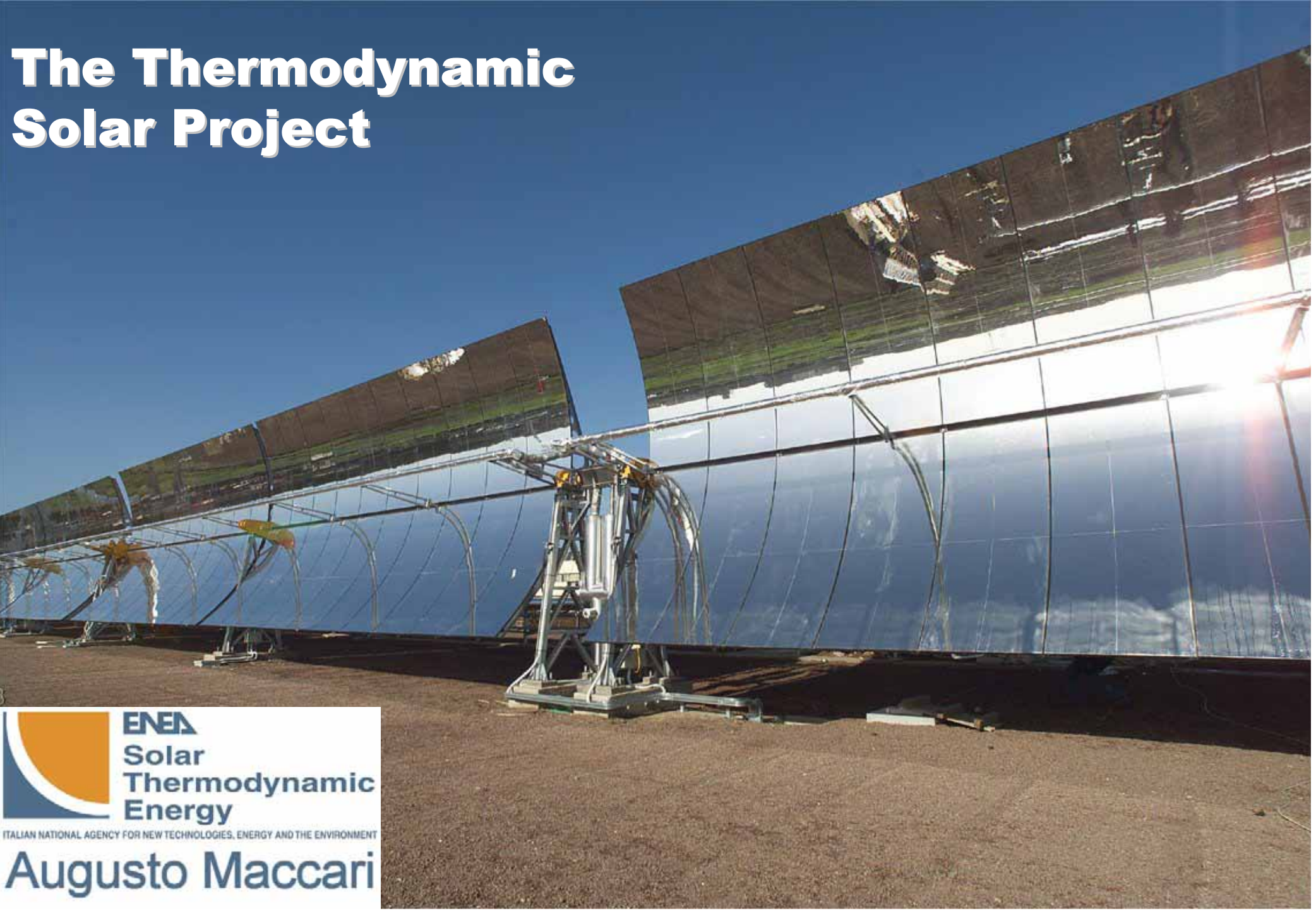
The Thermodynamic Solar Project



ENEA
Solar Thermodynamic Energy
ITALIAN NATIONAL AGENCY FOR NEW TECHNOLOGIES, ENERGY AND THE ENVIRONMENT

Augusto Maccari

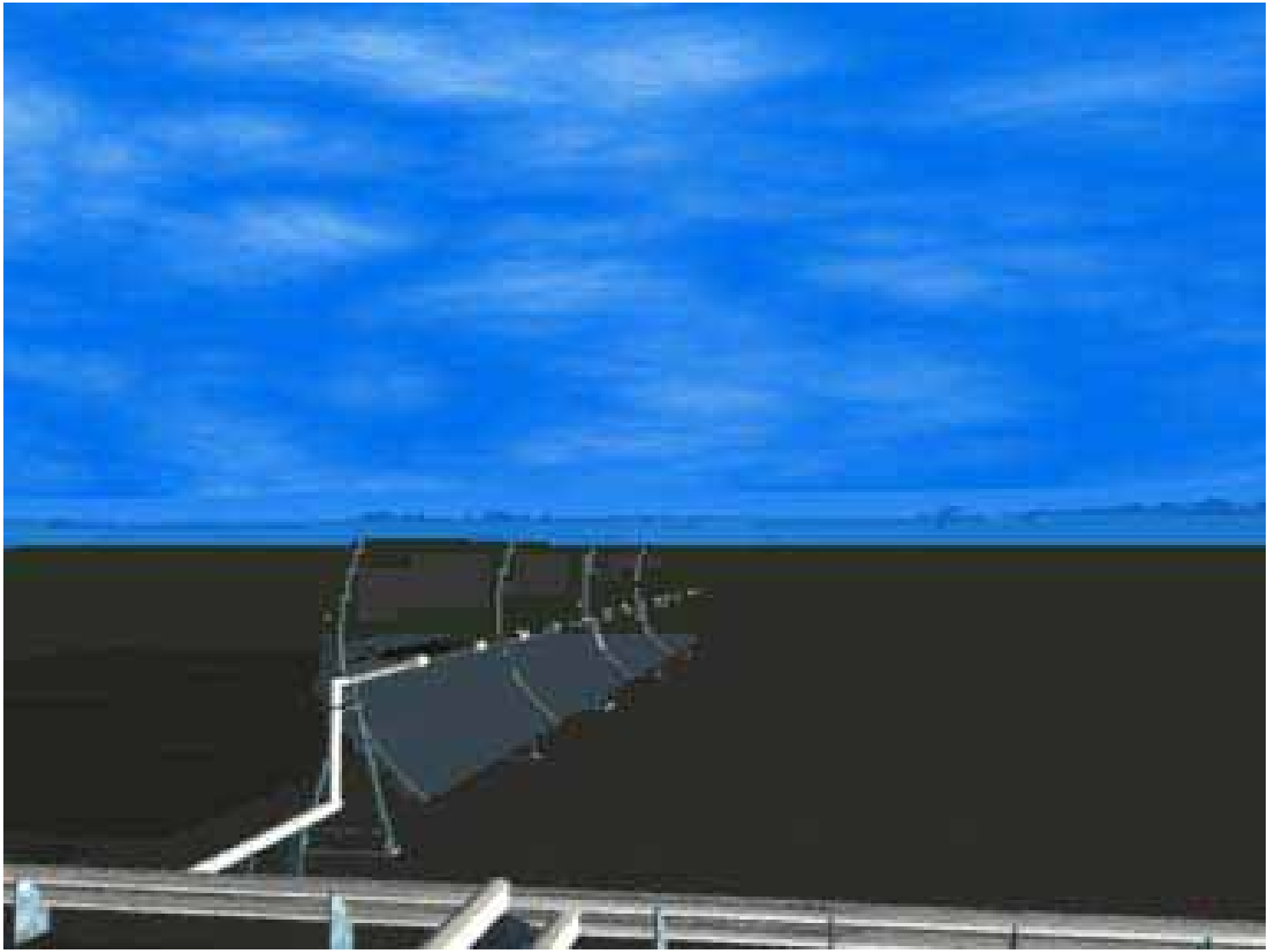
ENEA Programme Main Strategic Choices

Since 2001, a vigorous ENEA programme has been launched on two main subjects. Both activities are suitably funded and organised as large projects:

1. Medium temperature (about 550°C) heat collection and storage, primarily intended for electricity production.
2. High temperature (greater than 850°C) heat collection for direct hydrogen production.

Actually 75 researchers are involved in the program, the budget until now has been 17 Ml €.

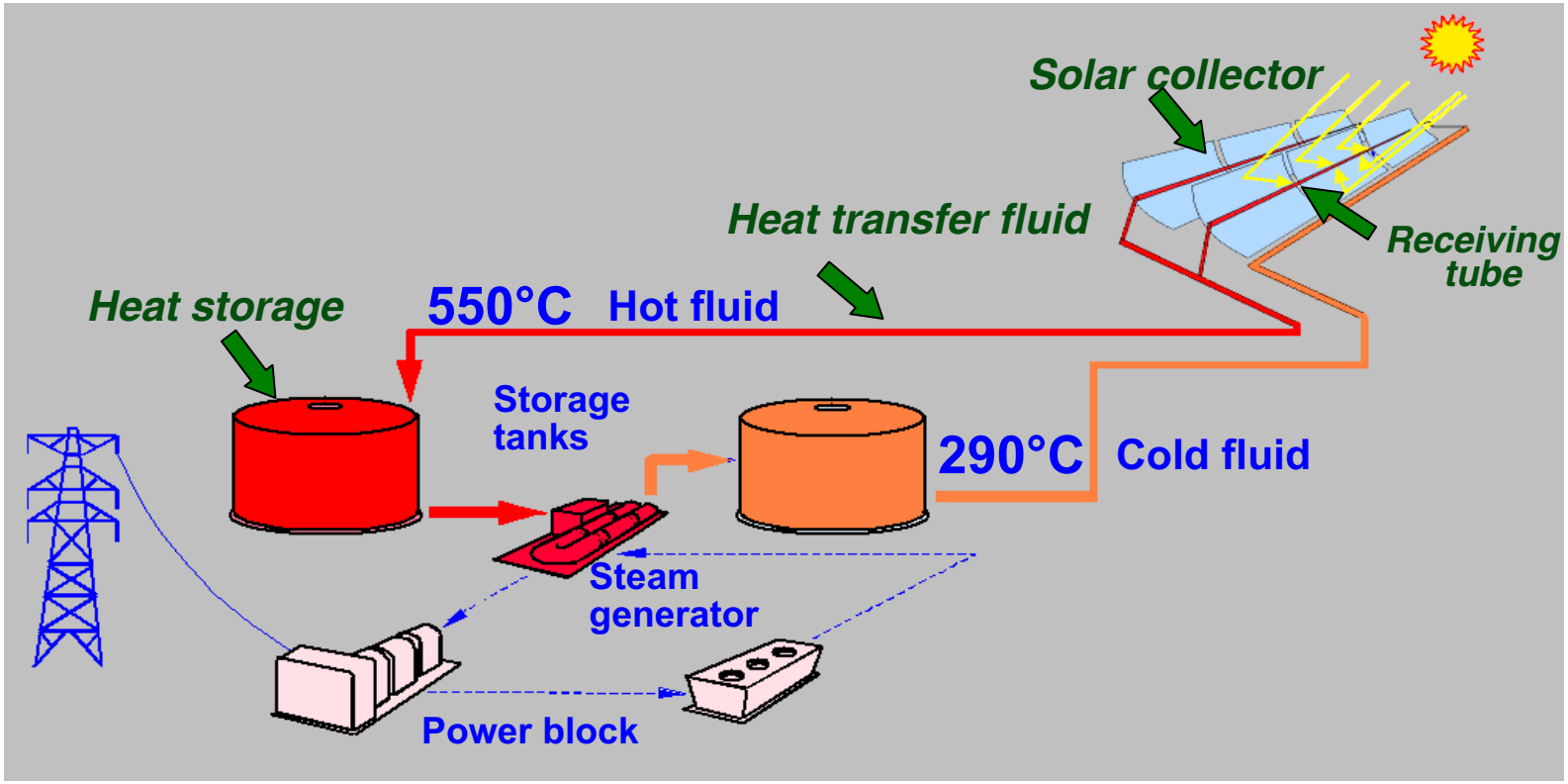
The parabolic trough technology



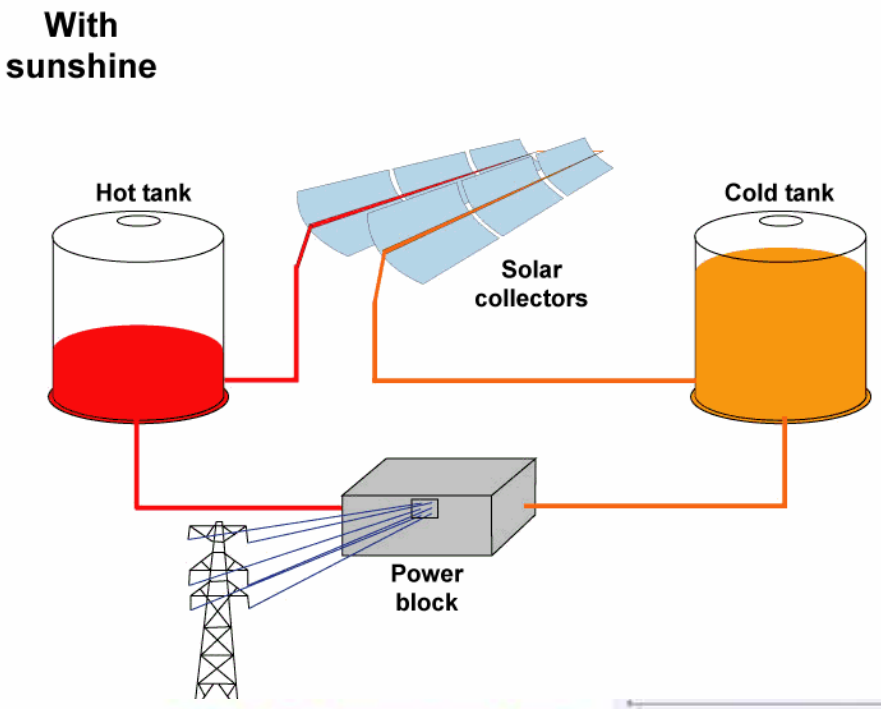
The innovations in *trough* technology introduced by ENEA

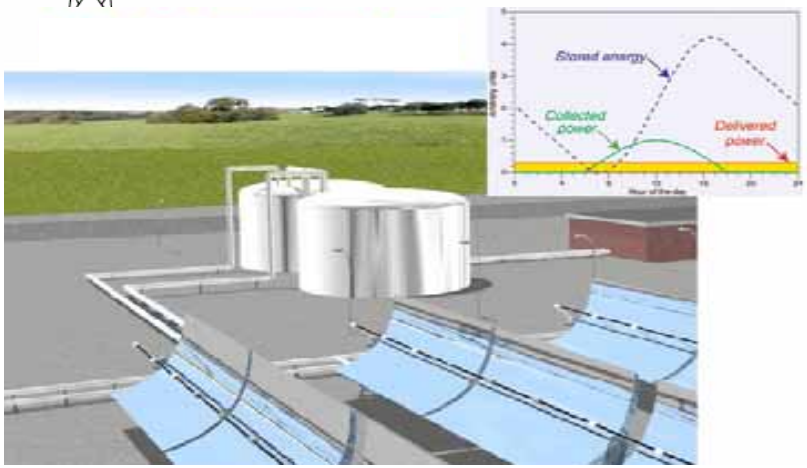
ENEA design introduces relevant improvements to the current technology

- The introduction of an adequate energy storage
- The use of an alternative transfer fluid
- A new solar collector design
- An innovative receiving tube design



The thermal storage





- Any mature energy producing technology must be available according to demand.
- In the ENEA system two thermal tanks are included to completely separate the heat collection phase from the heat usage phase.
- Thermal storage process is very efficient (less than 1% loss per day).
- With molten salt mixture between 290 and 550 °C, 5 m^3/MWh are required

Discontinuity	*Compensation*
Short term clouds	**Yes**
Night time	**Yes**
Bad days	**Partially**
Seasonal variations	**No**

The heat transfer fluid

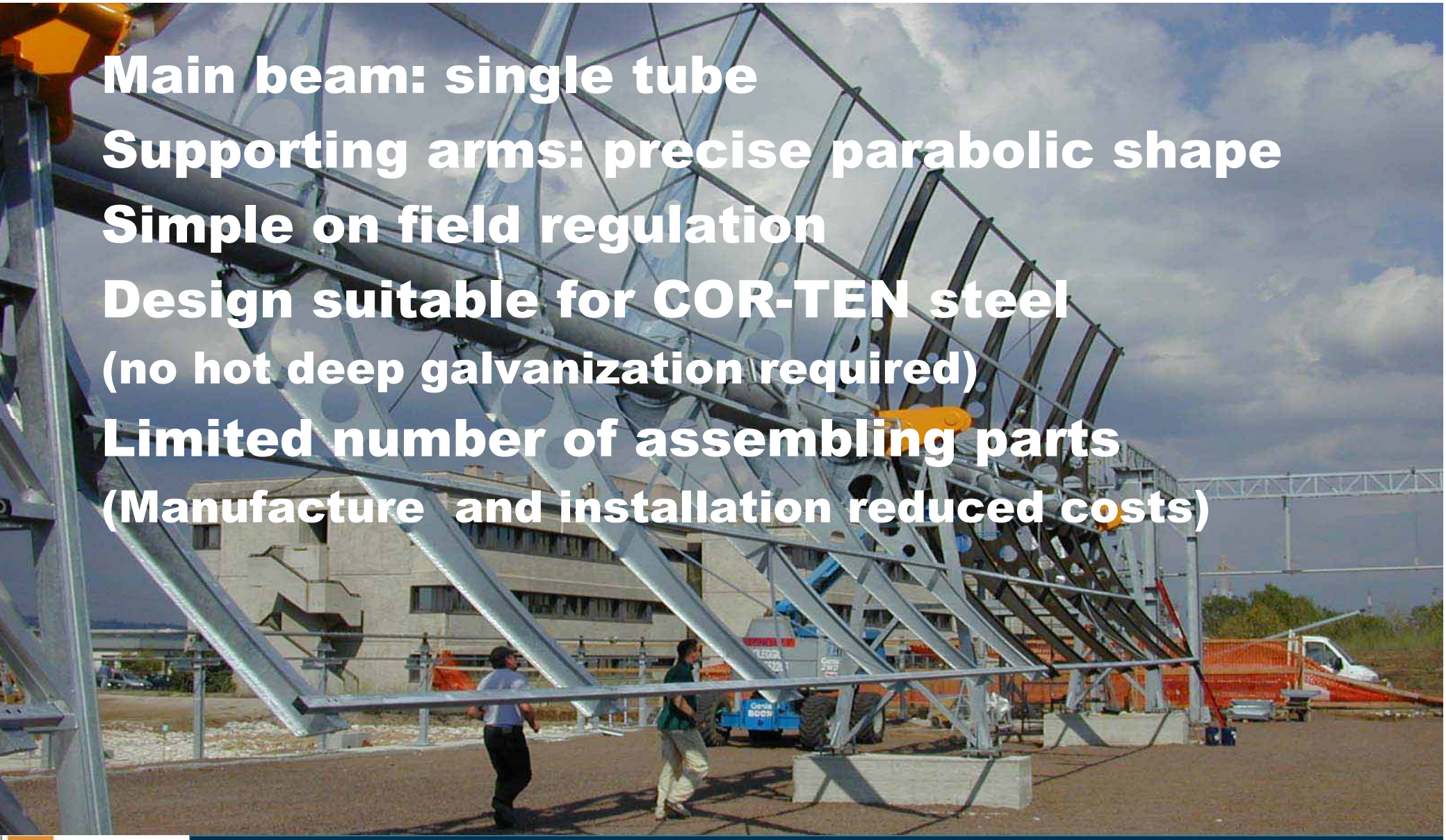
Current technology:

Mineral oil at medium operating temperature
(up to 390°C).
High costs, high environmental impact and easily flammable.
Not good as thermal storage media.

ENEA choice:

Molten salt mixture (KNO_3 - $NaNO_3$) at high operating temperature (290 -550°C).
Low costs and environmental friendly (used in agriculture as fertilizer).
Very good as thermal storage media.

Supporting structure design concepts



Main beam: single tube

Supporting arms: precise parabolic shape

Simple on field regulation

Design suitable for COR-TEN steel

(no hot deep galvanization required)

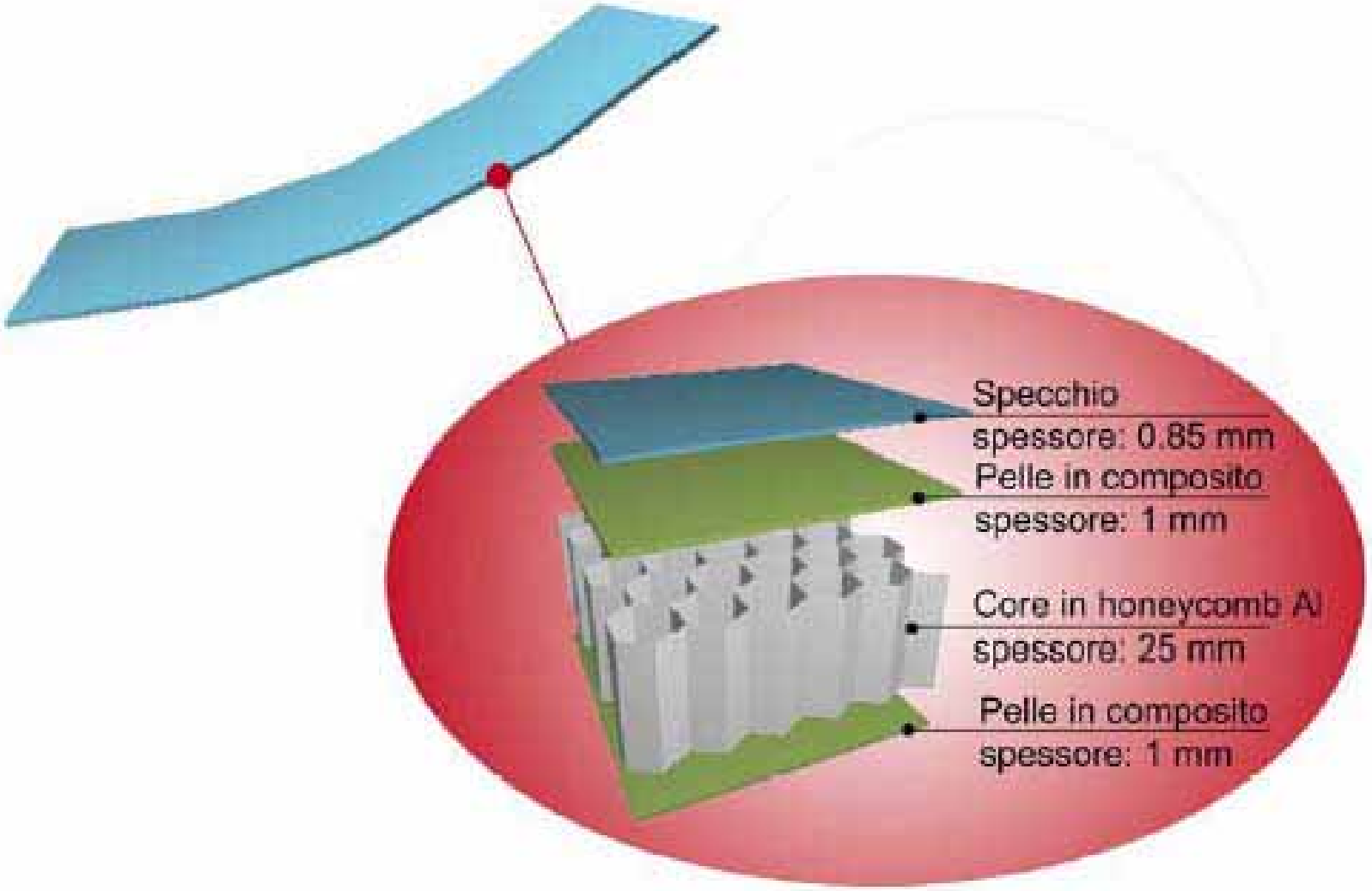
Limited number of assembling parts

(Manufacture and installation reduced costs)

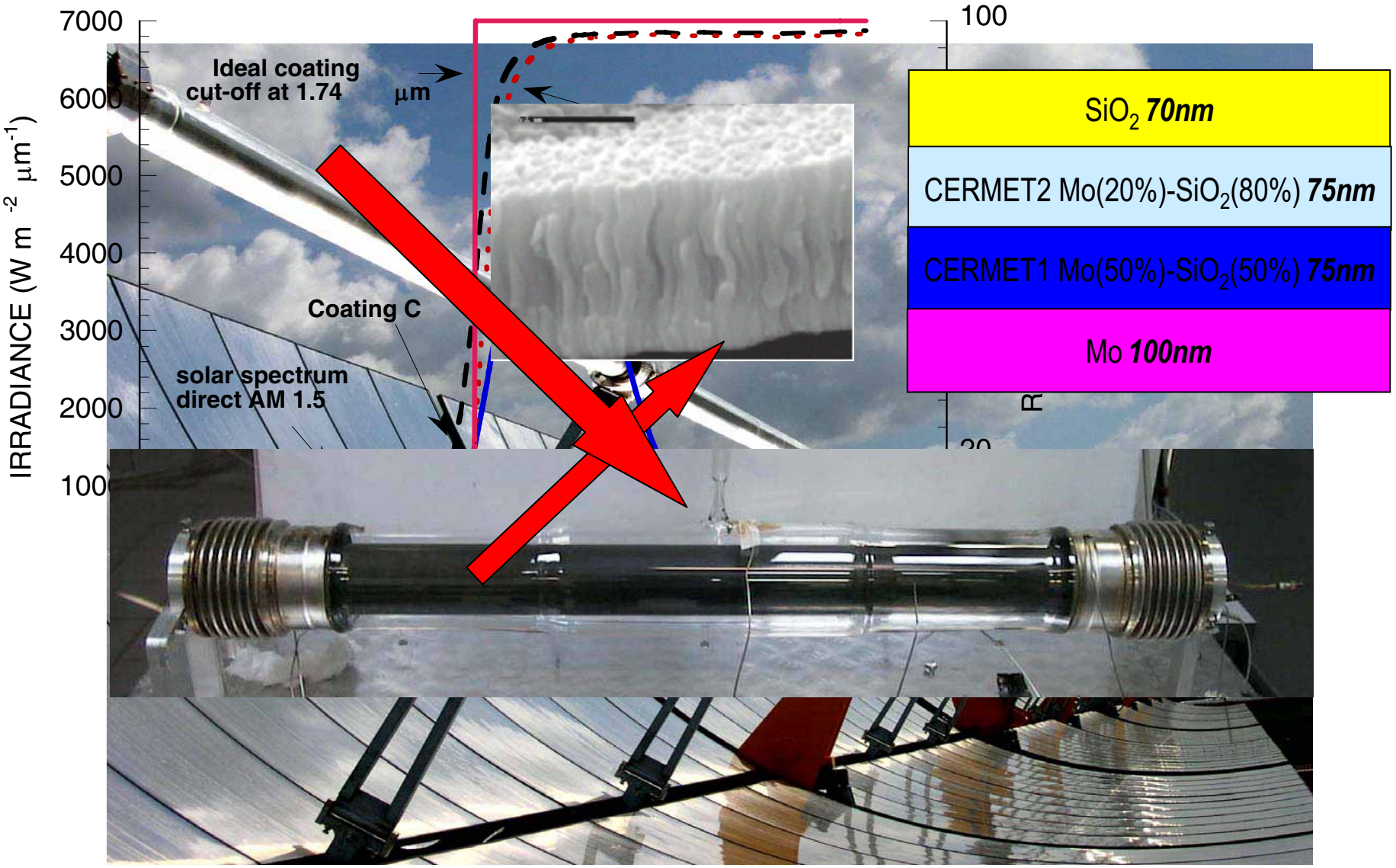
Reflecting panels

- Composite material panels
  - ➔Large size (an half parabola each)
  - ➔Easy to assemble
  - ➔Excellent mechanical properties
  - ➔Very good optical performances

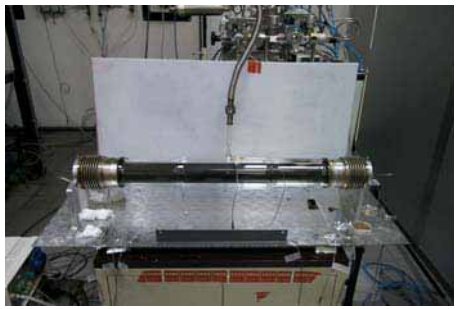
Reflecting panels: honeycomb sandwich

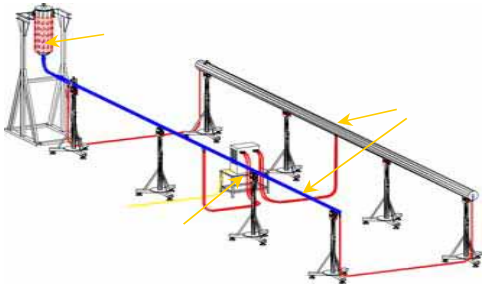


The ENEA receiving tube



The road toward the ENEA industrial plant



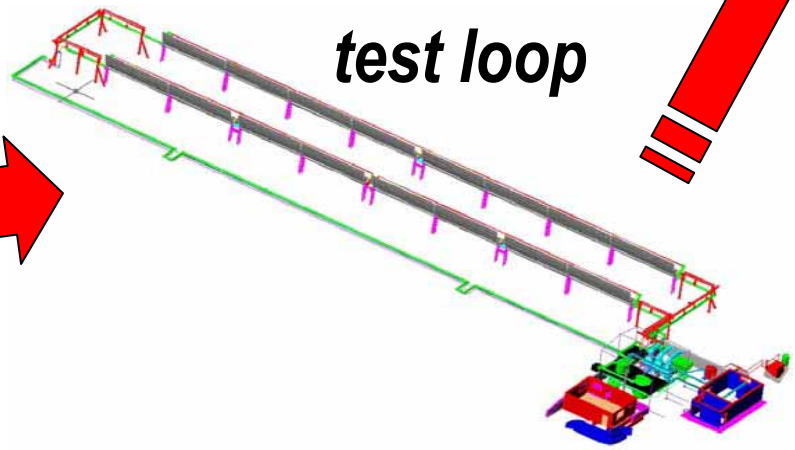


Industrial prototype

Crogioli in acciaio AISI 304

Full scale test loop

R&D qualification programme



PCS: Solar Collector Assembly Test Loop

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Main objectives

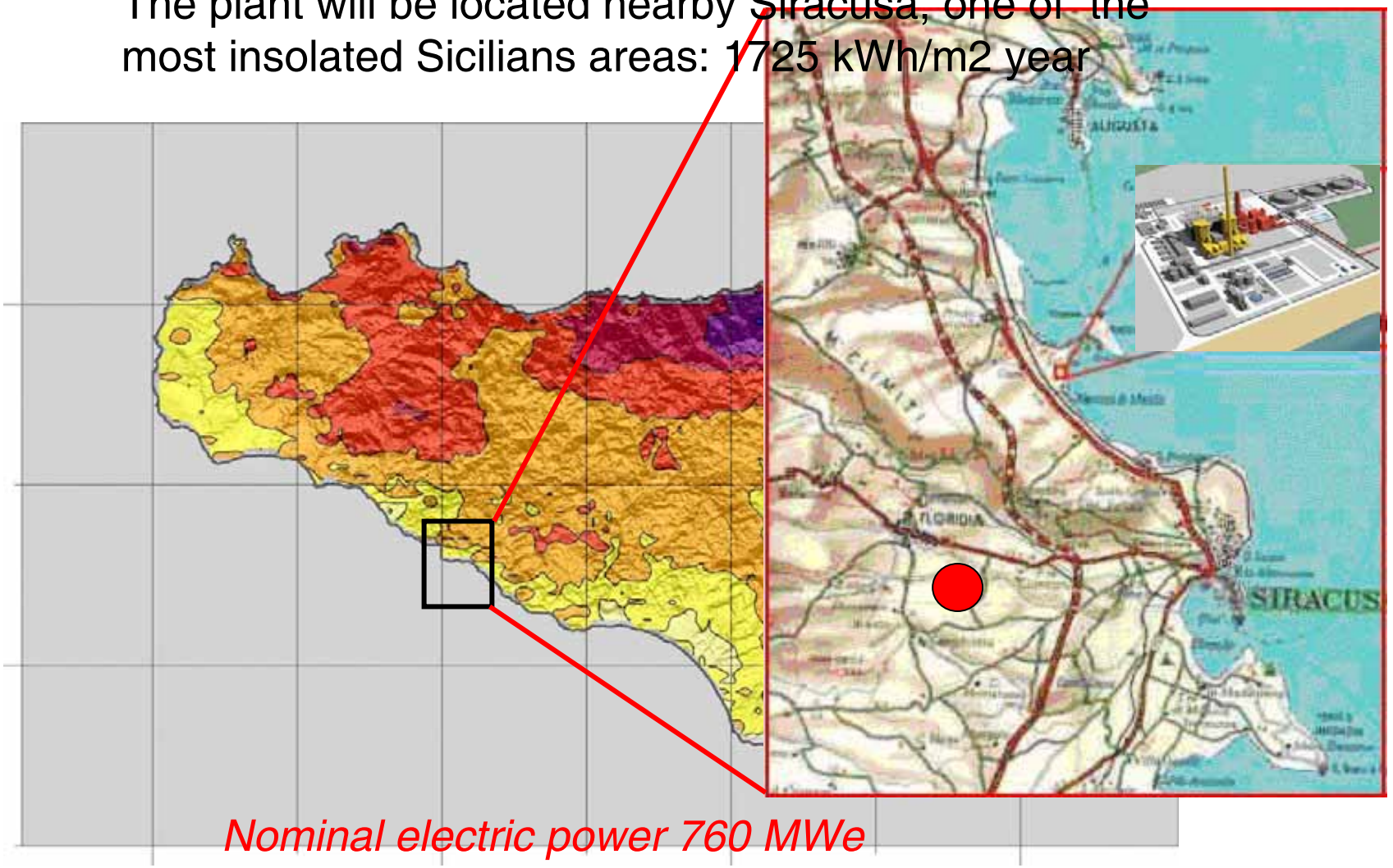
- Test the optical and thermal efficiency of the new solar collector assembly developed in ENEA
- Analyze the behavior of the process components (pump, valves, piping…) with molten salt as heat transfer fluid
- Verify the instrumentation, control system and operating procedures (molten salt management)

All the tests are performed with the same operating parameters (flow, temperature) of the power plant.

The “Archimede” project

A traditional oil electric generation plant was here recently converted in a modern combined cycle plant

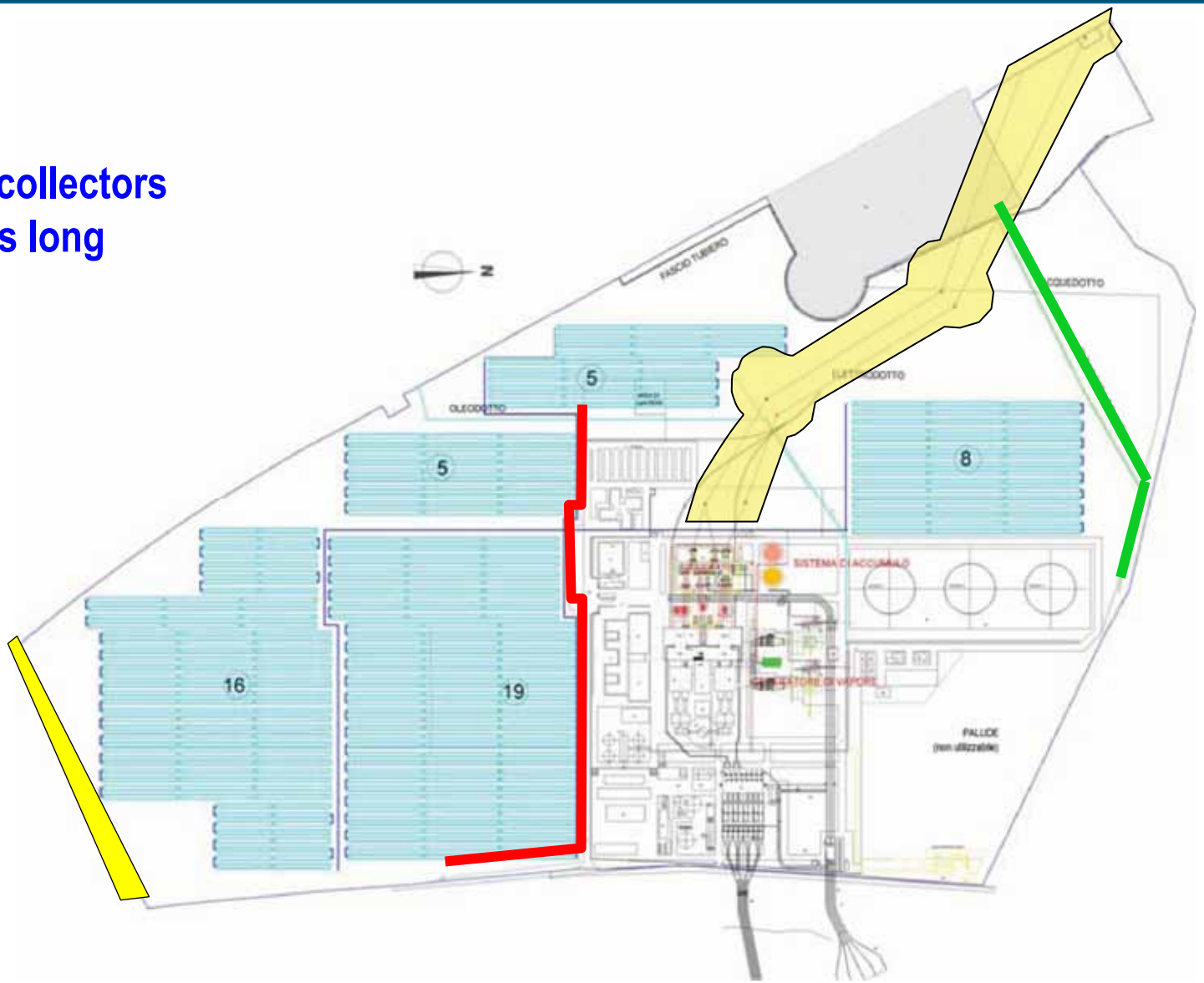
The plant will be located nearby Siracusa, one of the most insolated Sicilians areas: 1725 kWh/m2 year



Nominal electric power 760 MWe

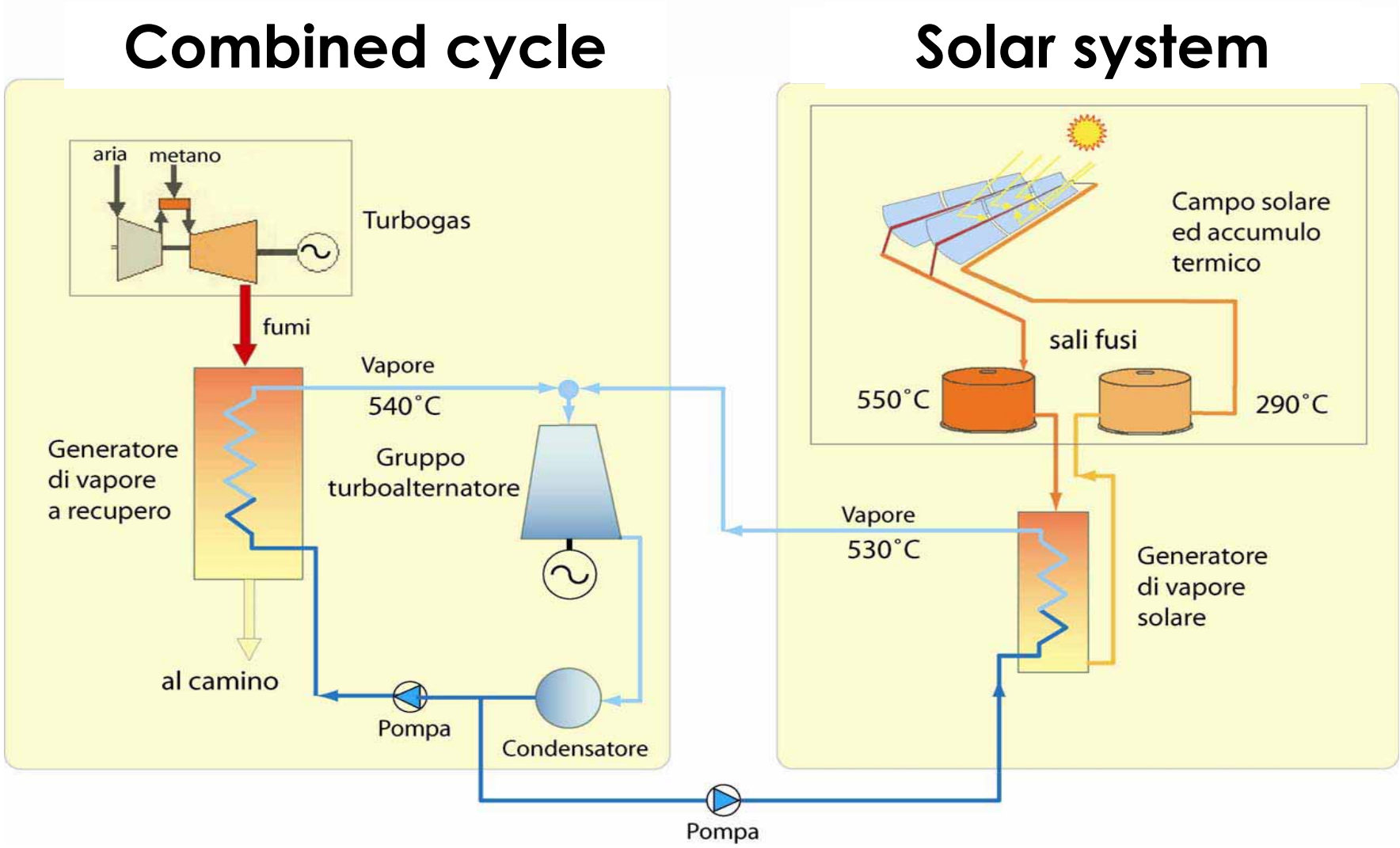
“Archimede” project: the solar field

318 solar collectors
100 meters long



“Archimede” project: photographic reconstruction

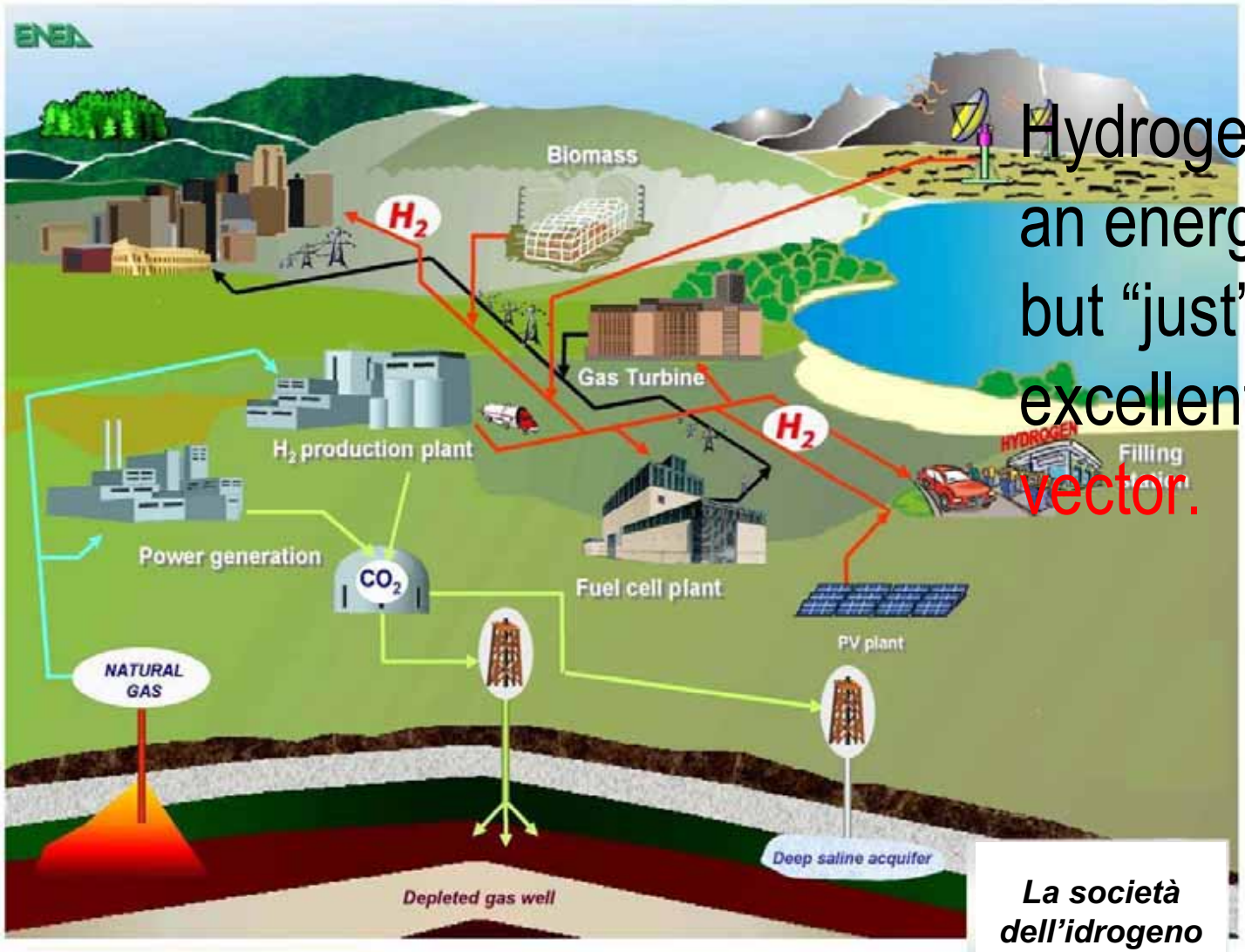
The “Archimede” project: the systems integration



“Archimede” project main parameters

Collectors orientation		***NS***
Number of collectors		318
Thermal energy collected	GWh/y	156.5
Storage capacity	MWh	500
Thermal energy stored	GWh/y	149.9
Nominal electric power	MWe	28.1
Gross plant efficiency	%	43.6
Delivered electric energy	GWh/y	55.9
Primary energy savings	TEP	11,835
CO_2 emission avoided	ton/y	36,306

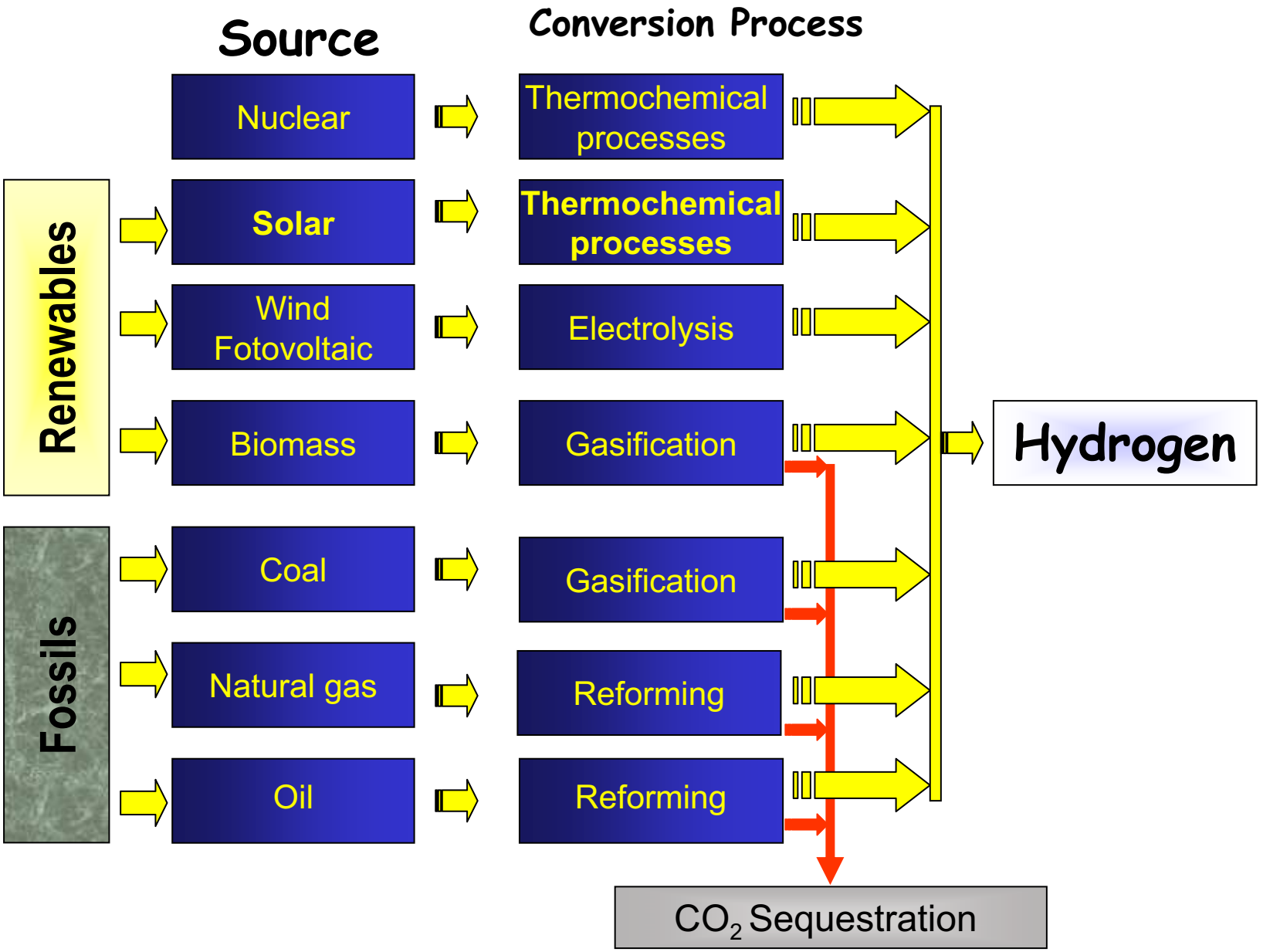
Hydrogen: a great opportunity for the future



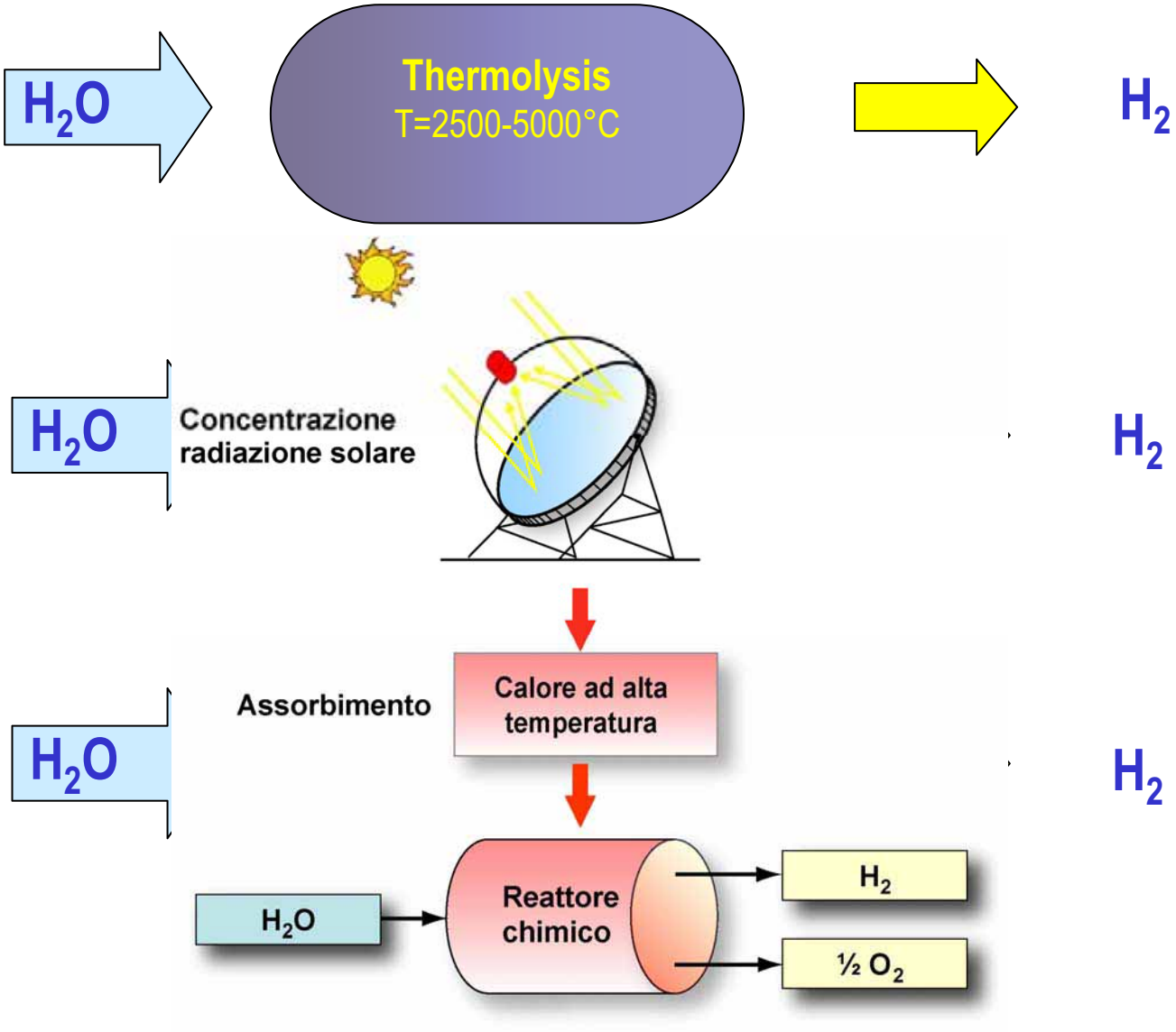
Hydrogen is not an energy source but "just" an excellent energy vector.

La società dell'idrogeno

Hydrogen production methods



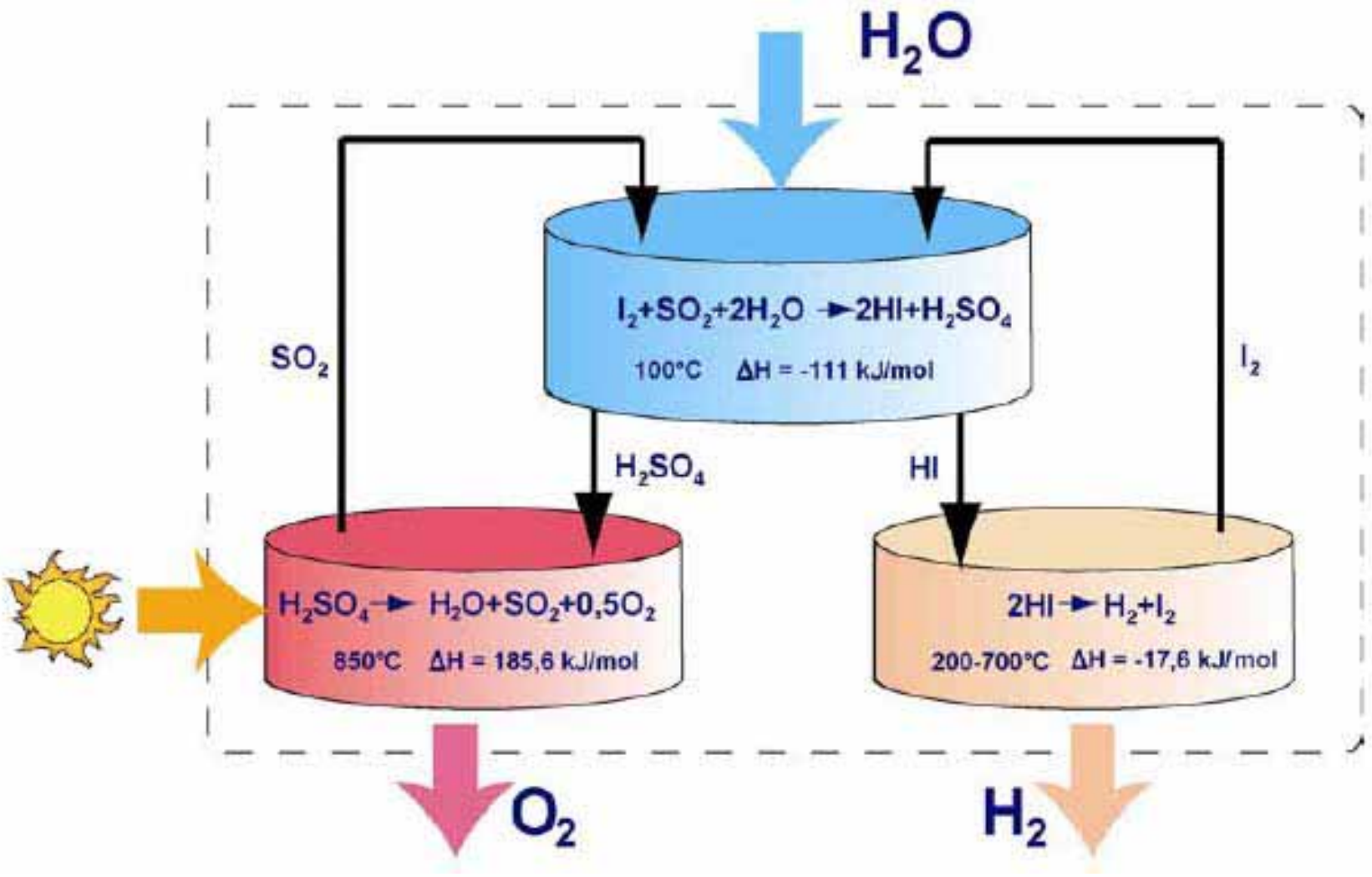
Hydrogen production using solar heat



Hydrogen production using solar heat

- A number of interesting processes have been reported in the literature and are under a deep investigation by ENEA:
  - ➔UT-3 Process(760 °C)
  - ➔**Sulphur-Iodine GA(850 °C)**
  - ➔**Metal oxides (1000 °C)**
  - ➔Zinc-oxidation(2000 °C)

Sulphur-Iodine process



Conclusion

- Solar energy has to play an important role in the future energy supply scenario particularly for the countries in the “sun belt”
- ENEA has launched a vigorous research, development and demonstration program on concentrating solar energy in order to prepare the basis for solar energy massive utilization
- The operation of the real scale test circuit is demonstrating the achievement of the main targets of the project
- The “Archimede” project will hopefully start the realization of a number of solar systems using the ENEA technology
- Solar Hydrogen production is really promising and the reasearch activity curried on in ENEA is creating the basis for the design and realization of the first pilot plant