

II. Energy storage

- **1. Introduction**

- Energy storage allows for the adjustment of energy supply and demand over time.
- It mainly concerns the storage of electricity and heat.

- Storage is considered **high capacity** if it exceeds 10 MWh. In this case, we refer to it as mass energy storage.
- **2. Massive energy storage technologies**
- **2.1 Mechanical storage mode**

a/ Pumped storage power station (PSPS)(STEP)

- •This system, linked to hydraulic energy,
- •Electricity is used to pump water from a lower basin to an upper basin. Electricity is stored in the form of water reserves and reproduced as needed by allowing the water to flow down by gravity from the upper reservoir to the lower reservoir, passing through a turbine.

How does pumped storage hydropower work ?

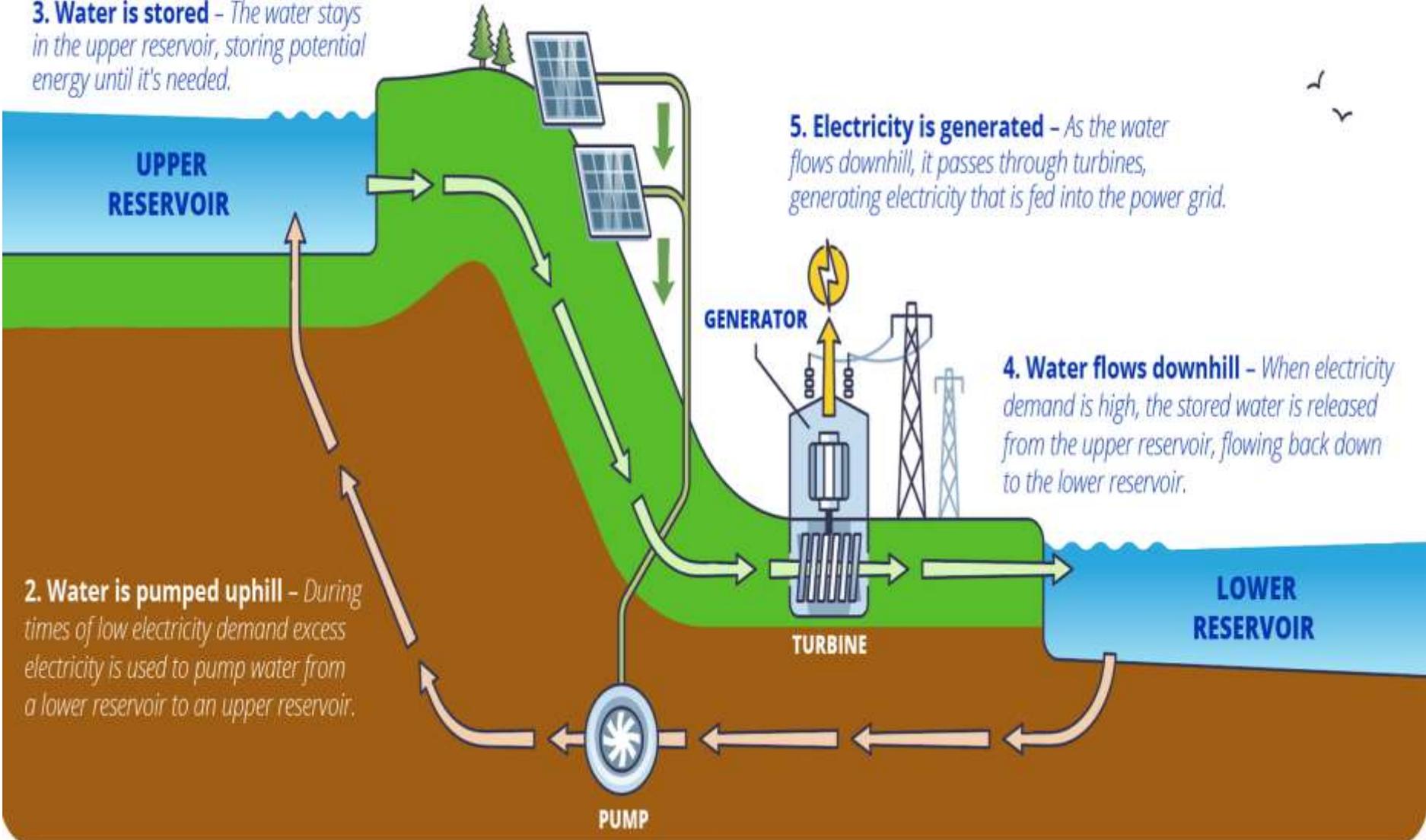
1. Renewable energy is stored - Excess energy generated through solar or wind power is used to power the pump

3. Water is stored - The water stays in the upper reservoir, storing potential energy until it's needed.

5. Electricity is generated - As the water flows downhill, it passes through turbines, generating electricity that is fed into the power grid.

4. Water flows downhill - When electricity demand is high, the stored water is released from the upper reservoir, flowing back down to the lower reservoir.

2. Water is pumped uphill - During times of low electricity demand excess electricity is used to pump water from a lower reservoir to an upper reservoir.

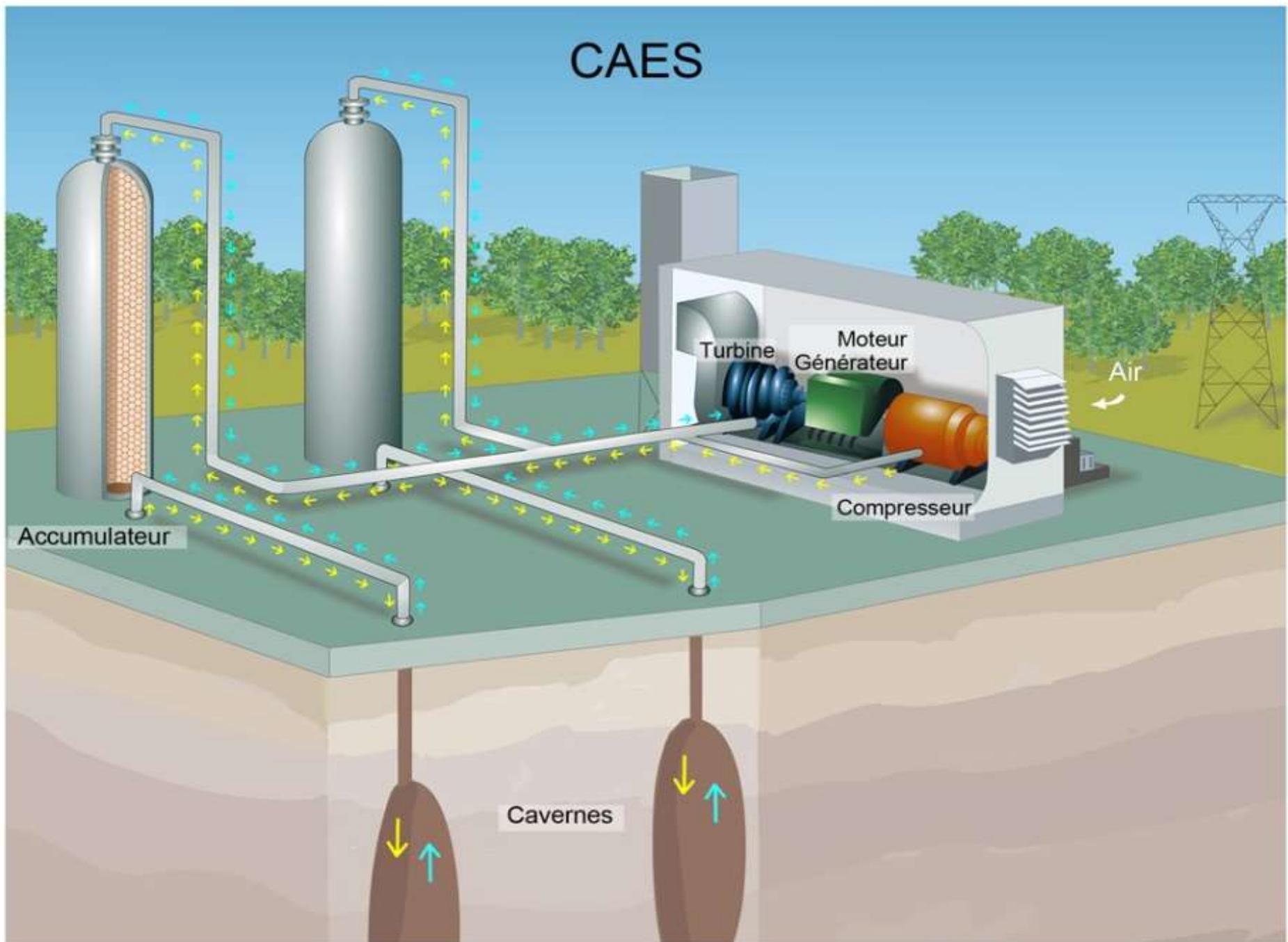


b/ Compressed Air Energy Storage (CAES)

Stockage par air comprimé classique

- Electricity powers a compressor that compresses air, which is then stored in underground caverns. The air then flows from the caverns to a turbine to generate electricity again.

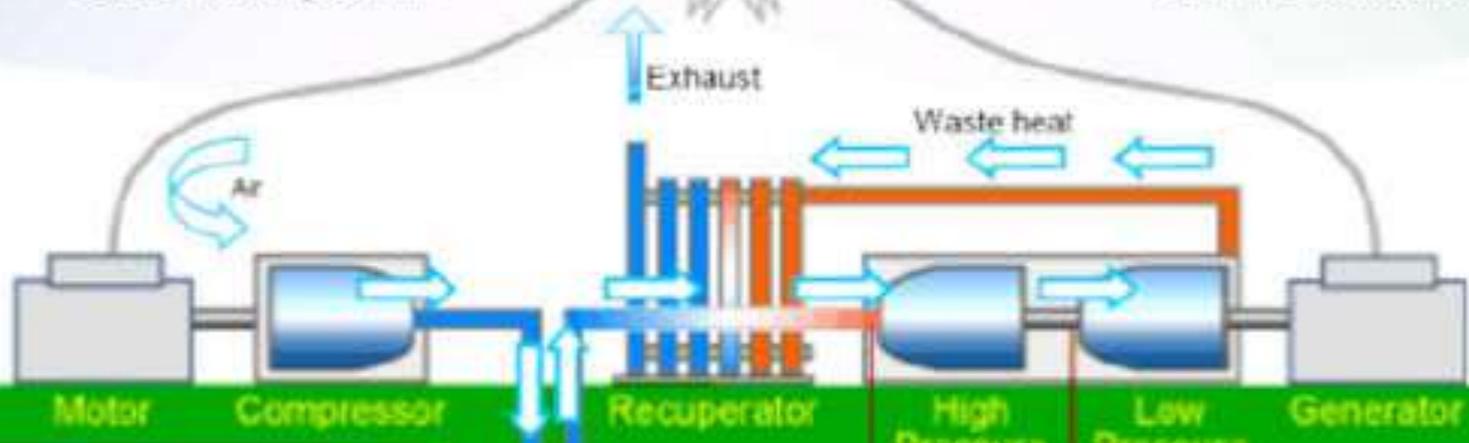
CAES





1. Excess or off-peak power is used to compress air

4. The electricity produced is delivered back onto the grid



2. Air is pumped underground and stored for later use

3. When electricity is needed, the stored air is used to run a gas-fired turbine-generator



Salt Dome

Cavern

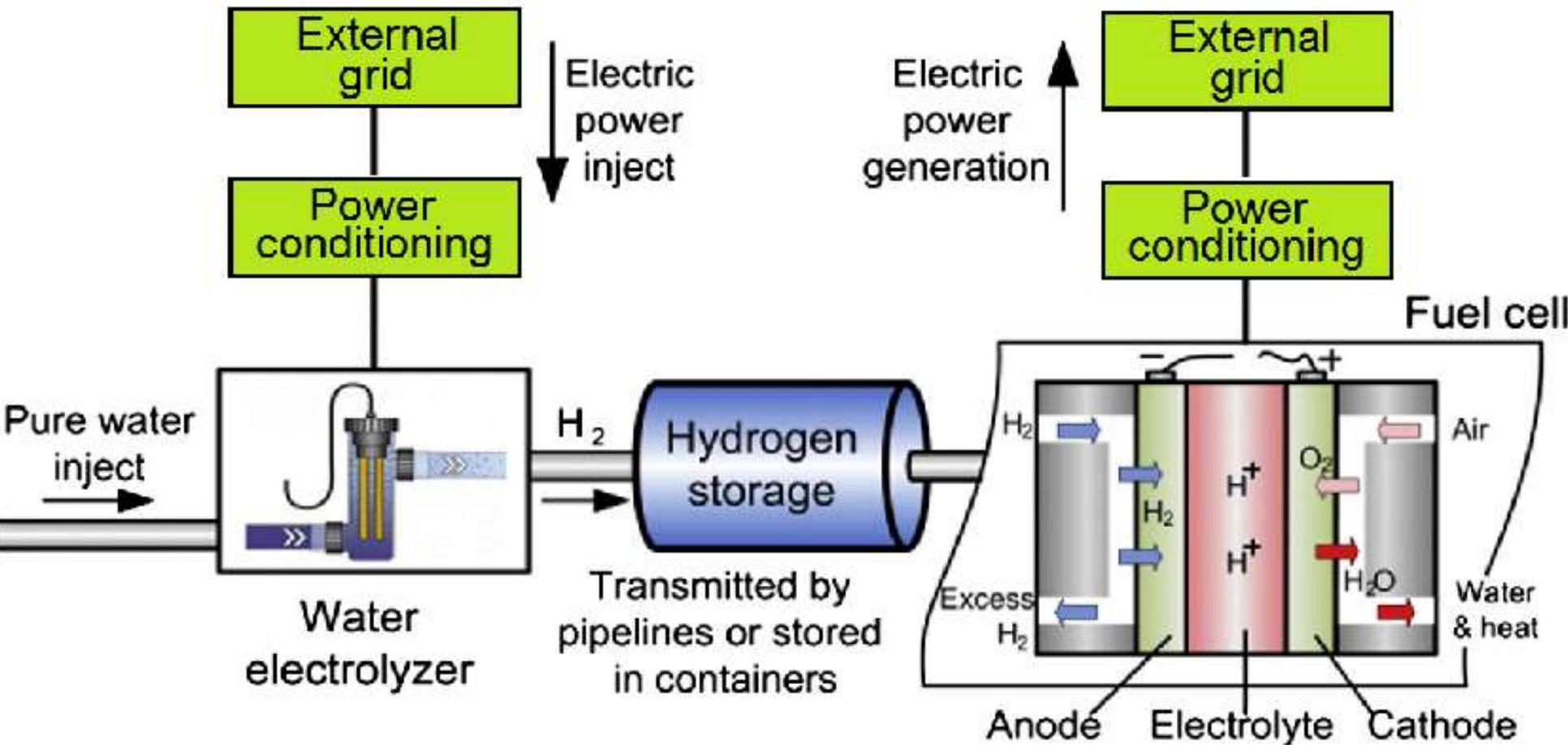
Fuel (Natural Gas)

2.2 Electrochemical and electrostatic storage mode

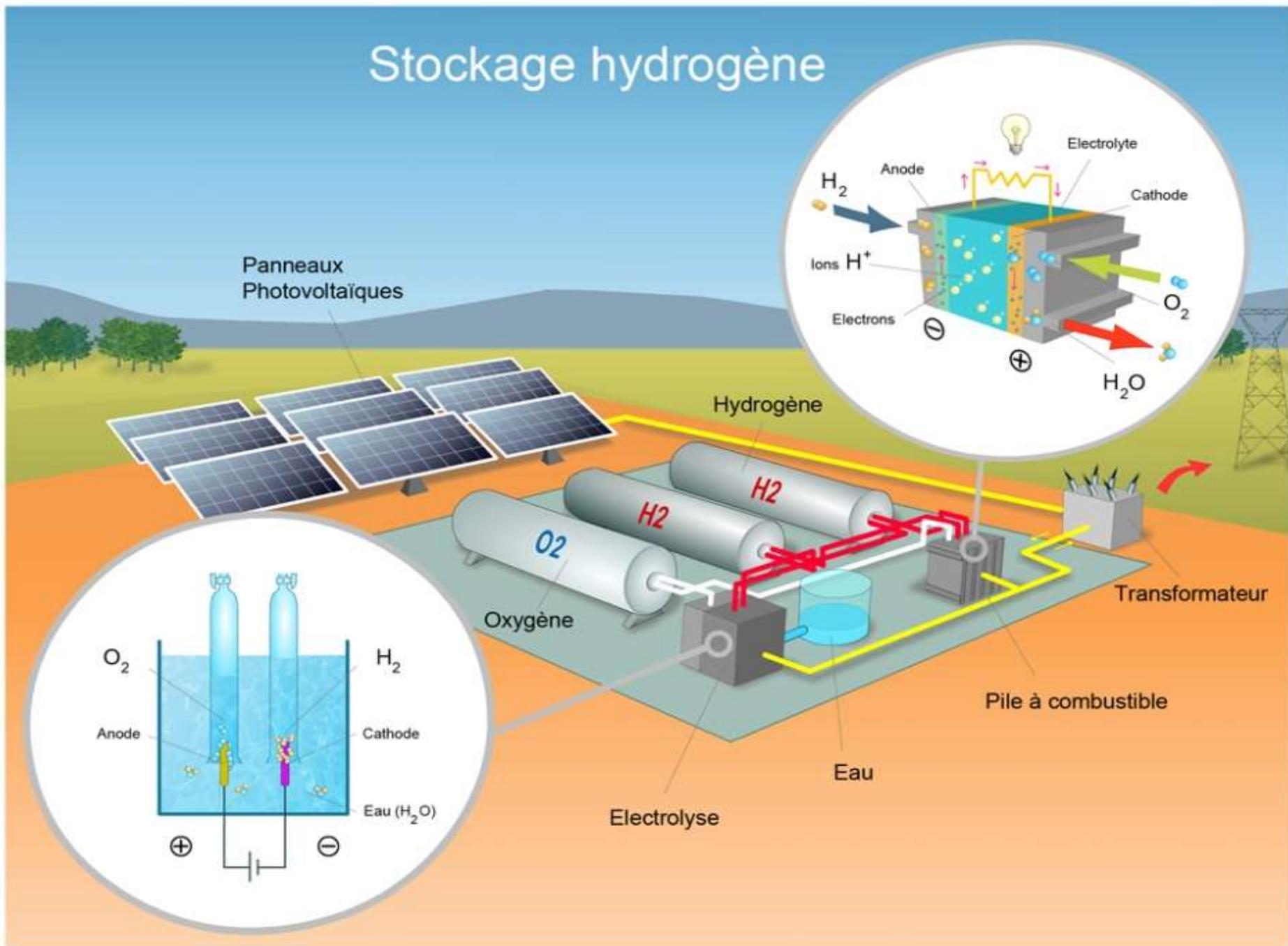
- This storage method, which is based on the **conversion of chemical energy into electrical energy**, mainly concerns batteries, cells, and accumulators.

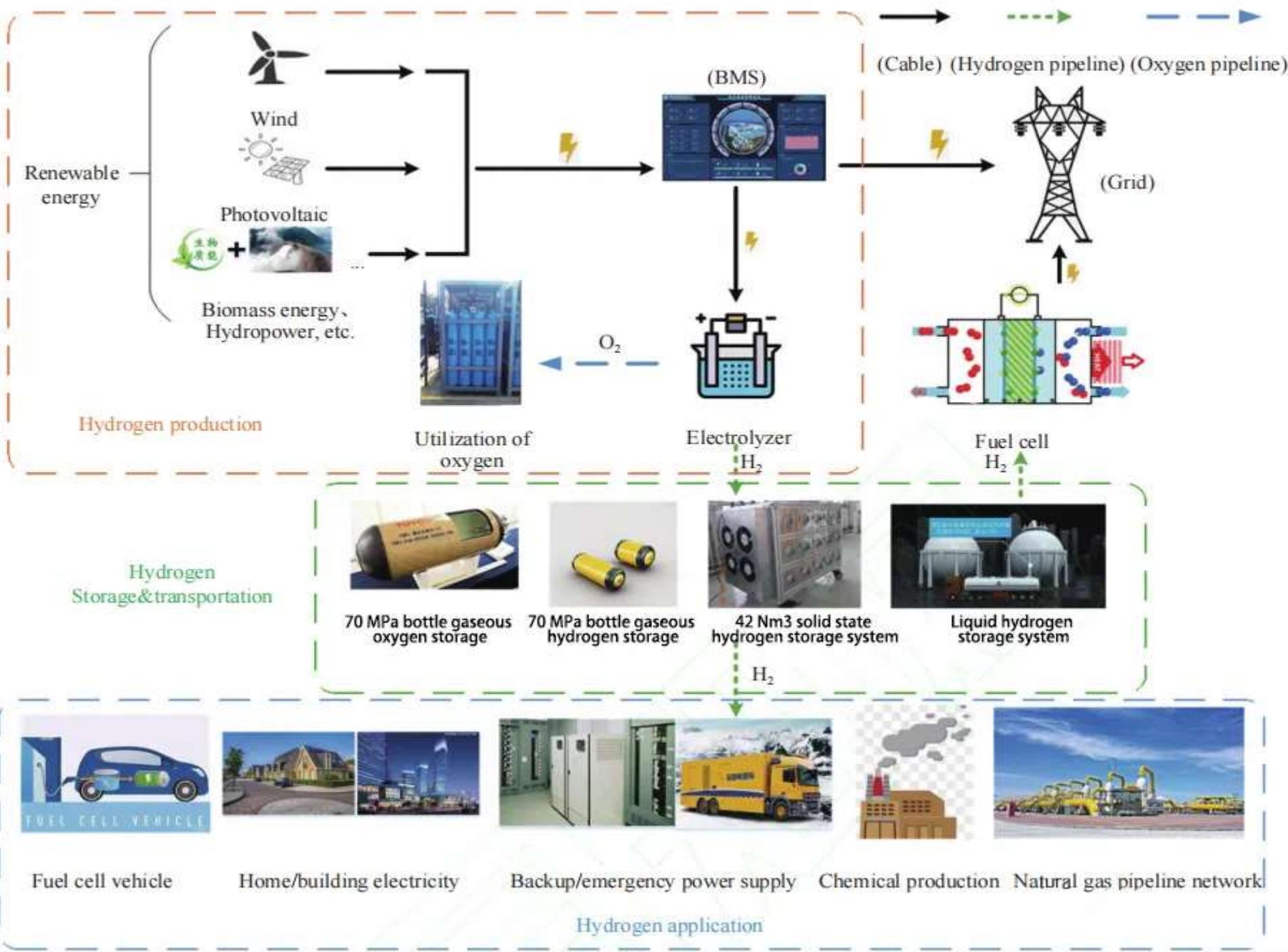
2.3 Chemical storage method: hydrogen

- Electricity will be used to produce hydrogen via an electrolyzer. The gas is then stored in liquid, solid, or gaseous form before being consumed in a fuel cell. When recombined with oxygen, it produces water and electricity.



Stockage hydrogène



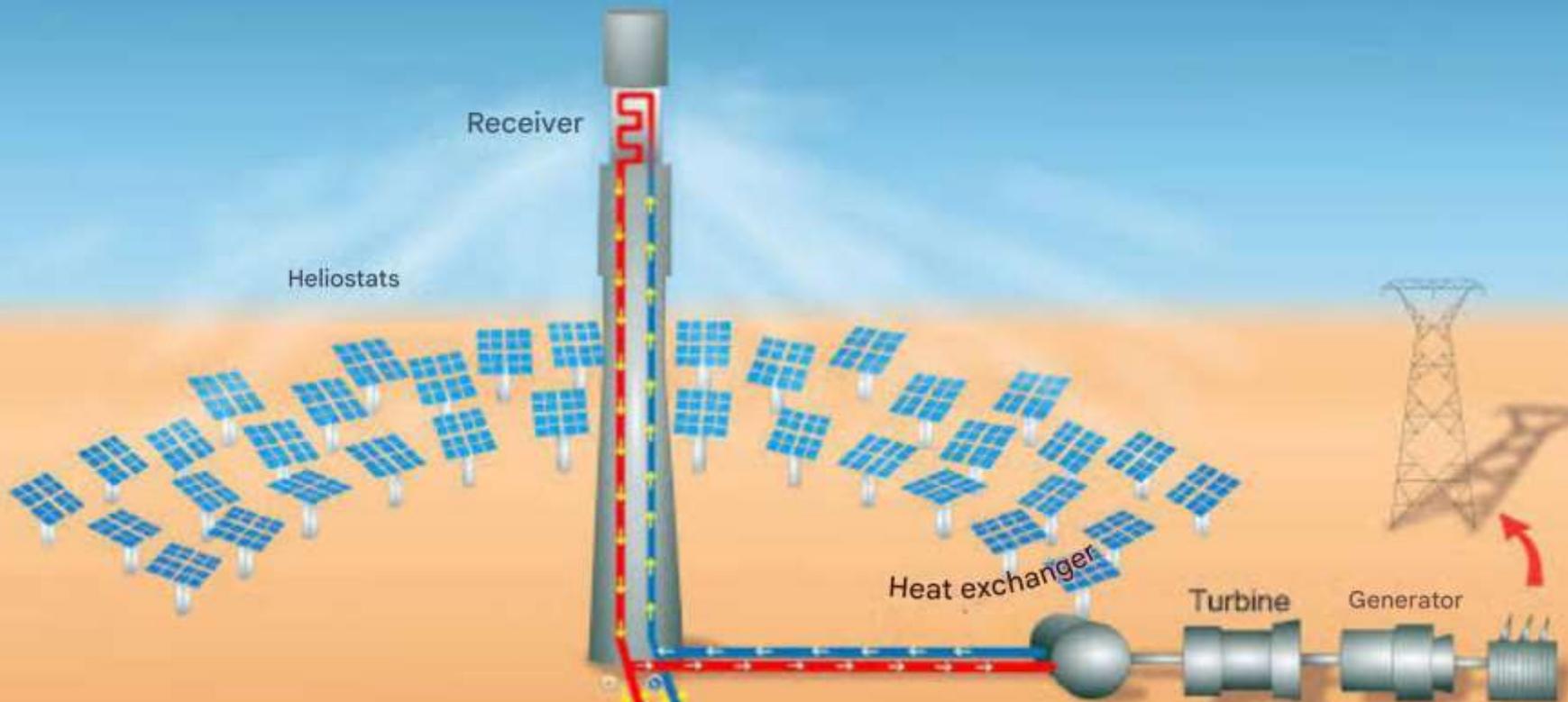


2.4 Thermal storage mode

- Heat sources primarily come from solar energy, for which storage would reduce the effects of its intermittency and the gap between the most productive periods (daytime/summer) and periods of peak demand (evening/winter).

a/ Sensitive heat storage

- That is, by changing the temperature of the material, heat is then stored in the material.
- Il consiste à chauffer un fluide caloporteur ou un solide. La chaleur est ensuite récupérée en chauffant un autre fluide.
- •It involves heating a heat transfer fluid or a solid. The heat is then recovered by heating another fluid.



At night:

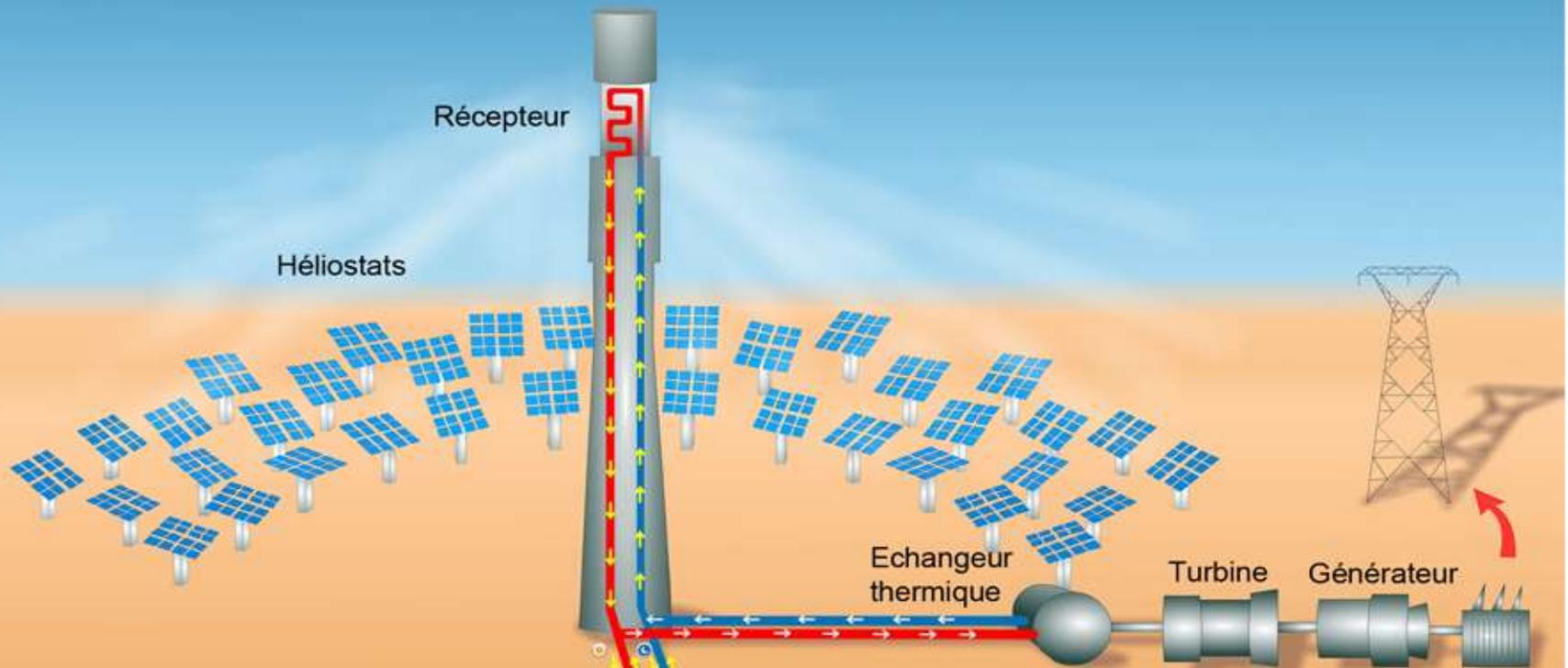
The hot salts stored during the day transfer their heat to the heat transfer fluid via the heat exchanger to produce electricity.



During the day:

The cold salts absorb heat from the heat transfer fluid via the heat exchanger and are stored in the hot salt tank

Stockage par chaleur sensible



La nuit :

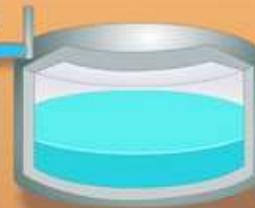
Les sels chauds stockés en journée cèdent leur chaleur au fluide caloporteur via l'échangeur pour produire de l'électricité.



Réservoir sels chauds



Echangeur thermique



Réservoir sels froids

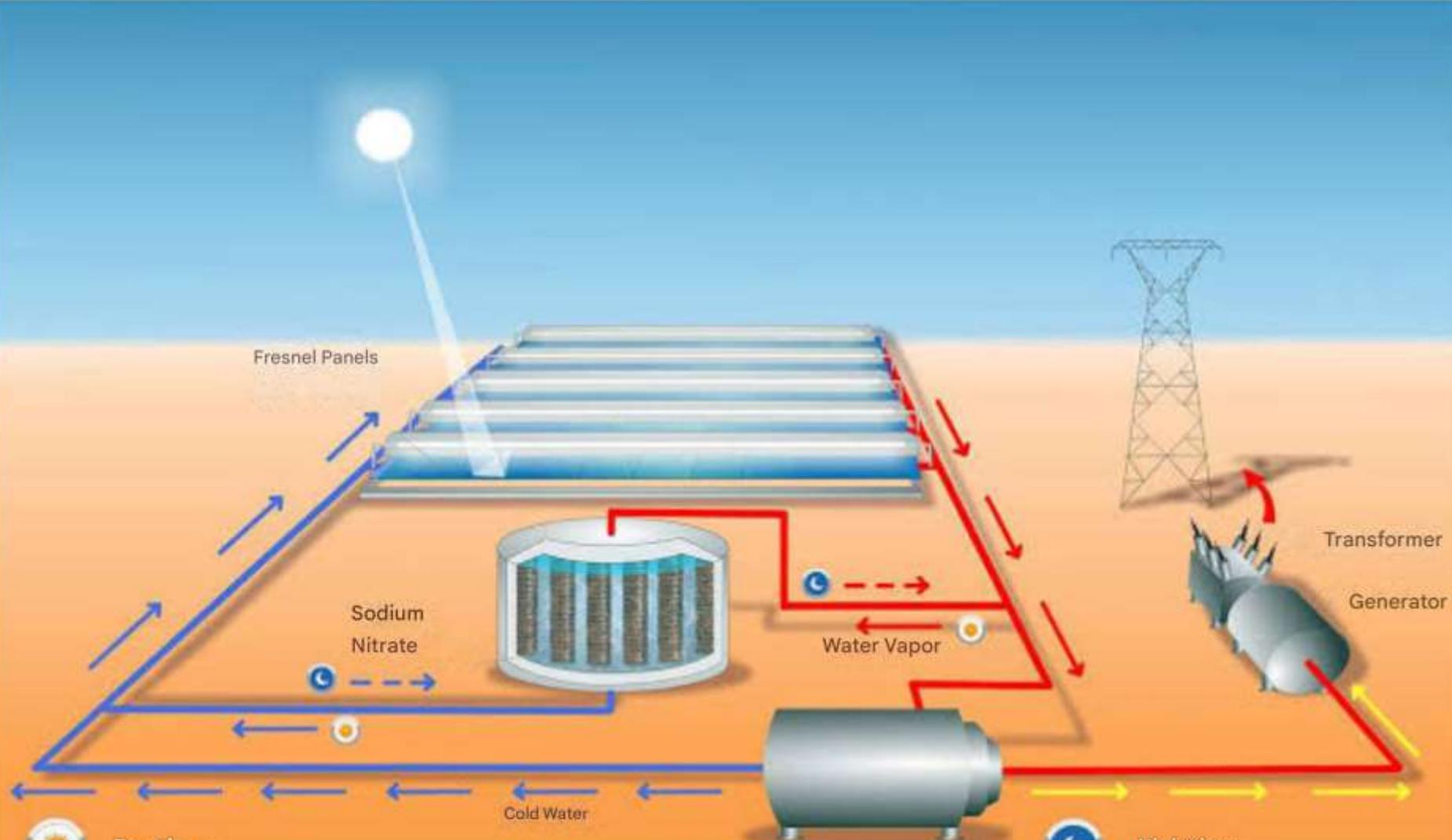


Le jour :

Les sels froids récupèrent la chaleur du fluide caloporteur via l'échangeur et sont stockés dans la cuve de sels chauds.

b/ Phase change heat storage

- Through the use of materials whose heat causes them to change from a solid to a liquid state. This is the case, for example, with paraffin, which has a melting point of around 70°C. It releases this heat when it returns to a solid state.



Daytime:

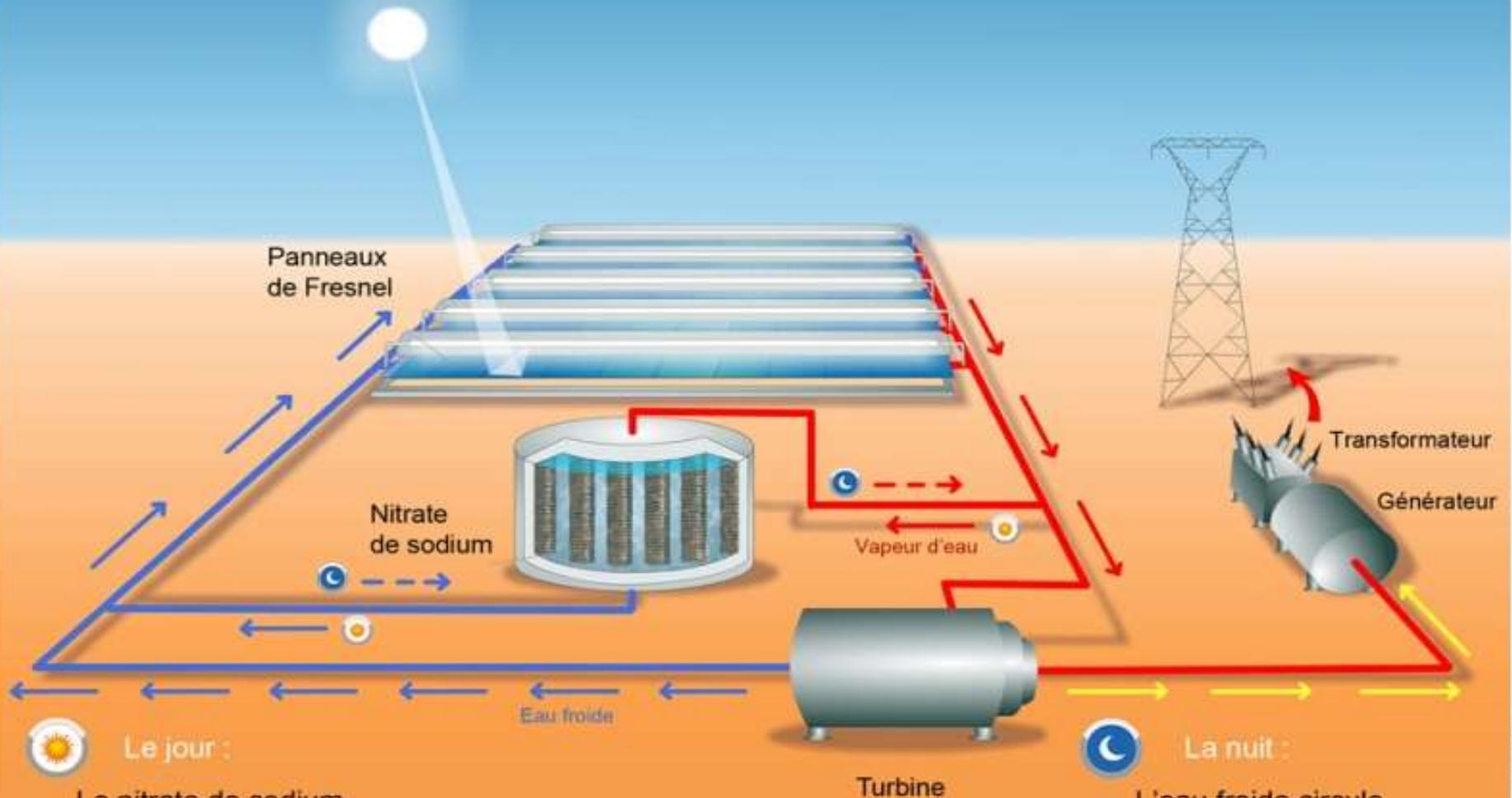
Sodium nitrate liquefies thanks to the heat released by the water vapor passing through the tank.



Nighttime:

Cold water circulates through the sodium nitrate tank and absorbs heat from the resolidifying material

Stockage par changement de phase



Le jour :
Le nitrate de sodium se liquéfie grâce à la chaleur cédée par la vapeur d'eau qui traverse la cuve.

La nuit :
L'eau froide circule à travers la cuve de nitrate de sodium et récupère la chaleur du matériau qui se resolidifie.

3. Importance of storage

- Storage is necessary to ensure that energy consumption and resources are balanced at all times and to provide consumers with a constant supply of energy.

- - Renewable energies have irregular and intermittent production. Energy storage is one of the solutions for increasing their deployment within an efficient and smart electricity grid.
- - Natural gas is generally stored in depleted gas or oil fields, aquifers, or salt cavities.