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A Sensitivity study of Thermo-electric energy storage system based on TES

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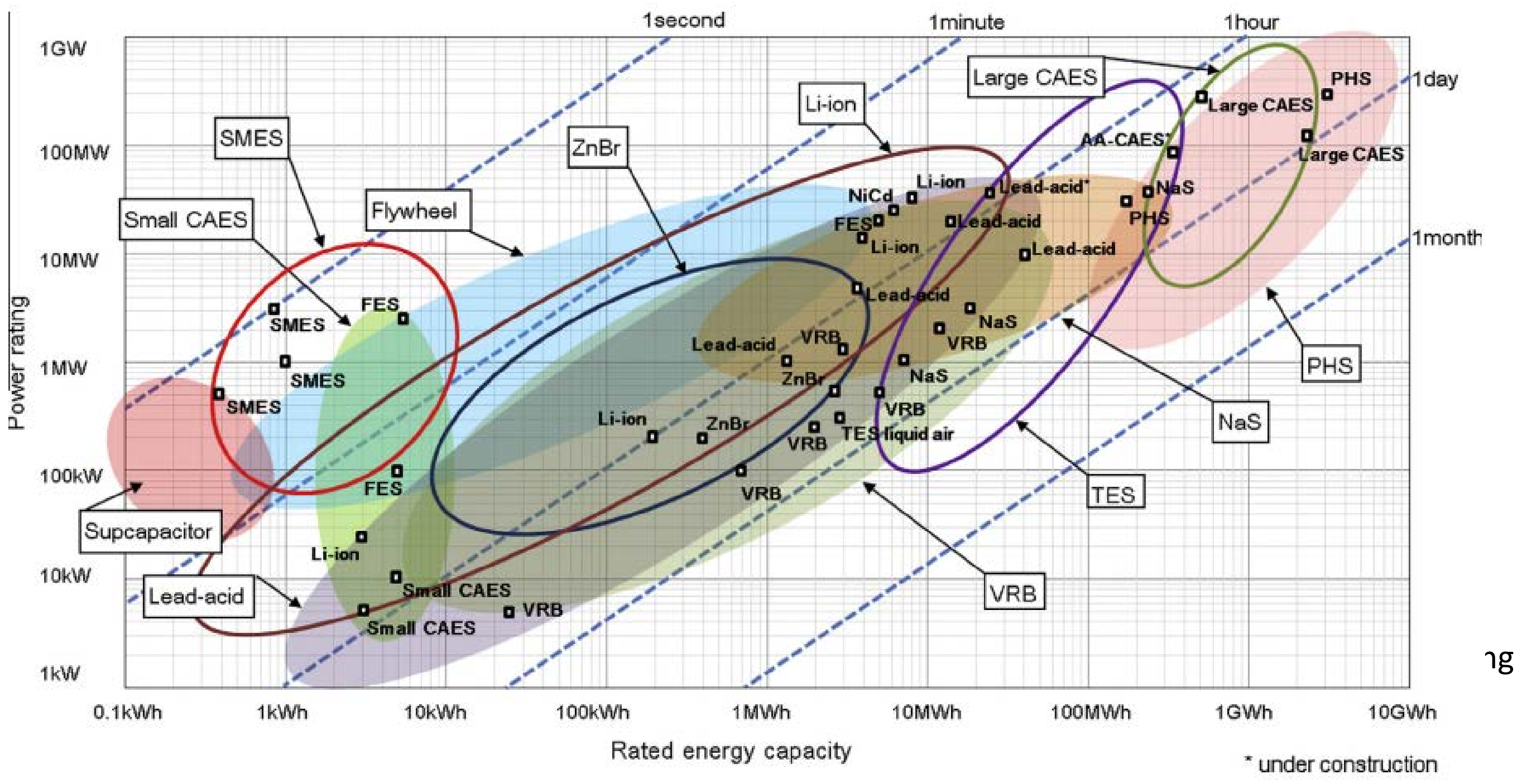
Introduction

● The national greenhouse gas reduction target of 37% compared to business as usual (BAU) by 2030 encourages new energy technologies to emerge.

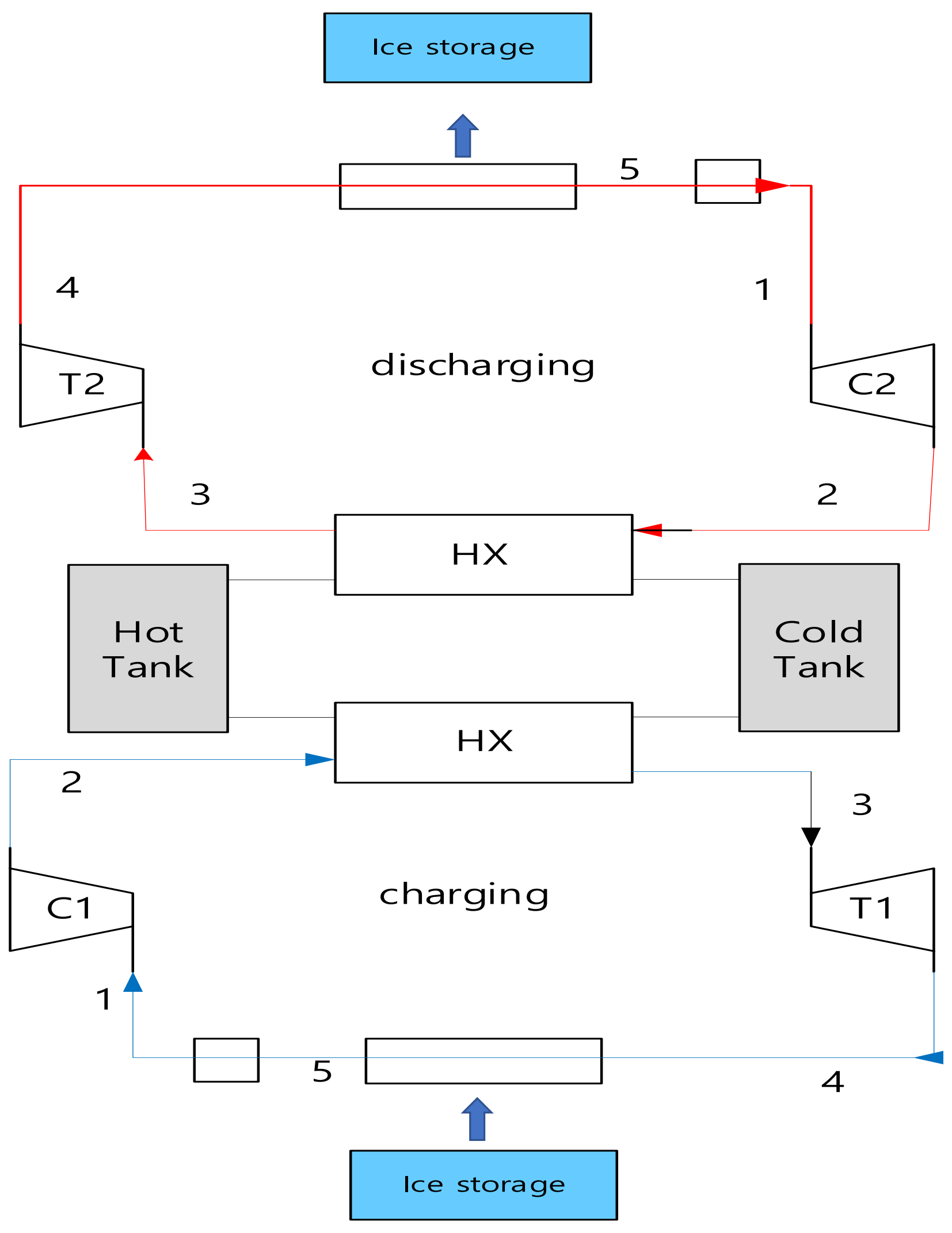
● The penetration of renewable energy will increase, and its intermittency has to be countered with the energy storage system.

● Electricity can be stored as heat and that it has a high-power density increases the possibility of early commercialization.



Thermodynamic modeling

● Layout of TEES



● Assumption

- There is no pressure drop in the pipelines.
- Turbines and compressor have constant isentropic efficiencies, respectively.
- There are no changes in potential and kinetic energies.
- Same pressure drop 1% in all heat exchanger
- The total volume of ice storages is equal to half the volume of hot tank and cold tank.

● Heat exchanger

the effectiveness, ε is defined, $\varepsilon = \frac{Q}{Q_{max}}$

In counterflow heat exchanger, $Q_{max} = C_{p,min}(T_{hot,inlet} - T_{cold,inlet})$

the enthalpy of heat exchanger, $h_{HX,out} = h_{HX,in} - eff_{HX} \cdot Q_{max}/\dot{m_{co_2}}$

Result

● System parameters

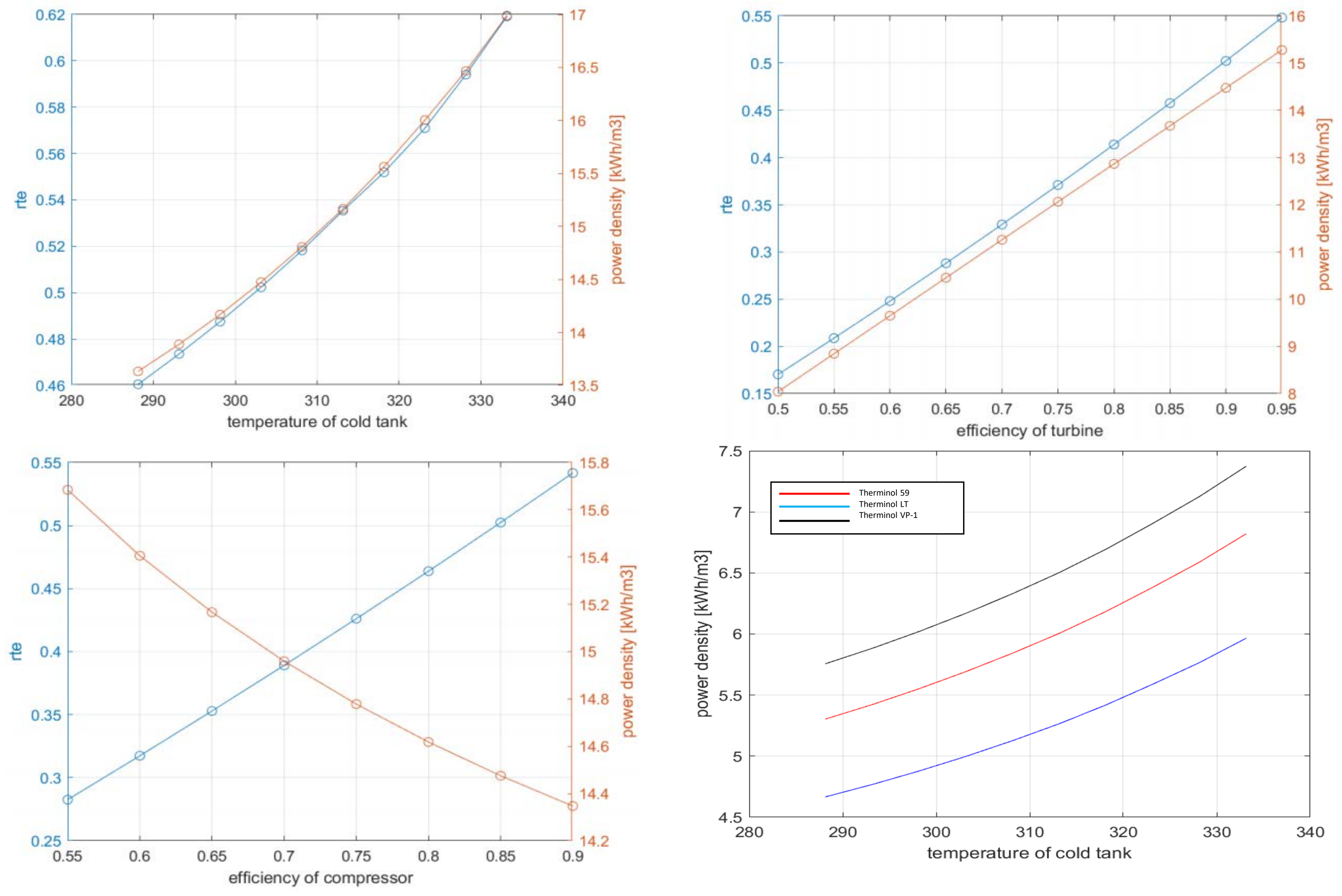
parameters	value	Unit
Effectiveness of HX	0.95	%
Maximum of pressure	16	Mpa
Minimum of pressure	3.7	Mpa
Isentropic efficiency of turbine	0.9	%
Isentropic efficiency of compressor	0.85	%
Pressure drop in HX	1	%
Mass flow rate ratio (co_2:tank fluid)	1:2	

Variable	value	unit
Temperature of cold tank	303	K
Isentropic efficiency of turbine	0.9	%
Isentropic efficiency of compressor	0.85	%

● Definition of RTE and power density

$$\text{RTE} = \frac{W_{discharging}}{W_{charging}} = \frac{W_{T2} - W_{c2}}{W_{c1} - W_{T1}}$$

$$\text{Power density} = \frac{W_{turbine1} + W_{turbine2}}{V_{hot\ tank} + V_{cold\ tank} + V_{ice\ storage}}$$



· The higher temperature of cold tank is, the higher the RTE and power density.

· The higher efficiency of compressor is, the higher the RTE but lower the power density will be.

· And according to type of the tank fluid, the power density are different as the graph.

Summary and Future works

· The temperature of the cold tank and the efficiencies of turbine and compressor are increased to understand how component efficiency determines the efficiency of TEES.

· The optimal temperature between heat exchanger and ice storage will be obtained to find a more suitable working fluid.