E+03
LAND USE (KG C DEFICIT)
6.58E+03
4.86E+03
WATER RESOURCE DEPLETION (M3 WATEREQ)
3.12E-01
3.35E-02
ABIOTIC DEPLETION POTENTIAL - MINERALS (KG SBEQ)

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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

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Eco label sensibility

The results of the techno-economic analysis and of the LCA studies will be synthesized by using specific technical, economic, social, energy and environmental indicators identified in Activity A5-2.

TO BE DEVELOPED AFTER TECHNO-ECONOMIC AND LCA ANALYSES WILL BE COMPLETED

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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.

The main goal of this activity is to develop a draft document defining the 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.

OUR PROPOSAL: To define the KPI on the basis of the three pillars of sustainability (economy, environment, society). In addition, indicators on the technical performances of the systems could be used.

Developed actions: UNIPA is identifying KPI that will be summarized by using an "ad hoc" format.

Results:

- The definition of KPI is in progress.
- The format was developed.

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Energy and environmental indicators

State-of-the-art analysis on the energy and environmental labels currently available.

32 LABELS

The main characteristics of each label will be summarized in a specific format.

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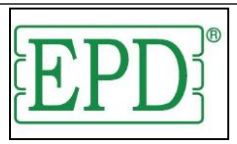
An example for the label EPD

LABEL NAME	EPD (Environmental Product Declaration)
SYMBOL	
GOAL	The International EPD® System has, as a main objective, the ambition to help and support organisations to communicate the environmental performance of their products (goods and services) in a credible and understandable way by: 1) offering a complete programme for any interested organisation in any country to develop and communicate environmental declarations according to ISO 14025 and EN 15804, supplementary information on particular environmental issues, such as the carbon footprint of products according to ISO/TS 14067 as “Single-issue EPDs,” 2) supporting other environmental declarations programmes (national, sectorial, etc.) in seeking cooperation and harmonisation and helping organisations to broaden the use environmental declarations on an international market.
SHORT DESCRIPTION	An EPD® is a certified Environmental Product Declaration, which reports environmental data over the life cycle of products in accordance with the international standard ISO 14025. The International EPD® System is a programme to develop and register EPDs for goods and services. The system is international, third party verified and deliver flexible source information. EPD® is a registered trademark for environmental product declarations registered in the International EPD® System.
CATEGORIES OF PRODUCTS AND SERVICES	Any type of goods and services
REGULATION	Type III ISO 14025:2006
WEBSITE	www.environdec.com
ENERGY AND ENVIRONMENTAL IMPACT INDICATORS	Use of resources: 1) non-renewable resources (material and energy resources); 2) renewable resources (material and energy resources); 3) water resource use. Potential environmental impacts: 1) Emission of greenhouse gases; 2) Emission of acidifying gases; 3) Emission of substances to water contributing to eutrophication; 4) Emission of gases contributing to the photochemical oxygen creation potential; 5) Emission of ozone-depleting gases; 6) Land use and land use change; 7) Abiotic resource depletion. Waste production: 1) Non-hazardous waste; 2) Hazardous waste; 3) Radioactive waste.

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Energy indicators Global Energy Requirement (MJ) Non renewable Energy Requirement (MJ) Renewable Energy Requirement (MJ) Energy payback time (years) Energy return ratio (a-dimensional)	**Economic indicators** Economic savings during the operation (€) Initial cost of the system (€) Operation/maintenance costs (€) Payback period (years)
Environmental indicators 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)	**Social indicators** Additional income per person (€) Customer satisfaction (qualitative) Ease of use of the systems (qualitative) Impact on new employment (qualitative)

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Technical indicators

Useful life (years)
Efficiency (to be defined)
Reliability (qualitative)
Degree of required skill for design, installation and maintainance (qualitative)
Percentage of breakdown (%)

The definition of KPI is in progress…

… The debate is open!

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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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Update of the LCA tool developed within Task 48

The LCA tool developed within Task 48 will be updated.

In detail:

-To add the energy and environmental impacts of conventional chillers and of components of the SHC systems, by using data from scientific literature (if available) and the results of the studies carried out within the activity A5.1.

-To split the worksheet related to the solar heating and cooling system in three sections:

✓Section for thermal solar heating and cooling systems;

✓Section for photovoltaic solar heating and cooling systems;

✓Section for thermal and photovoltaic (hybrid) solar heating and cooling systems.

The update is in progress.

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Dissemination of the results

6th International Conference
Solar
Air-
Conditioning

OTTI

A simple tool for life cycle assessment of solar heating and cooling systems

Marco Beccali, Maurizio Cellura, Sonia Longo

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Available online at www.sciencedirect.com

ScienceDirect

Energy Procedia 00 (2015) 000–000

Energy Procedia

www.elsevier.com/locate/procedia

SHC 2015, International Conference on Solar Heating and Cooling for Buildings and Industry

A simplified LCA tool for solar heating and cooling systems

Marco Beccali[a]*, Maurizio Cellura[a], Sonia Longo[a], Daniel Mugnier[b]

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Solar Energy Materials & Solar Cells ∎ (∎∎∎∎) ∎∎∎–∎∎∎

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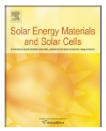

Solar heating and cooling systems versus conventional systems assisted by photovoltaic: Application of a simplified LCA tool

Marco Beccali, Maurizio Cellura, Sonia Longo*, Francesco Guarino

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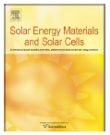

Life Cycle Assessment of a compact Desiccant Evaporative Cooling system: The case study of the "Freescoo"

Pietro Finocchiaro, Marco Beccali, Maurizio Cellura, Francesco Guarino*, Sonia Longo

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THANK YOU FOR YOUR ATTENTION

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