From Physics to Daily Life

Solar Thermal Electricity Plants

From Physics to a new Solar Energy Technology based on Solar Concentration Devices

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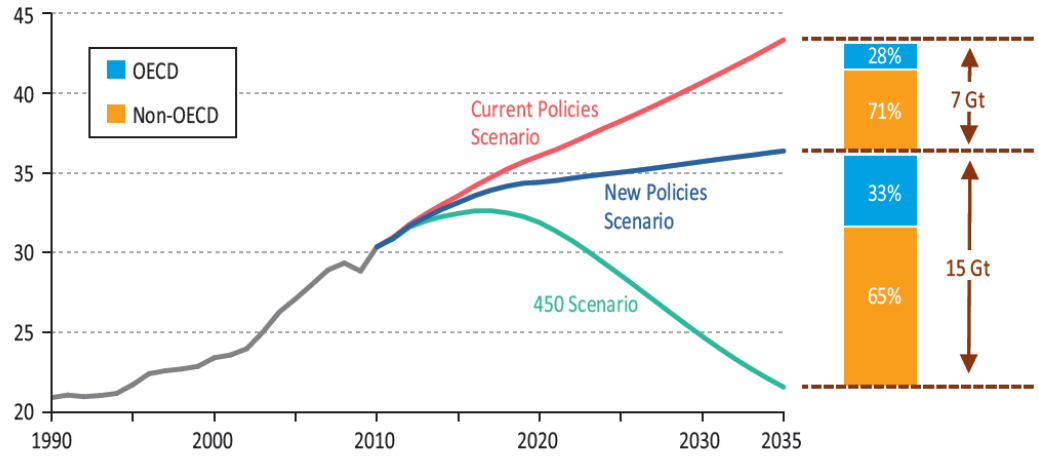
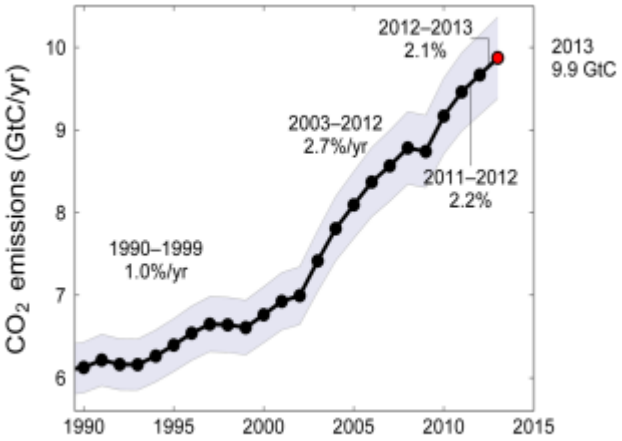
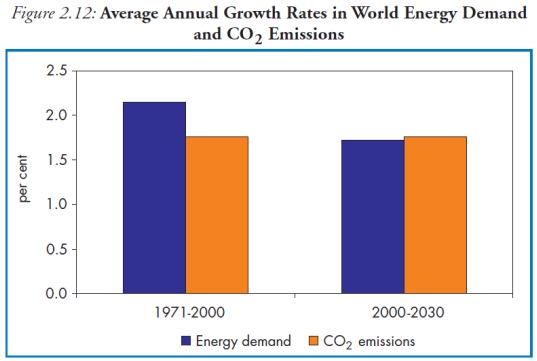
Are we reducing CO_2 emissions?



The global energy consumption (population growth + economic development) is growing at a yearly rate of about 1,5%

BUT, the emissions are growing at a yearly rate of about 2,5% in the last decade.



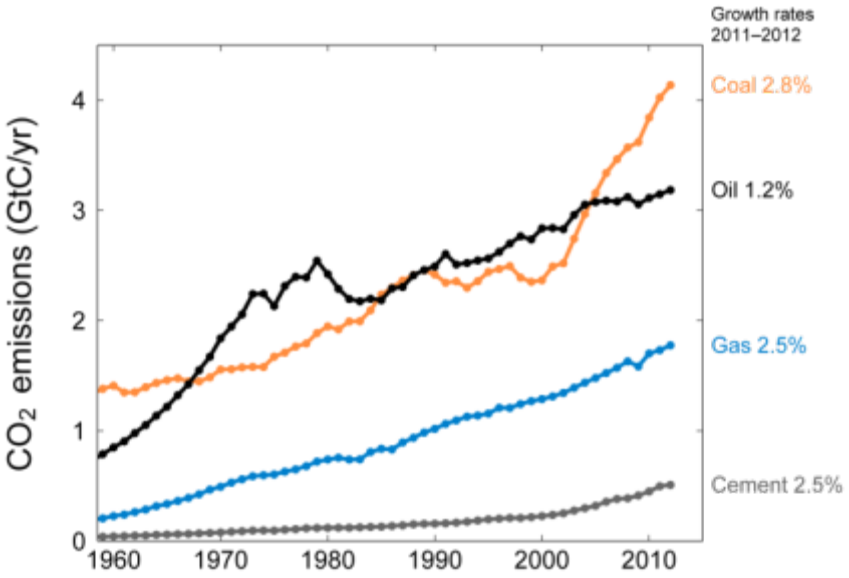


Prospects of CO_2 emissions growth rate by the WEO-2002 for 2000-2030: 1,6-1,7%

SO, instead of reducing a factor of 2 the yearly emissions in 50 years (IEA 450 scenario) we follow the path to more than double them.

No hope to limit the temperature increase to 2 ºC

The source of the emissions



The share of the fossil fuels in the commercial primary energy production is more than 85%.

And coal, the most pollutant fossil fuel, is also the most rapidly growing source of primary energy in the world

This energy scheme is clearly not sustainable:

- Fossil fuels are not renewable. They are limited and it will be more and more difficult and expensive to extract them (specially oil and natural gas)
- They are very oddly distributed (specially oil and gas)
- They produce huge amounts of CO_2 emissions (specially coal and oil)

The path towards sustainability

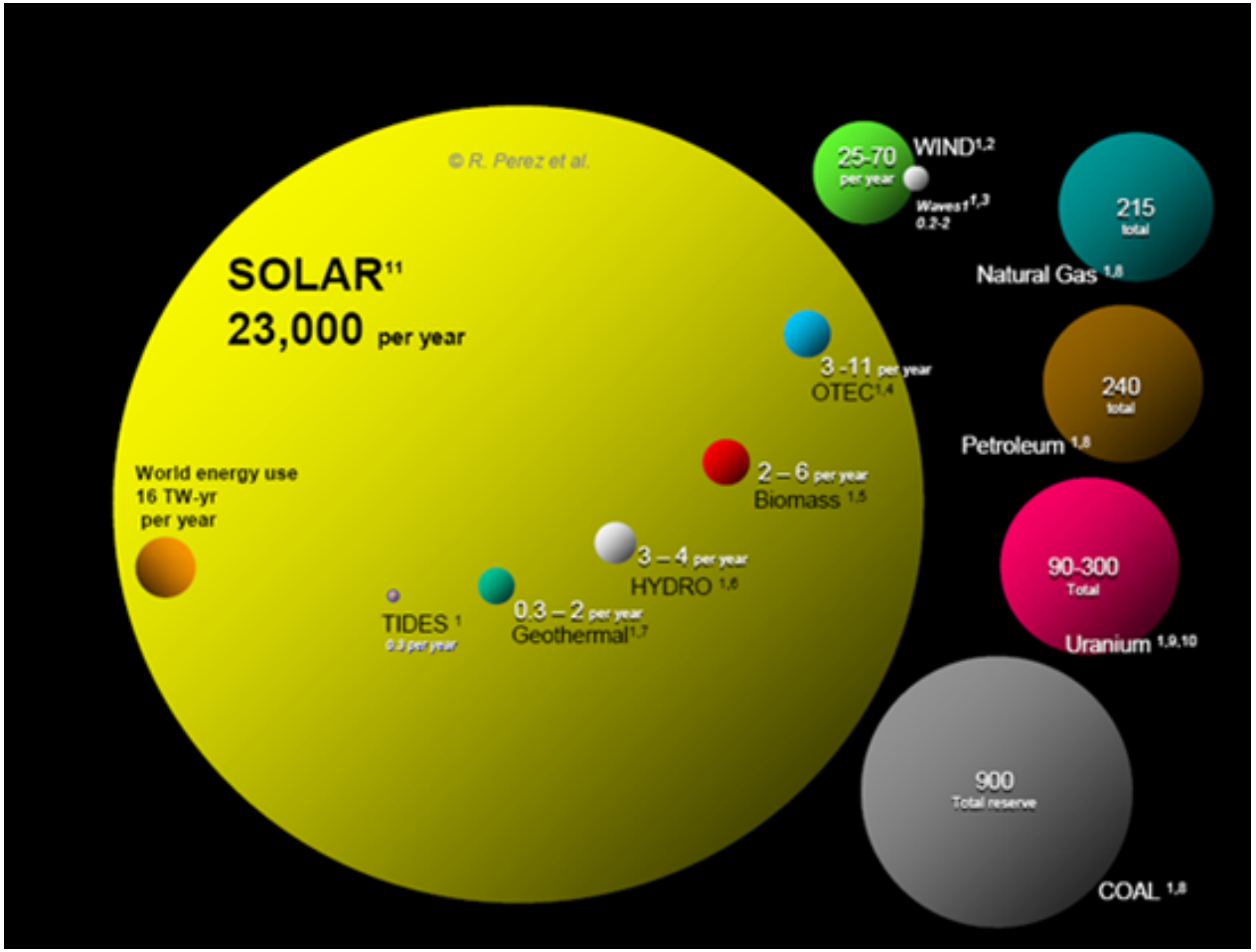
The serious drawbacks of the existing energy supply scheme
Imply a change whose main vector is:

Reduce the carbon content of the primary energy sources

Energy saving and efficiency increase
Less fossil fuels. (Gas as a “brigde” source of energy)
More renewables
More nuclear (Fukushima accident?, Gen IV?)
Possible clean use of coal (CO_2 capture and sequestration)
Fusion (not available in the short term)

None of these alternatives is free of problems. To implement them, a big effort in technology development and political support is required.

Availability of renewable (and not renewable) sources of energy



Source: Professor Richard Perez, ASRC, University of Albany

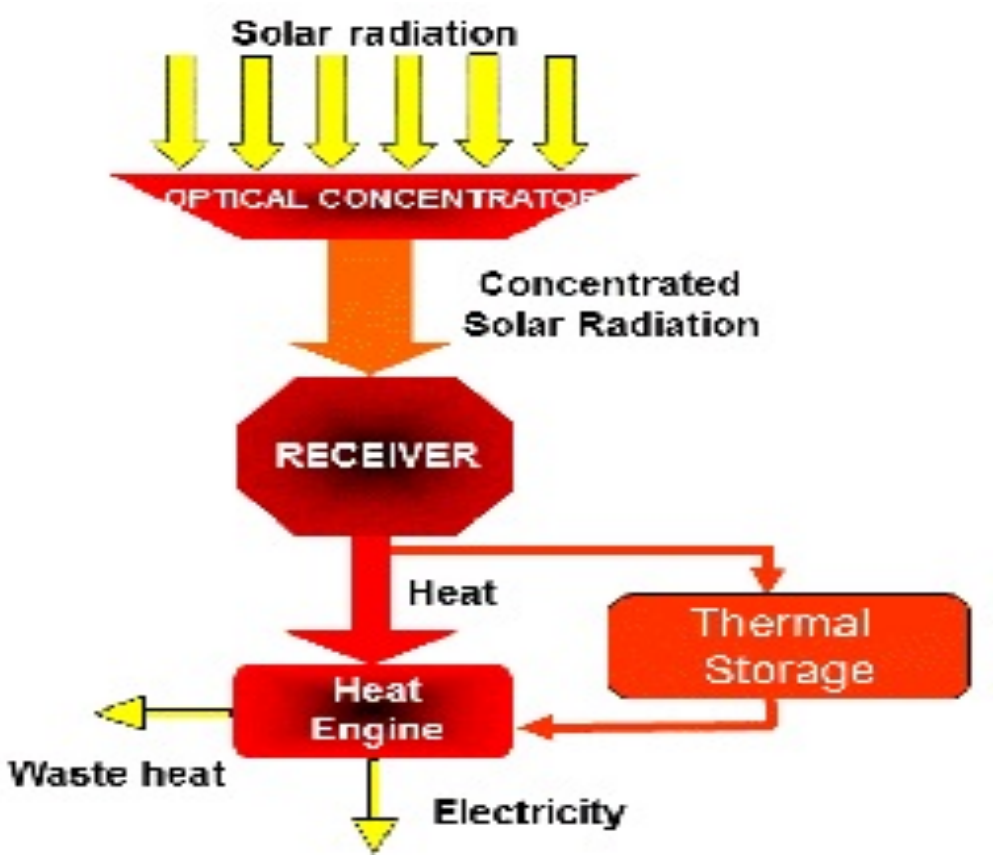
1% of land: 230 TW

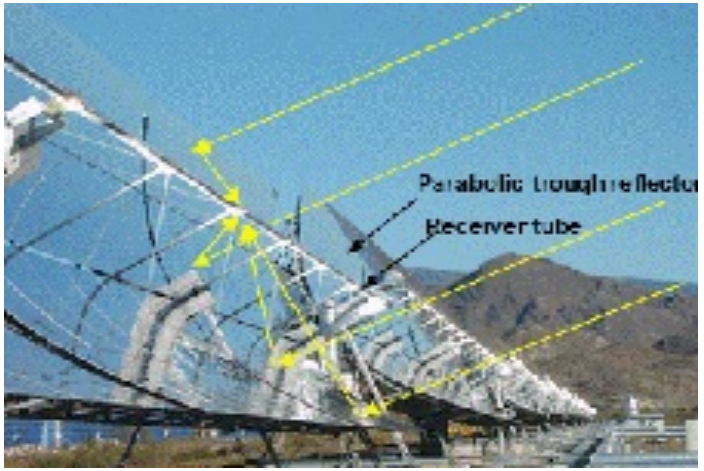
With a 12% conversion efficiency: 28 TW

Almost double the current energy consumption on the planet.

Solar energy is plentiful but very diffuse. We need to concentrate it

Concentration Solar Power





Energy Storage
Hibridization with other thermal sources (natural gas, biomass, etc)

Parabolic troughs. The storage system

50 MWe

Two molten salt tanks

28.500 tons

7,5 hours of storage at full power

Andasol 2, Granada (Spain)

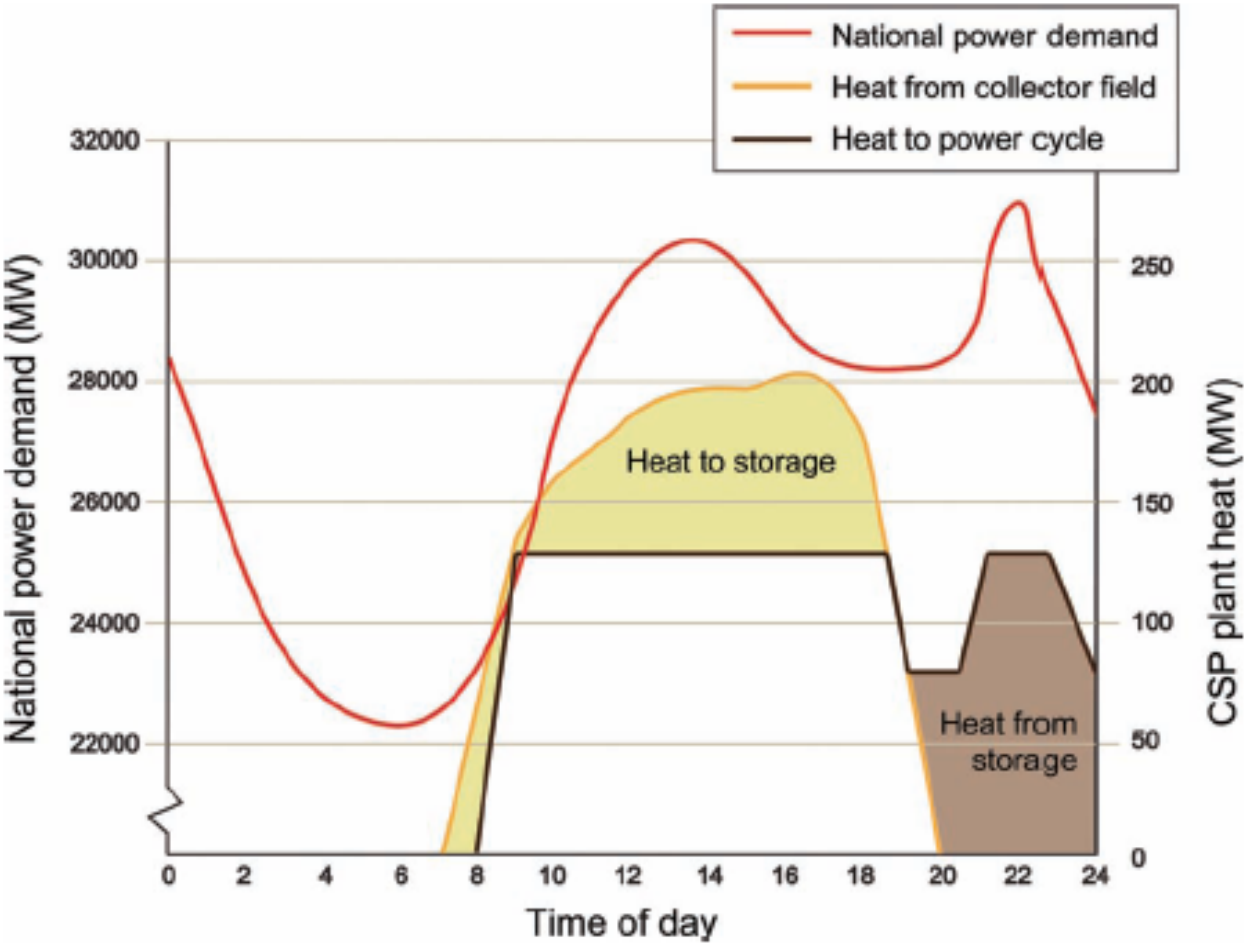
Central receiver

Gemasolar, Sevilla (Spain)

20 MWe
15 hours of storage at full power
In summer it is in operation 24h/day

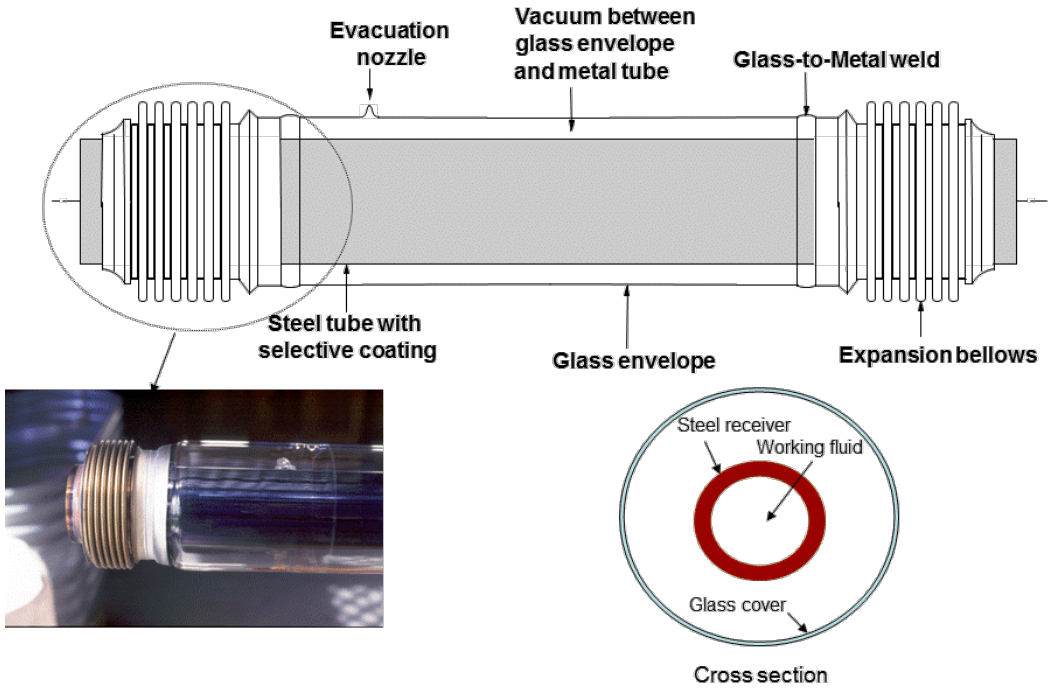
Storage allows to fit the production to the

Figure 4.2 Extending operating hours of a 50 MWe CSP plant with thermal storage, to follow the demand curve of a normal mid-summer day in Spain. Demand curve derived from RED Electrica de España (2011) and CSP load from computer simulation (https://demanda.ree.es/demandaEng.html)



Physics issues related to STE plants. 1

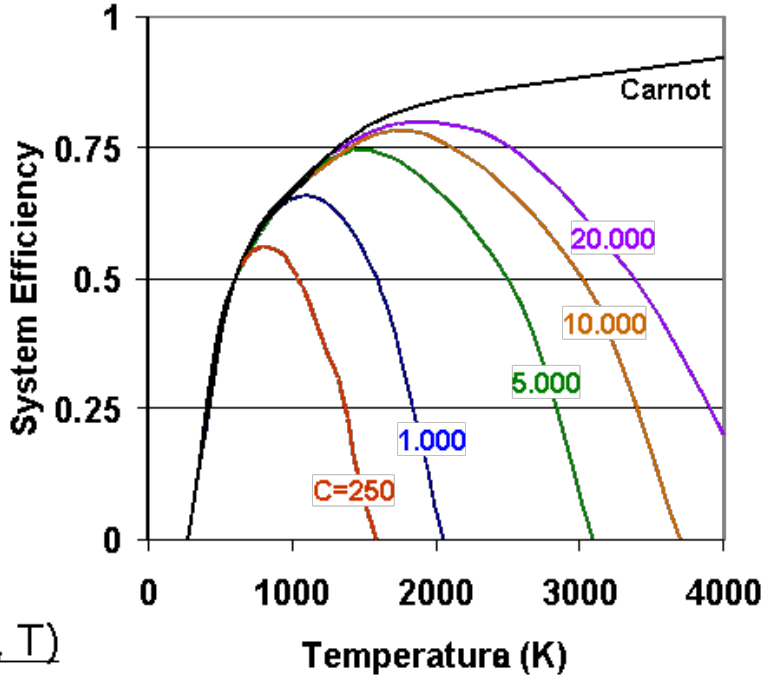
- Optics
  - Solar concentrators
  - Selective and antireflective coatings



  - Thermography

Physics issues related to STE plants. 2

- Thermodinamics
  - Global efficiency



$\eta = f(C, T)$

Parabolic troughs: C ≈ 100

$T_{optimal} \approx 550$ ºC

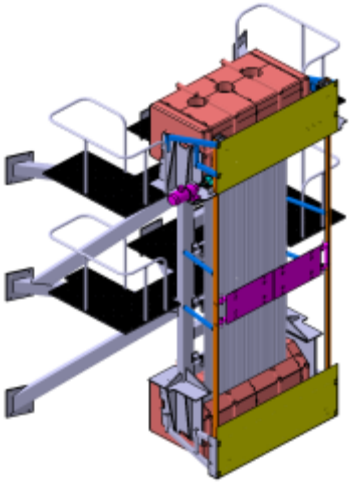
Central receiver: C ≈ 1000

$T_{optimal} \approx 1000$ ºC

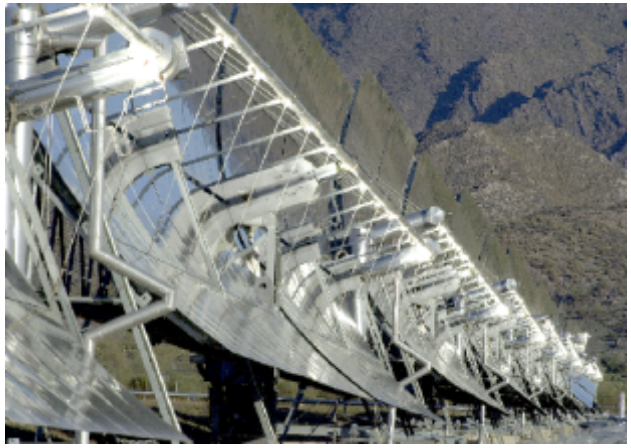
  - Thermodinamical cycles: Rankine, Brayton, Stirling…

Physics issues related to STE plants. 3

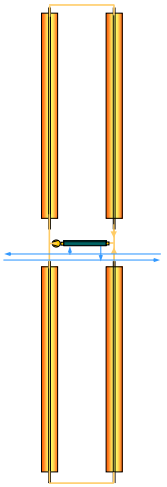
- Heat transfer
- Materials for thermal storage
- Metallurgy and materials for components
- Working fluids



Molten salts



Direct steam generation



Pressurized gas

- Fluid mechanics

The Plataforma Solar de Almería