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**

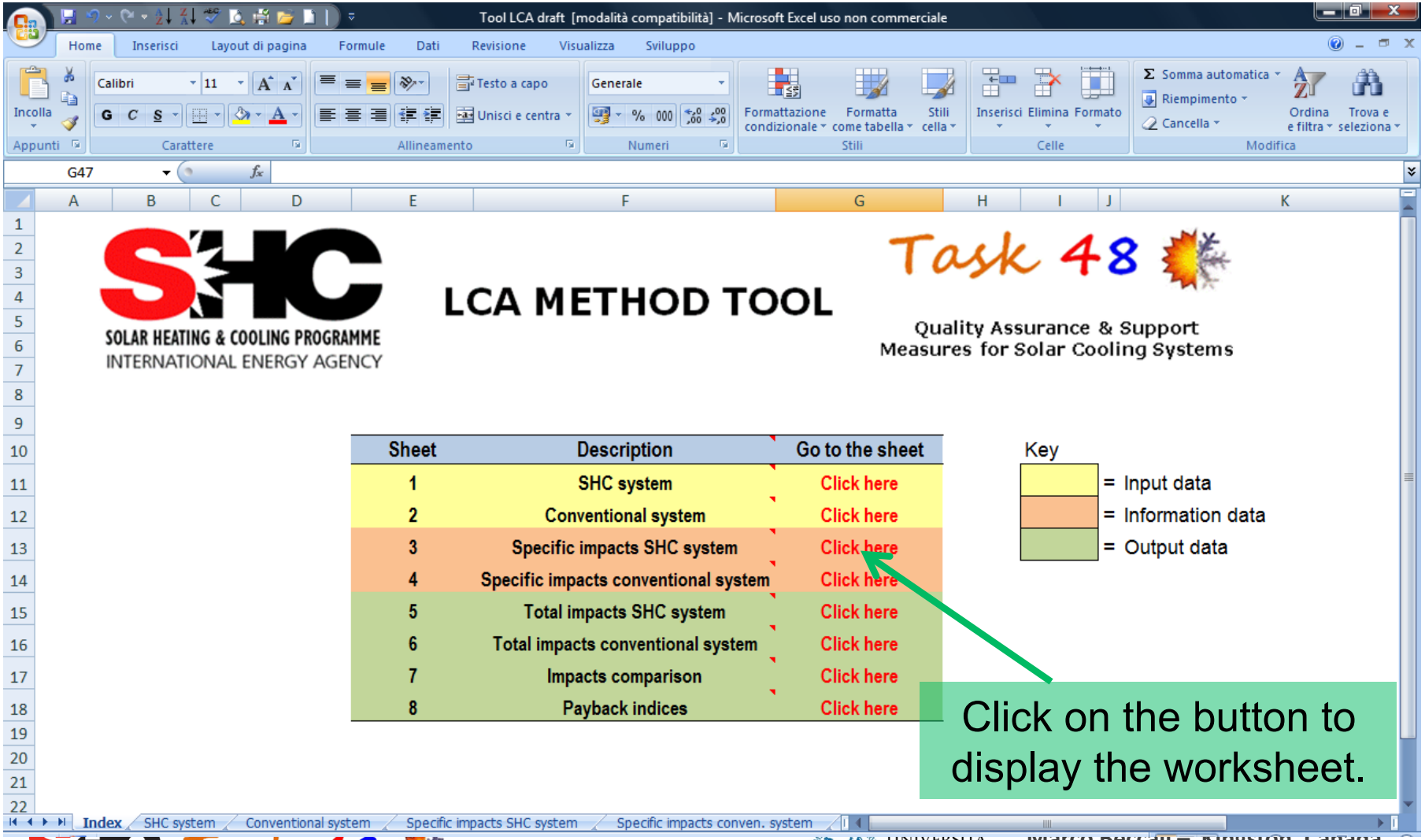
# LCA METHOD TOOL

**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.**

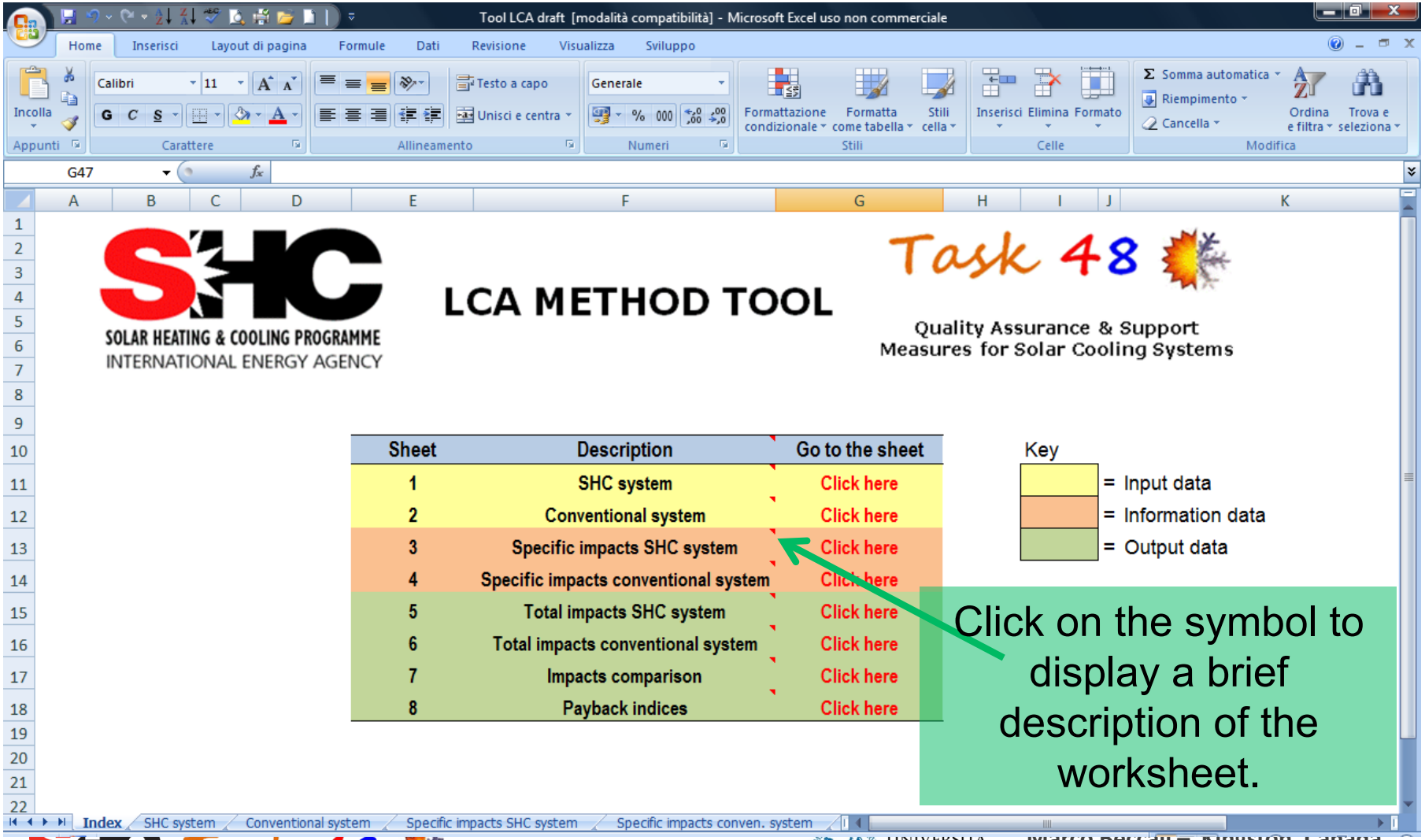
# LCA METHOD TOOL

## Sheet "Index": It contains a list of the worksheets



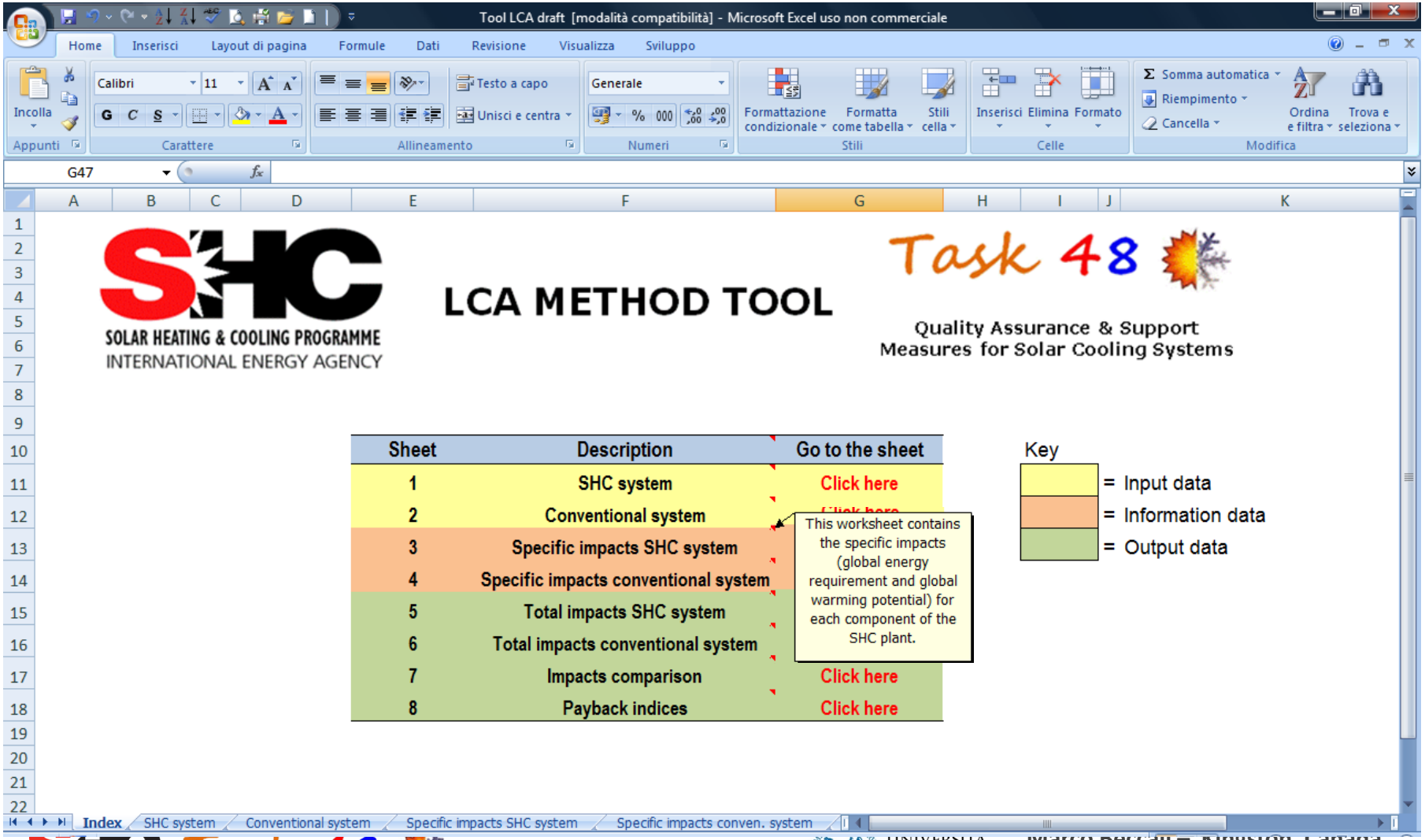
# LCA METHOD TOOL

## Sheet "Index": It contains a list of the worksheets



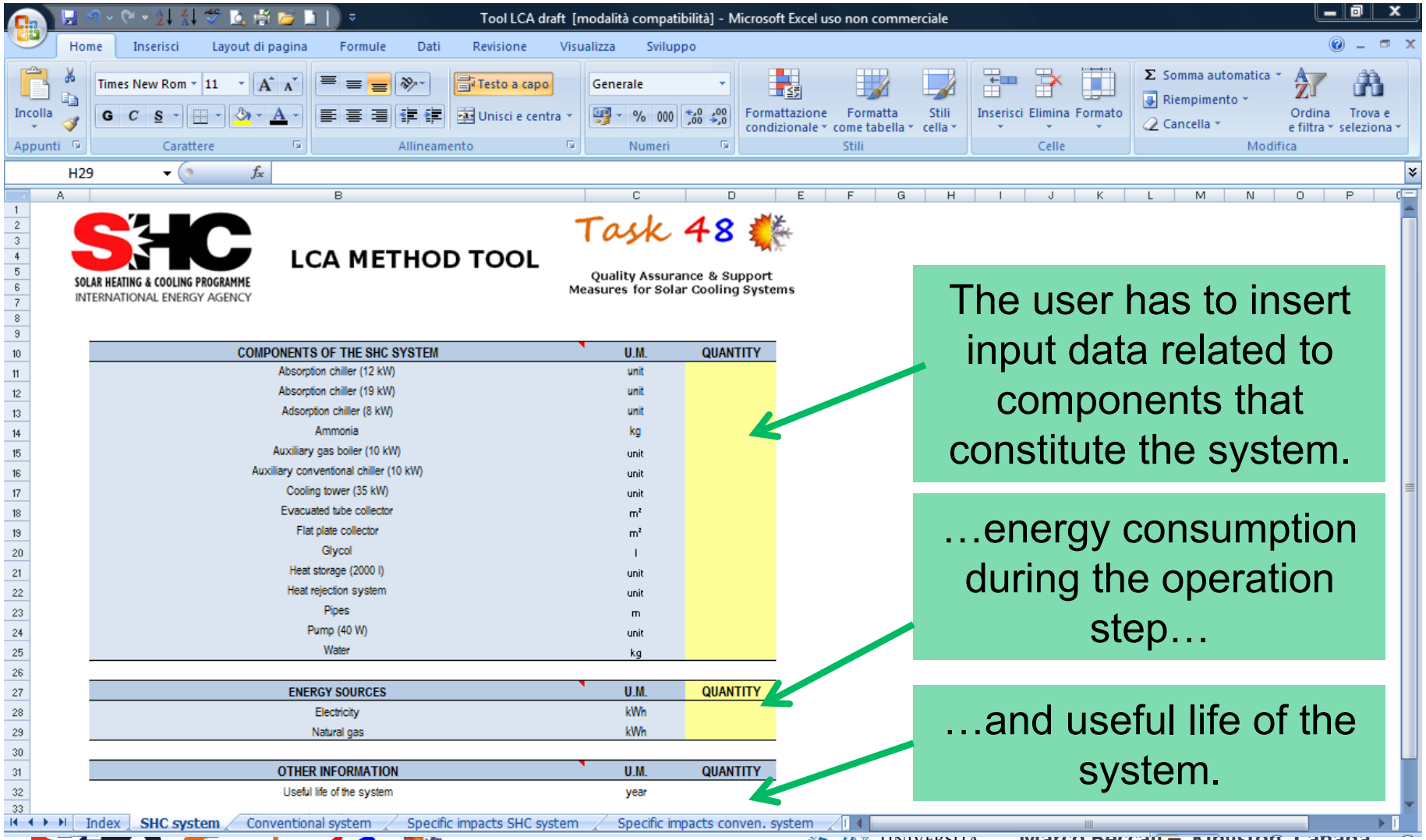
# LCA METHOD TOOL

## Sheet "Index": It contains a list of the worksheets



# LCA METHOD TOOL

## Sheet No.1: SHC system




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 | |
| | MJ | |

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)

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

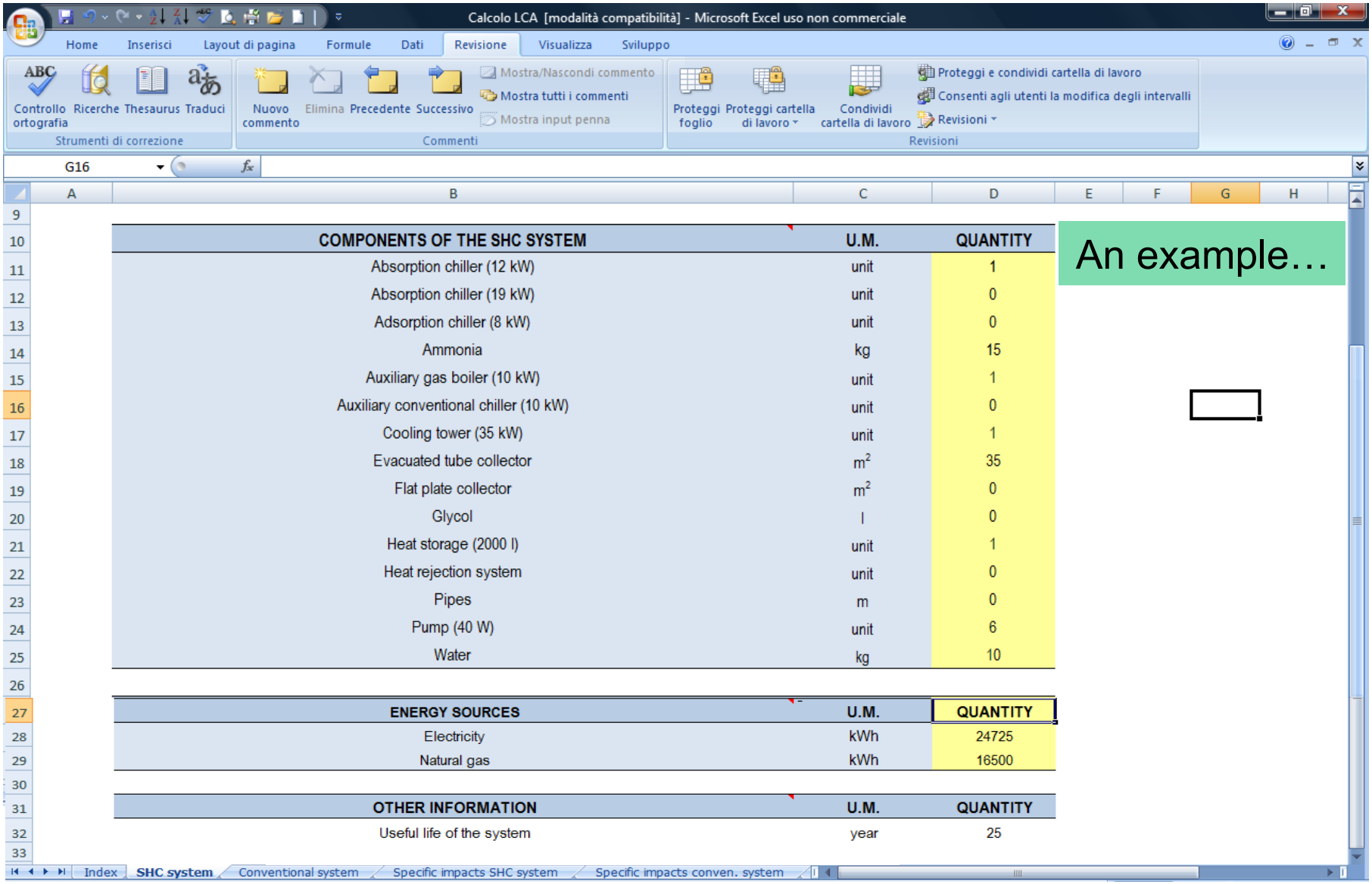
| ENERGY SOURCES | U.M. | QUANTITY |
|---|---|---|
| Electricity | kWh | |
| Natural gas | MJ | |

Natural gas, burned in boiler atmosferic burner non-modulating, <100 kW, Europe
Natural gas, burned in boiler atmosferic 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 SHC system.

# LCA METHOD TOOL

## Sheet No.1: SHC system




| 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 |

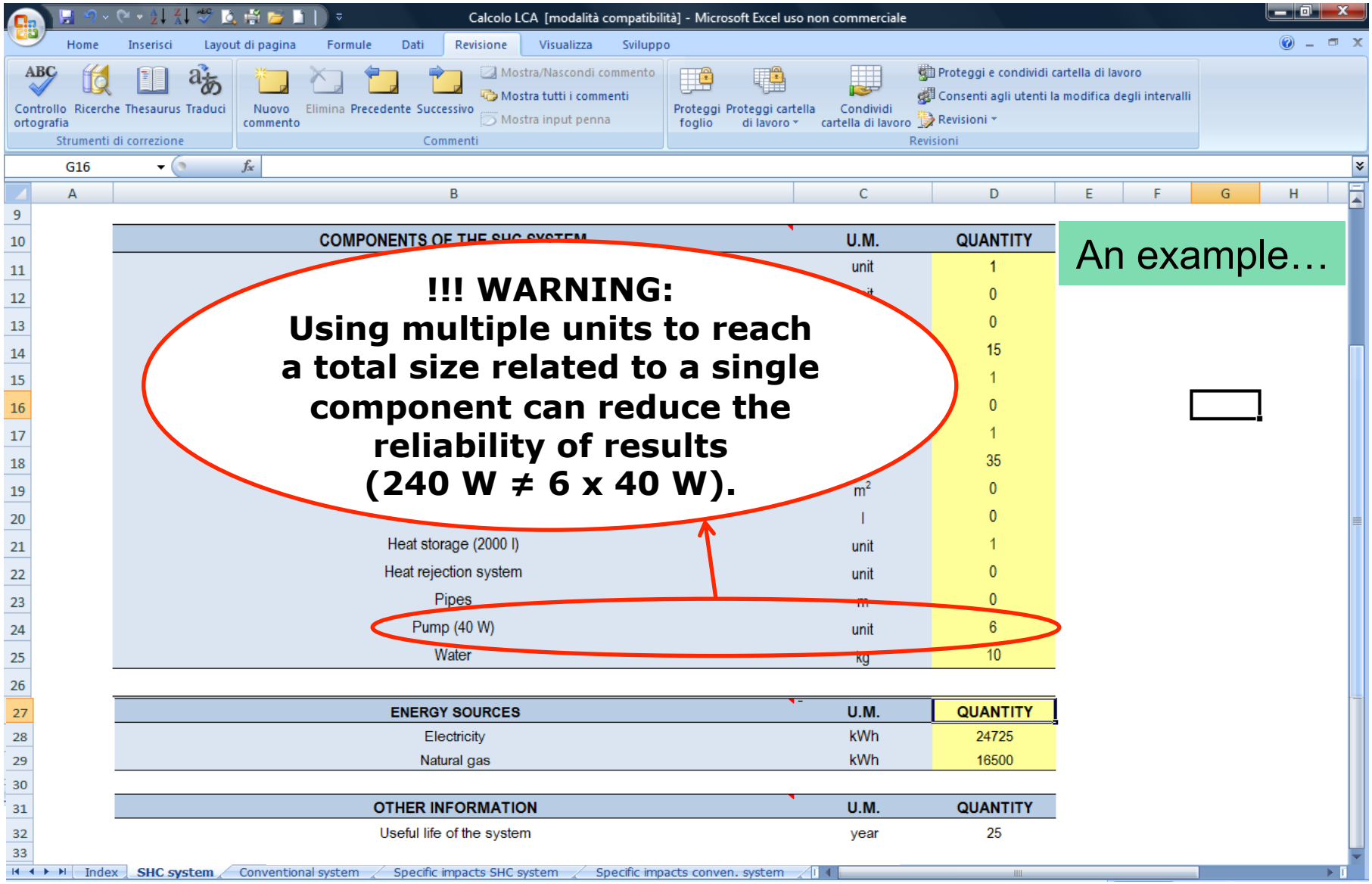
| ENERGY SOURCES | U.M. | QUANTITY |
|---|---|---|
| Electricity | kWh | 24725 |
| Natural gas | kWh | 16500 |

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

An example…

# LCA METHOD TOOL

## Sheet No.1: SHC system



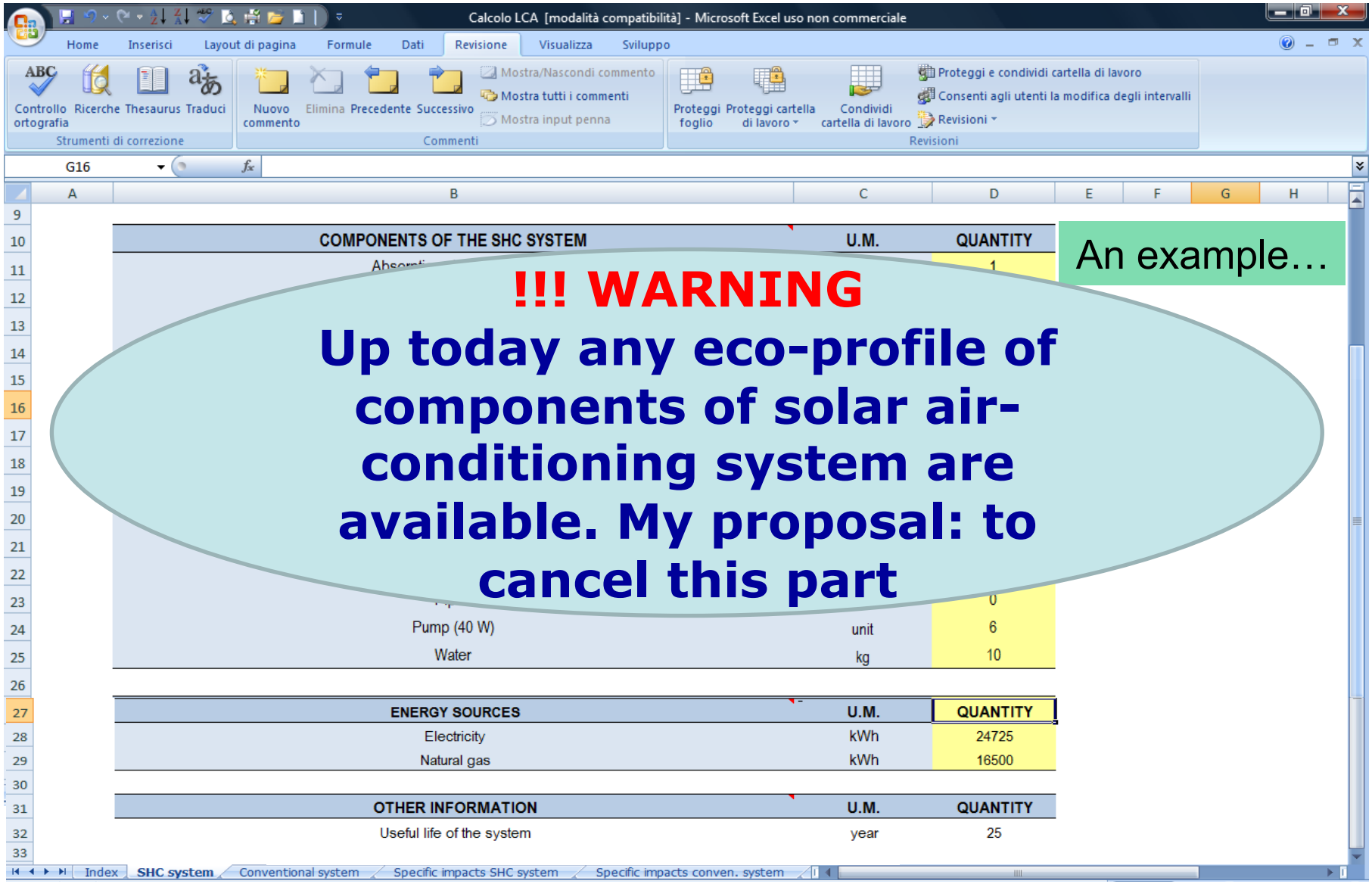

| COMPONENTS OF THE SHC SYSTEM | U.M. | QUANTITY |
|---|---|---|
| | unit | 1 |
| | | 0 |
| | | 0 |
| | | 15 |
| | | 1 |
| | | 0 |
| | | 1 |
| | | 35 |
| | $m^2$ | 0 |
| | l | 0 |
| Heat storage (2000 l) | unit | 1 |
| Heat rejection system | unit | 0 |
| Pipes | m | 0 |
| Pump (40 W) | unit | 6 |
|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

# LCA METHOD TOOL

## Sheet No.1: SHC system



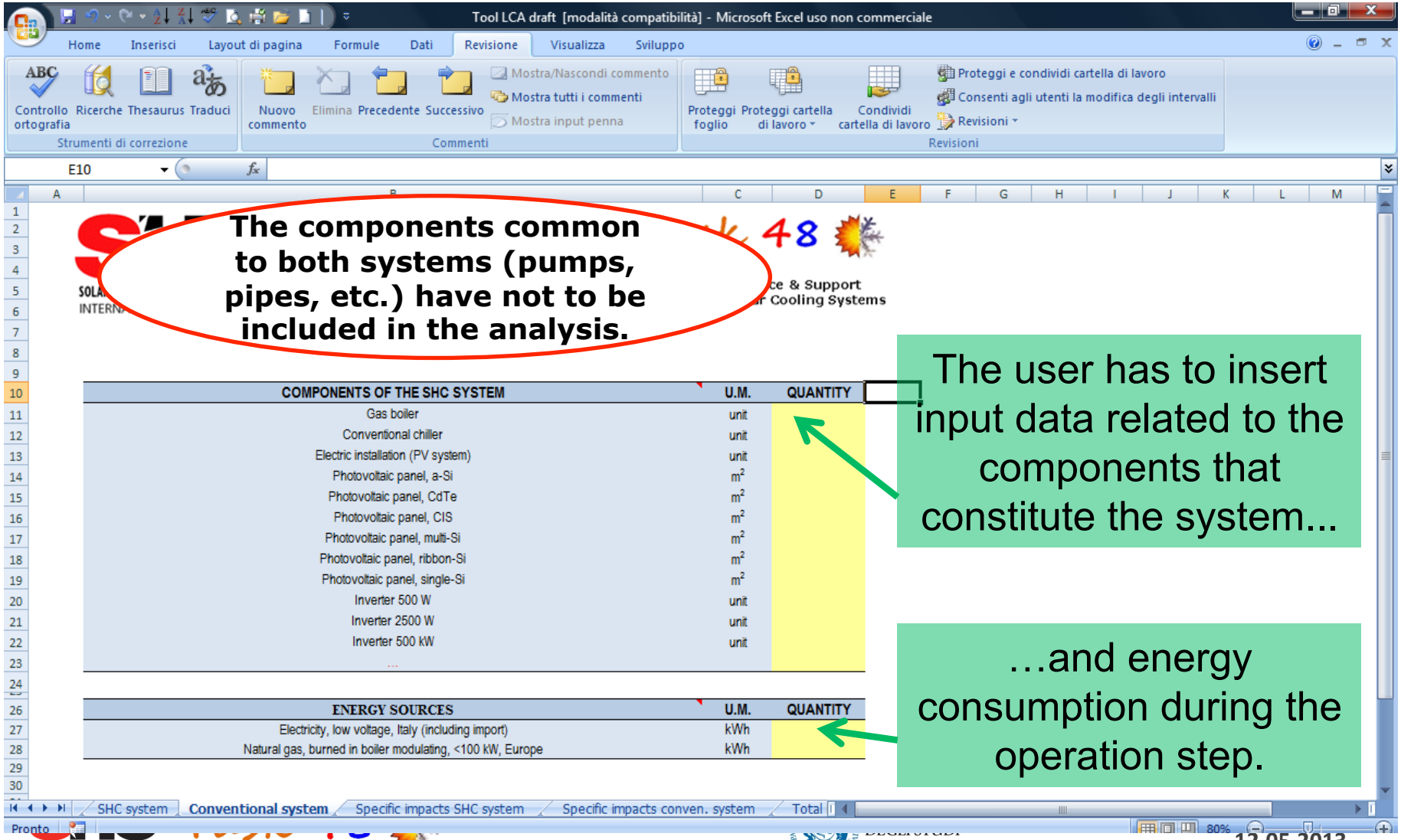

An example…

**!!! WARNING**

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

# LCA METHOD TOOL

## Sheet No.2: Conventional system




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

…and energy consumption during the operation step.

# LCA METHOD TOOL

## Sheet No.2: Conventional system

| ENERGY SOURCES | U.M. | QUANTITY |
|---|---|---|
| Electricity | kWh | |
| | MJ | |

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)

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

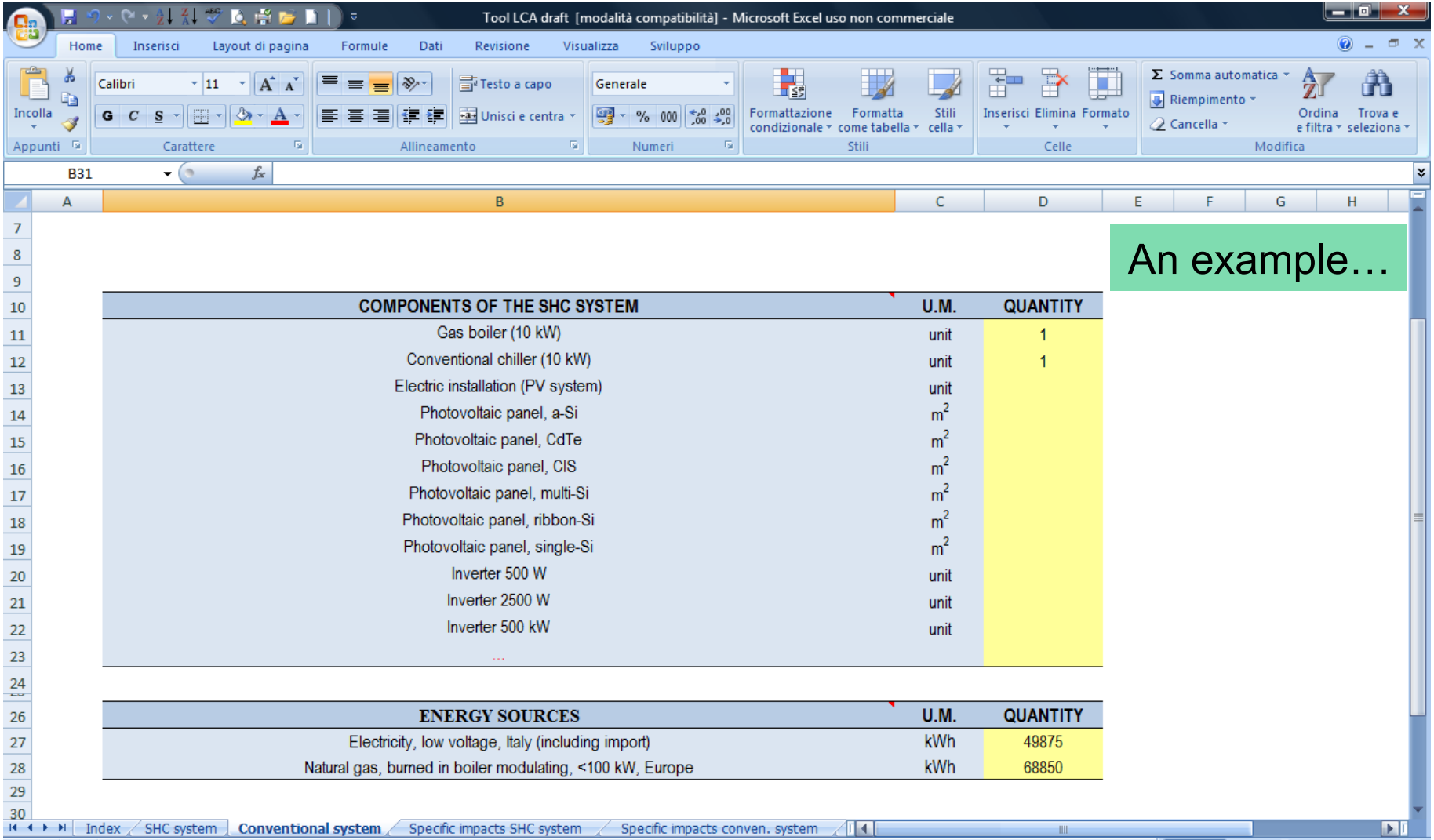
| ENERGY SOURCES | U.M. | QUANTITY |
|---|---|---|
| Electricity | kWh | |
| Natural gas | MJ | |

Natural gas, burned in boiler atmosferic burner non-modulating, <100 kW, Europe
Natural gas, burned in boiler atmosferic 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

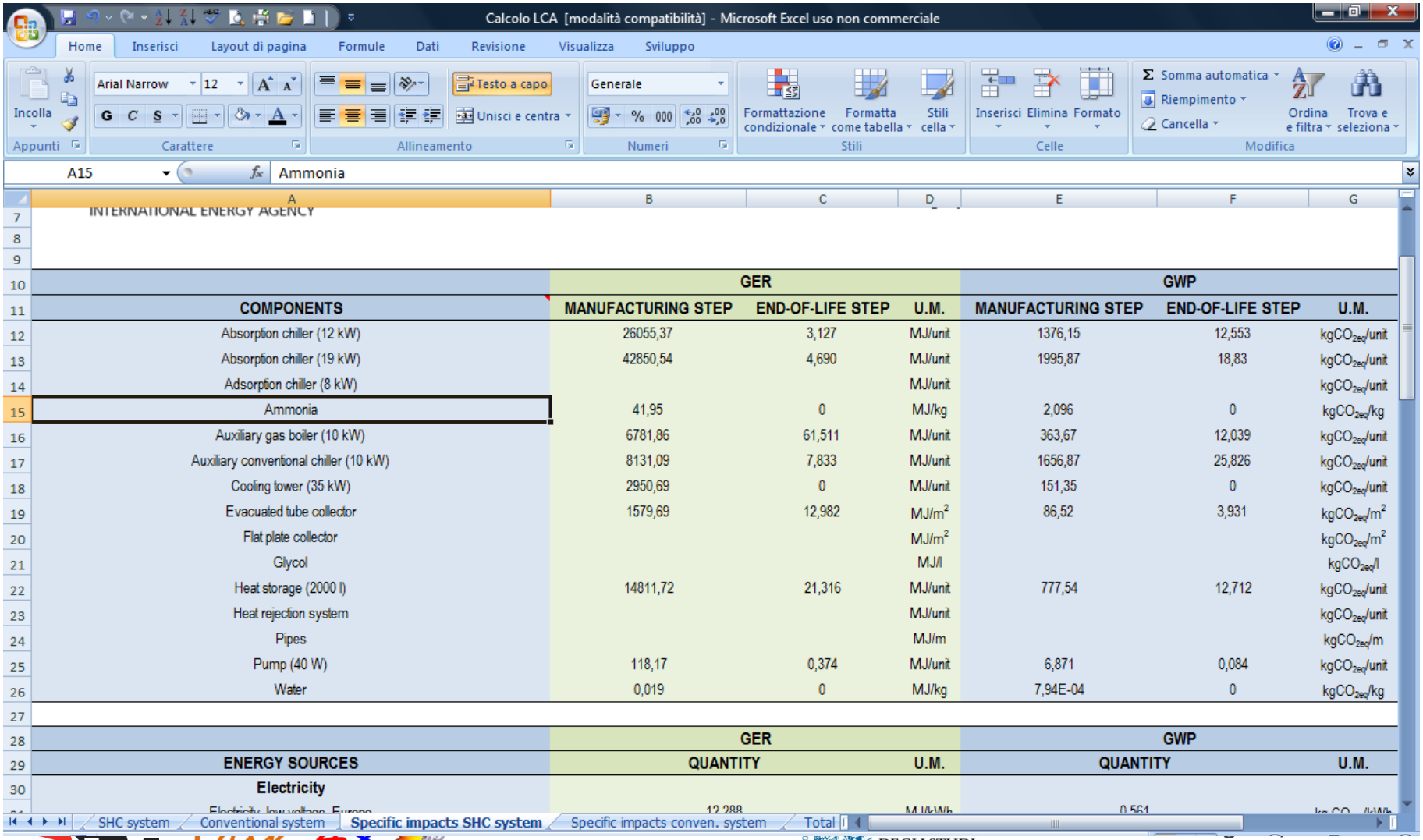



| COMPONENTS OF THE SHC SYSTEM | U.M. | QUANTITY |
|---|---|---|
| Gas boiler (10 kW) | unit | 1 |
| Conventional chiller (10 kW) | unit | 1 |
| Electric installation (PV system) | unit | |
| Photovoltaic panel, a-Si | $m^2$ | |
| Photovoltaic panel, CdTe | $m^2$ | |
| Photovoltaic panel, CIS | $m^2$ | |
| 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

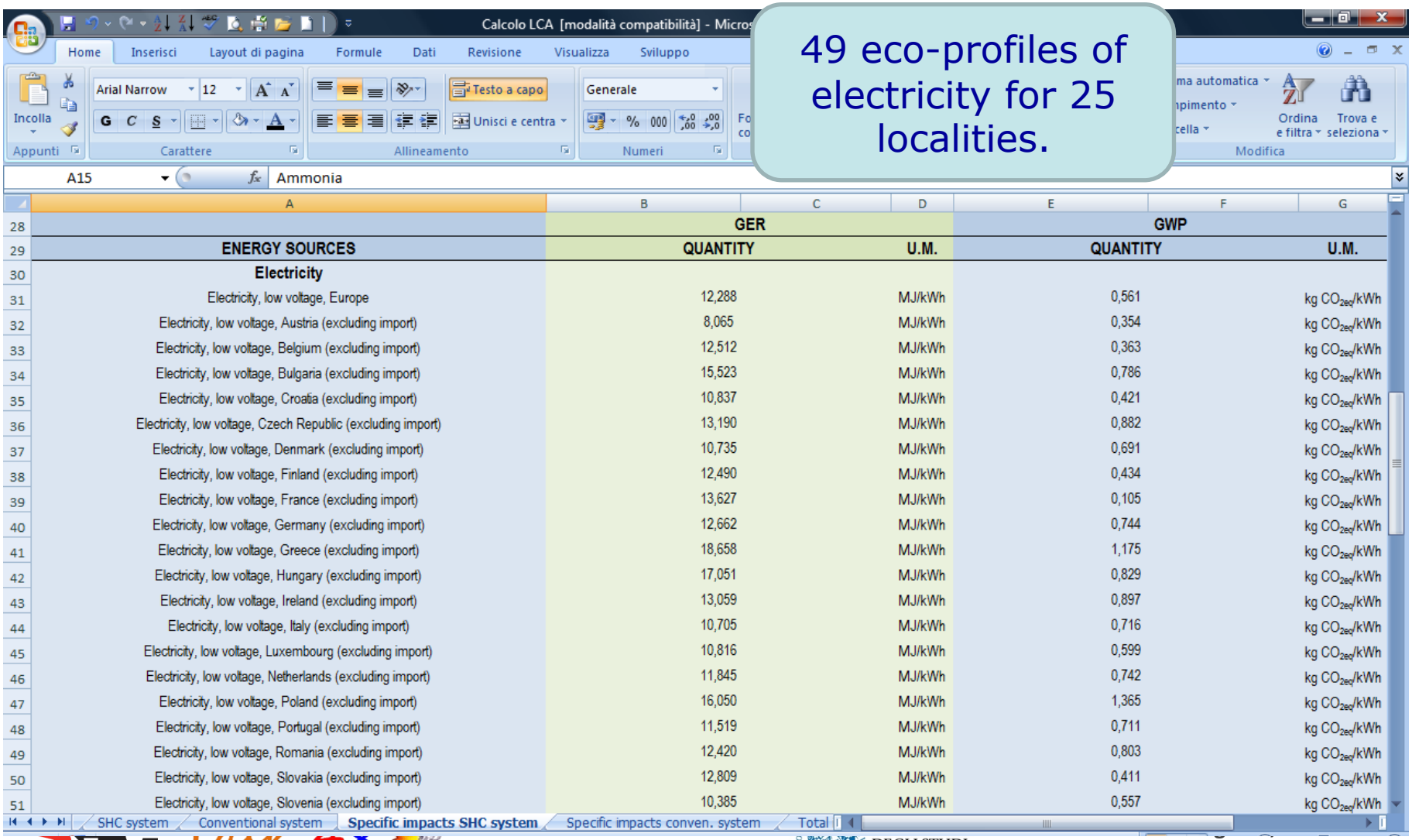



| | GER | | | GWP | | |
|---|---|---|---|---|---|---|
| **COMPONENTS** | **MANUFACTURING STEP** | **END-OF-LIFE STEP** | **U.M.** | **MANUFACTURING STEP** | **END-OF-LIFE STEP** | **U.M.** |
| Absorption chiller (12 kW) | 26055,37 | 3,127 | MJ/unit | 1376,15 | 12,553 | $kgCO_{2eq}$/unit |
| Absorption 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** | | | | |
| Electricity, low voltage, Europe | 12,288 | MJ/kWh | 0,561 | kg CO ... /kWh |

# LCA METHOD TOOL

## Sheet No.3: Specific impacts for SHC system

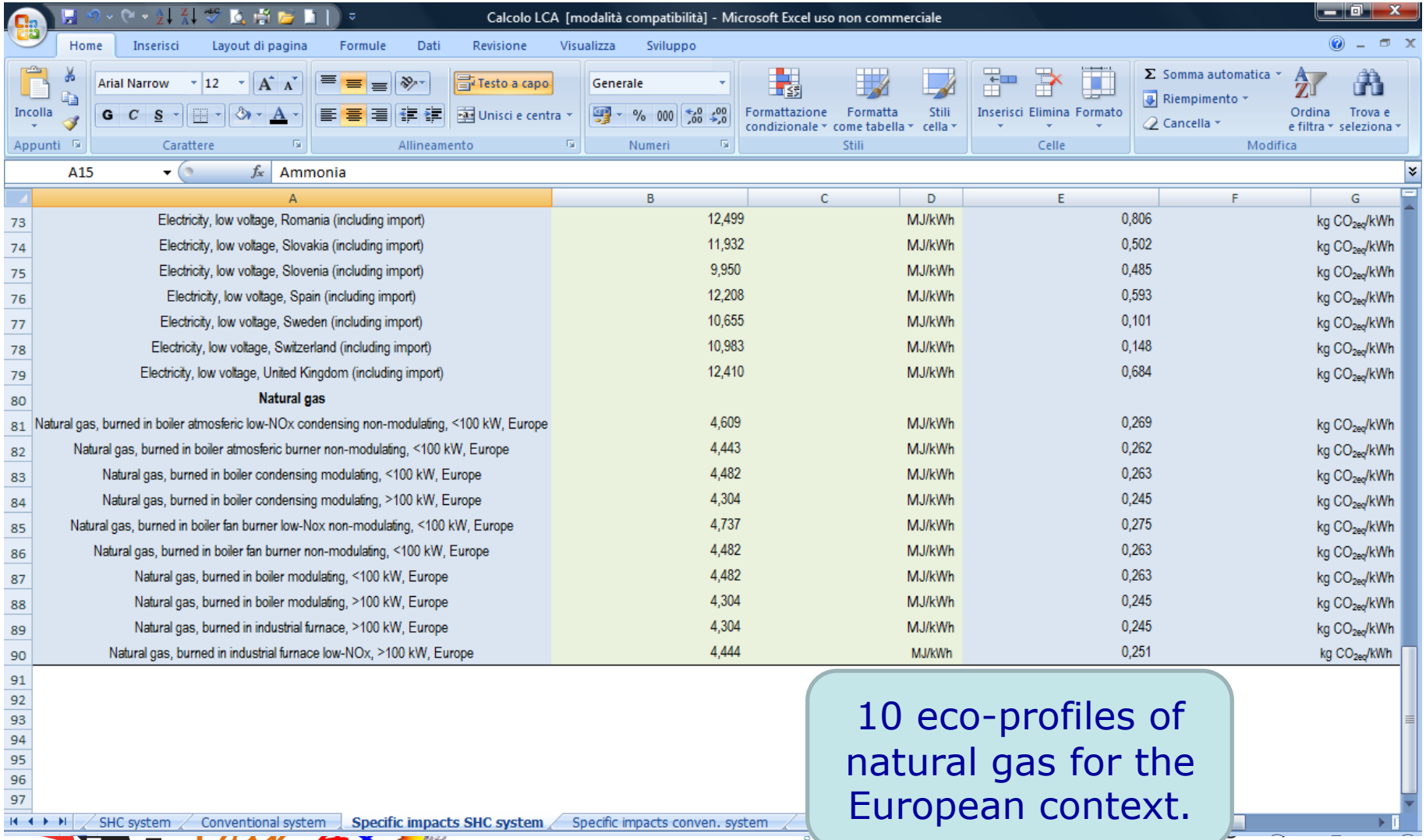


49 eco-profiles of electricity for 25 localities.

| | A | B | C | D | E | F | G |
|---|---|---|---|---|---|---|---|
| 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 |
| 34 | Electricity, low voltage, Bulgaria (excluding import) | 15,523 | | MJ/kWh | 0,786 | | kg $CO_{2eq}$/kWh |
| 35 | Electricity, low voltage, Croatia (excluding import) | 10,837 | | MJ/kWh | 0,421 | | kg $CO_{2eq}$/kWh |
| 36 | Electricity, low voltage, Czech Republic (excluding import) | 13,190 | | MJ/kWh | 0,882 | | kg $CO_{2eq}$/kWh |
| 37 | Electricity, low voltage, Denmark (excluding import) | 10,735 | | MJ/kWh | 0,691 | | kg $CO_{2eq}$/kWh |
| 38 | Electricity, low voltage, Finland (excluding import) | 12,490 | | MJ/kWh | 0,434 | | kg $CO_{2eq}$/kWh |
| 39 | Electricity, low voltage, France (excluding import) | 13,627 | | MJ/kWh | 0,105 | | kg $CO_{2eq}$/kWh |
| 40 | Electricity, low voltage, Germany (excluding import) | 12,662 | | MJ/kWh | 0,744 | | kg $CO_{2eq}$/kWh |
| 41 | Electricity, low voltage, Greece (excluding import) | 18,658 | | MJ/kWh | 1,175 | | kg $CO_{2eq}$/kWh |
| 42 | Electricity, low voltage, Hungary (excluding import) | 17,051 | | MJ/kWh | 0,829 | | kg $CO_{2eq}$/kWh |
| 43 | Electricity, low voltage, Ireland (excluding import) | 13,059 | | MJ/kWh | 0,897 | | kg $CO_{2eq}$/kWh |
| 44 | Electricity, low voltage, Italy (excluding import) | 10,705 | | MJ/kWh | 0,716 | | kg $CO_{2eq}$/kWh |
| 45 | Electricity, low voltage, Luxembourg (excluding import) | 10,816 | | MJ/kWh | 0,599 | | kg $CO_{2eq}$/kWh |
| 46 | Electricity, low voltage, Netherlands (excluding import) | 11,845 | | MJ/kWh | 0,742 | | kg $CO_{2eq}$/kWh |
| 47 | Electricity, low voltage, Poland (excluding import) | 16,050 | | MJ/kWh | 1,365 | | kg $CO_{2eq}$/kWh |
| 48 | Electricity, low voltage, Portugal (excluding import) | 11,519 | | MJ/kWh | 0,711 | | kg $CO_{2eq}$/kWh |
| 49 | Electricity, low voltage, Romania (excluding import) | 12,420 | | MJ/kWh | 0,803 | | kg $CO_{2eq}$/kWh |
| 50 | Electricity, low voltage, Slovakia (excluding import) | 12,809 | | MJ/kWh | 0,411 | | kg $CO_{2eq}$/kWh |
| 51 | 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

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Appunti | Carattere | Allineamento | Numeri | Stili | Celle | Modifica

A15 | Ammonia

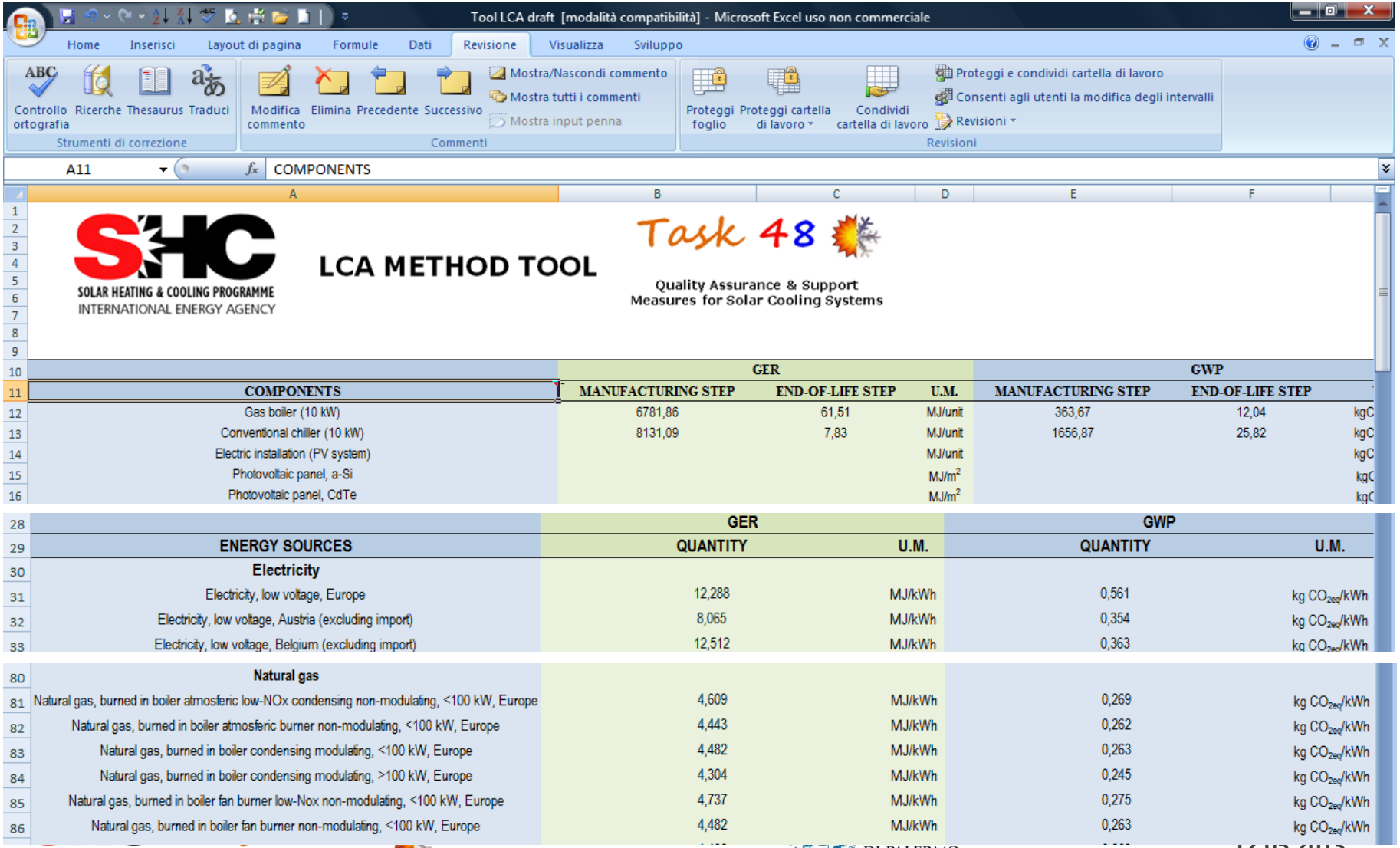
| | A | B | C | D | E | F | G |
|---|---|---|---|---|---|---|---|
| 73 | Electricity, low voltage, Romania (including import) | 12,499 | | MJ/kWh | 0,806 | | kg $CO_{2eq}$/kWh |
| 74 | Electricity, low voltage, Slovakia (including import) | 11,932 | | MJ/kWh | 0,502 | | kg $CO_{2eq}$/kWh |
| 75 | Electricity, 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 | | | | | | | |
| 96 | | | | | | | |
| 97 | | | | | | | |

SHC system | Conventional system | Specific impacts SHC system | Specific impacts conven. system

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

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Controllo ortografia | Ricerche | Thesaurus | Traduci — Strumenti di correzione

Modifica commento | Elimina | Precedente | Successivo | Mostra/Nascondi commento | Mostra tutti i commenti | Mostra input penna — Commenti

Proteggi foglio | Proteggi cartella di lavoro | Condividi cartella di lavoro | Proteggi e condividi cartella di lavoro | Consenti agli utenti la modifica degli intervalli | Revisioni — Revisioni

A11 COMPONENTS

SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

LCA METHOD TOOL

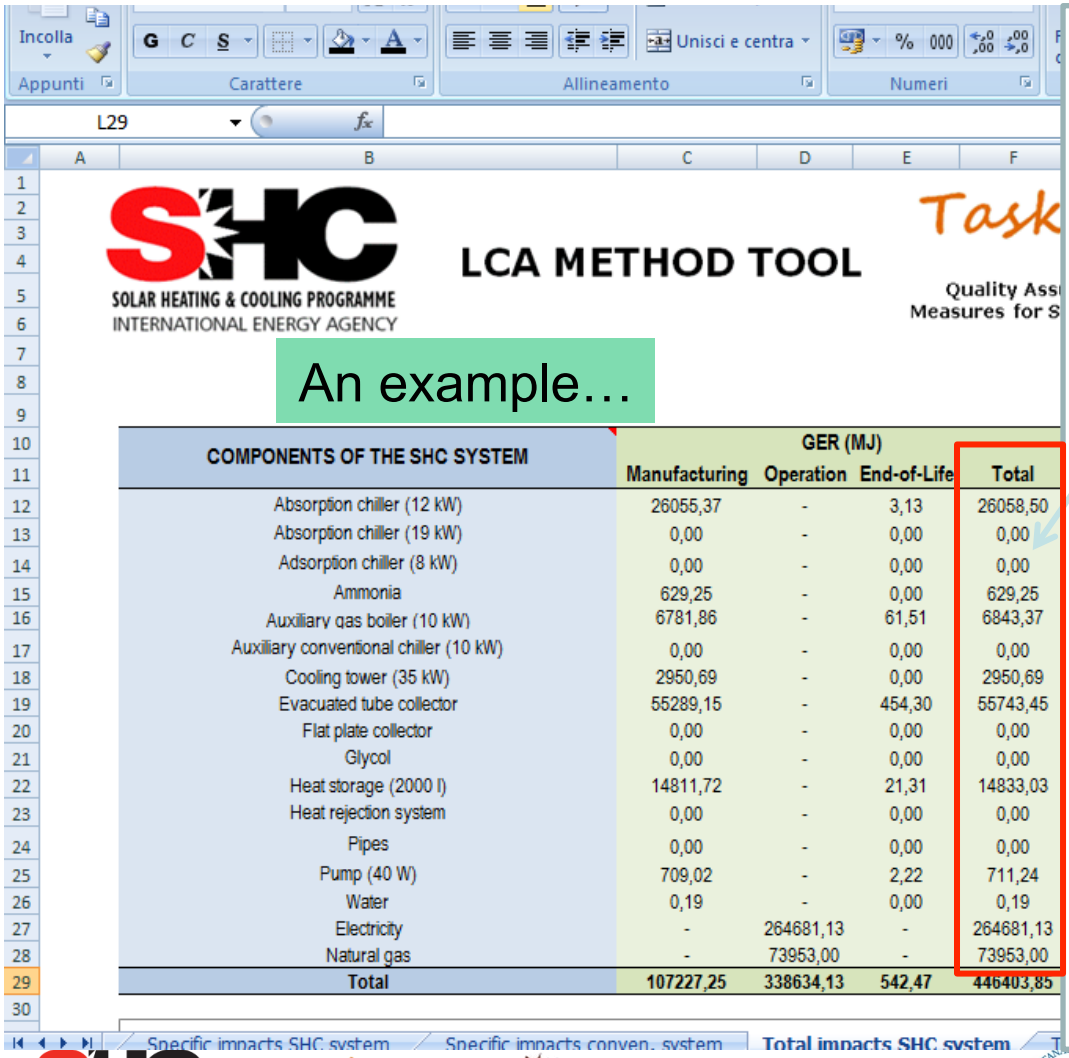
Task 48
Quality Assurance & Support Measures for Solar Cooling Systems

| | GER | | | GWP | | |
|---|---|---|---|---|---|---|
| COMPONENTS | MANUFACTURING STEP | END-OF-LIFE STEP | U.M. | MANUFACTURING STEP | END-OF-LIFE STEP | |
| Gas boiler (10 kW) | 6781,86 | 61,51 | MJ/unit | 363,67 | 12,04 | kgC |
| Conventional chiller (10 kW) | 8131,09 | 7,83 | MJ/unit | 1656,87 | 25,82 | kgC |
| Electric installation (PV system) | | | MJ/unit | | | kgC |
| Photovoltaic panel, a-Si | | | MJ/m² | | | kgC |
| Photovoltaic panel, CdTe | | | MJ/m² | | | kgC |

| | GER | | GWP | |
|---|---|---|---|---|
| ENERGY SOURCES | QUANTITY | U.M. | QUANTITY | U.M. |
| **Electricity** | | | | |
| 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 |
| **Natural gas** | | | | |
| Natural gas, burned in boiler atmosferic low-NOx condensing non-modulating, <100 kW, Europe | 4,609 | MJ/kWh | 0,269 | kg $CO_{2eq}$/kWh |
| Natural gas, burned in boiler atmosferic burner non-modulating, <100 kW, Europe | 4,443 | MJ/kWh | 0,262 | kg $CO_{2eq}$/kWh |
| Natural gas, burned in boiler condensing modulating, <100 kW, Europe | 4,482 | MJ/kWh | 0,263 | kg $CO_{2eq}$/kWh |
| Natural gas, burned in boiler condensing modulating, >100 kW, Europe | 4,304 | MJ/kWh | 0,245 | kg $CO_{2eq}$/kWh |
| Natural gas, burned in boiler fan burner low-Nox non-modulating, <100 kW, Europe | 4,737 | MJ/kWh | 0,275 | kg $CO_{2eq}$/kWh |
| 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



SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

LCA METHOD TOOL

Task

Quality Ass
Measures for S

An example…

| 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** |

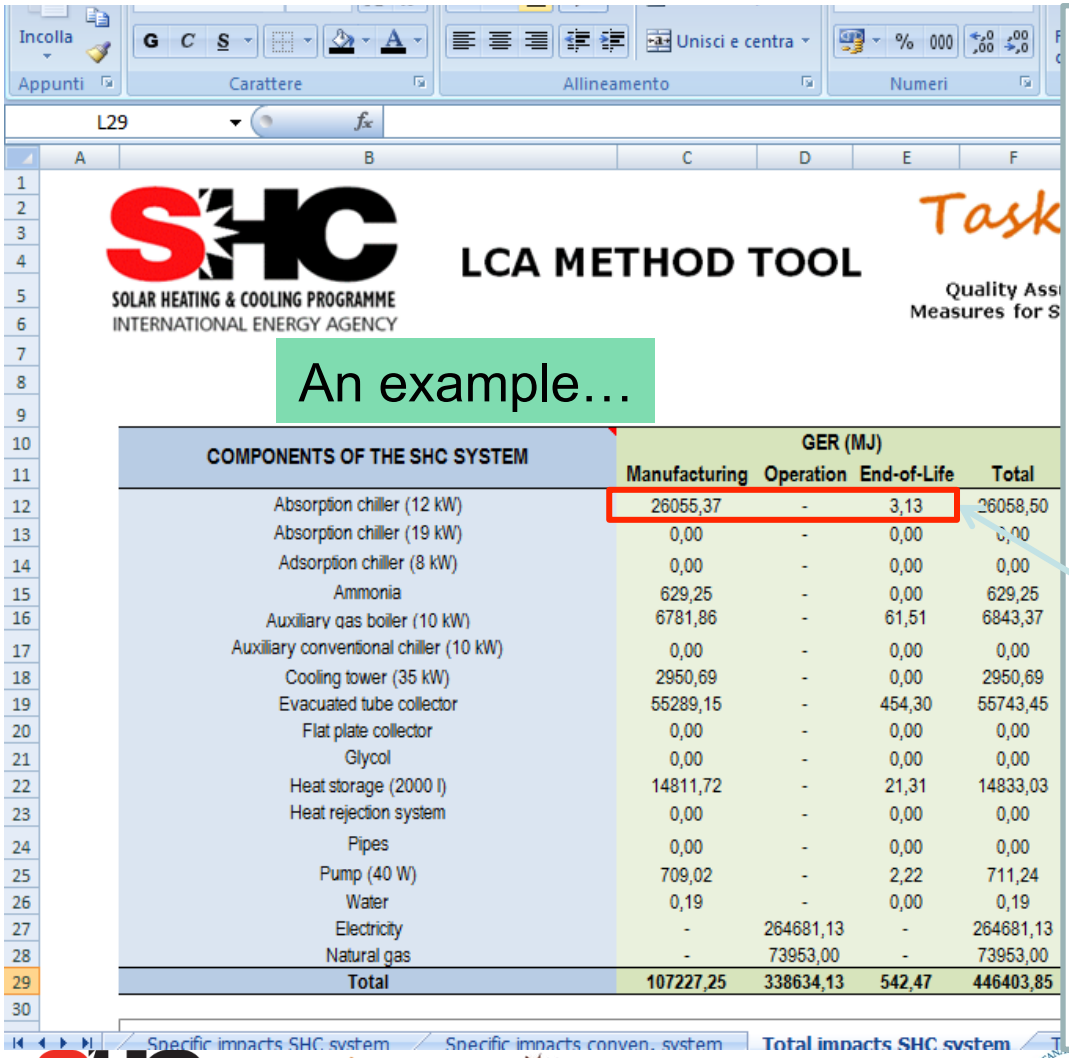
Specific impacts SHC system | Specific impacts conven. system | Total impacts SHC system

**The tool shows:**

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

# LCA METHOD TOOL

## Sheet No.5: Total impacts for SHC system



SOLAR HEATING & COOLING PROGRAMME
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LCA METHOD TOOL

Task

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Measures for S

An example…

| 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 |
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| 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 |
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| 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** |

Specific impacts SHC system | Specific impacts conven. system | Total impacts SHC system

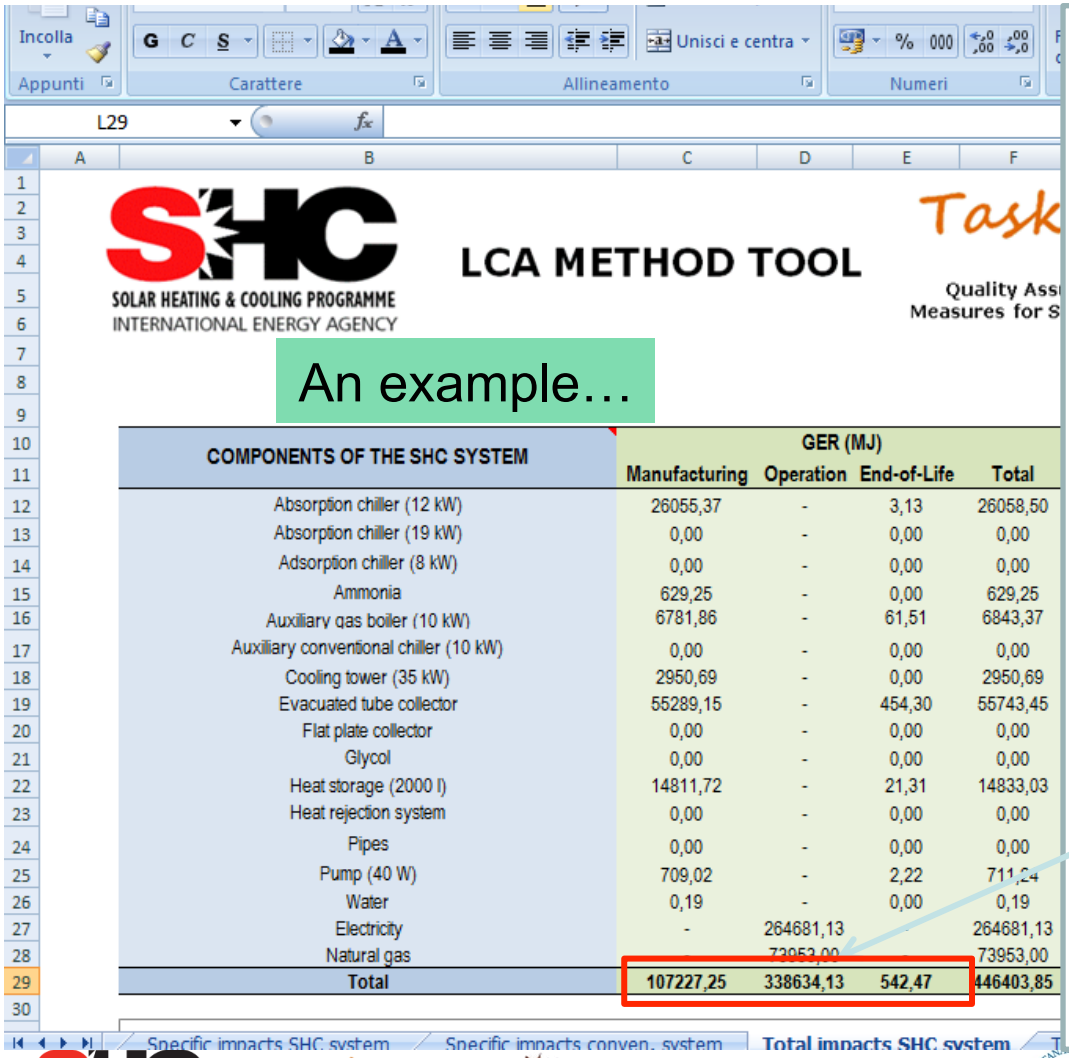
**The tool shows:**

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



SOLAR HEATING & COOLING PROGRAMME
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Task

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An example…

| 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 |
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| 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:**

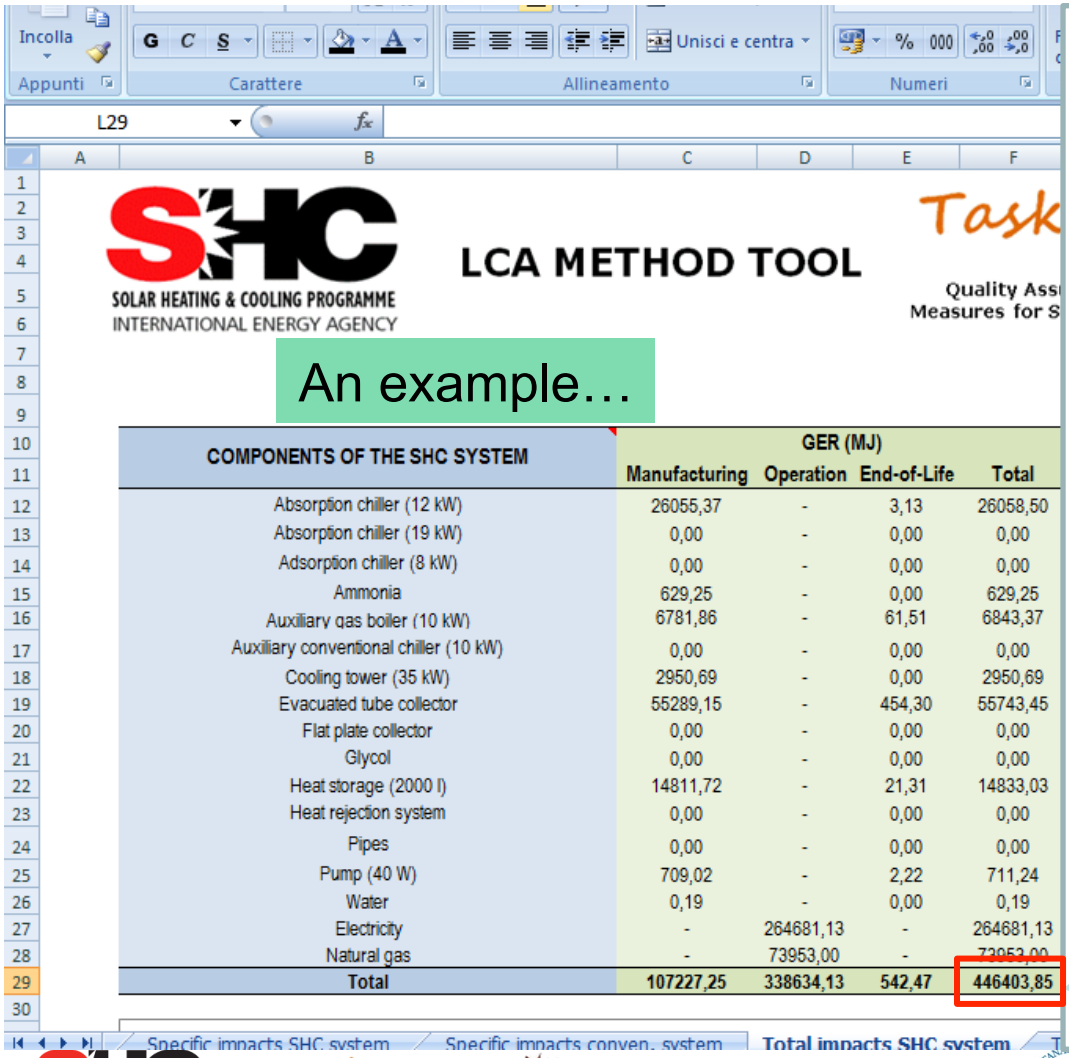
1) **The total impact for each component/energy source;**

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);**

# LCA METHOD TOOL

## Sheet No.5: Total impacts for SHC system



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An example…

| 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;**

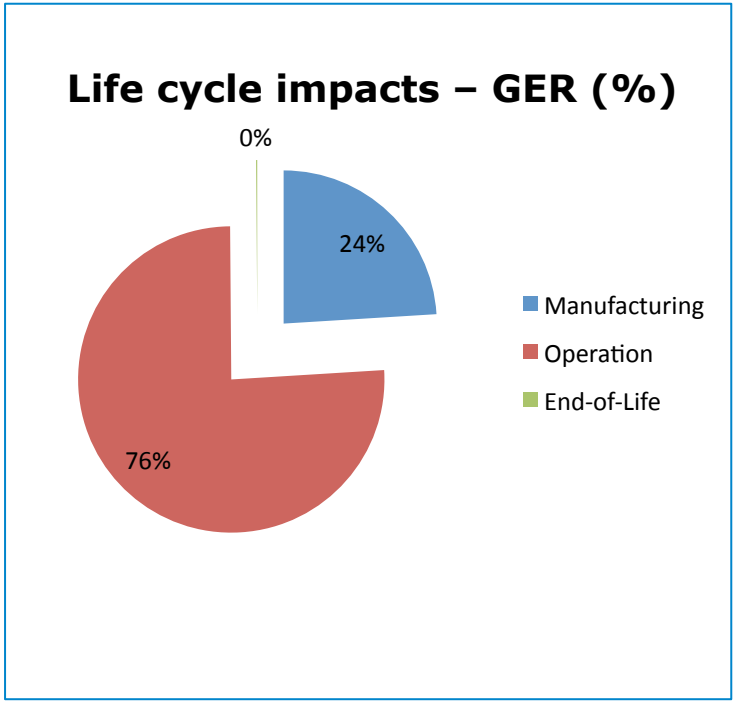
3) **The total impact for each life-cycle step (manufacturing, operation, end-of-life);**

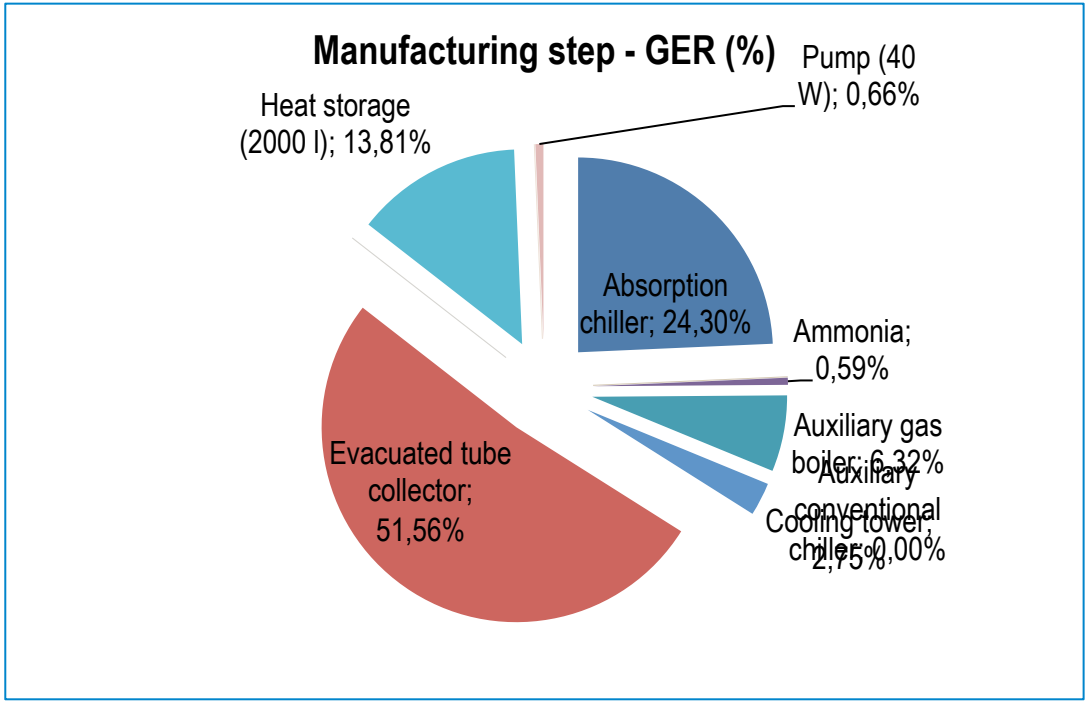
4) **The total impact for the life-cycle of the SHC system.**

# LCA METHOD TOOL

## Sheet No.5: Total impacts for SHC system

A picture of results…

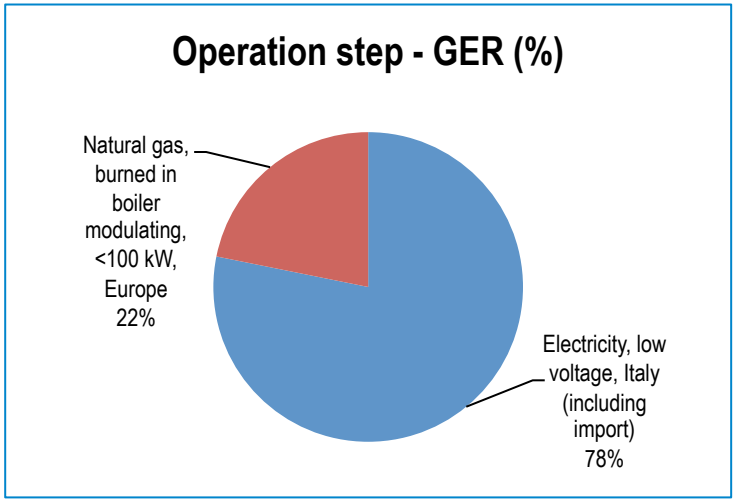


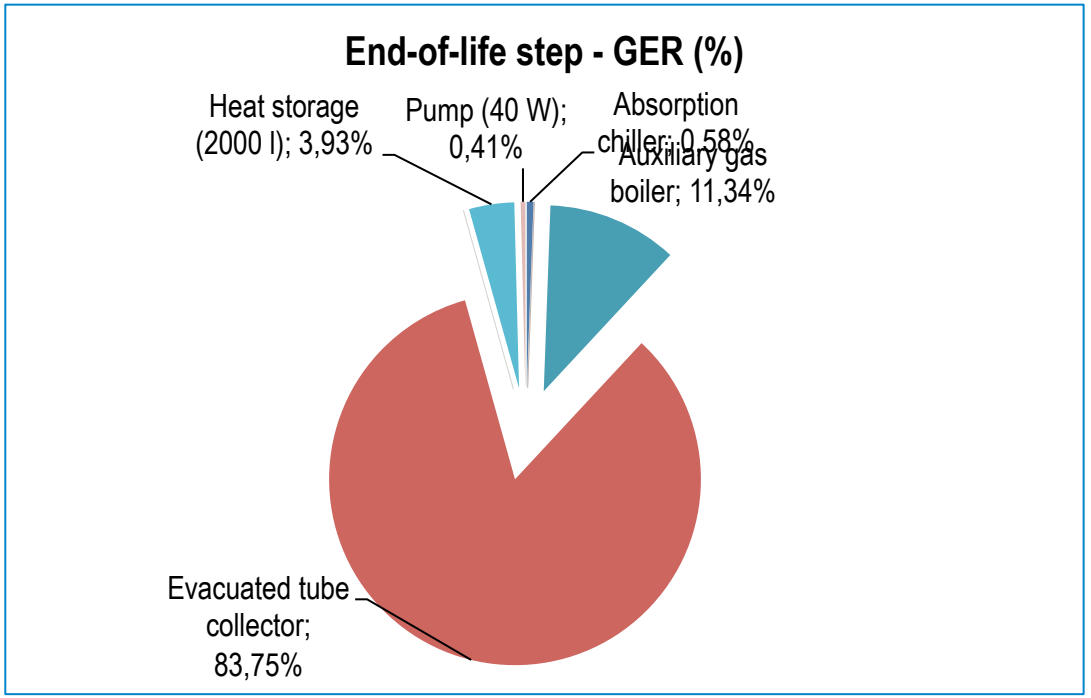



# LCA METHOD TOOL

## Sheet No.5: Total impacts for SHC system

A picture of results…



# 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;**

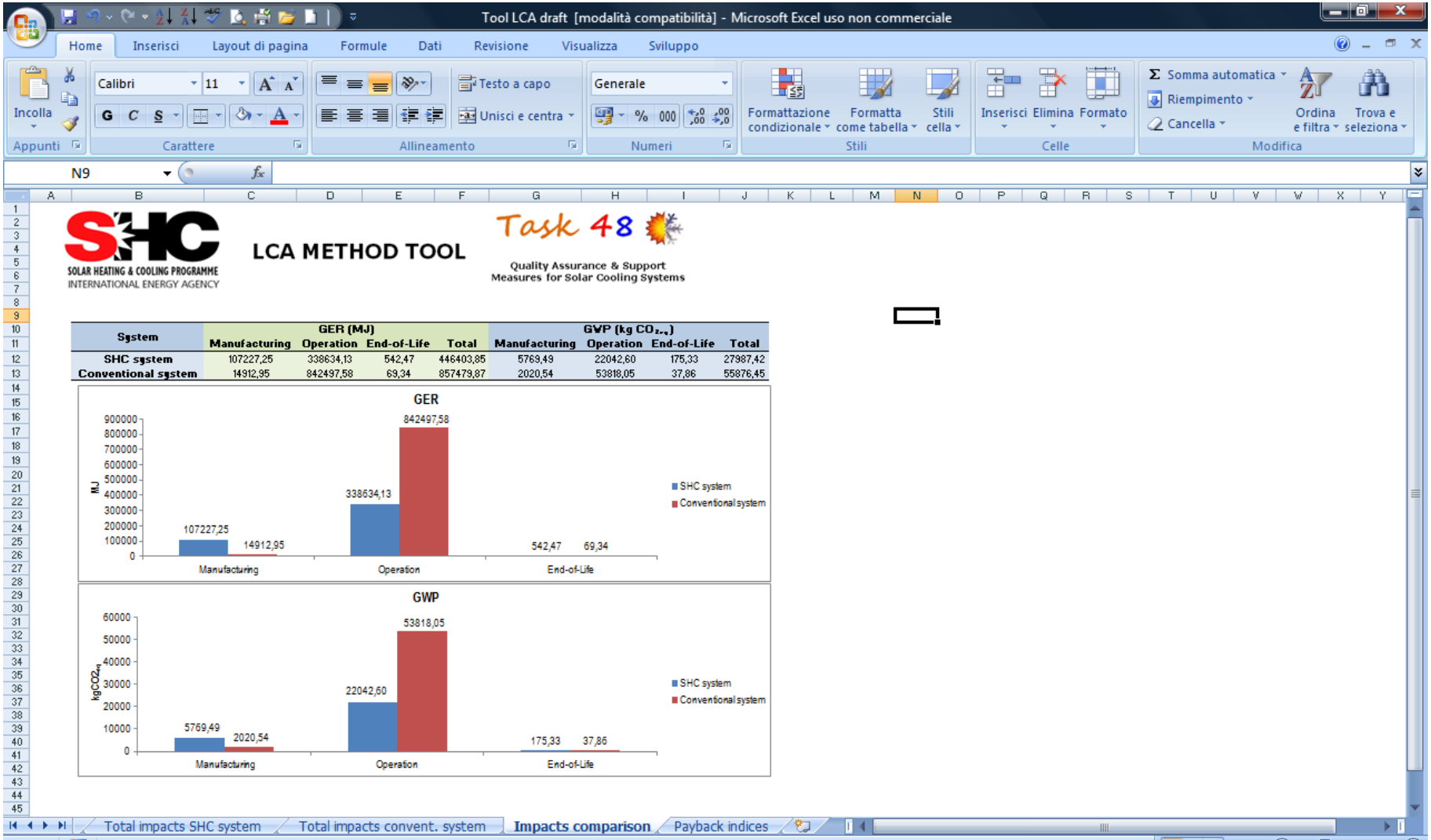
**3) The total impact for each life-cycle step (manufacturing, operation, end-of-life);**

**4) The total impact for the life-cycle of the SHC system;**

**5) A picture of results.**

# LCA METHOD TOOL

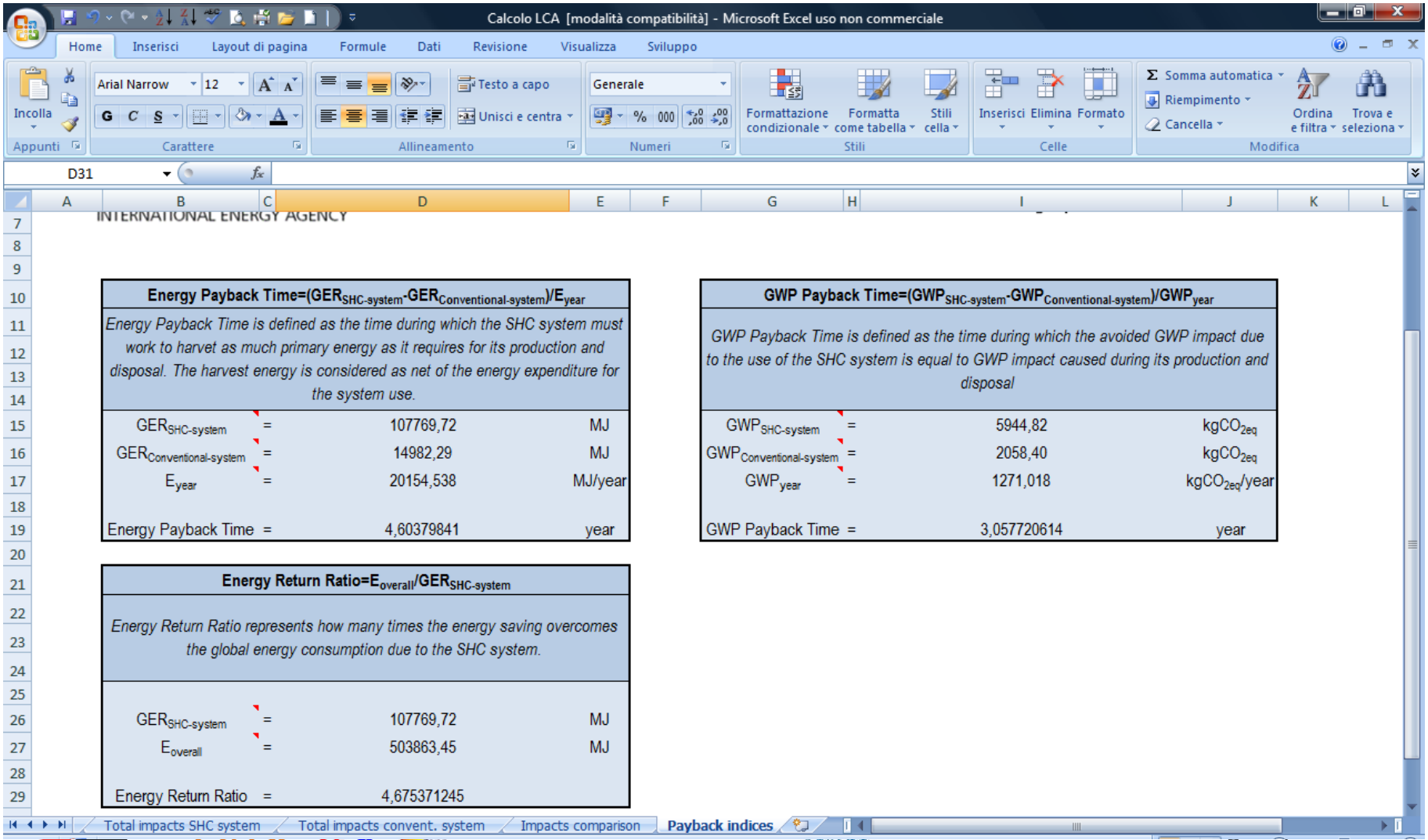
## Sheet No.7: Impacts comparison




| System | GER (MJ) | | | | GWP (kg $CO_{2eq}$) | | | |
|---|---|---|---|---|---|---|---|---|
| | Manufacturing | Operation | End-of-Life | Total | Manufacturing | Operation | End-of-Life | Total |
| SHC system | 107227,25 | 338634,13 | 542,47 | 446403,85 | 5769,49 | 22042,60 | 175,33 | 27987,42 |
| Conventional system | 14912,95 | 842497,58 | 69,34 | 857479,87 | 2020,54 | 53818,05 | 37,86 | 55876,45 |

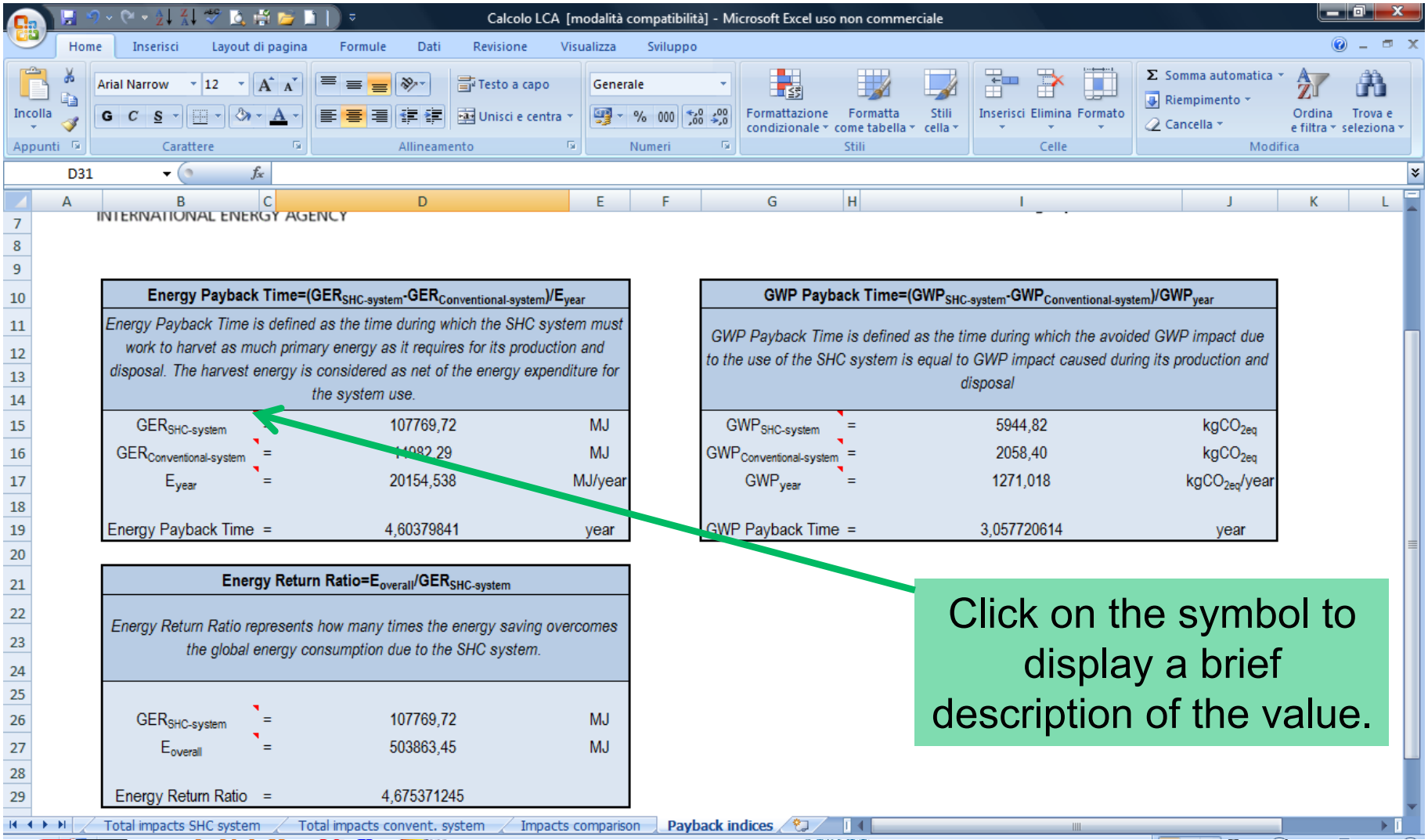
# LCA METHOD TOOL

## Sheet No.8: Payback indices



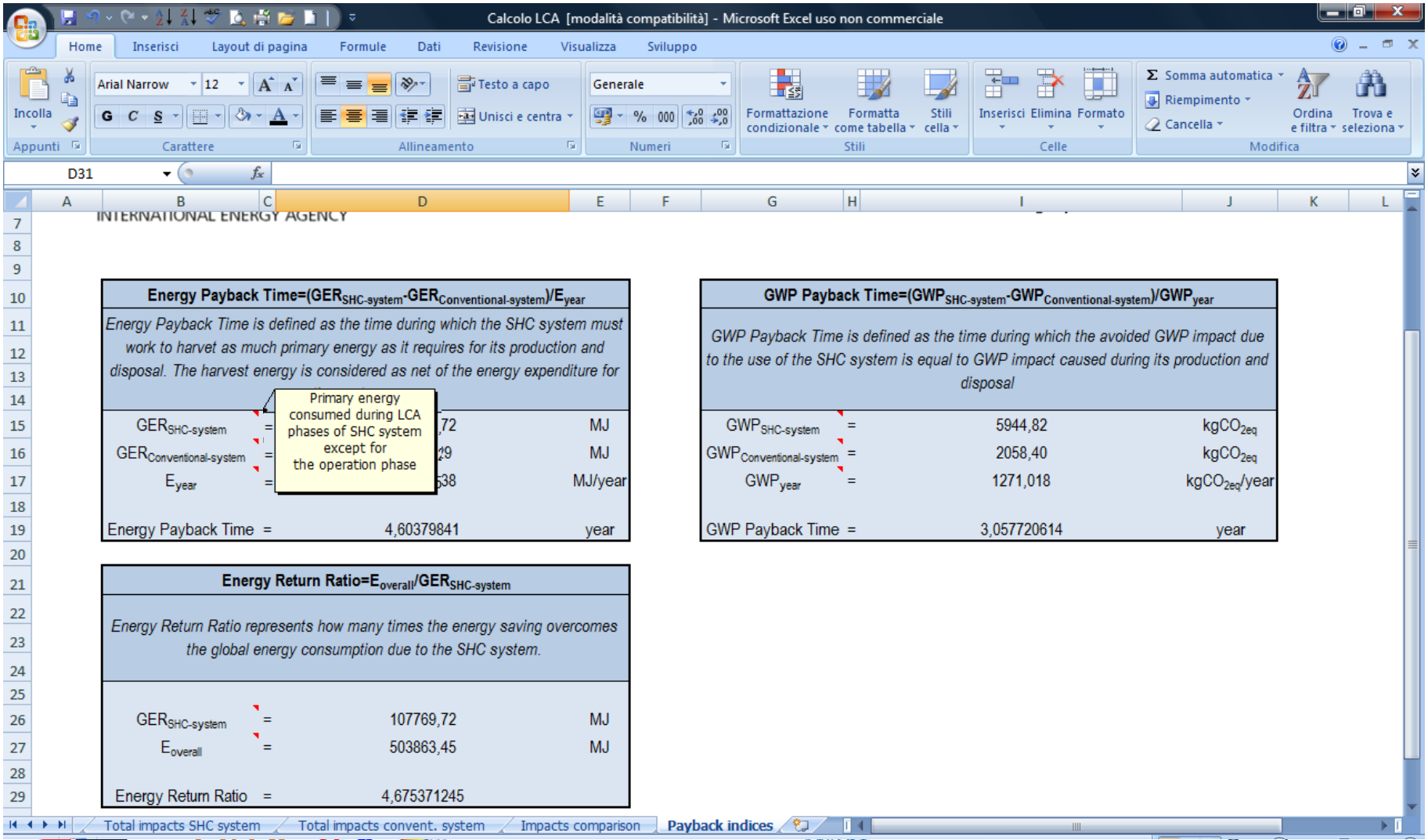
# LCA METHOD TOOL

## Sheet No.8: Payback indices



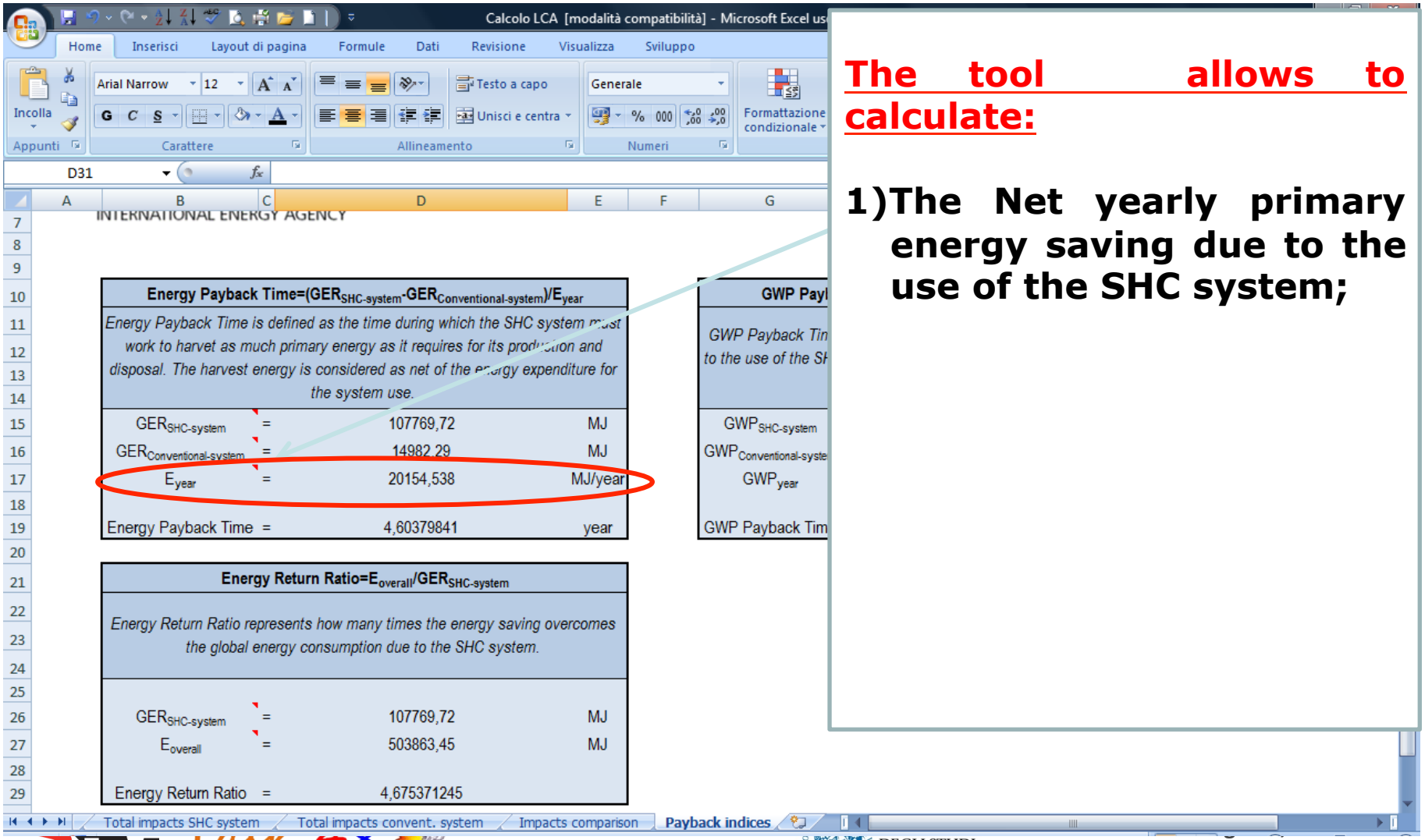
# LCA METHOD TOOL

## Sheet No.8: Payback indices



# LCA METHOD TOOL

## Sheet No.8: Payback indices



| Energy Payback Time=($GER_{SHC\text{-}system}$-$GER_{Conventional\text{-}system}$)/$E_{year}$ | | | |
|---|---|---|---|
| *Energy Payback Time is defined as the time during which the SHC system must work to harvet 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.* | | | |
| $GER_{SHC\text{-}system}$ | = | 107769,72 | MJ |
| $GER_{Conventional\text{-}system}$ | = | 14982,29 | MJ |
| $E_{year}$ | = | 20154,538 | MJ/year |
| Energy Payback Time | = | 4,60379841 | year |

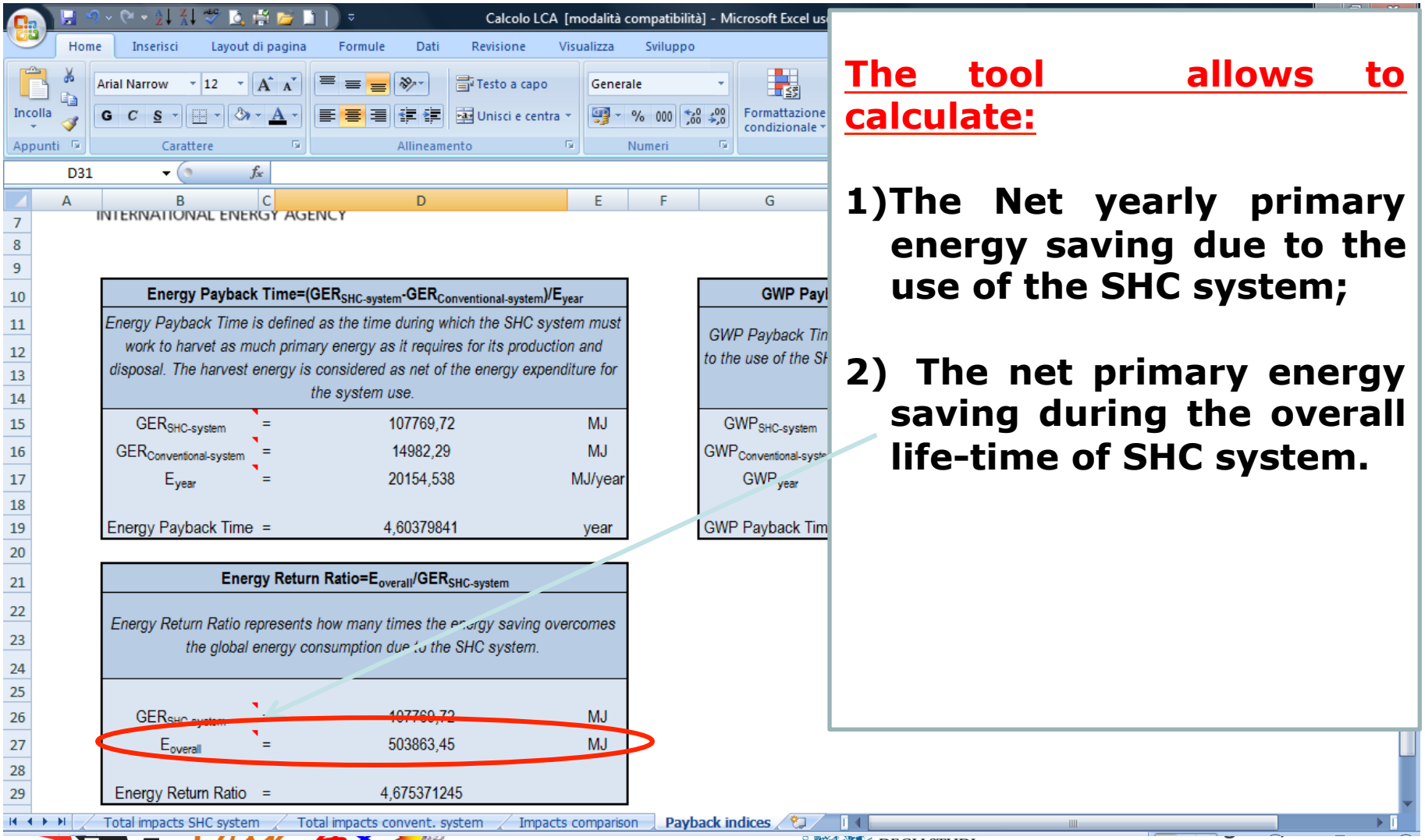
| Energy Return Ratio=$E_{overall}$/$GER_{SHC\text{-}system}$ | | | |
|---|---|---|---|
| *Energy Return Ratio represents how many times the energy saving overcomes the global energy consumption due to the SHC system.* | | | |
| $GER_{SHC\text{-}system}$ | = | 107769,72 | MJ |
| $E_{overall}$ | = | 503863,45 | 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



Calcolo LCA [modalità compatibilità] - Microsoft Excel

INTERNATIONAL ENERGY AGENCY

| Energy Payback Time=$(GER_{SHC\text{-}system}-GER_{Conventional\text{-}system})/E_{year}$ | | | |
|---|---|---|---|
| *Energy Payback Time is defined as the time during which the SHC system must work to harvet 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.* | | | |
| $GER_{SHC\text{-}system}$ | = | 107769,72 | MJ |
| $GER_{Conventional\text{-}system}$ | = | 14982,29 | MJ |
| $E_{year}$ | = | 20154,538 | MJ/year |
| Energy Payback Time | = | 4,60379841 | year |

| Energy Return Ratio=$E_{overall}/GER_{SHC\text{-}system}$ | | | |
|---|---|---|---|
| *Energy Return Ratio represents how many times the energy saving overcomes the global energy consumption due to the SHC system.* | | | |
| $GER_{SHC\text{-}system}$ | = | 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

**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

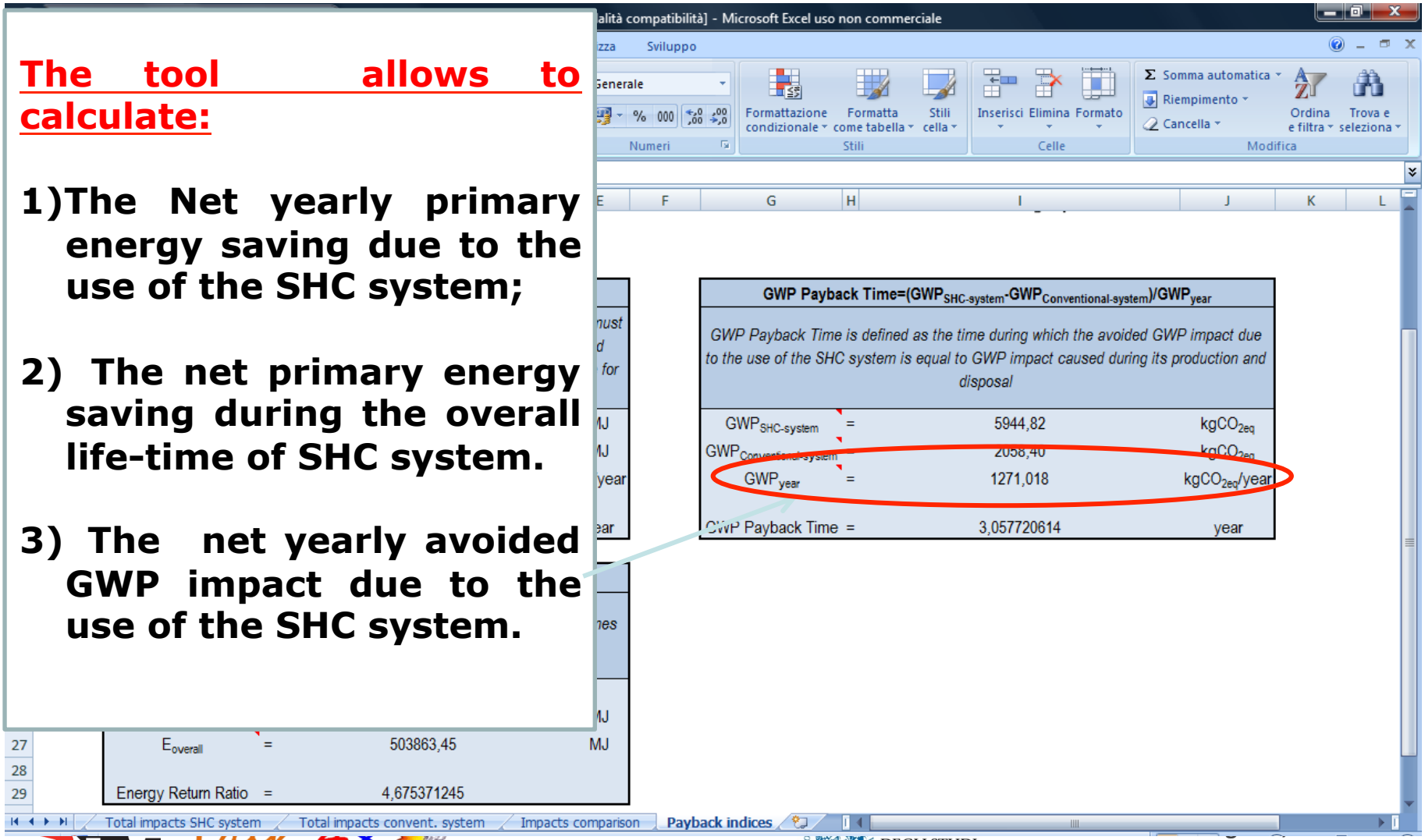
## Sheet No.8: Payback indexes

**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.**



# LCA METHOD TOOL

**The tool will be completed within October 2014.**

# LCA METHOD TOOL

# Thank you for your attention