NEW GENERATION OF SOLAR COOLING AND HEATING SYSTEMS DRIVEN BY PHOTOVOLTAIC OR SOLAR THERMAL ENERGY

An innovative HCP/T collector and its potential SHC applications

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Idea Srl is an integrator between research and industry, coordinating innovation projects in the fields of renewable energies and energy saving, low impact materials and products, environmental engineering, mechatronics.
MJ solar cells for HCPV Systems

Why CPV?

The most efficient solar cells are MJ cells based on III-IV compound semiconductor materials.

The higher efficiency cells used in CPV systems allows an higher energy density per square meter than traditional PV in locations with high DNI.

Graph of spectral irradiance

Si solar cells

Ga$_{0.33}$In$_{0.67}$P/Ga$_{0.83}$In$_{0.17}$As/Ge solar cells

Solar cells for CPV Systems

Why CPV?

The new generations of multi-junction solar cells convert 46% of the solar light into electric power.

The comparison at locations with high irradiation 2000KWh/m²a shows that PV have a lower reduction than CVP and CSP.

Actual limit of CPV:
- Greater investment costs than PV
- Complexity of the system
- Maintenance
- Reduced integration in urban area

Development of a new generation of CHP module for competitive systems able to produce:
- Electrical energy
- Thermal Energy (for DHW and cooling)
- Desalination
- Light
Solar light is concentrated by double curvature parabolic mirrors 45x45 cm into a secondary optic.

Solar beams are focused from an area of 0.2m² to 1cm² with a concentration factor of 2,000 suns.

Optical losses in reflective and refractive transmissions are reduced using:
- Solar glass with Ag reflective coating
- Pure glass materials for secondary optic light pipe
- High transmission glues for optical connection between components
HCPV system needs an active cooling circuit

DNI : 900 W/m²

Concentrated solar power: 160 W

Module efficiency: 30%

Electric energy: $50W_e$

Available thermal energy: $110W_{th}$

Max operative cell temperature 110°C
The MJ cell is connected to an active heat transfer system properly designed in order to reduce the thermal resistance of each substrate of connection material. The particular fluid dynamic geometry of the heat sink allows to keep the cell at a high level of electrical efficiency ($\eta_e > 30\%$), while bringing the heat transfer fluid (water and glycol) up to an output temperature of 70-80°C, suitable for civil and industrial low temperature applications.
HCE-PV/T system

Idea HCPV system can act as a combined heat and power (CHP) solar system, generating both electricity from the photovoltaic (PV) cells and thermal energy (heat) (T) extracted from the cell’s back surface.

HCHE-PV/T (high concentration – high efficiency thermo/photovoltaic system) shows a CHP efficiency of 72 to 85% with an electrical efficiency ranging from 27 to 30% and a thermal efficiency of about 45 to 55% within the temperature of 40-70°C of the cooling heat transfer fluid.

To be developed:
an hybrid receiver reaching 90°C with an electric efficiency reduced by at most 2%
CPV MJ cells work with direct sun radiation

2 axis sun tracker is used for a module composed by 20 solar cells
20 primary and secondary optic

Energy production
\[ \approx 1 \, \text{kJ}_{\text{el peak}} \]
\[ \approx 2 \, \text{kJ}_{\text{th peak}} \]
Outlet water temperature \( \approx 70^\circ\text{C} \)
The configuration of HCPV system can be integrated in urban areas for electrical and thermal energy use

- Net surface single mirror: 2,025 cm²
- Solar concentrator: ≈ 2,000x
- Optical efficiency: 90%
- N. Mirrors per module: 20
- N. Cells per module: 20
- Module Elect. efficiency: ≈ 30%
- Module Thermal efficiency: ≈ 45%
- Overall efficiency: ≈ 75%
- Peak electrical power: ≈ 1,000 W_{ep}
- Peak thermal power: ≈ 2,000 W_{thp}
- Tracking system: Alt-Alt
- Dimension: 1.4 x 6.5 m
- Weight: 280 Kg
- Heat transfer fluid: glycol & water
- Flow rate per module: 4 l/min
- Heating temperature: 70°C
Example of energy produced:
Solar field installed at the University Campus of Palermo
4 HCPV modules (80 MJ cells)
HTF: desalinated water - Volume Storage 0.2m³
Starting temperature 20°C  T set point: 60°C

HCPV power generation

HCPV power generation

Thermal efficiency: 45%
Thermal energy gained in 5 operative hours: 35 kWh at 60°C
Electric energy produced in 5 operative hours: 21 kWh
HCPV integrated for electricity and DHW demand

Hydraulic and thermal layout for 5 HCPV modules for the roof of civil dwellings for DHW (and electricity) production
Achieving near Zero and Positive Energy Settlement in Europe using Advanced Energy Technology

- 16% initial cost reduction with the reference case
- Net regulated energy consumption of less than 20 KWh/m² per year
- Energy production by RES of at least 50kWh/m² per year

HCPV installations:

- Voreppe (France)
- Paphos (Cyprus)
Thank you

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