Solar driven heat pump for cooling and desalination

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Outline

Context

- the water issue and growing cooling demand

Presentation of the heat pump

- PV power supply
- HP for simultaneous needs
  - Cooling ▸ refrigerated cabinet or space cooling
  - Heating ▸ desalination

Vapour transfer (heat and mass)

- Equations and model validation

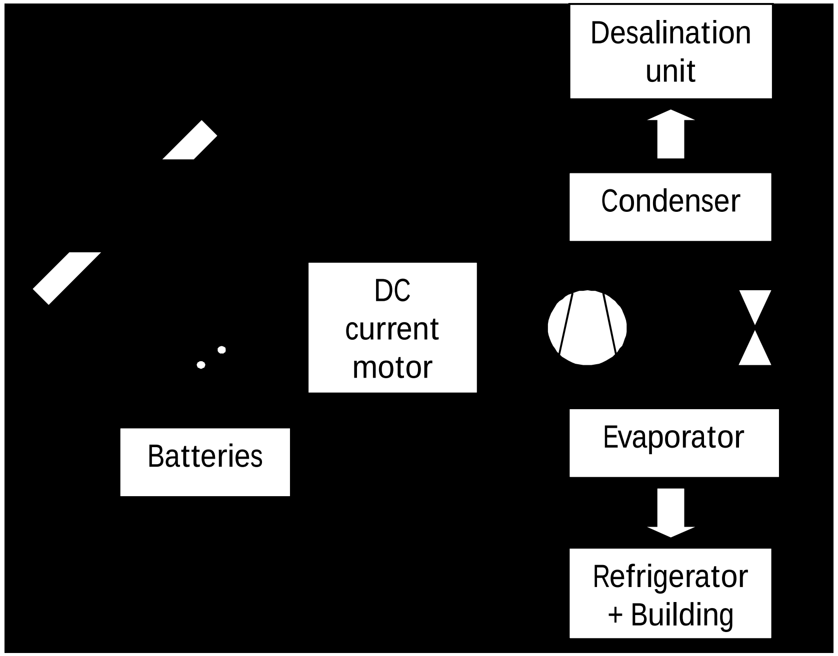
Simulation results

Conclusions et perspectives

Examples of applications

- **Cooling and drinkable water demand**
  - Refrigerated cabinets, space cooling
  - Desalination or brakish water treatment
  - food storage and isolated clinics, marine or buildings on coastlines
- **Membrane distillation**
  - Alklaibi and Lior, Desalination 2004
    - Minimal energy: $\Delta h_{vap\text{-}40\,°C}$ = 2406 kJ/kg (668,3 kWh_{th}/m^3)
    - Waste heat recovery: 1,25 kWh_{th}/m^3 (5000 l/j)
  - Citations by Charcosset, Desalination 2009
    - Using direct solar energy: 11 to 14 €/m^3 (100 à 500 l/j)
    - Waste heat recovery: 0.26 \$/m^3 against 0.45 \$/m^3 for RO

Heat pump for desalination



- Modelling and simulation TRNSYS and EES
  - Coupling and co-solving method (dt = 1 h)

Heat and Mass transfer

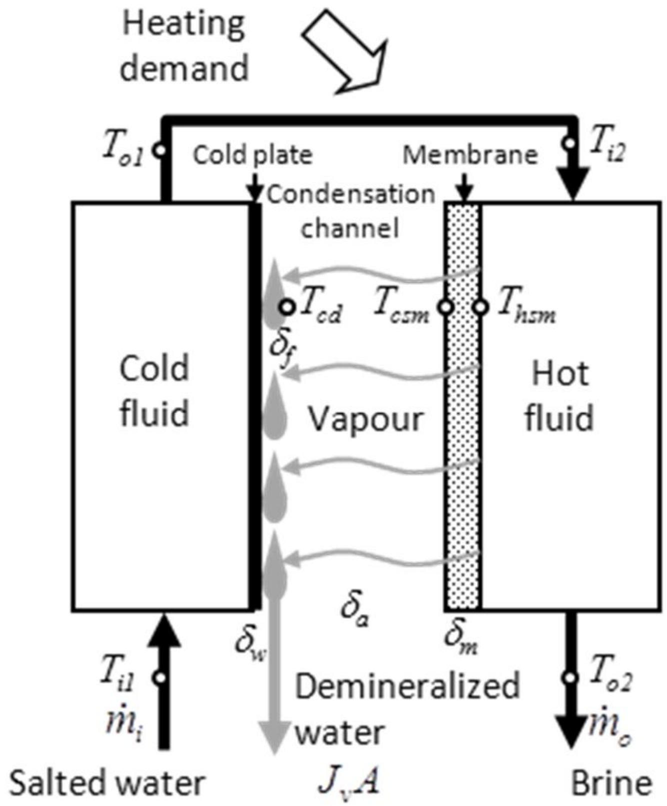
- **Mass balance**

$$\dot{m}_e = \dot{m}_s + J_v A$$

- **Vapour flux**

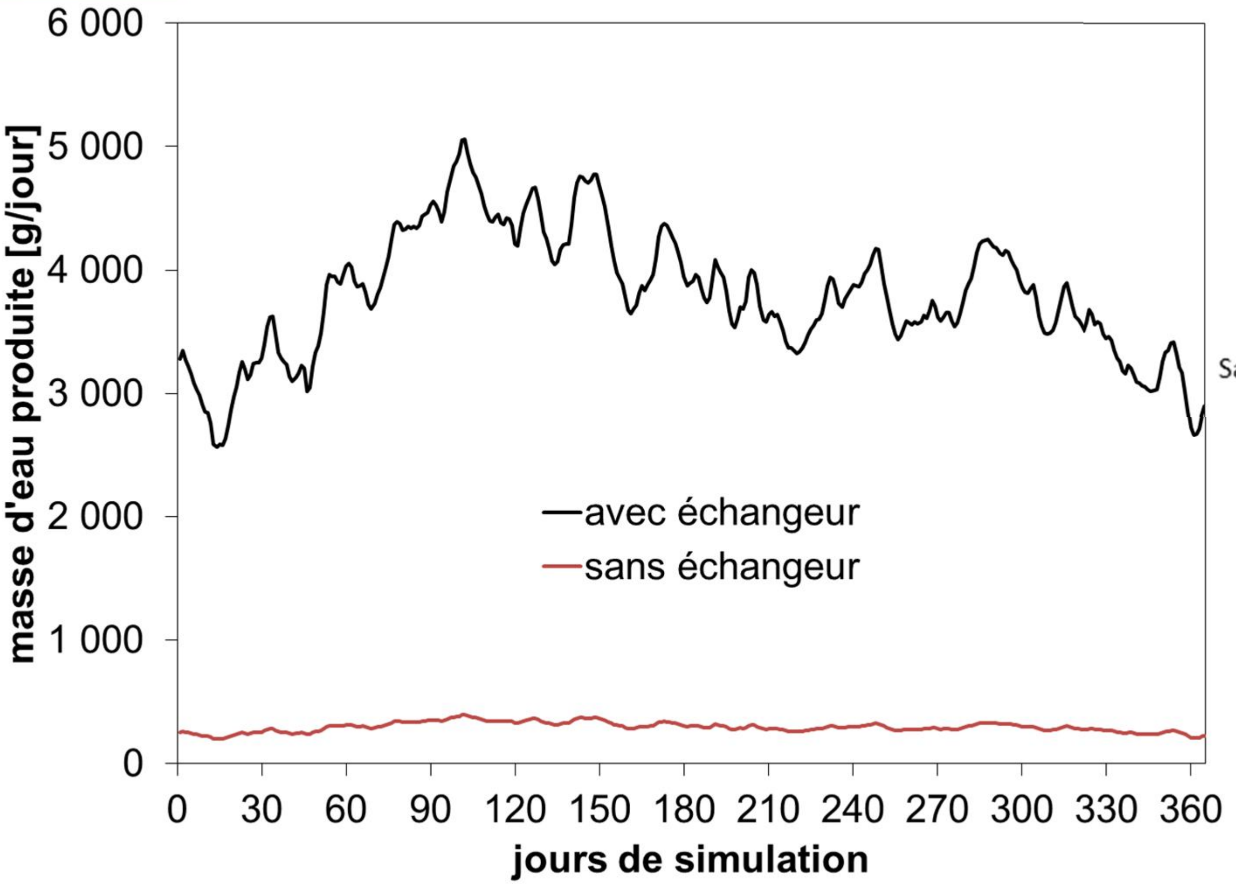
$$J_v = K\Delta p_v$$

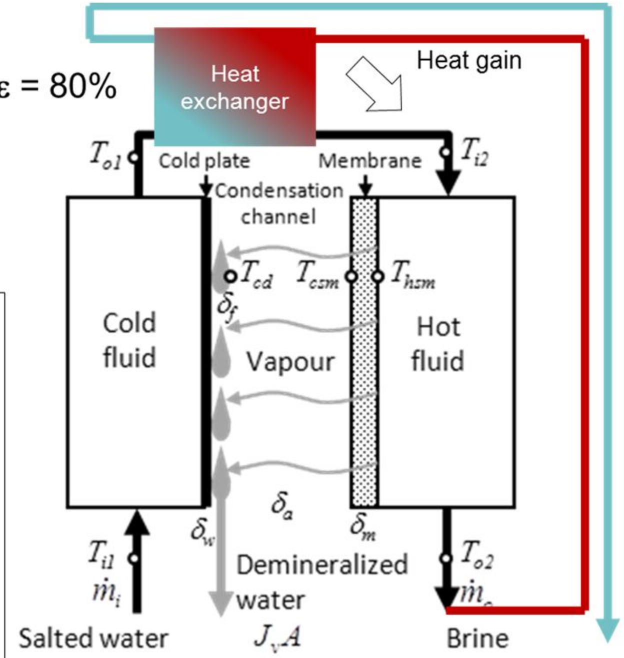
- **K, membrane permeance**
  - Molecular diffusion model



m_{water}, with heat exchanger

- **Validation**
- **Annual simulations**





1385 kg
574 kWh_{elec}
2336 kWh_{heat}
1687 kWh/m^3

Objective
668,3 kWh/m^3

First conclusions

- **Ratios m_{water}/C_{elec}, C_{elec}/m_{water}, C_{heat}/m_{water}**
- **First simulation results :**
  - Encouraging efficiency
  - PV : « free » electric energy
  - HP : « free » heating energy

Perspectives

- **Solar electric power supply, membranes, system**
  - Prototype and modelling
  - Definition of efficiency factors
- **Join the SHC programme (subtasks A, B and C)**
  - Desalination as a new application for solar heating