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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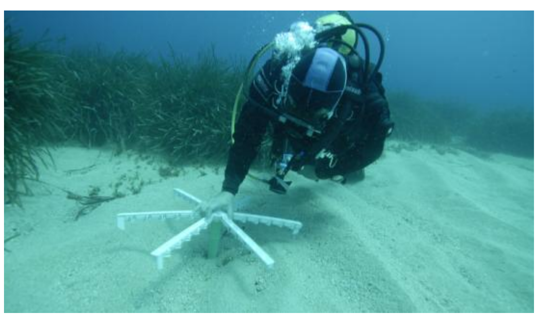
The mission

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.



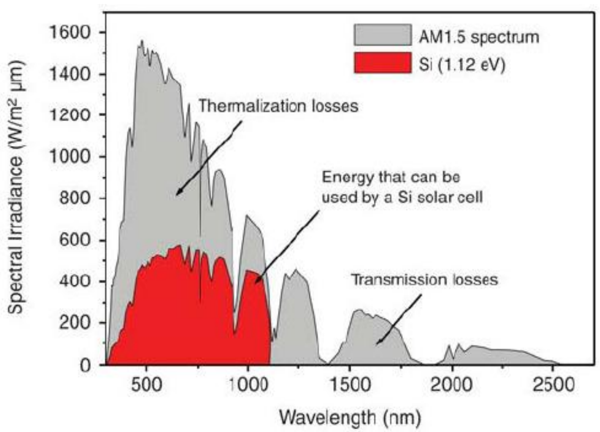
MJ solar cells for HCPV Systems

Why CPV?

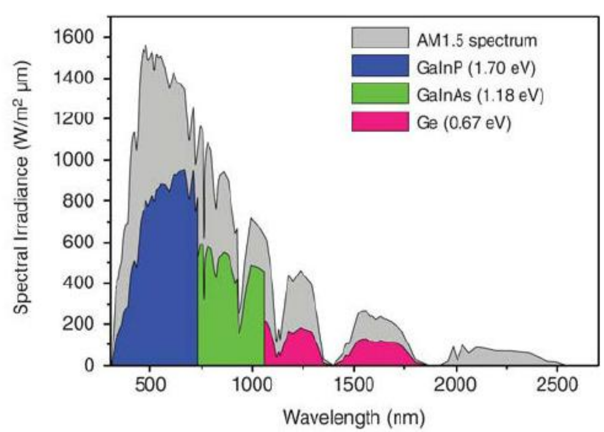
The most efficient solar cells are MJ cells based on III-IV compound semiconductor materials

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

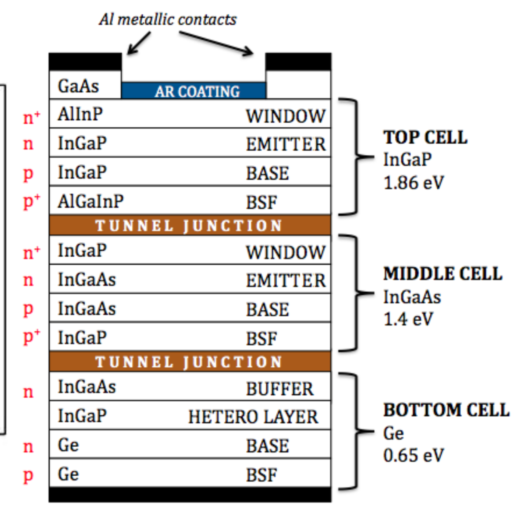
Graph of spectral irradiance



Si solar cells



$Ga_{0.35}In_{0.65}P/Ga_{0.83}In_{0.17}As/Ge$ solar cells

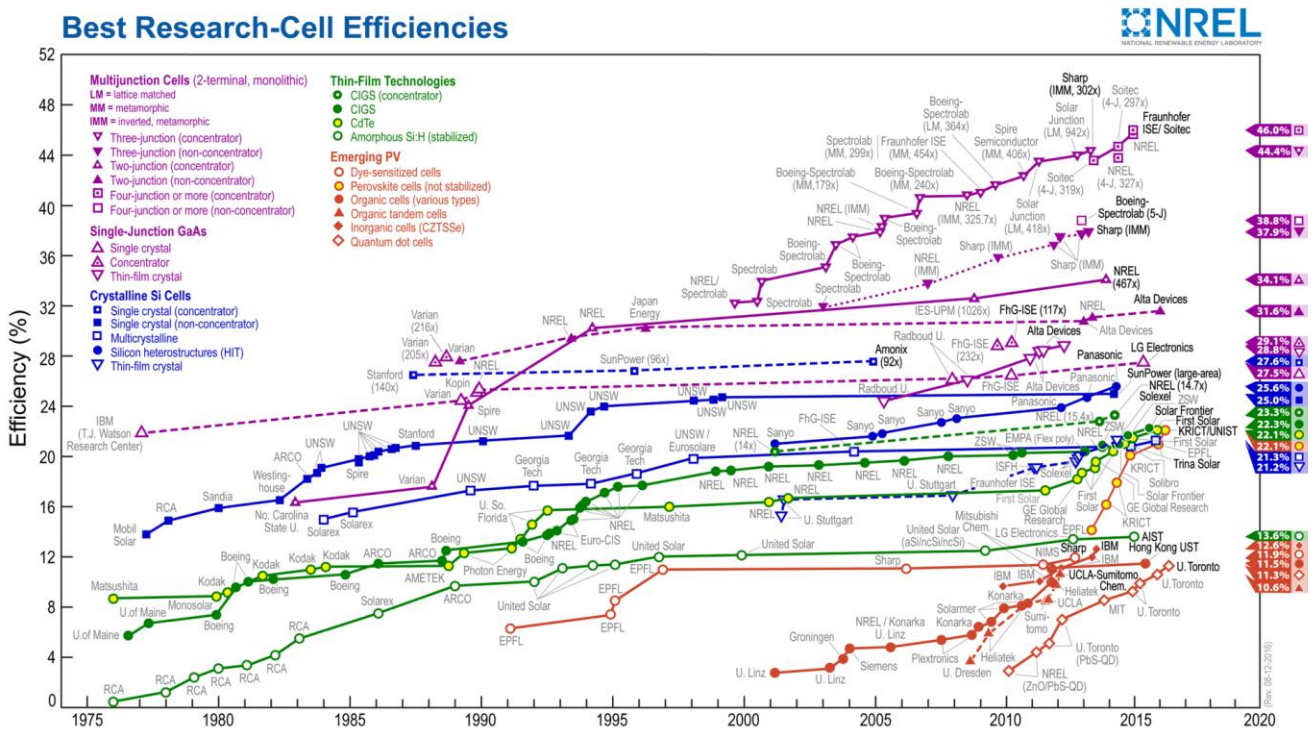


Source - N.V.Yastrebova (2007). High-efficiency multi-junction solar cells: current status and future potential

Solar cells for CPV Systems

Why CPV ?

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



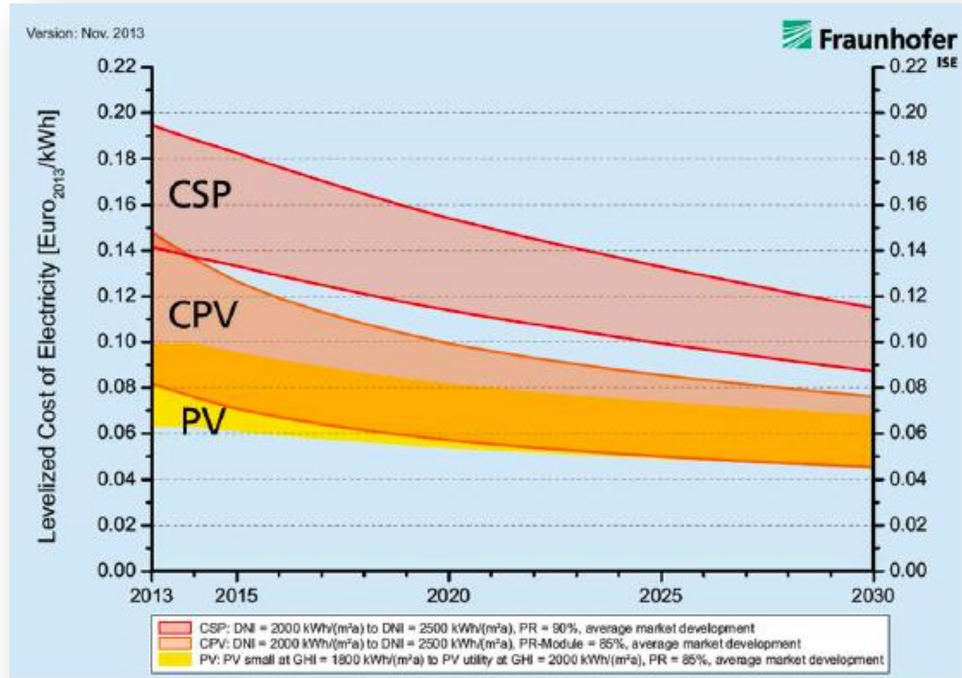
Source: National Renewable Energy Laboratory (NREL) - National Renewable Energy Laboratory (NREL), Golden, CO – United States Department of Energy

CPV Scenario

The comparison at locations with high irradiation 2000KWh/m^{2}a 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

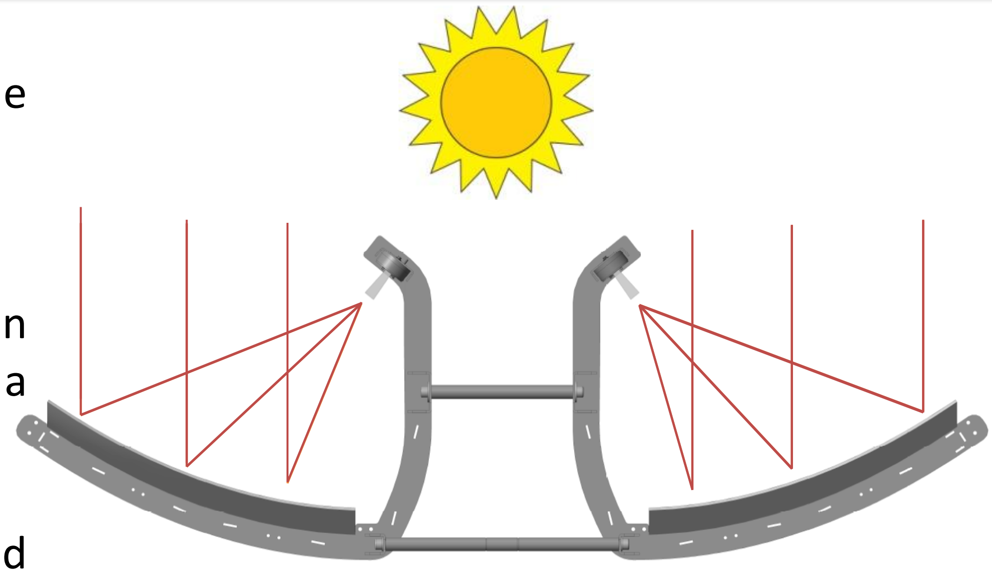
IDEA UHCPV system – primary and secondary optic

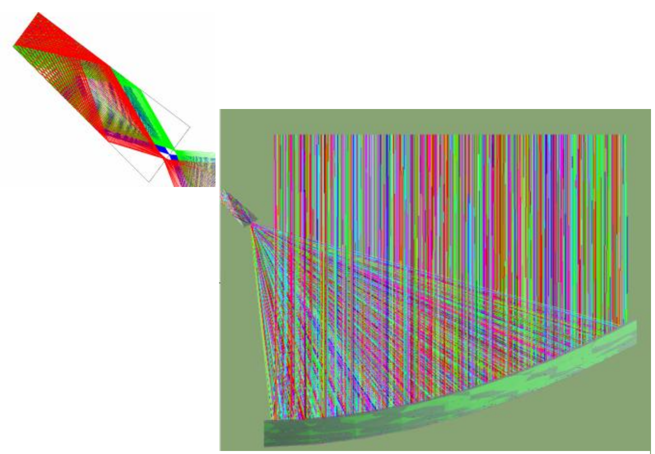
Solar light is concentrated by double curvature parabolic mirrors 45x45 cm into a secondary optic.

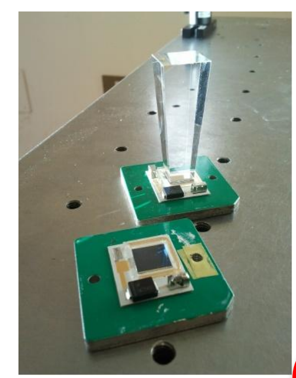
Solar beams are focused from an area of 0,2m^2 to 1cm^2 with a concentration factor of 2,000 suns.

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



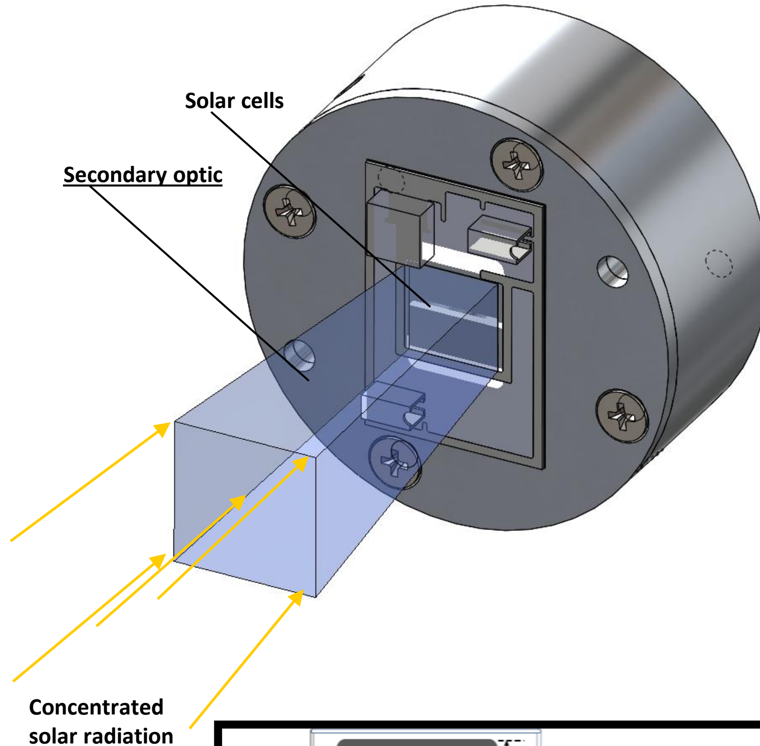




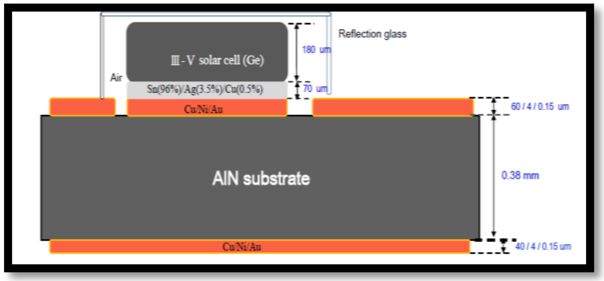
UHCPV – power generation

HCPV system needs an active cooling circuit

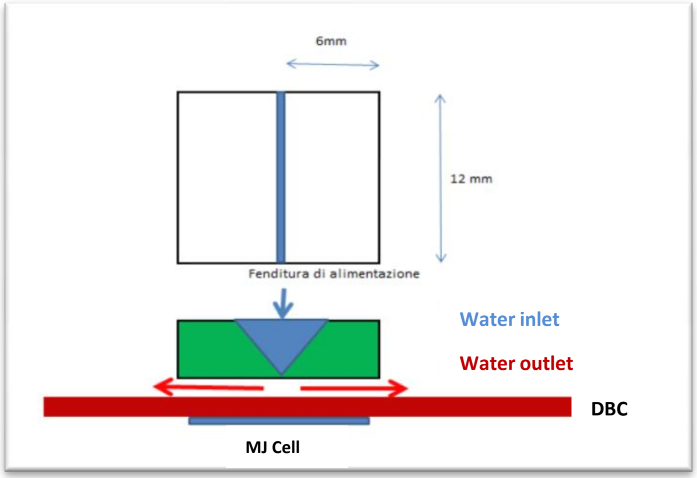
DNI :	900 W/m2
Concentrated solar power:	160W
Module efficiency:	30%
Electric energy:	$50W_e$
Available thermal energy:	$110W_{th}$

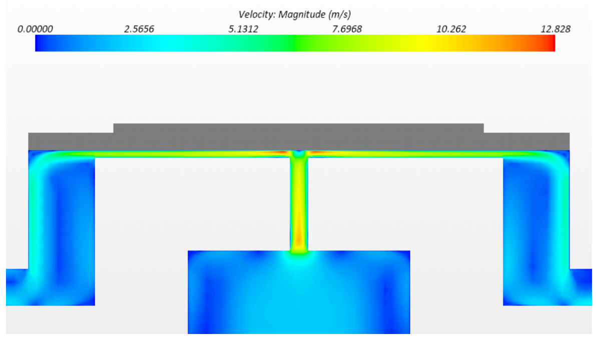


Max operative cell temperature 110°C



UHCPV - active cooling system



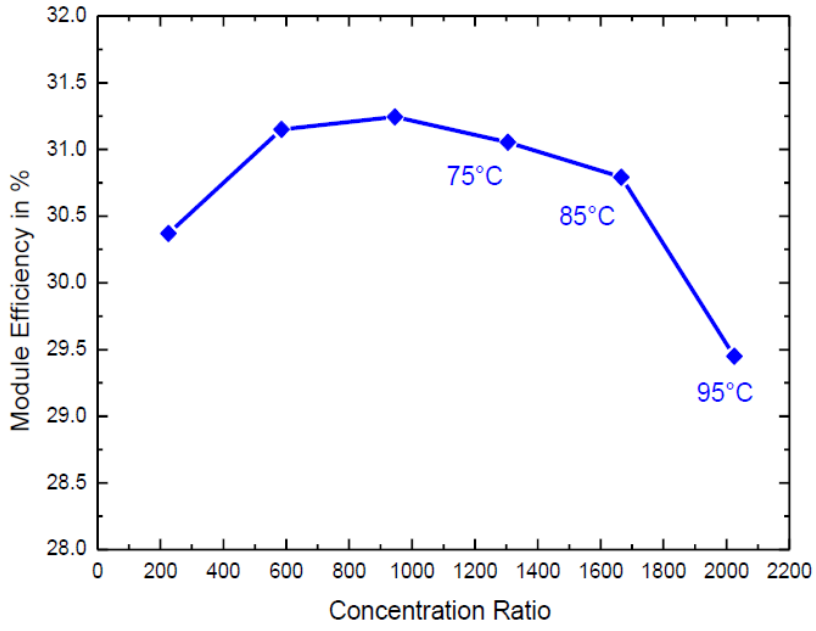


The MJ cell is connected to an active heat transfer system properly designed in order to reduce the thermal resistance of each substrate of connection material. The particular fluid dynamic geometry of the heat sink allows to keep the cell at a high level of electrical efficiency ($\eta el > 30\%$), 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.

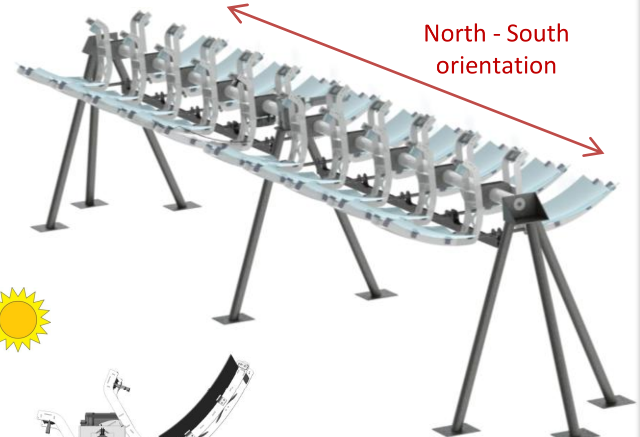
HCHE-PV/T (high concentration – high efficiency thermo/photovoltaic system) shows a CHP efficiency of 72 to 85% with an electrical efficiency ranging from 27 to 30% and a thermal efficiency of about 45 to 55% within the temperature of 40-70°C of the cooling heat transfer fluid



To be developed:

an hybrid receiver reaching 90°C with an electric efficiency reduced by at most 2%

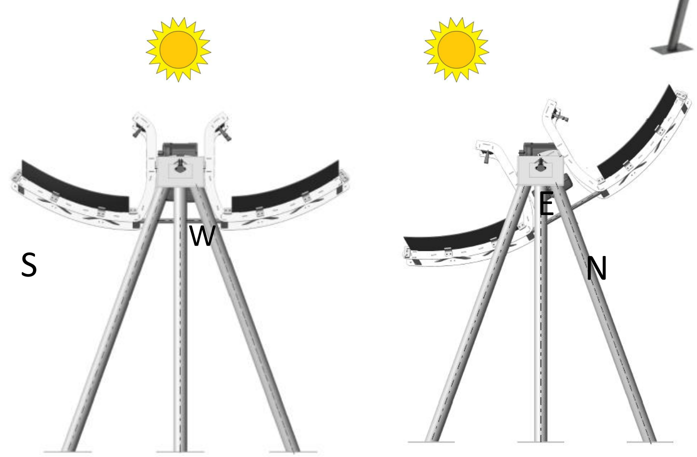
Tracking system and module configuration

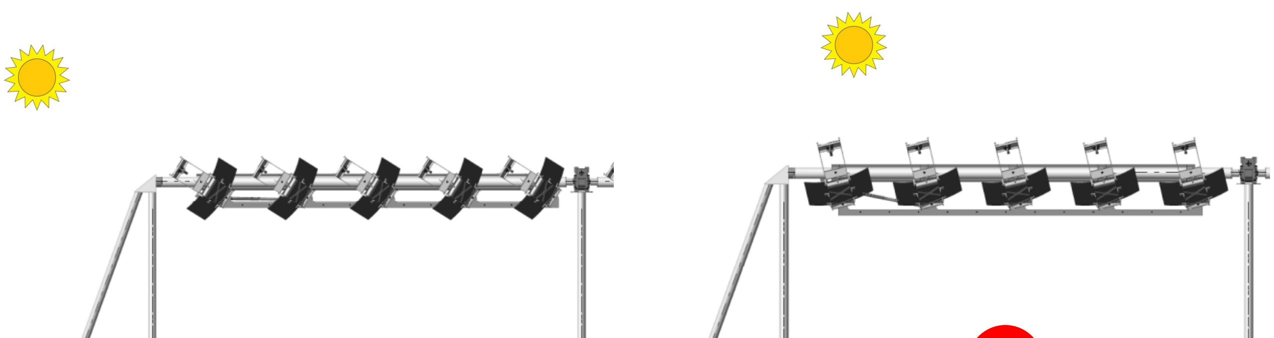


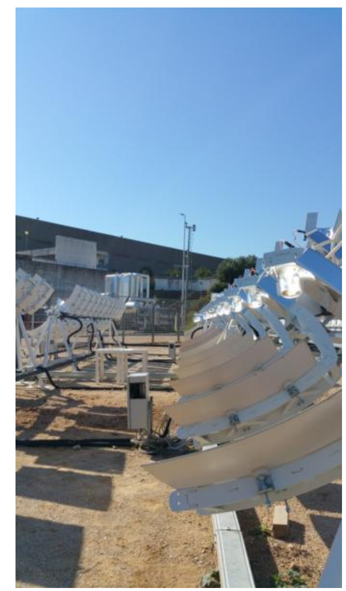
CPV MJ cells work with direct sun radiation

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

Energy production
≈ 1 $kW_{el\ peack}$
≈ 2 $kW_{th\ peack}$
Outlet water temperature ≈70°C







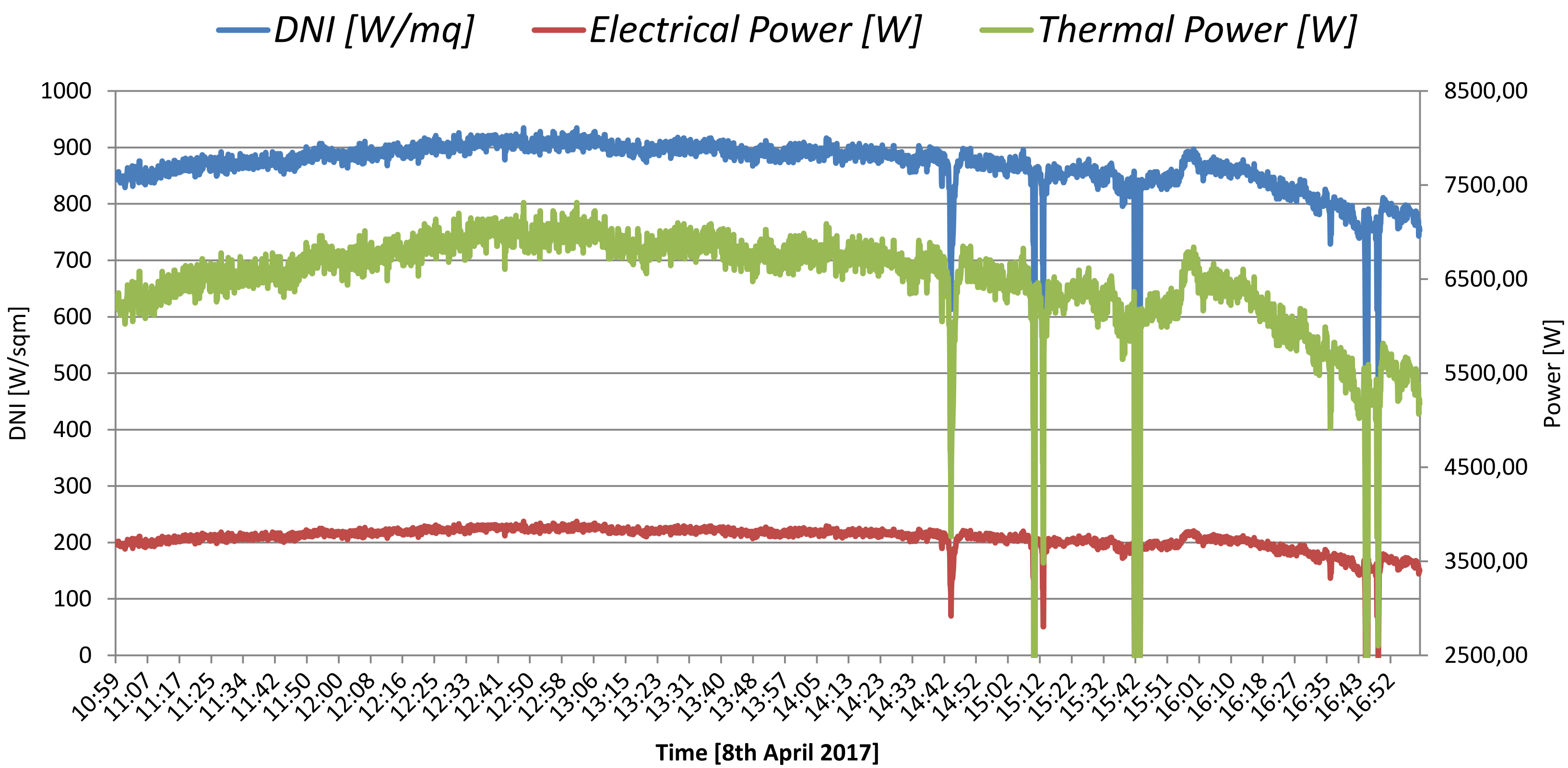
UHCPV modules and integration in urban areas

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

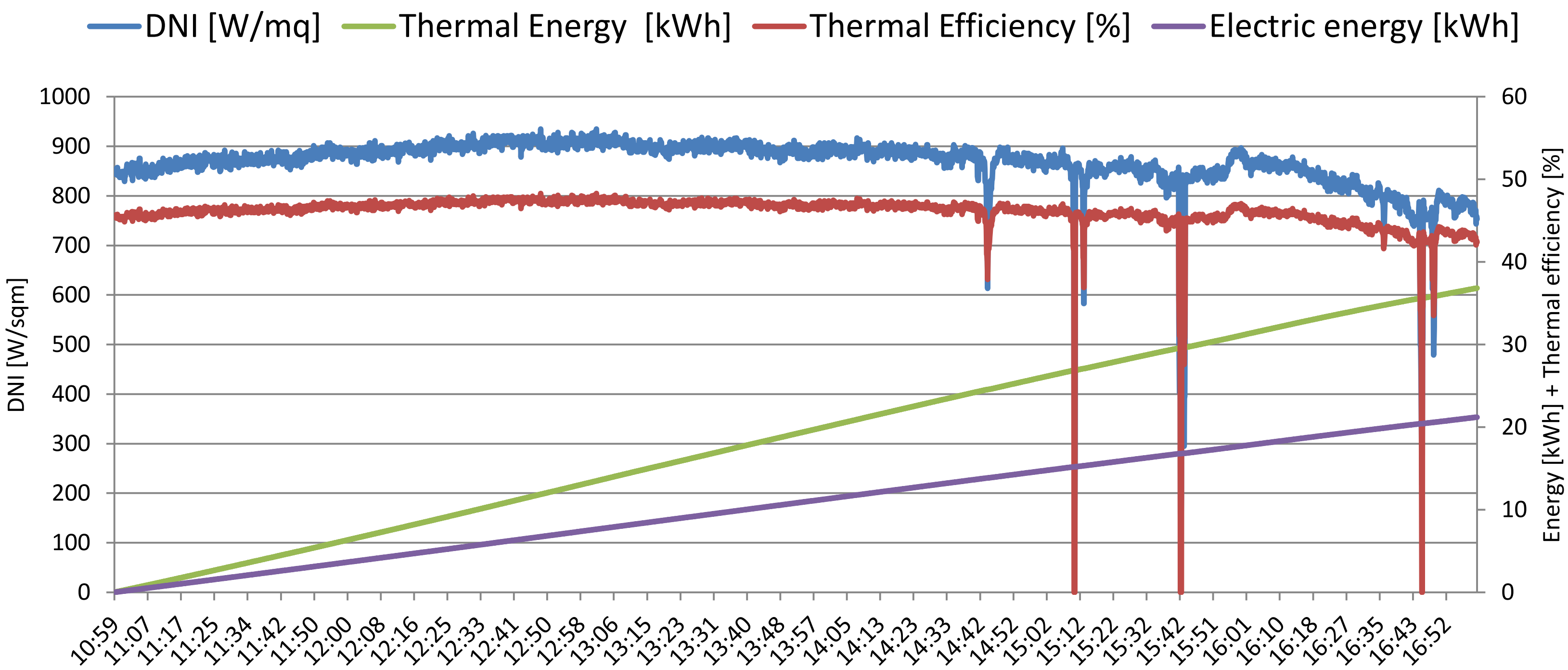
HCPV power generation

Example of energy produced:
Solar field installed at the University Campus of Palermo
4 HCPV modules (80 MJ cells)
HTF: desalinated water - Volume Storage 0.2m^3
Starting temperature 20°C T set point: 60°C



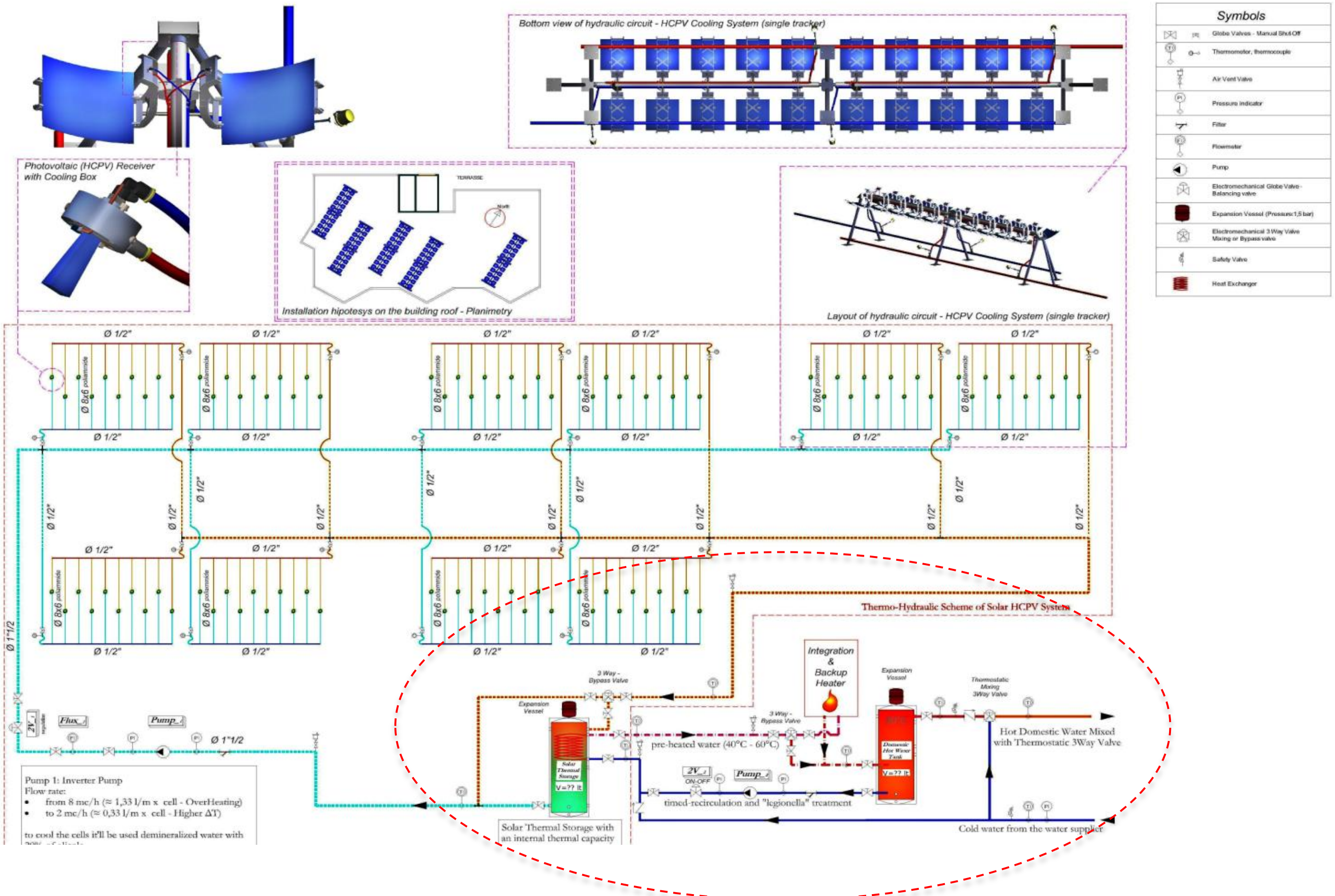
HCPV power generation

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



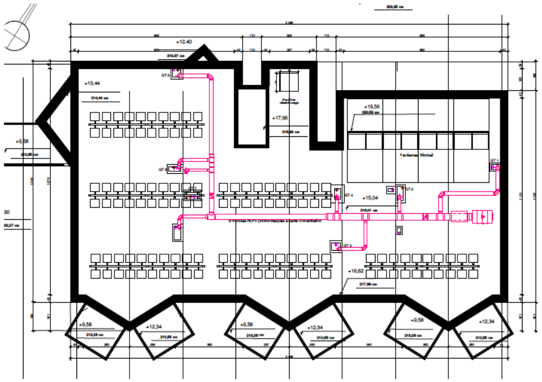
ZEB for heat and power generation – H2020 Zero Plus Project

Achieving near Zero and Positive Energy Settlement in Europe using Advanced Energy Technology

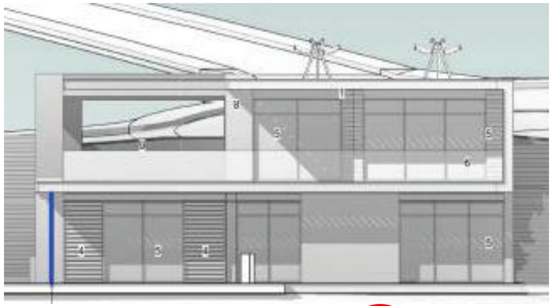
- 16% initial cost reduction with the reference case
- Net regulated energy consumption of less than 20 KWh/m^2 per year
- Energy production by RES of at least 50kWh/m2 per year

HCPV installations:

Voreppe (France)



Paphos (Cyprus)



Thank you

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