Torresol Energy
reinventing solar power

Transforming the energy system to achieve the 2ºC target: investment risks and policy challenges

CSP Technologies Available and Risks Associated to large-scale Solar Plants in North Africa

Juan Ignacio Burgaleta
Director of Tehnology

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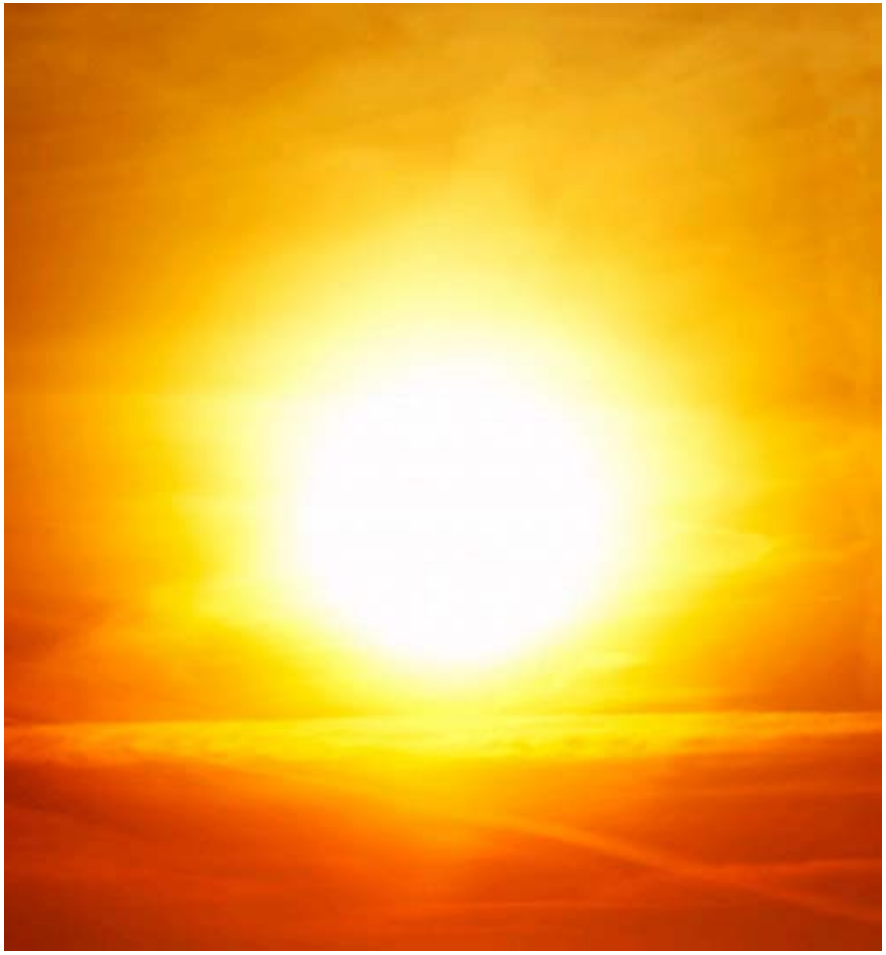
1. Solar Energy: advantages & disadvantages

- Solar energy can be converted into other useful forms of energy such as heat and electricity.

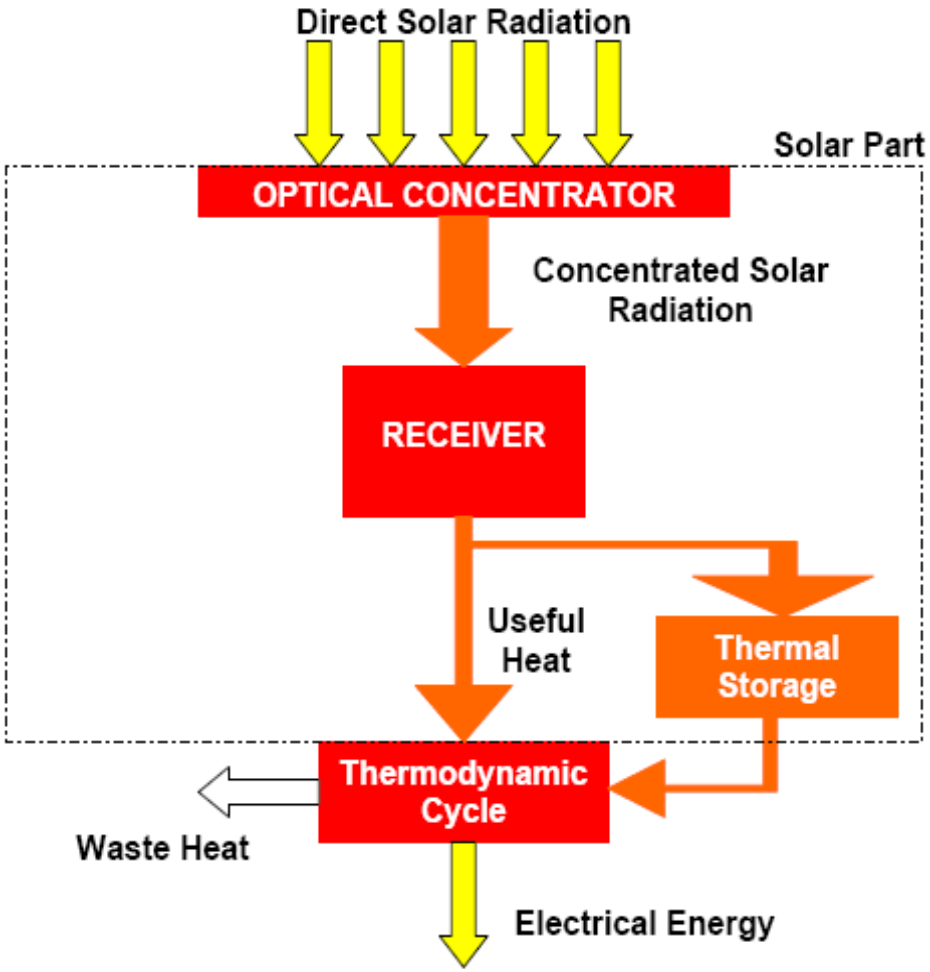
- **Advantages:**
  - **Inexhaustible** energy source.
  - **Clean**, it avoids CO_2 emissions and solid or liquid waste.
  - **More** electricity production capacity than other renewable energies.
  - Energy storage capacity (CSP).

- **Disadvantages:**
  - It is **unevenly distributed** across the world.
  - **Discontinuous** (day-night) and **seasonal**.



2. Concentrating Solar Power (CSP)

- In countries with a great solar radiation level, CSP technologies have a great potential for satisfying the growing electricity demand.
- All of these technologies use the **direct component of the sunlight** and require a solar tracking system.

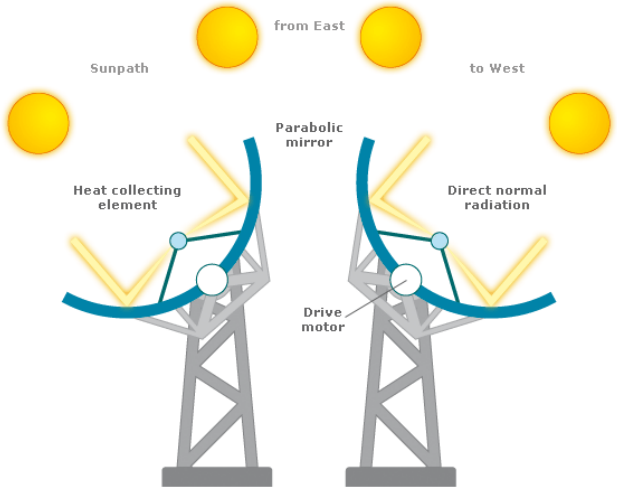


2. Concentrating Solar Power (CSP)

- **Technologies** that are actually **available for commercial plants:**
  - **Parabolic Trough Collector (PTC)**
  - **Power Tower (PT)**
- **Advantages** of CSP technologies over the photovoltaic plants:
  - **Storage System.**
  - **Lifetime** guaranteed for 25 years. As example, the *SEGS* plants which are operated since the 80´s in California.
- **Other alternatives** that are not commercially available:
  - Dish Stirling
  - Fresnel technology

3. PTC Technology

- **PTC** is the most mature thermo-solar technology. The current objectives are the reduction of costs and the improvement of performances.
- There are nine plants operated in California since the 80's (***SEGS*** plants).
- The **reflectors** reflect and focus the sunlight on the **receiver tubes** located in the focal line. The concentrated heat is transferred to the working fluid to obtain overheated steam to produce electricity by a turbo-generator system.
- This technology requires sun tracking system, great precision structures and high tech tubes to avoid thermal losses.
- The performance of the plant is limited by the maximum operating temperature of the fluid (thermal oil – 390º C).
- **Concentration ratio:** 80-100



3. PTC Technology

- Plants in operation in Spain:

Solar Plant	Power (MW)	Storage
Andasol 1 (1)	50	Molten Salts (7,5 hours)
Puertollano Ibersol	50	No
La Risca	50	No
Andasol 2 (1)	50	Molten Salts (7,5 hours)
Extresol 1 (1)	50	Molten Salts (7,5 hours)

Total = 250 MW

- Plants under construction in Spain

Solar Plant	Power (MW)	Storage
Majadas	50	No
Palma del Río II	50	No
Palma del Río I	50	No
La Florida	50	Molten Salts (7,5 hours)
La Dehesa	50	Molten Salts (7,5 hours)
Manchasol 1 (1)	50	Molten Salts (7,5 hours)
Extresol 2 (1)	50	Molten Salts (7,5 hours)
Solnova 4	50	No
Helioenergy 1	50	No
Helioenergy 2	50	No
Valle 1 (1) (2)	50	Molten Salts (7,5 hours)
Valle 2 (1) (2)	50	Molten Salts (7,5 hours)
Lebrija 1	50	No

(1) Participation of SENER: engineering and EPC

(2) Property of TORRESOL

Total = 650 MW

3. PTC Technology

- **Valle 1&2 projects (Torresol's plants):**
  - **Power:** 100 MW
  - **Storage:** 7,5 hours
  - **Electricity generation:** 350 GWh/year
  - **Reduction of CO_2 emissions:** 95.000 tons/year

3. PTC Technology

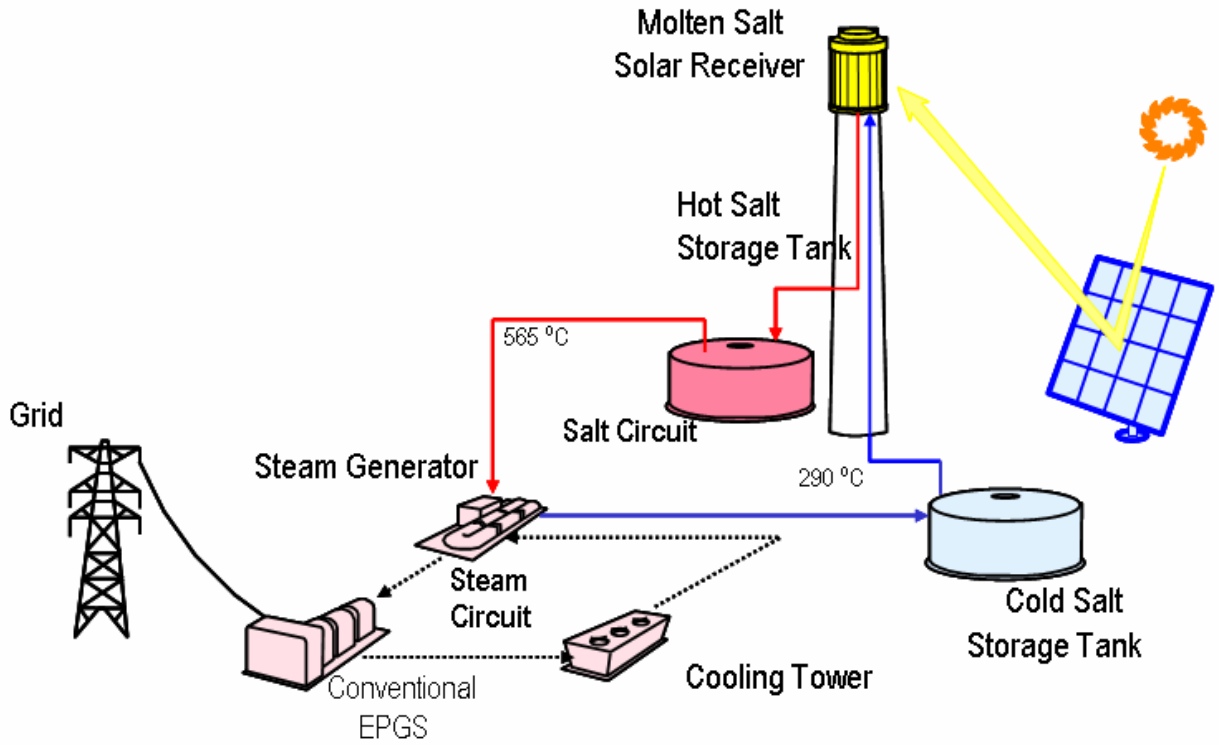
- **There are designed projects available for construction with 140 MW PTC plants with an unique turbine and molten salts thermal storage capacity up to 12 hours.**

- **Others existing projects:**

  Integrated solar combined cycle (ISCC), hybrid natural gas / parabolic trough plants 20 MW of solar generating capacity into larger natural gas facilities (Algeria, Morocco, Egypt).

4. PT Technology

- The **heliostats field** reflects and focuses the sunlight on the **central receiver** located at the top of the **tower**, transferring the heat to a fluid (water, air, molten salts, etc.) to generate high temperature steam.
- This technology requires two-axis sun tracking system and great precision structures.
- **Concentration ratio:** 1,000



4. PT Technology

- **Plants in operation:**
  - **PS10** and **PS20** with saturated steam(1)

    (1) **low efficiency**

- **Plants under construction:**
  - The ***Gemasolar*** plant, a Torresol Energy's project, will be the first commercial-scale plant in the world with technology of tower power, central receiver, heliostats field and molten salt storage system(2)

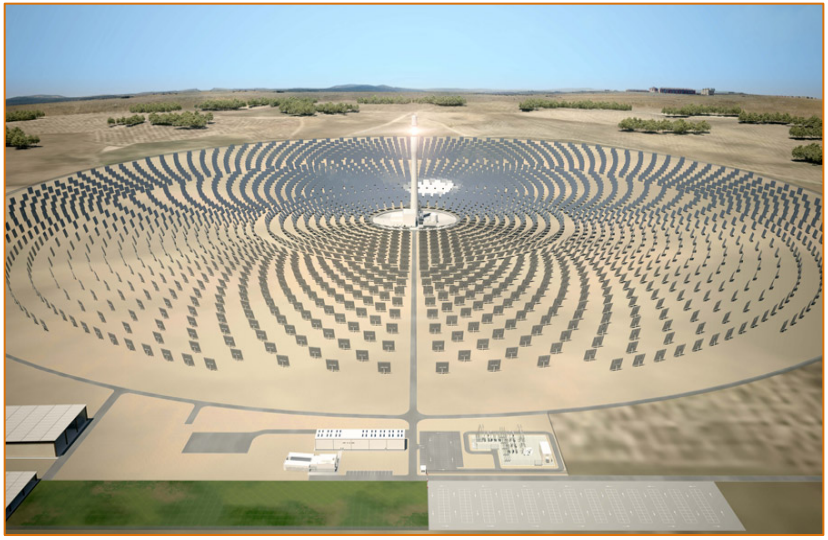
    (2) **attractive technology for future tower power plant according to the *ECOSTAR* study**

- The current objectives are the reduction of costs, the improvement of performances and the improvement of the receiver's technology.

- **There are designed projects available for construction with 50 – 100 MW tower plants and molten salts storage system with capacity up to 18 hours.**

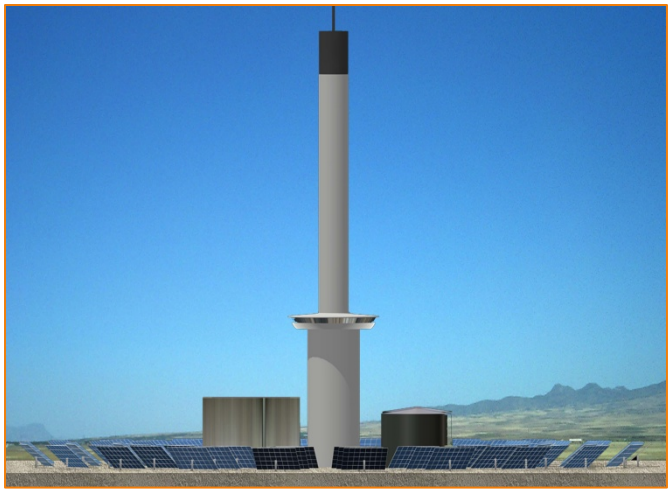
4. PT Technology

- ***Gemasolar* project (Torresol´s plant):**
  - **Power:** 17 MW.
  - **Storage:** 15 hours
  - **Electricity generation:** 110 GWh/year
  - **Reduction of CO_2 emissions:** 30.000 tons/year



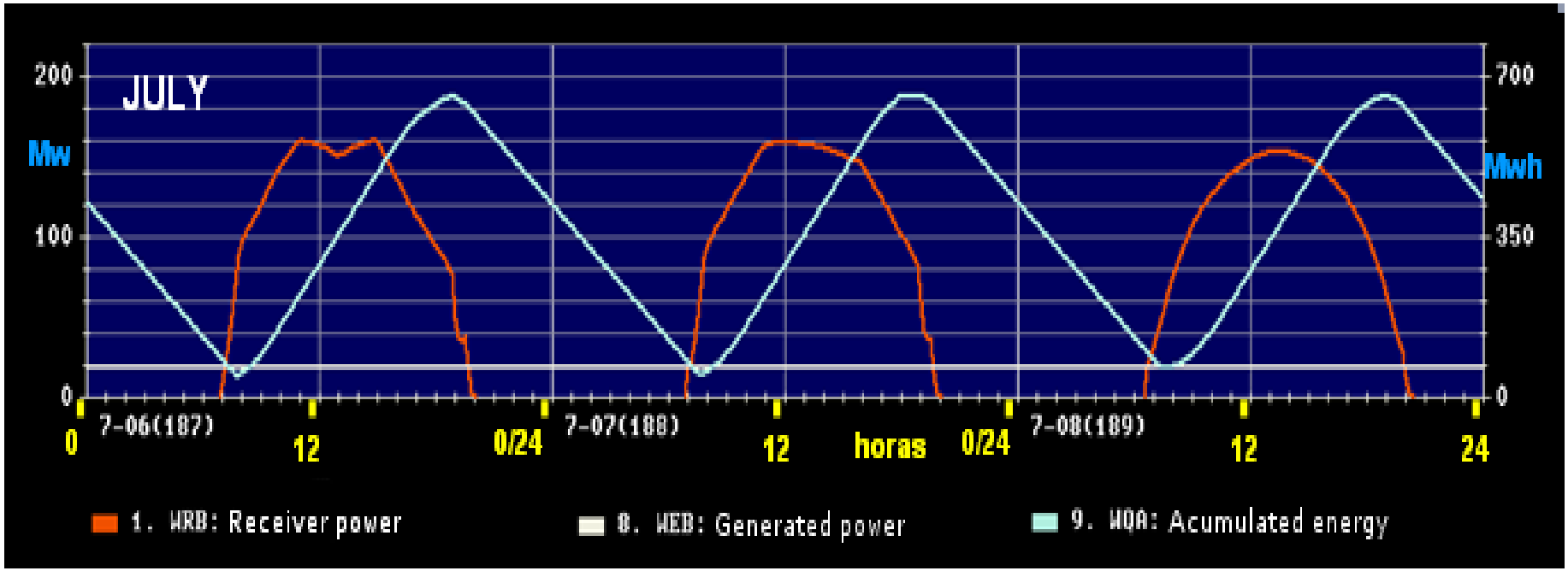
4. PT Technology

- ***Advantages of a central tower solar plant with thermal storage system***
  - High thermal storage capacity.
  - The same fluid is used for heat transfer and storage.
  - The molten salts reach the highest temperatures maximising thermodynamic efficiency.
  - The whole piping system is contained in an small area, reducing the heat losses, the maintenance costs and minimising the possibility of leaks.



4. PT Technology

- *Continuous electric energy generation*

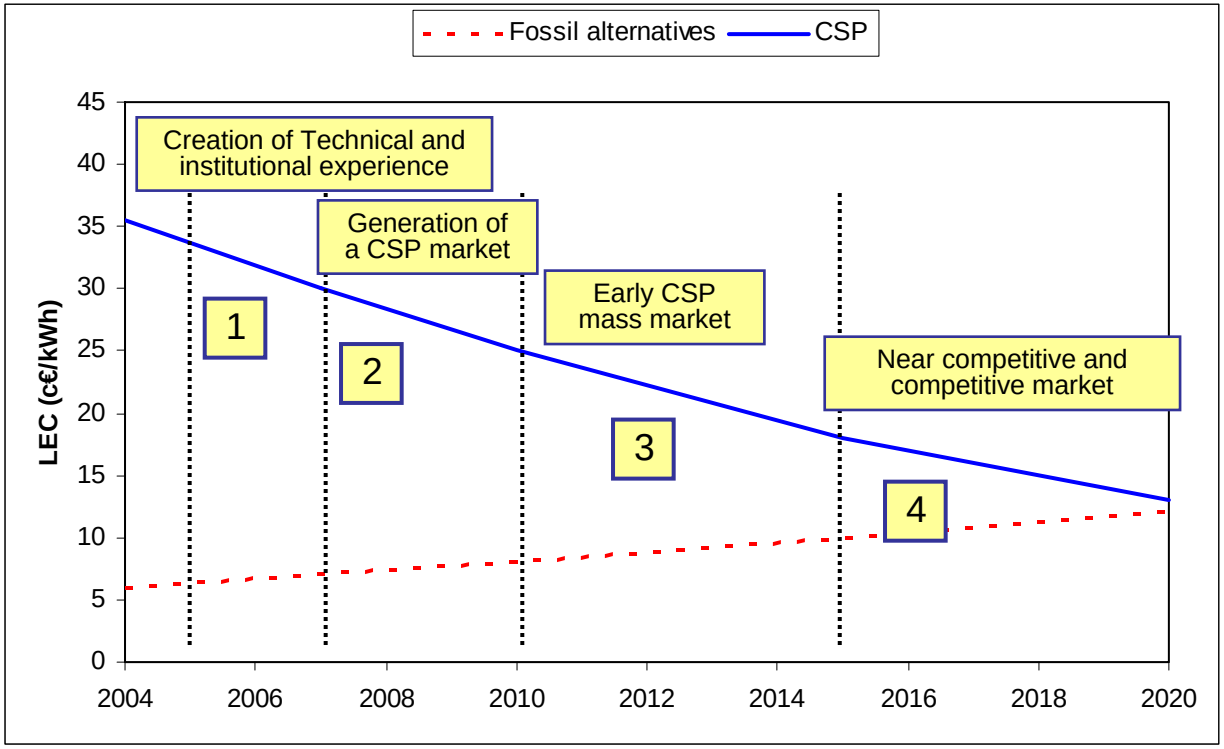


During the summertime, the plant supplies continuously energy to the grid

*Gemasolar computer simulation for July (Spain)

5. Generation Costs

- It is expected a important cost reduction of the KWh generated by CSP in the next ten years..



6. Areas of improvement to reduce the cost per KWh

- Factors and activities that will allow to reduce the generation costs:
  - Innovation, investigation and technological developments.
  - Efficiency improvements
  - Decrease of the investment, operation and maintenance costs.
  - Not to limit the power of the plants, and construction of a high number of them.
  - Normalization and standardization.
  - Collaboration with suppliers.

7. Risks Associated to Large-scale Solar Plants in North Africa

- Solar radiation suffers **atmospheric attenuation**, due to absorption and scattering processes. This atmospheric attenuation may be relevant in the **deserted zones** (sandstorms).
  - The **absorption** is caused mainly by the ozone (ultraviolet band) and vapor of water and CO_2 (infrared band).
  - The **scattering** is caused by the interaction of the solar radiation with air molecules, water (steam or condensate drops) and in general, by particles in suspension.
- **Connection to the grid**.
- Small number of local **suppliers**.
- **Lack of legislation**.
- **Need of water** for the operation and maintenance of the solar plants.
  - **Operation** → consumption similar to other electricity generation sources.
    - Enough water available → cooling tower
    - Insufficient water available → dry cooling
      - Inversion increased in 4-5%.
      - Production penalized in 2-3%
  - **Maintenance** → reduced consumption, primarily to clean mirrors.

8. Conclusions

- The **nowadays available CSP technologies** allow to start the construction of plants with thermal storage in North Africa:
  - **PTC:** projects of 50-140 MW with thermal storage capacity up to 12 hours.
  - **PT:** projects of 15-100 MWe with thermal storage capacity up to 18 hours.
- **Reasonable risks** associated to CSP plants in North Africa.

THANK YOU FOR YOUR ATTENTION !

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