

# Leveraging Heat Pump Technology to Convert Heat to Power!

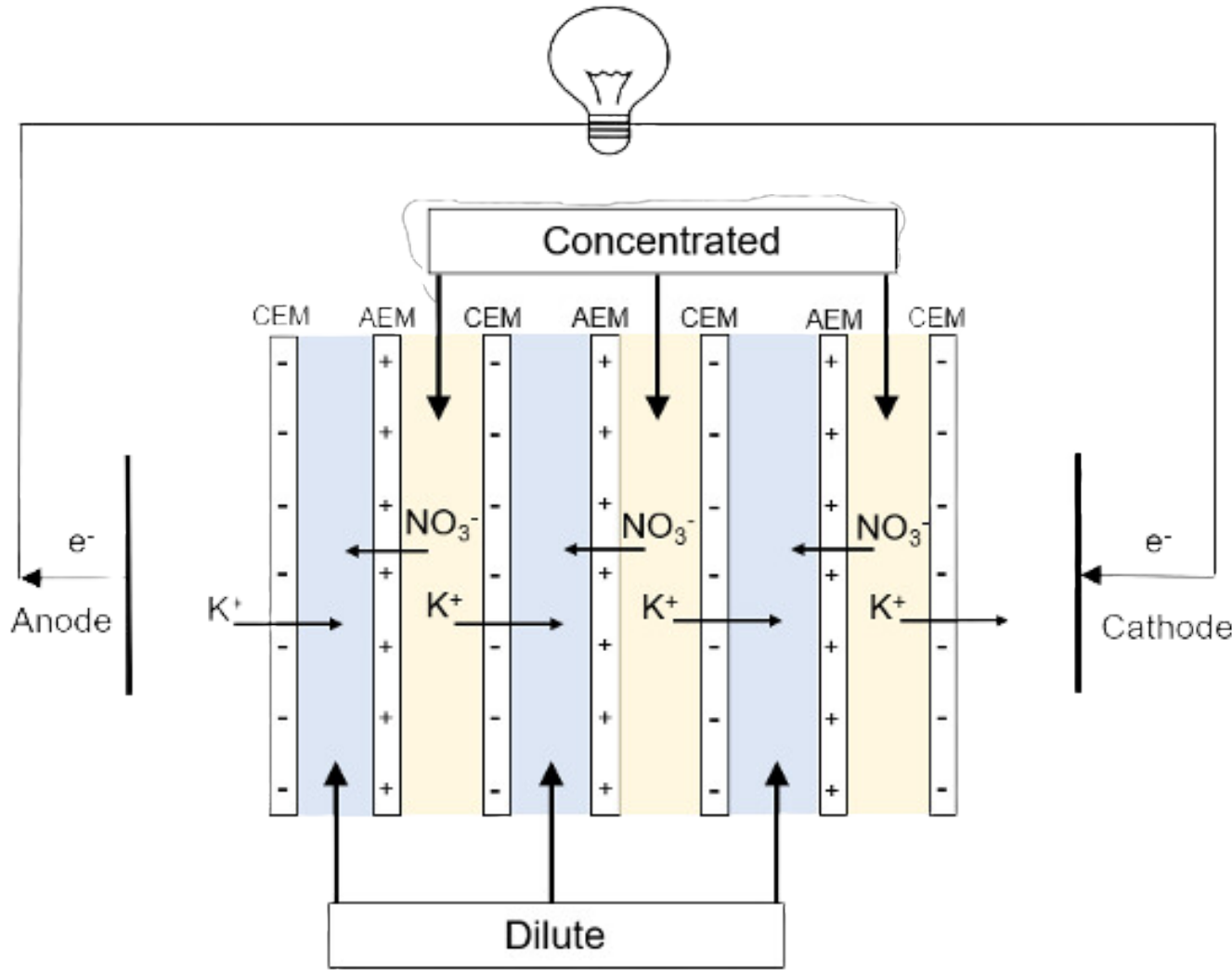


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## Reverse Electrodialysis

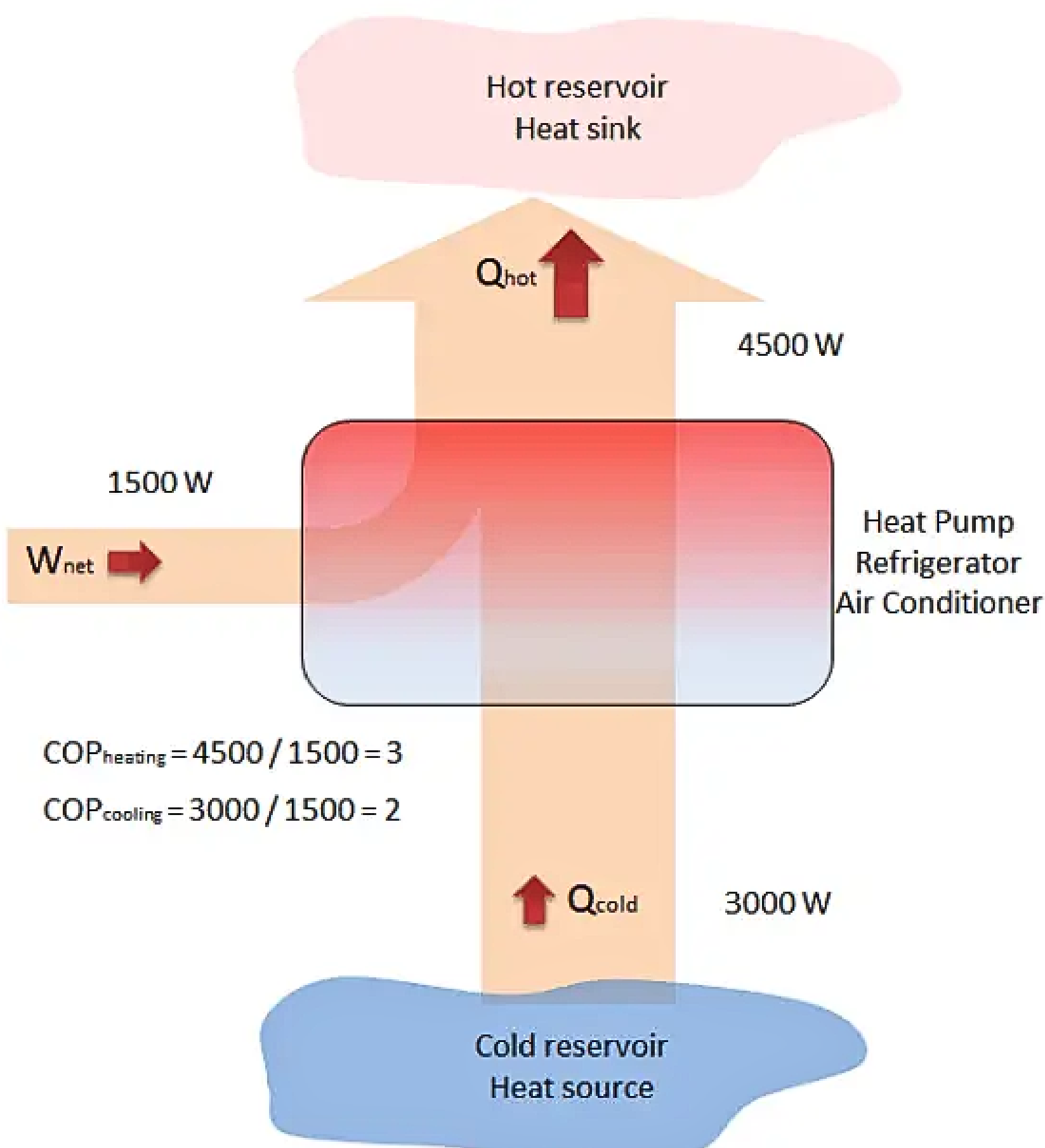


- Reverse electrodialysis (RED) technology provides a way to harness clean and sustainable energy from salinity gradients.
- When salt dissociates in water, two ions are formed (anions and cations) containing positive and negative charges.
- Anions migrate through the anion exchange membrane (AEM) toward the anode(s), and cations move through the cation exchange membrane (CEM) towards the cathode(s)
- As ions flow from the concentrated to dilute solution, ions from a separate recirculating rinse solution are pulled from one electrode to the other. This overall movement of ions creates a stack potential that can be harvested through an external load connected to both electrodes.

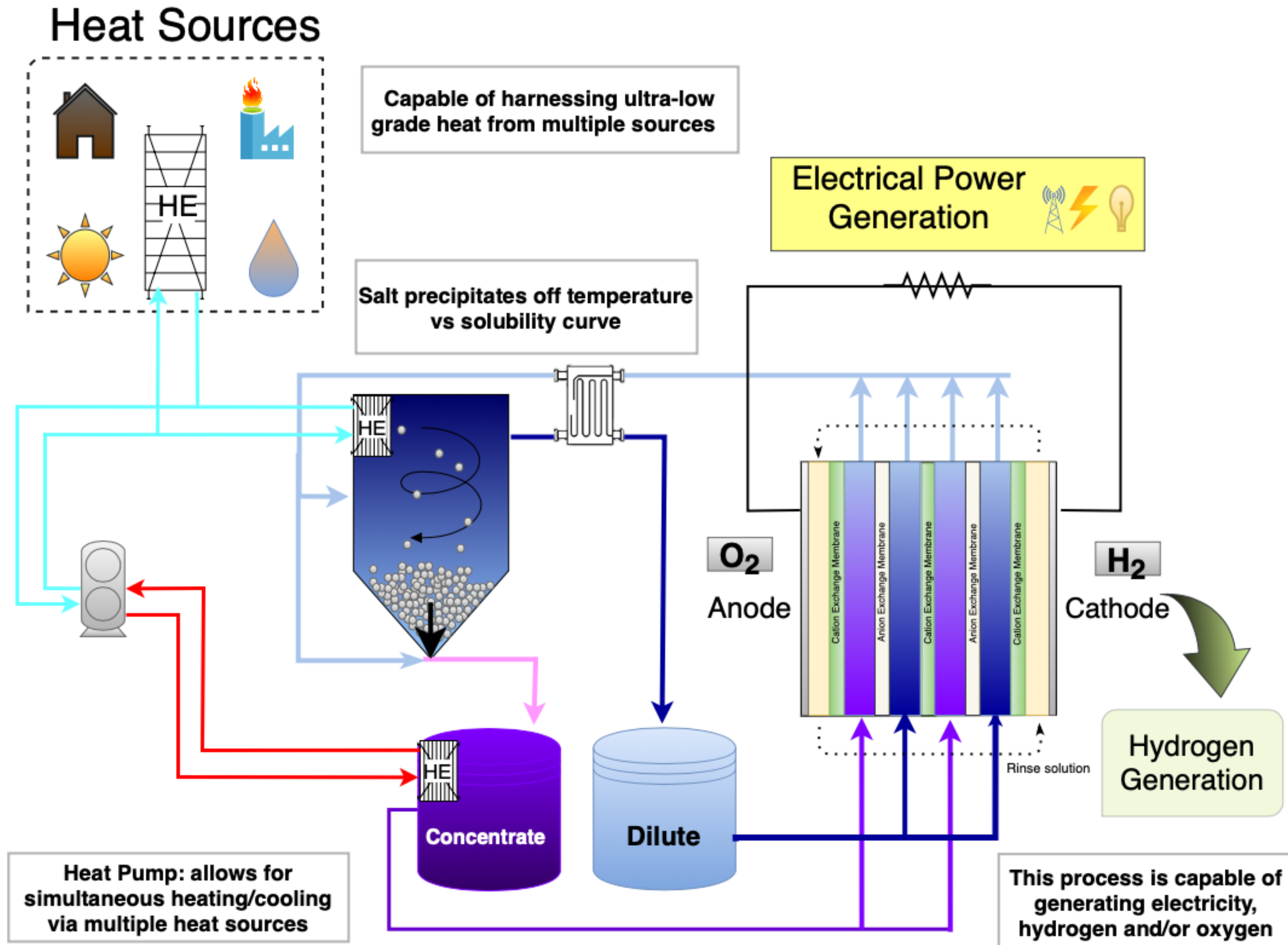
## Enhanced RED Heat Pump

- RED-HP is a closed loop process where Heat is the fuel! Cooling is a byproduct. RED-HP can cool a structure or process for free!
- The process is not limited to any one particular salt as it is a closed loop process that regenerates a synthetic man made salt gradient.
- RED-HP is capable of producing clean and sustainable electricity and/or hydrogen year round.

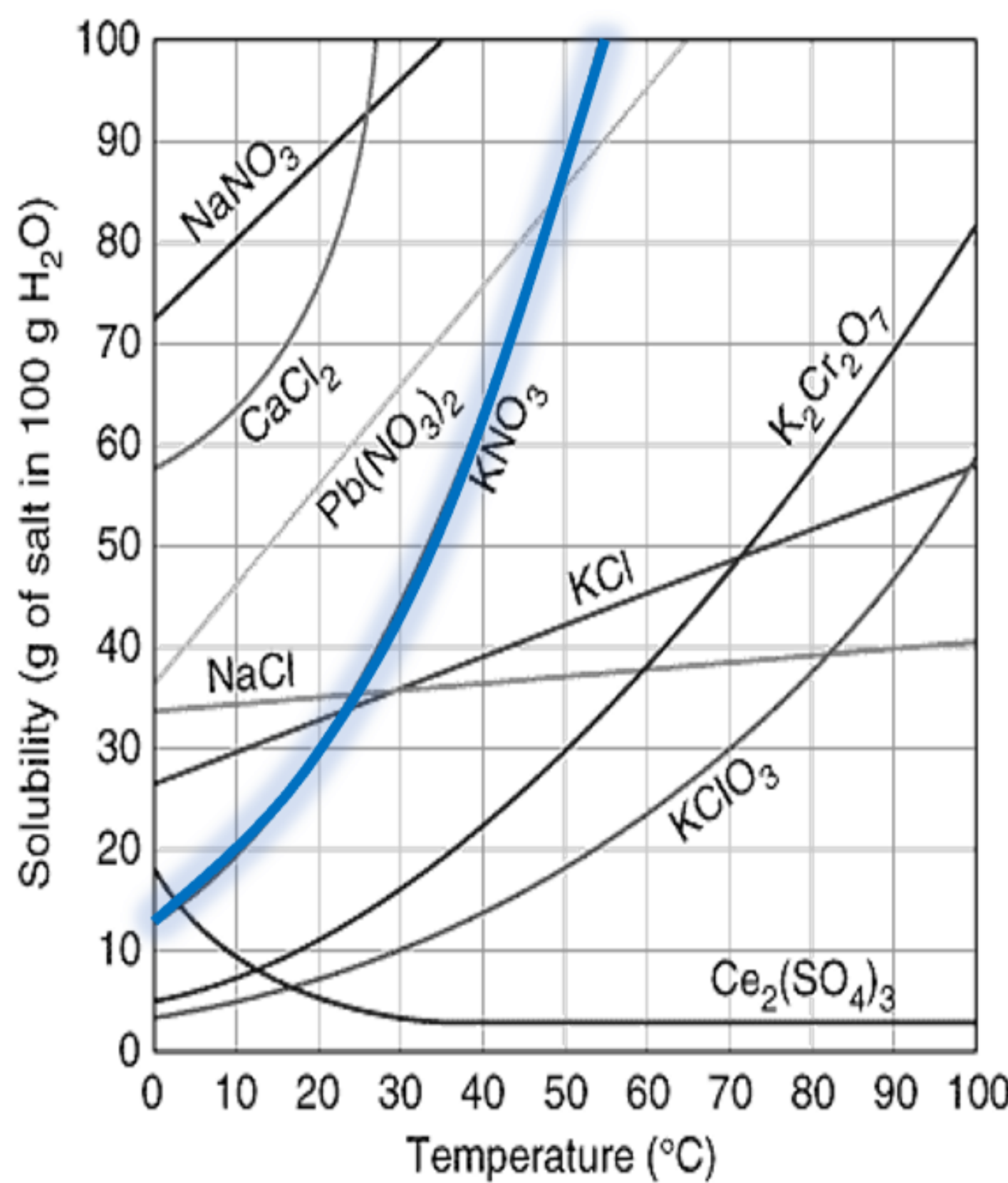
## Coefficient of Performance (COP)



## Closed Loop RED-HP



## Salt Solubility: Temperature Dependent



- The solubility of Potassium Nitrate (KNO<sub>3</sub>) is highly dependent on temperature.
- When heated, superconcentrated solutions of Potassium Nitrate solution can be formed.
- When chilled, Potassium Nitrate precipitates out of the solution as solid crystals.

## Technology Summary

- Economic feasibility
  - Dependent on the OEM price of the ion exchange membrane.
    - Current Price ~ \$20m<sup>2</sup>
      - <\$10m<sup>2</sup> (LCOE \$0.10/KWh)
      - <\$5m<sup>2</sup> (LCOE \$0.05/KWh)
  - Heat Pump COP
    - COP > 3.8 increases Net Power Production Beyond 100%.



RED Cell Stack

## Technology Applications

- |   |   |
|---|---|
| <ul style="list-style-type: none"> <li>Data Centers</li> <li>Industrial Heat Recovery Processes</li> <li>Residential/Commercial HVAC</li> </ul> | <ul style="list-style-type: none"> <li>Transportation (Cold Storage)</li> <li>Off-Grid Applications</li> <li>Solar Thermal</li> <li>Cruise Ships</li> </ul> |
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