REAL ACADEMIA CANARIA DE CIENCIAS

Facultad de Ciencias Físicas y Matemáticas

23 de Abril de 2019

The role of water for energy production from the Sun

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Energy and water

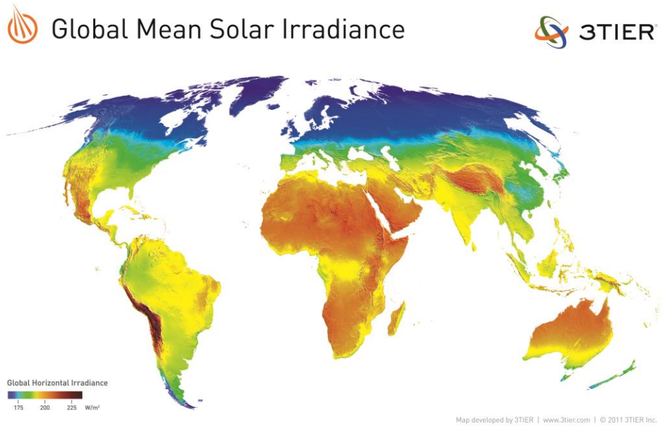
Solar water production

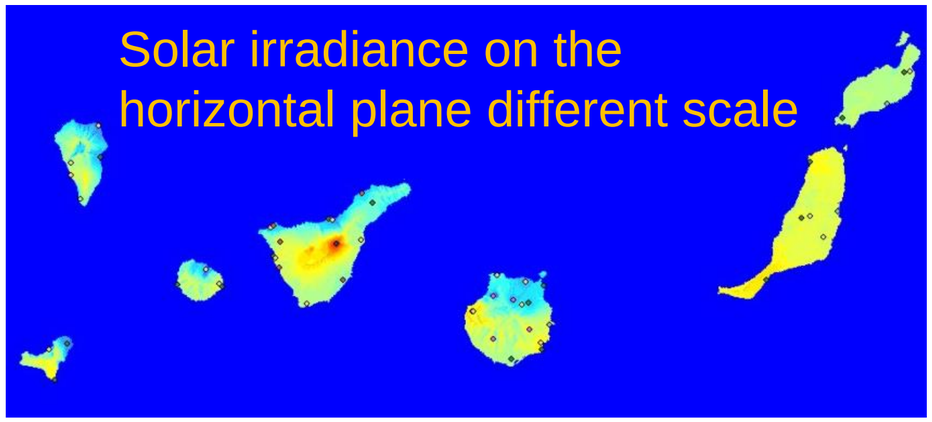
Water desalination as energy storage

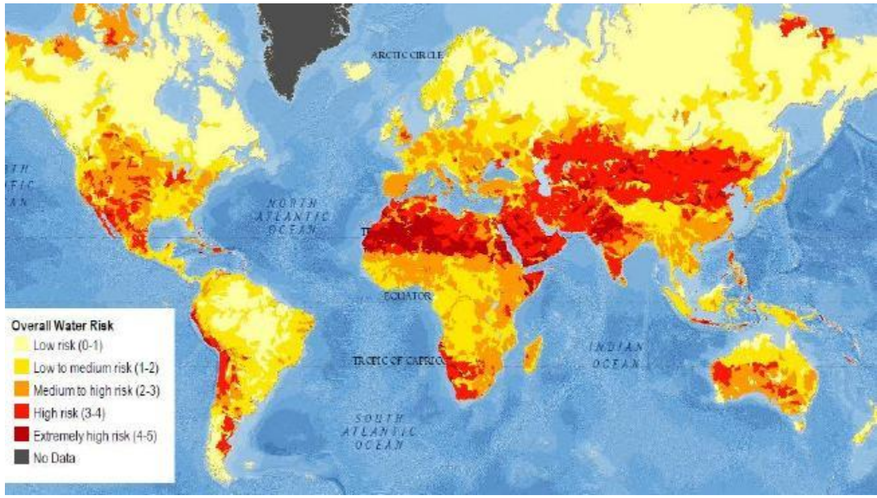
The TurboSol project

Negative nexus sweet water-solar availability

Donde hay sol, no hay agua porque se evapora, salvo ríos, lagos o subsuelo







Water risk

By 2050 the Energy consumption would triplicate, because:

- More population
- Higher per-capita consumption, especially from low GDP.
- ¿Climate change?

… The needs for water will also grow (70% for food production).
Solar energy can produce water.
Solar energy is the more abundant and inexhaustible, lowest price, flexible,clean and well spread.

Thus: **Solar energy** can reduce the water scarcity in sunny regions.

Residual or sea water recovery

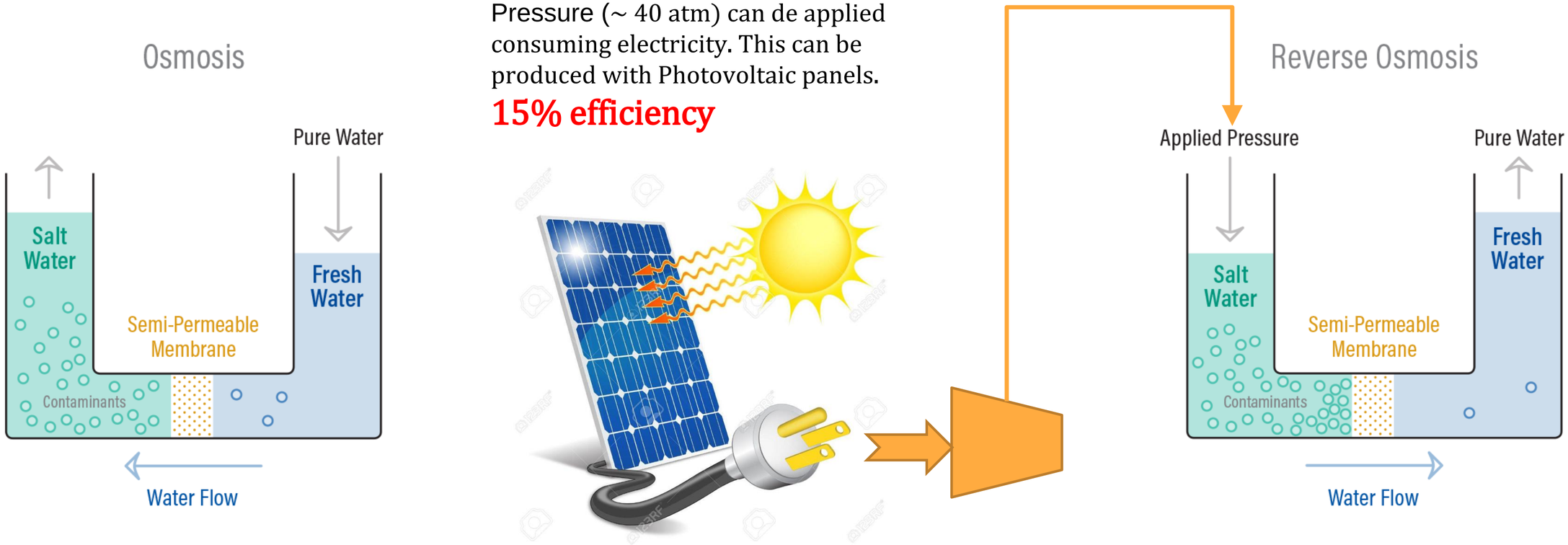
Normally contaminated water is higher than 90% pure, marine water contains only 35 g/l of salt, so ¿what is the problem with water?

- ☹ High dissolution capacity
- ☹ High evaporation heat Δh_{lv}
- ☹ High specific heat c
- ☹ Potable water needs a high purity and some minerals
- ☹ Agricultural and industrial water needs high purity
- ☹ Biological safety

☺ Good news: Fresh water can be easily stored. It is the **best battery** when water is produced consuming solar energy. ¿How can be produced? …

Solar water production

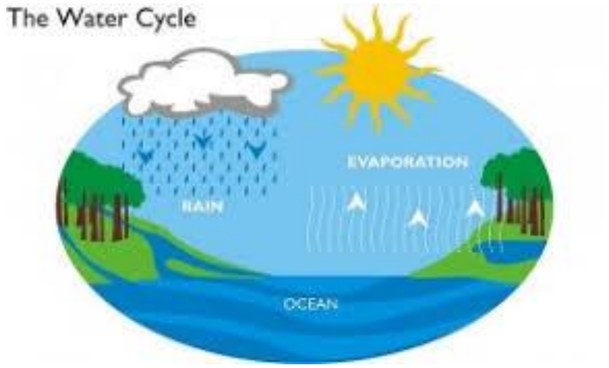
1. Reverse osmosis purification. The lowest electricity consumption but 3 times primary energy consumption.



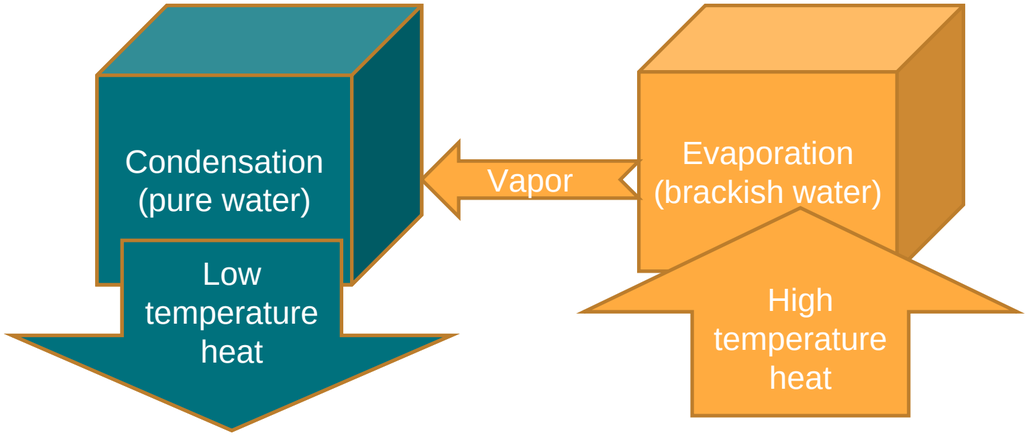
This is now the most used sea water desalination technology used (but not necessarily with photovoltaic solar energy but also other renewables: wind, thermosolar, ….

Solar water production

2. **Evaporation and condensation** using fossil energy (coal, oil or electricity) high energy consumption.



Mimicking nature:

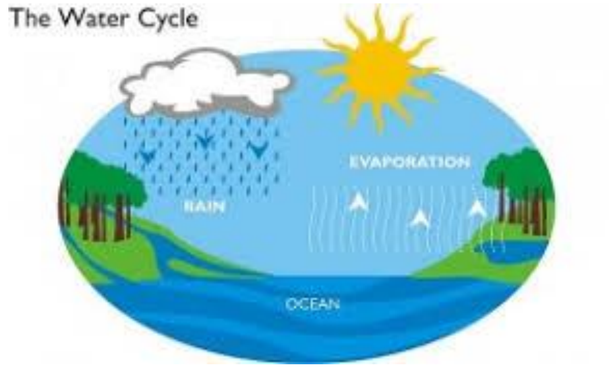


☝ What is the problem?, Thermodynamics!

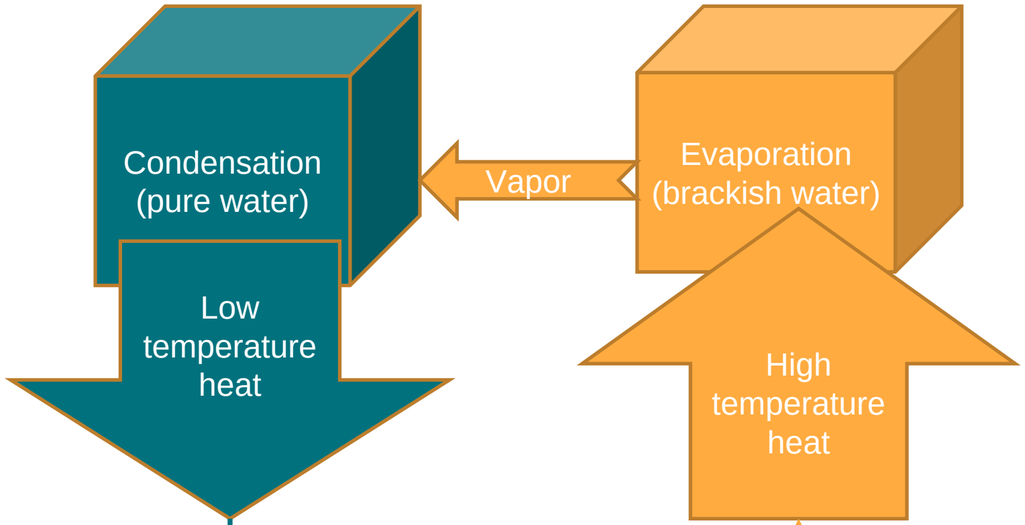
The fossil energy source causes high energy cost, **but with solar, the primary energy is free, only the devices cost, and evaporation + condensation is near natural processes.**

Solar water production

2. **Evaporation and condensation** using solar.



Mimicking nature:



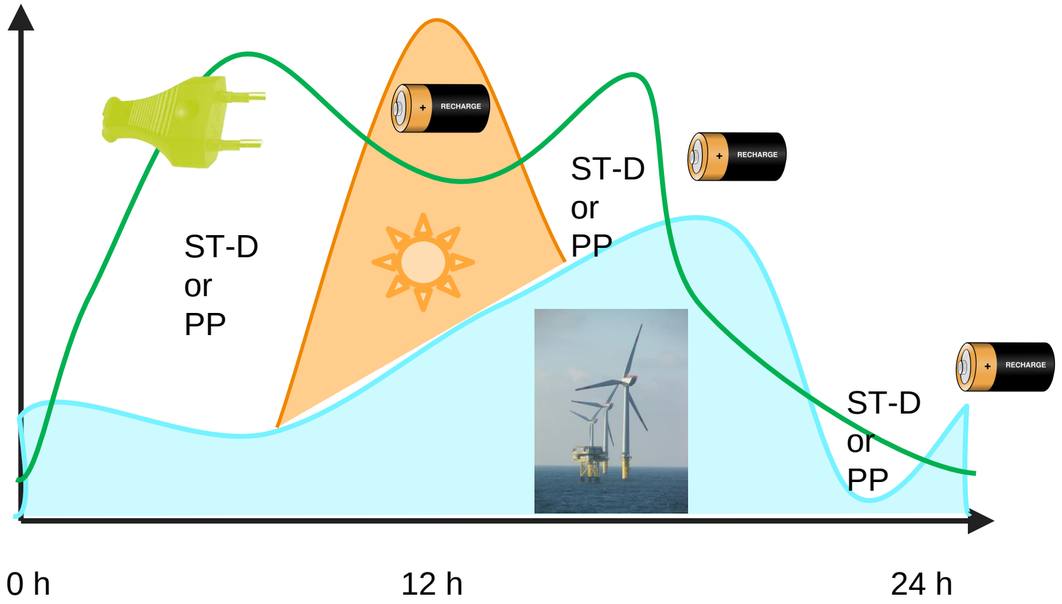
50% efficiency

Conclusion: There are technologies to:

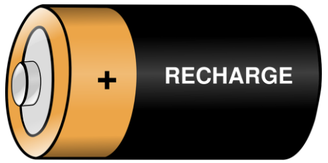
- Produce solar electricity that feeds desalination plants
  - PV or thermo-solar
- Directly desalinate with solar thermal, under development
- Minimize the water consumption of electrical power plants and especially the solar-thermal → dry cooling or ocean.

- So, ¿what is the problem in the Canaries?
  - Large investment needed
  - **Space requirements (the most critical in Macaronesia)**
  - Small size of the grid, requiring electricity **storage** and sophisticated managing. More on that …

Need for storage of renewable electricity



(**bio)Gas power** plants (PP) will help as a transitional backup, and **storage** is the solution



← Energy storage. This can be desalination and storage of water.
But only a fraction as electricity is needed on periods “ST-D or PP” meaning Storage Discharge or Power Plant.

Energy storage

Electricity

- **Batteries:** costly, but electric cars could help on that in the future, can be very large.
- **Dams (Gorona, Chira-Soria, …):** Excellent match with water management. Large space requirements and favorable orography. Difficult in some islands.
- **Electricity to fuels:** Highly interesting for transport, but still under development. Hydrogen?, Ammonia? Only 50% efficiency.
- **Submarine air compression:** Highly interesting for Macaronesia. Not much experience, 70% efficiency.

Heat for electricity

- **Molten salts**, mature technology and cost effective, 95% efficiency $\sim Batteries\ cost/10$. ¿Why not in Canaries?

Thermo-solar Power Plants with molten salt storage up to 14 h.
Centrales eléctricas termosolares con almacenamiento de 14h

Tower plants, e. g. http://torresolenergy.com/TORRESOL/home/en They do not require a flat terrain

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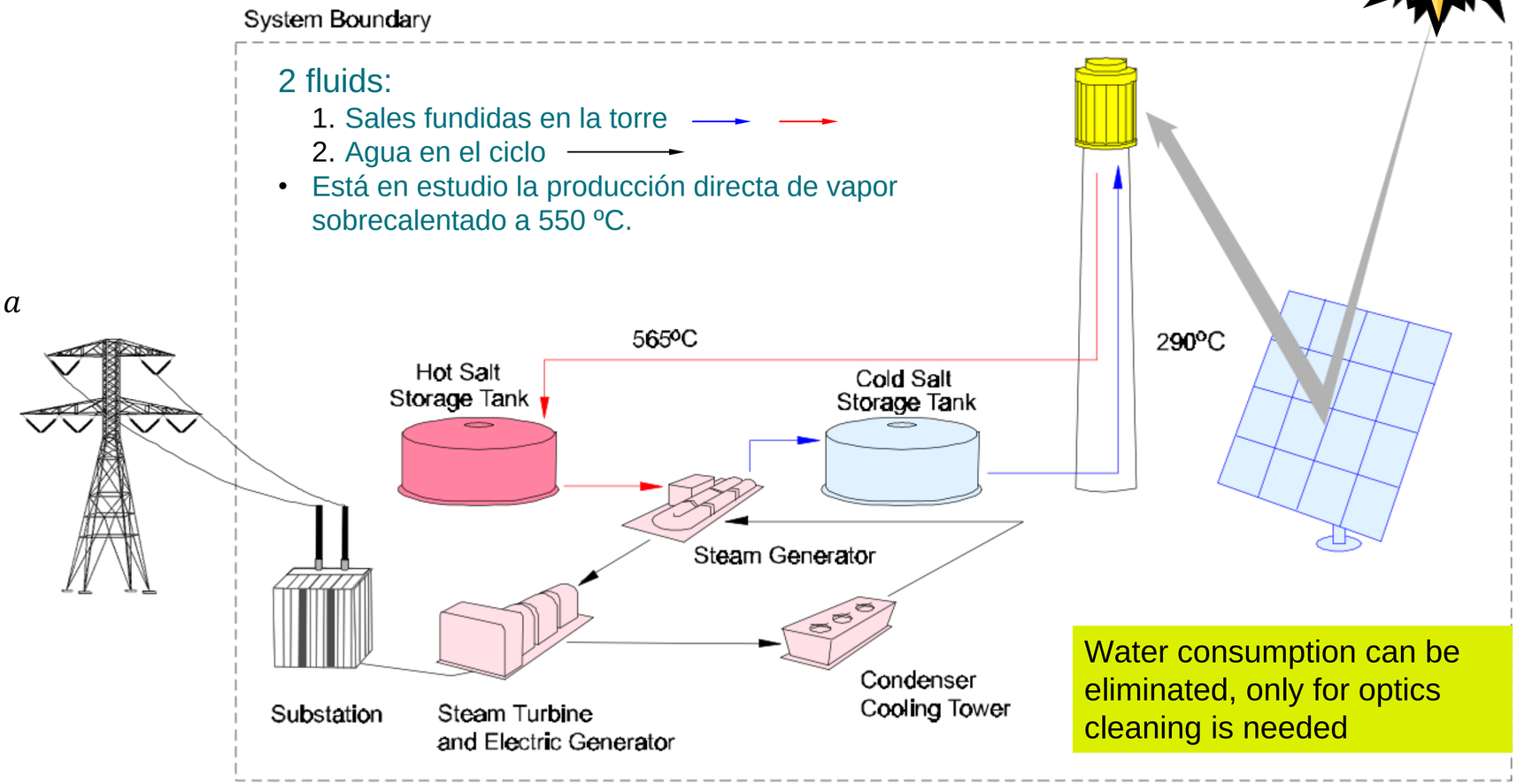


A 1km×1km solar field will produce 100 to 200 kWe. Actual cost 5,6 €/We (Ivanpah), PV is around 2 €/We but no storage; (even half of that). To cool the plant, it can be located on the ocean, or nearby 1km to 10 km inland?

Main competitor of thermo-solar is PV electricity production

☺ Can be constructed in any size

☺ Simple and robust.

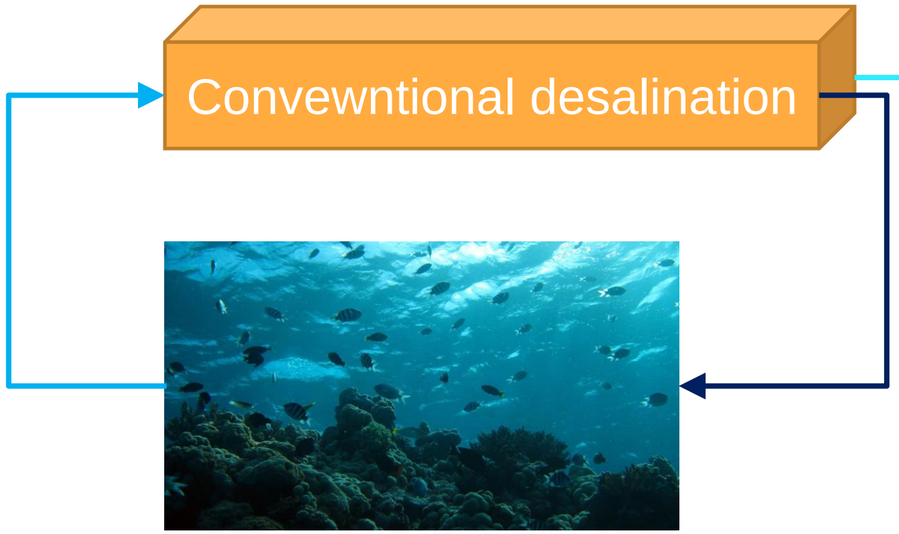
☺ Lightweight and low profile so that they can be installed anywhere.

☹ No inertia, so that their instantaneous power is erratic

☹ A high penetrations will cause grid problems

☹ Space requirements similar to thermo-solar

Desalination issues



Sweet water 50%

Sea water 100%

50%. This rejection of concentrated sea water perturbs the sea floor.
It would be better to concentrate up to obtaining salt crystals and eliminate this rejection

New techniques are needed to obtain:

1. More fresh water
2. Dry salt

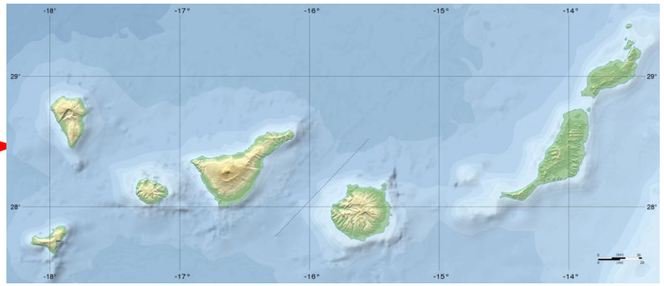
For that dryers through:

- Vacuum
- Thermal

…are appropriate

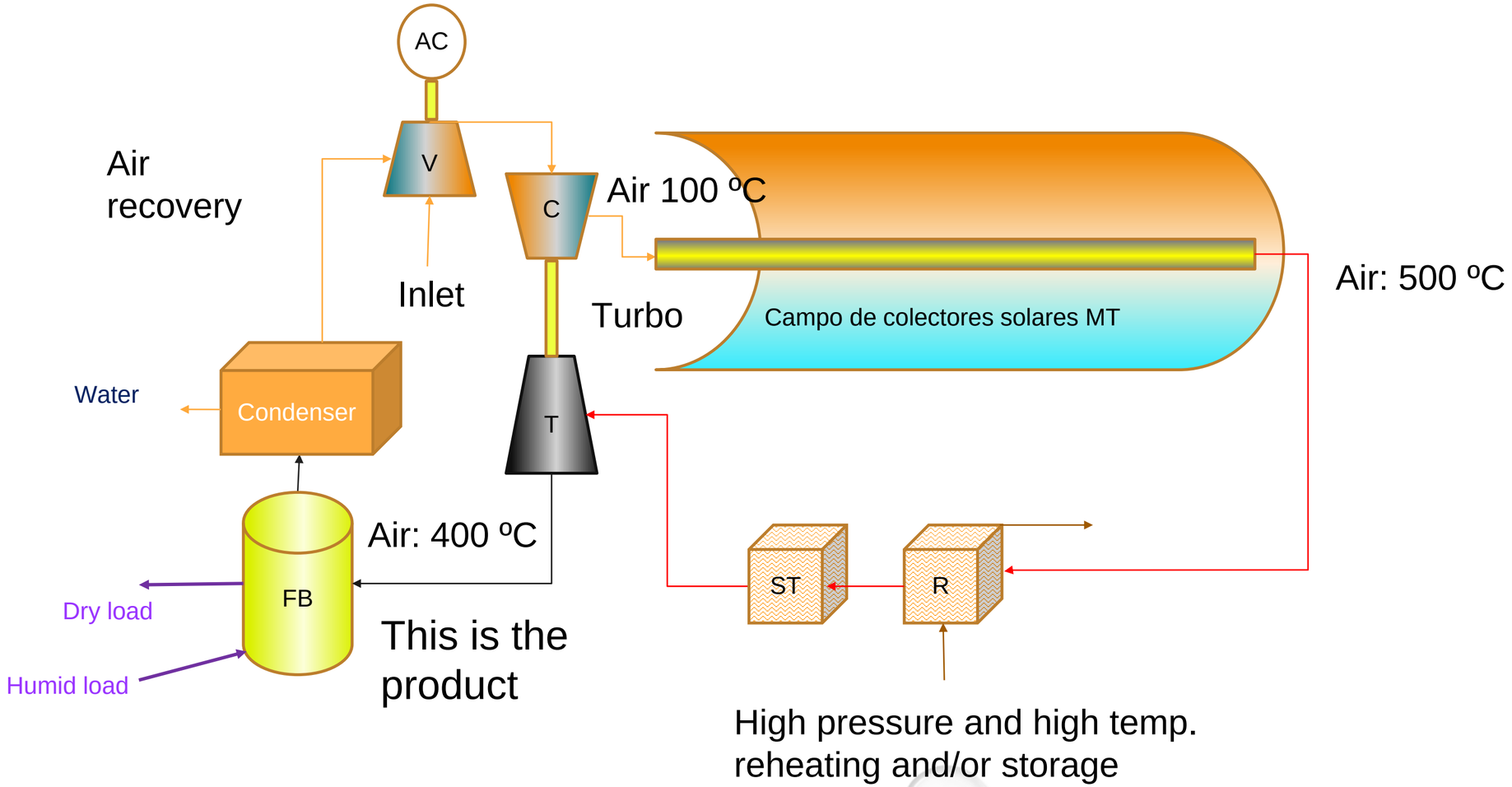
TurboSol project: Drying using **solar energy** and only **air** at medium temperatures. Applications:

- **Drying concentrated sea water**
- **Drying wastewater sludge**
- Drying alpeorujos and water from olives
- Curing painted pieces
- Drying minerals
- Ironing and drying clothes



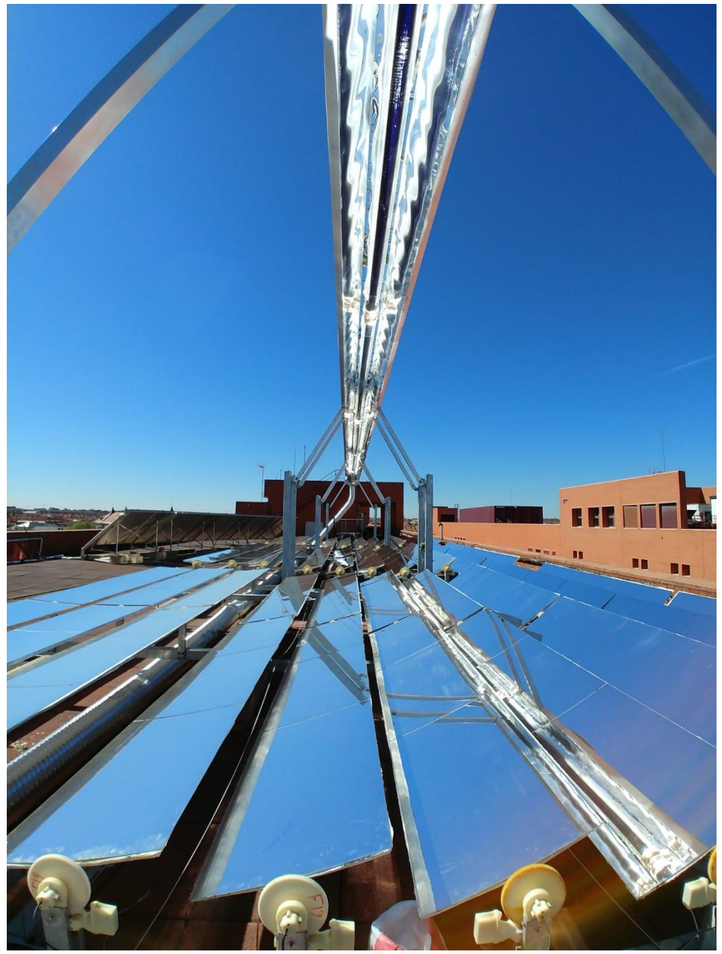
Concept: Air can be heated directly inside standard solar collector with pre-compressed to enhance heat transfer. A turbine recovers work: Brayton cycle with null work (patented)

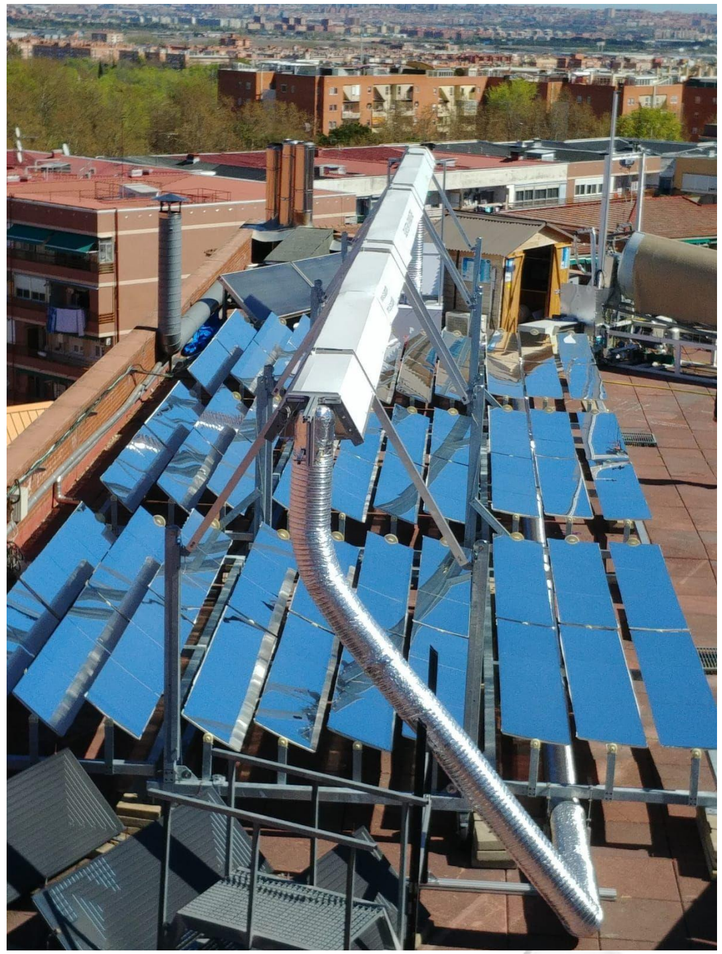
- No water
- No thermal oil
- No heat exchangers



The prototype at UC3M Campus in Madrid

The prototype at UC3M, under operation





- Funded by the local government and the EU Commission.
- Operative and being evaluated.
- Its use to dry water sludge is planned.
- This is similar to dry ocean water
- Now 450 ºC air has been achieved

Conclusions

- ✓ The marriage solar energy-water offers a great potential
- ✓ Water desalination is a storage option.
- ✓ Thermal and PV solar energy form a good complement.
- ✓ Solar thermal offers drying.
- ✓ This requires advanced laws and political decisions for many years in advance to arrive on time to the clean energy tsunami.

!Thank you, Gracias!

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