

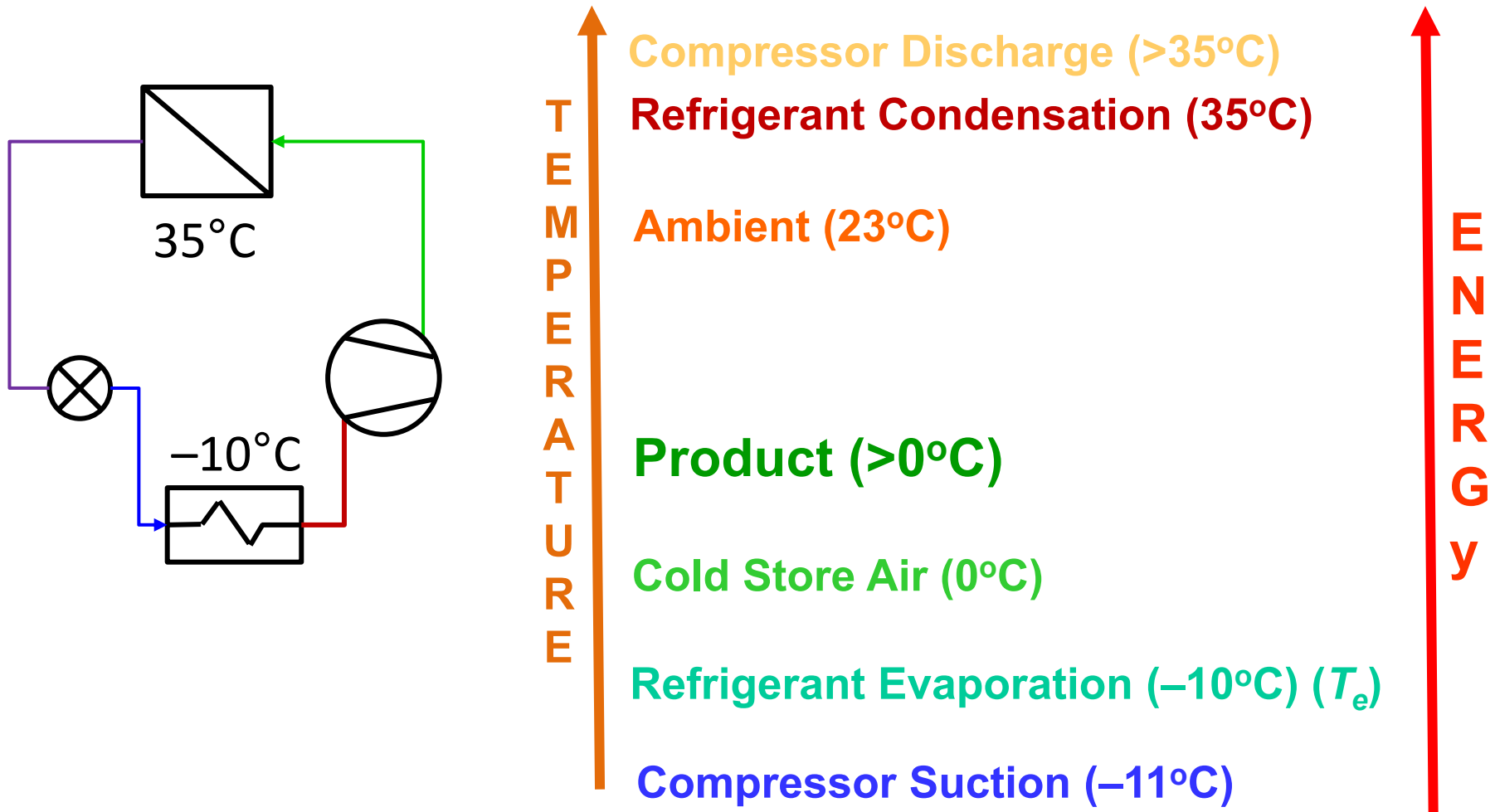
Condensing Temperature Trade-offs in Heat Recovery from Refrigeration

Richard Love & Don Cleland

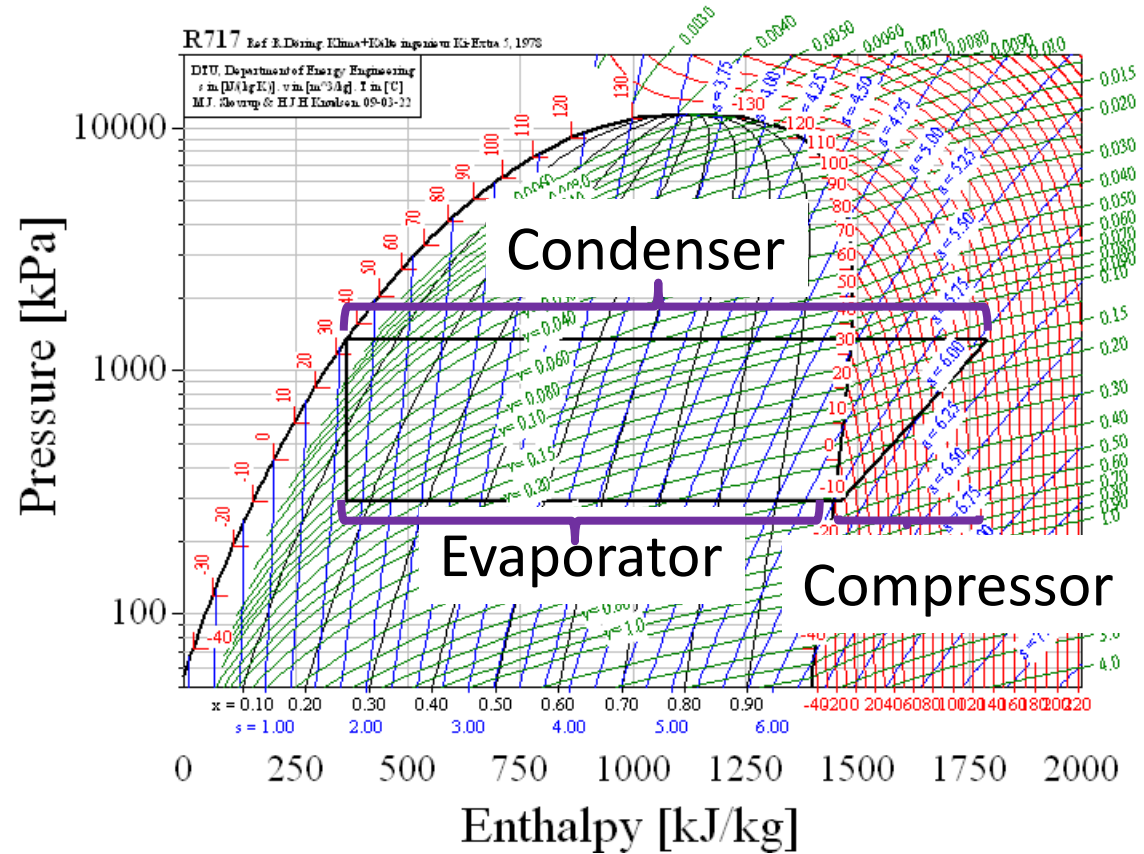
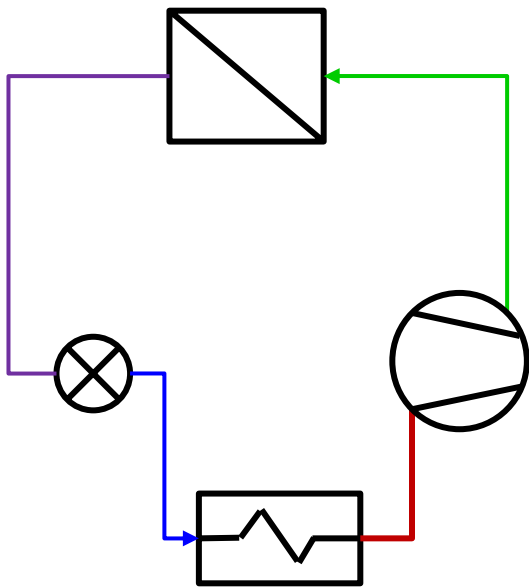
SCHOOL OF FOOD AND ADVANCED TECHNOLOGY

(r.j.love@massey.ac.nz)

Basic Refrigeration System

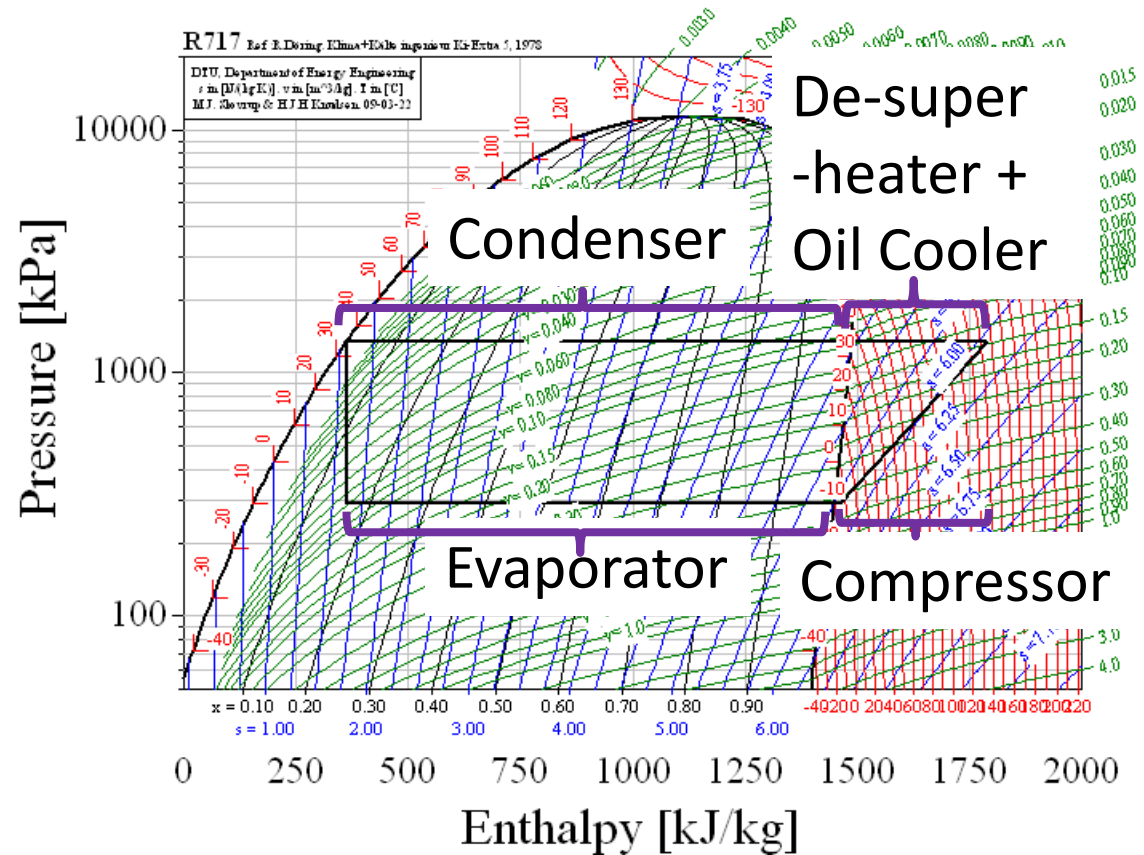
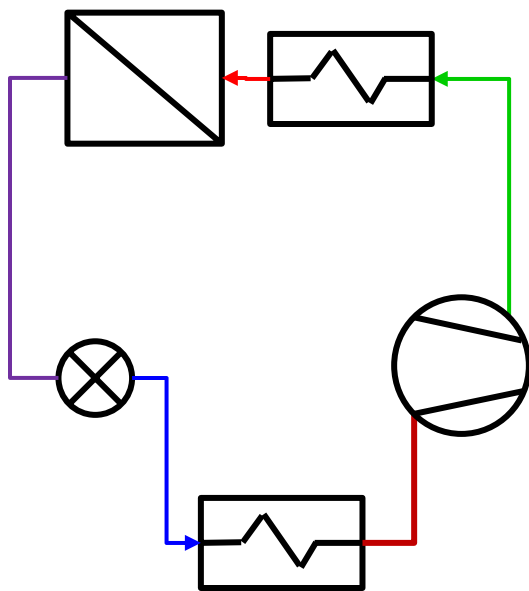


Basic Refrigeration System



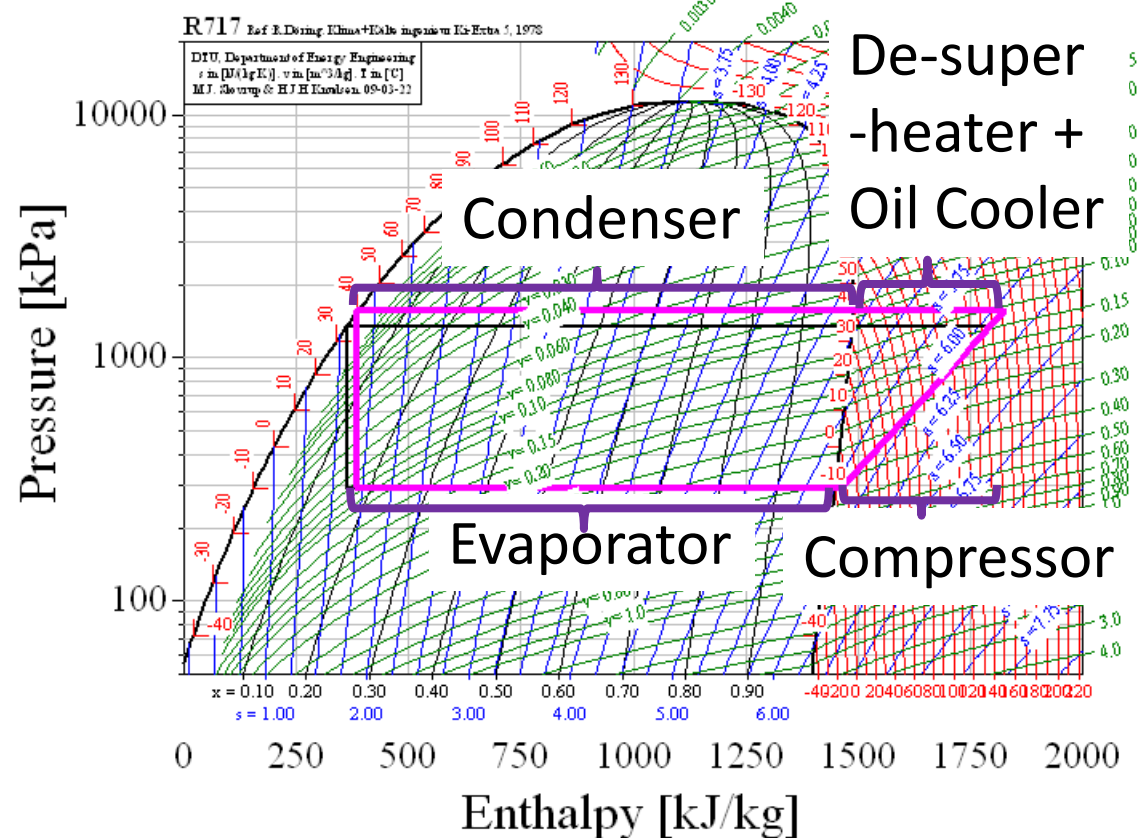
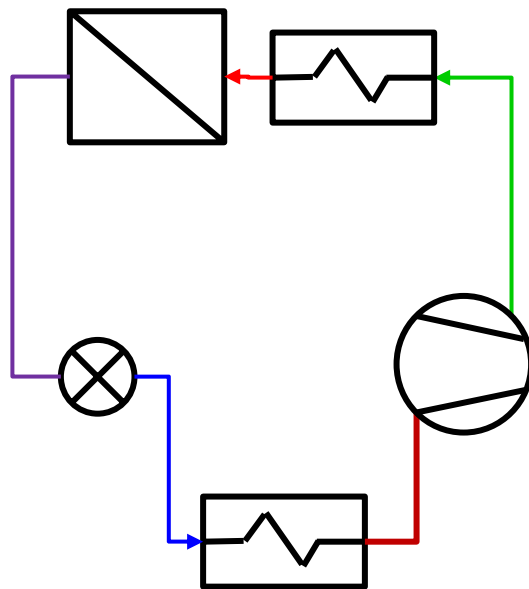
Heat Recovery Options

Oil cooler, de-superheater, and condenser heat recovery



Myth or Not?

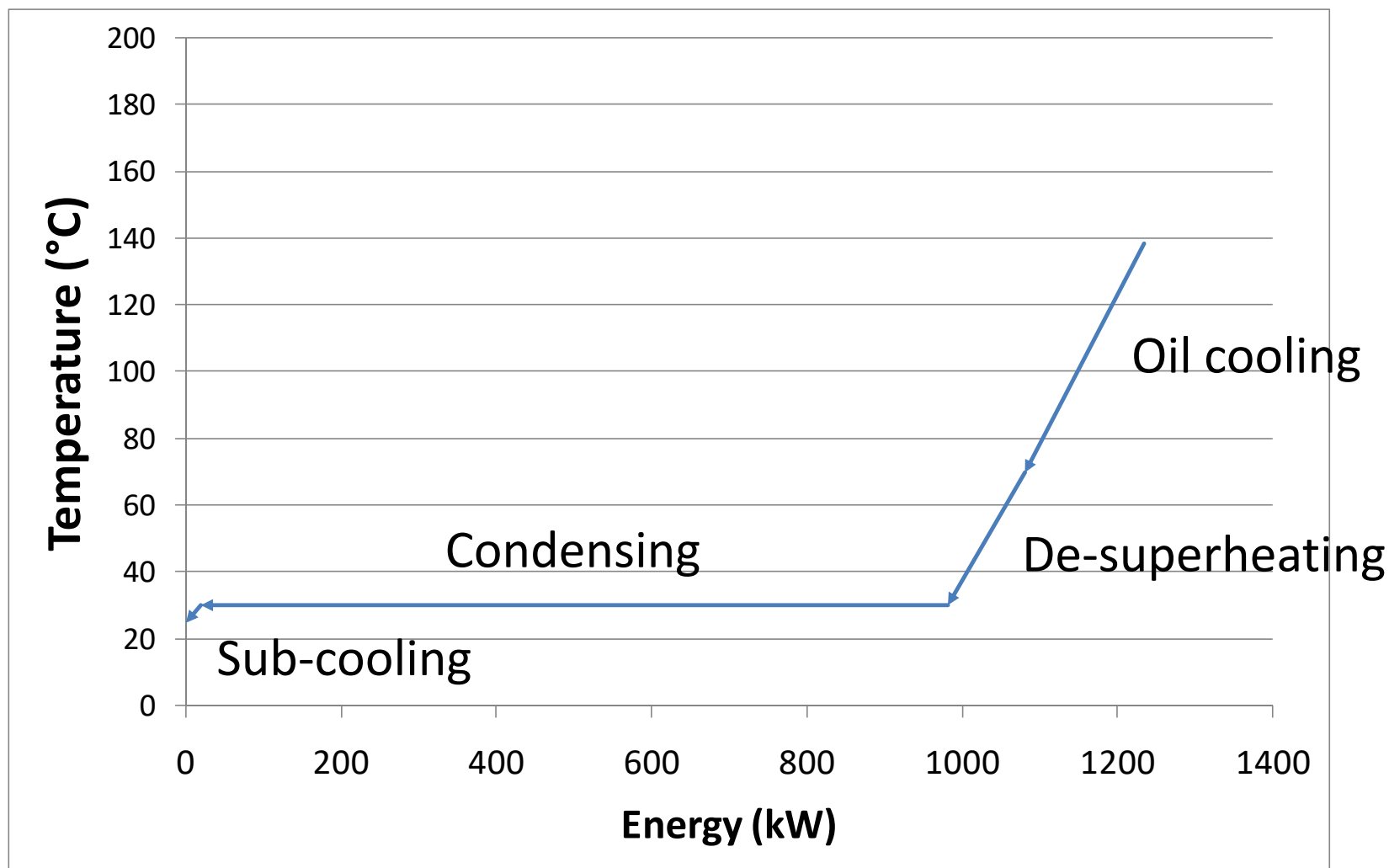
Raising discharge pressure is a good idea as it increases the amount of energy available for heat recovery?



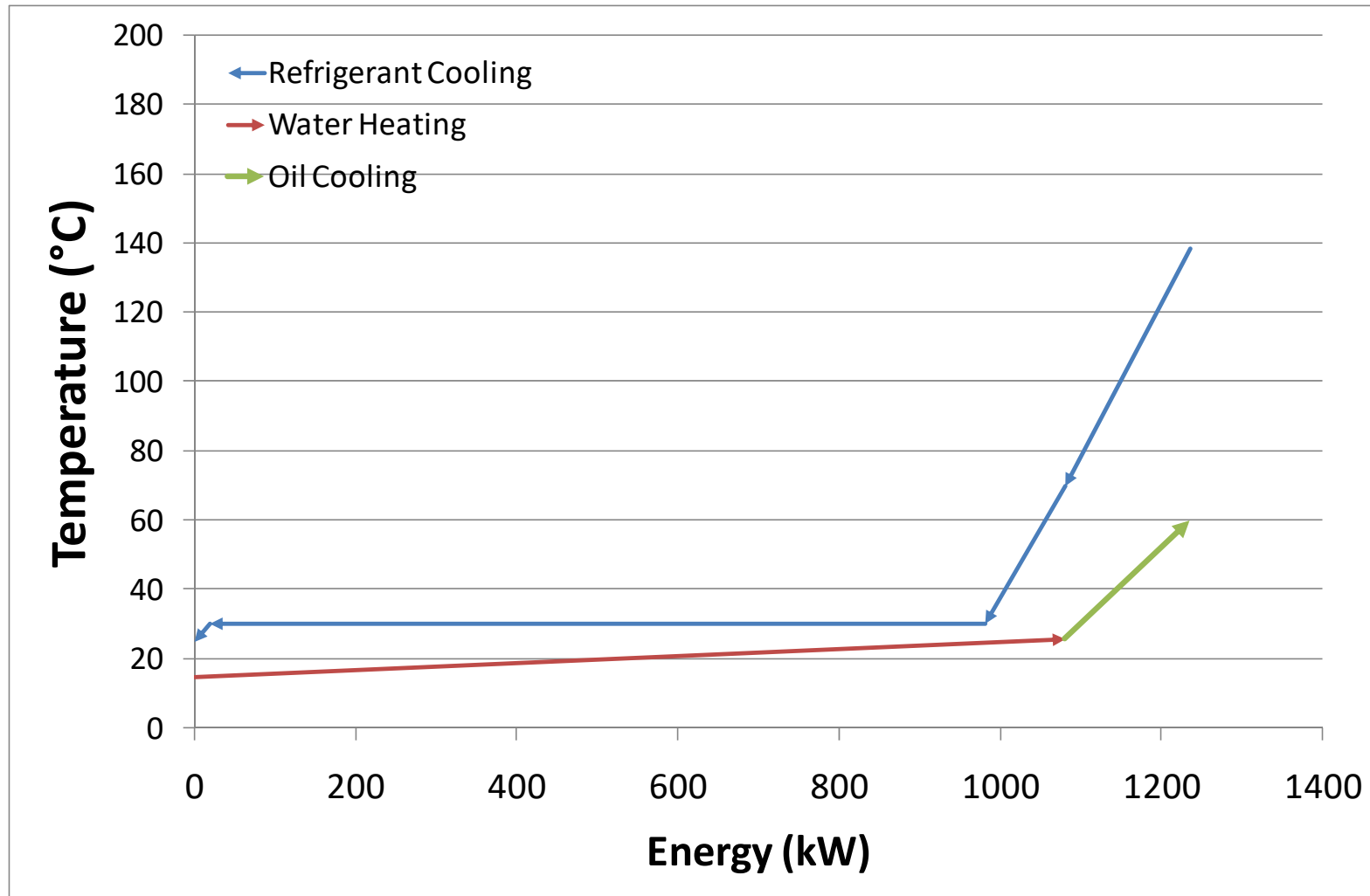
Example System

- 1000 kW of cooling.
- -10°C Evaporation temperature.
- Performance of compressor responds to operating conditions.
- NH_3 refrigerant.
- 5°C suction super-heat.
- Oil cooler cools discharge to 70°C .
- Condenser sub-cools to 25°C .
- 5°C temperature approach on heat recovery.
- We have water available at 15°C .
- We have a use for 60°C water.
- We may have a use for lower temperature warm water.

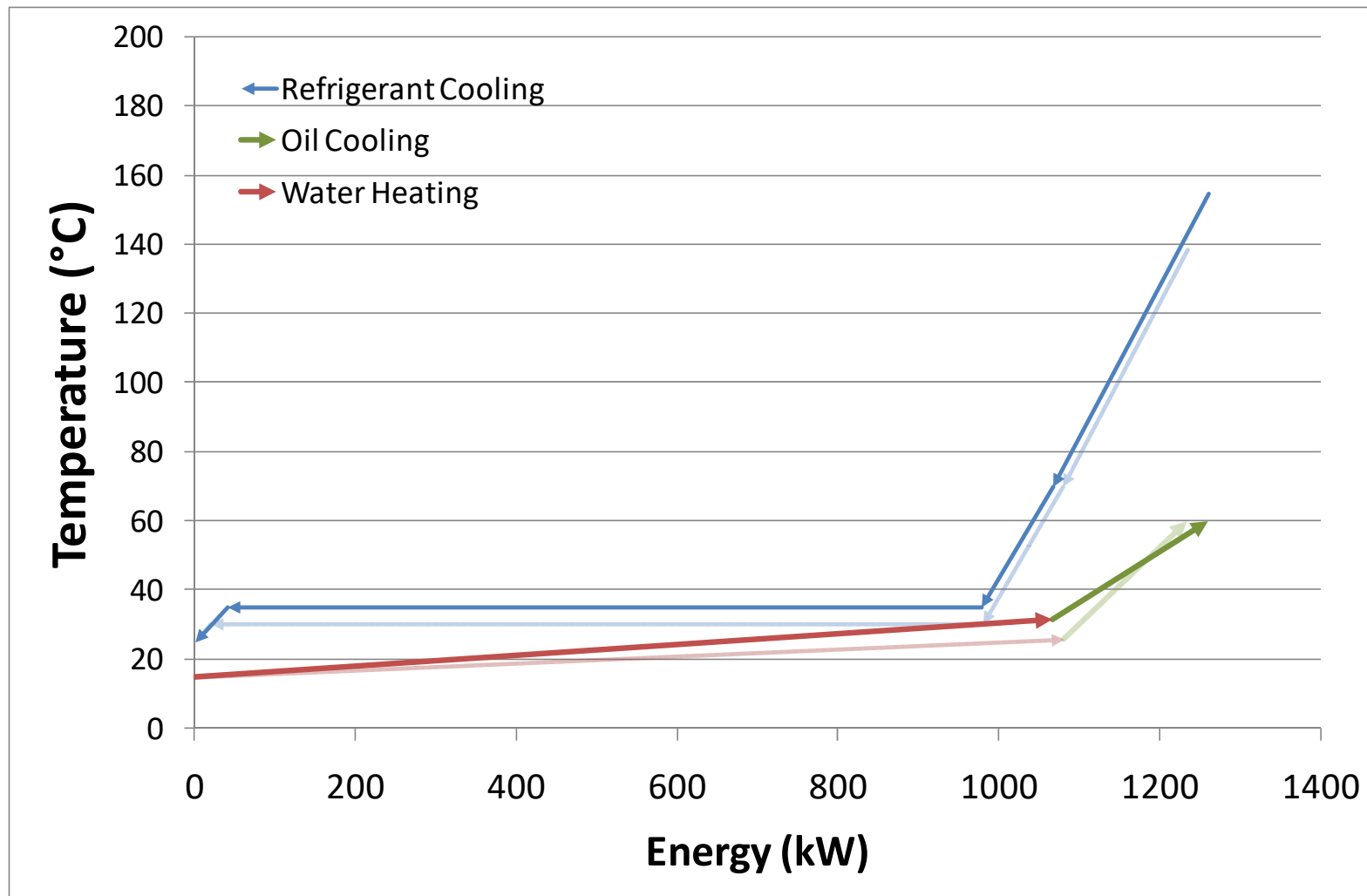
Base Case 30°C Condensation



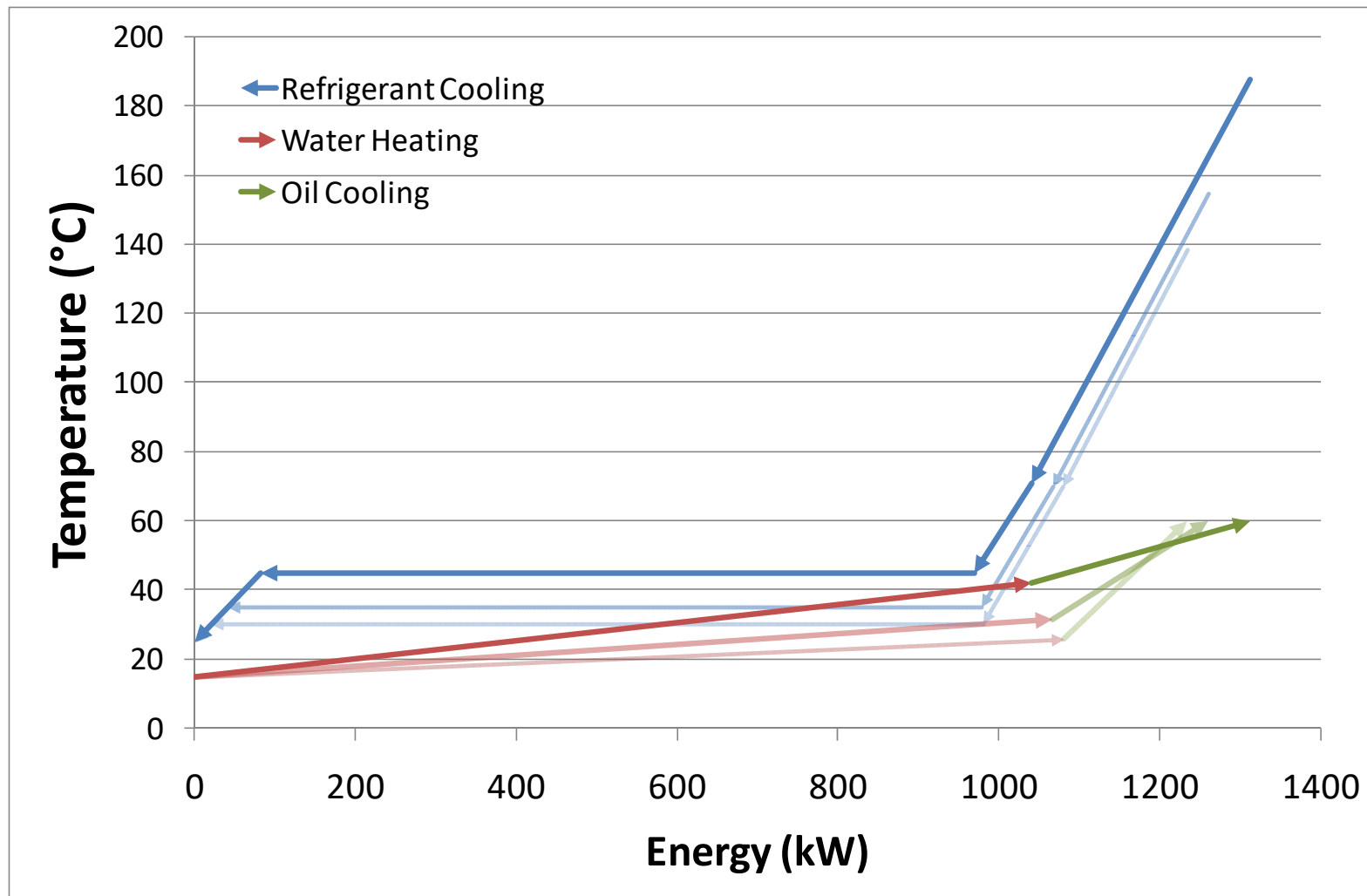
Base Case 30°C: Heating Water.



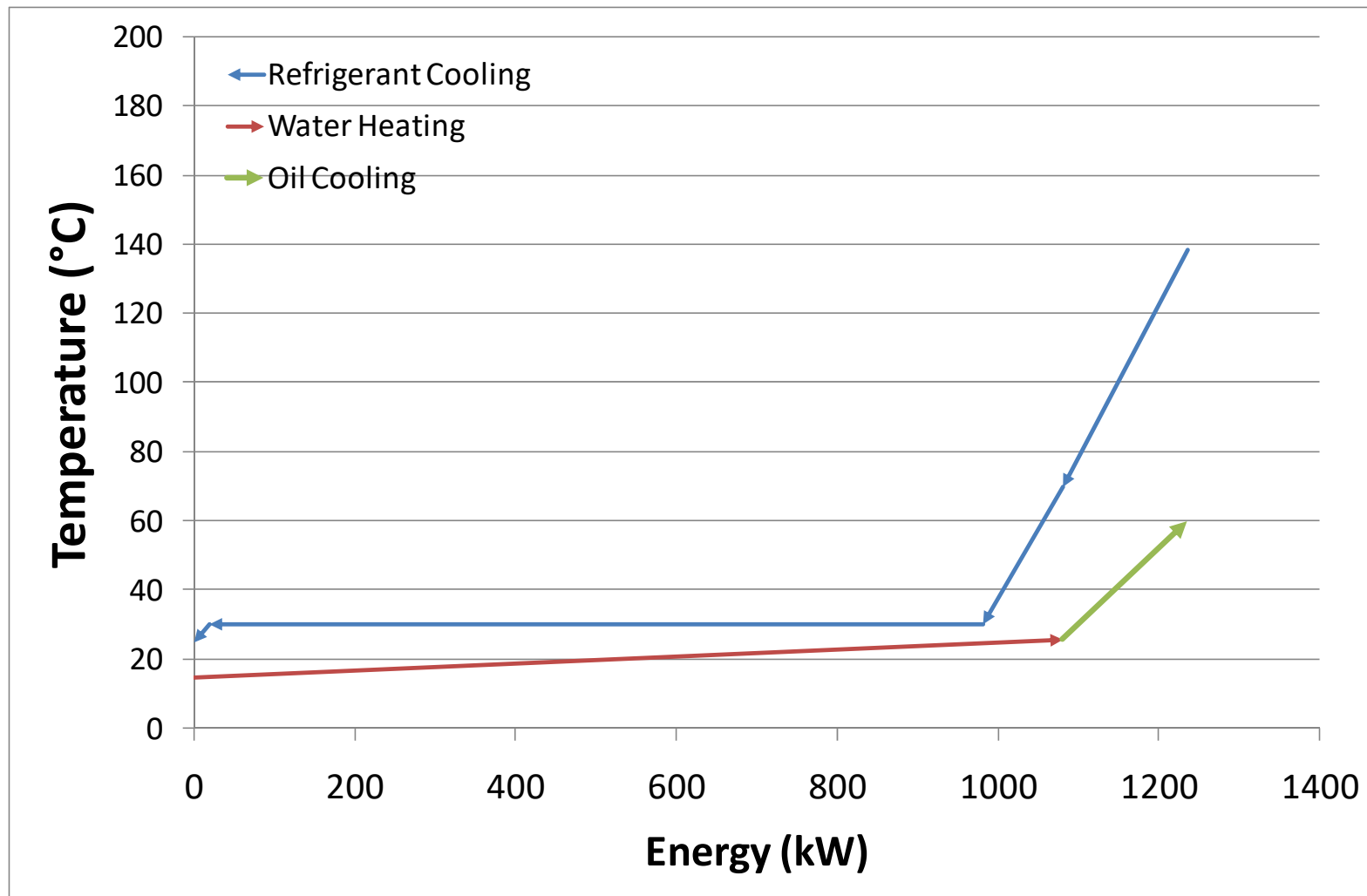
Increase Condensation Temp. to 35°C



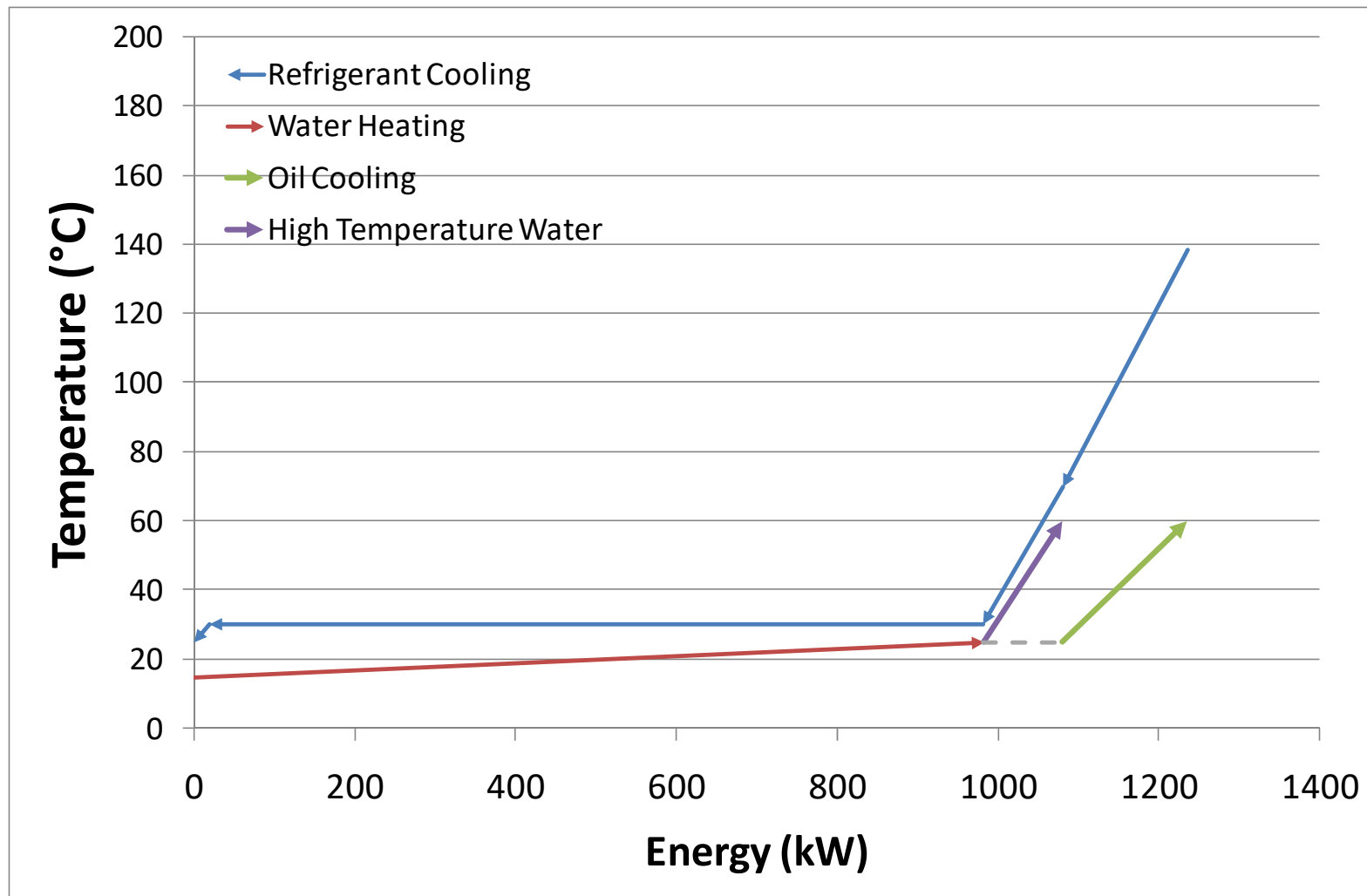
Increasing Condensation Temp. to 45°C



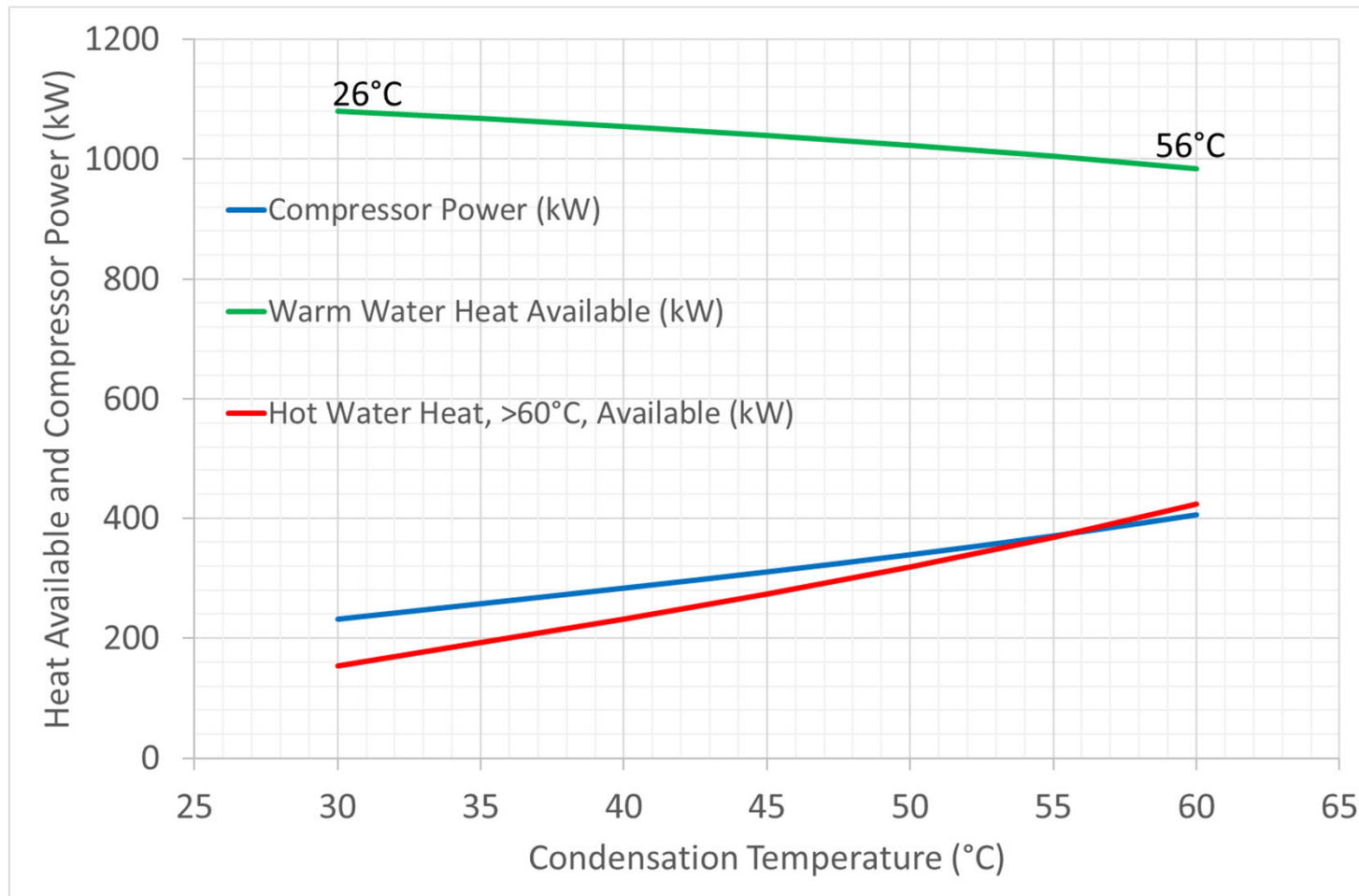
Heating a lot of water to a low temp.



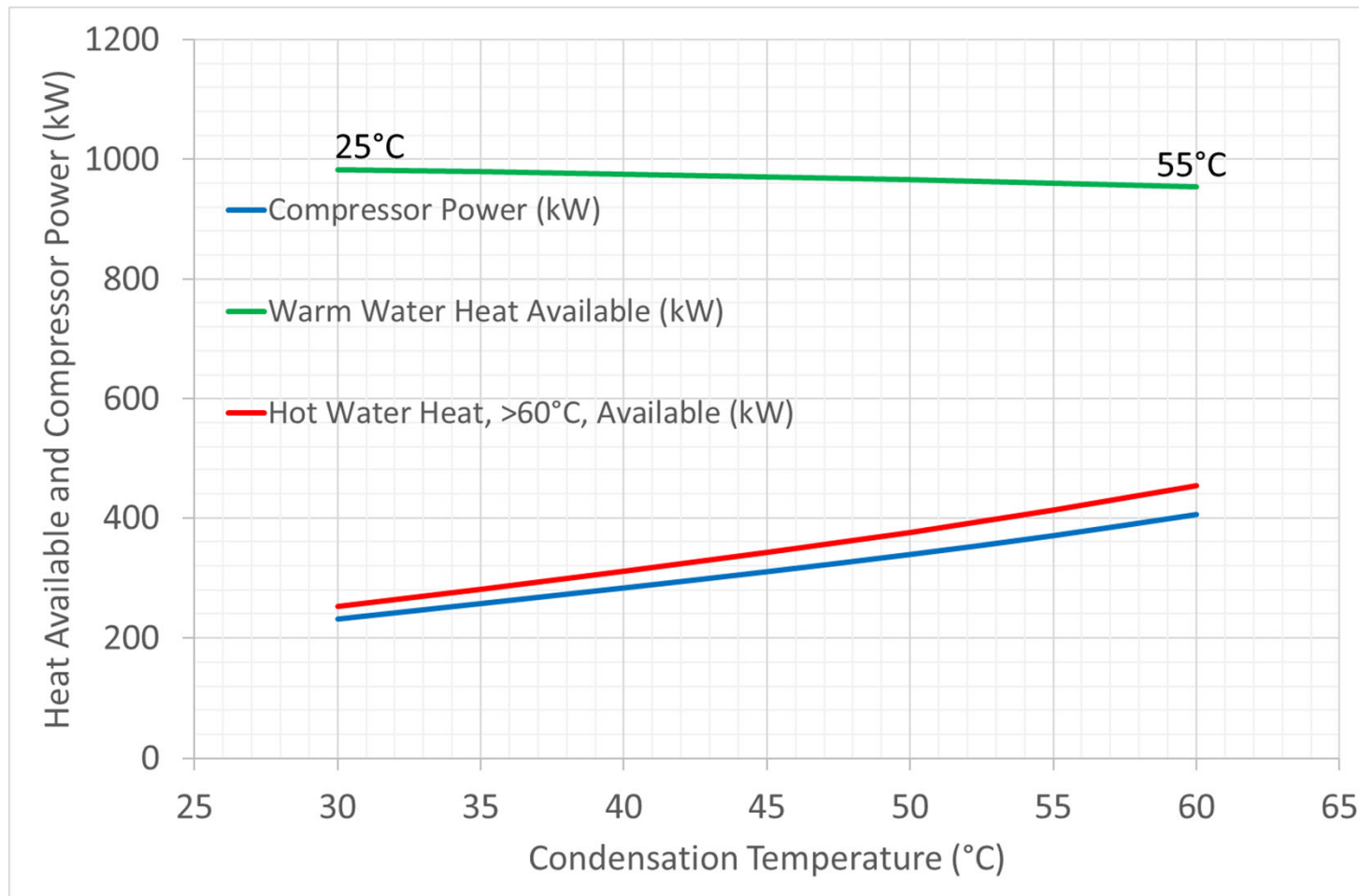
De-superheater to take a small fraction of water to a higher temp.



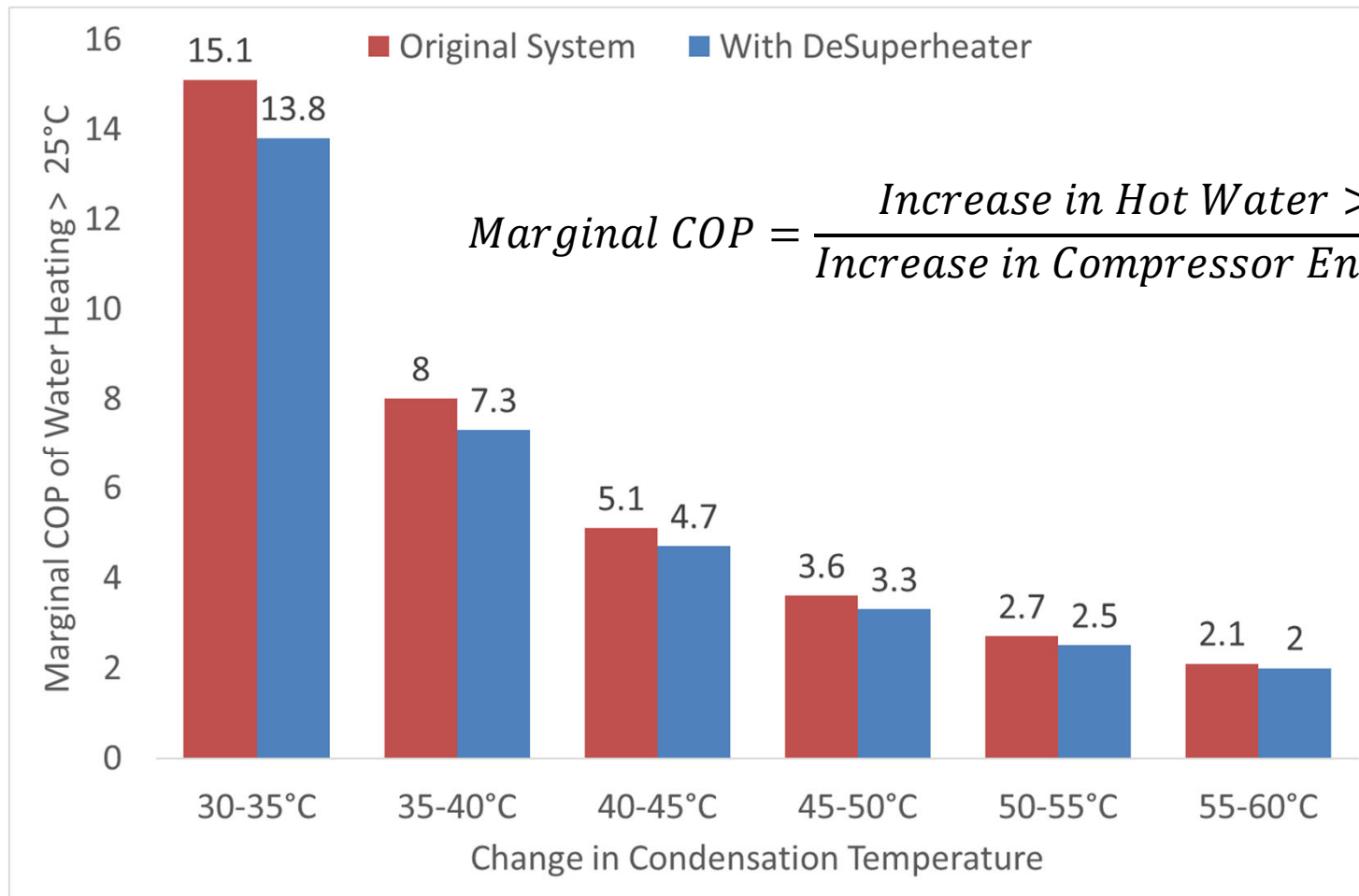
How Much Heating? Original Case



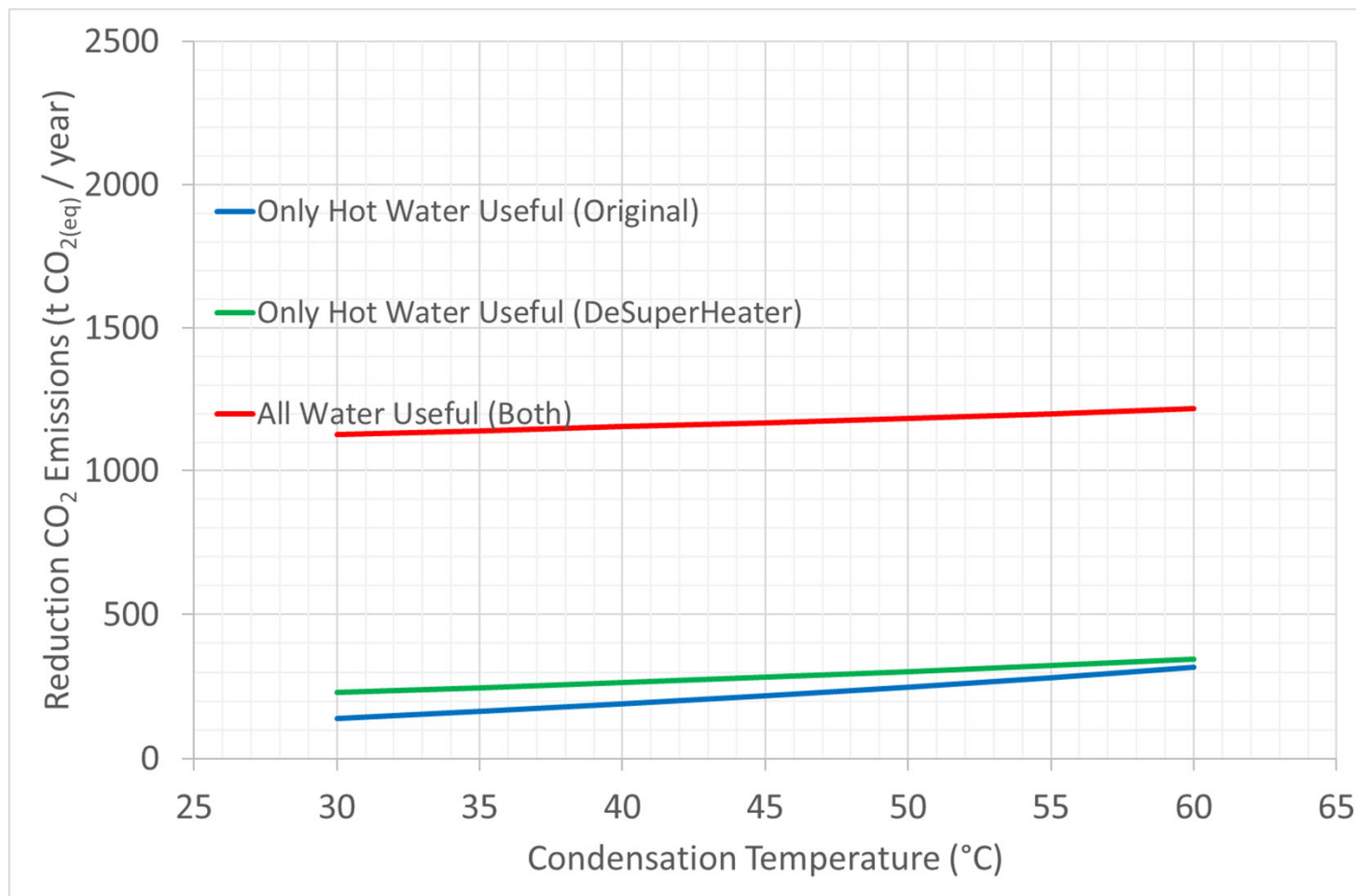
How Much Heating? De-Superheater



Marginal COP



Reduction in CO₂ emissions: replacing gas heating

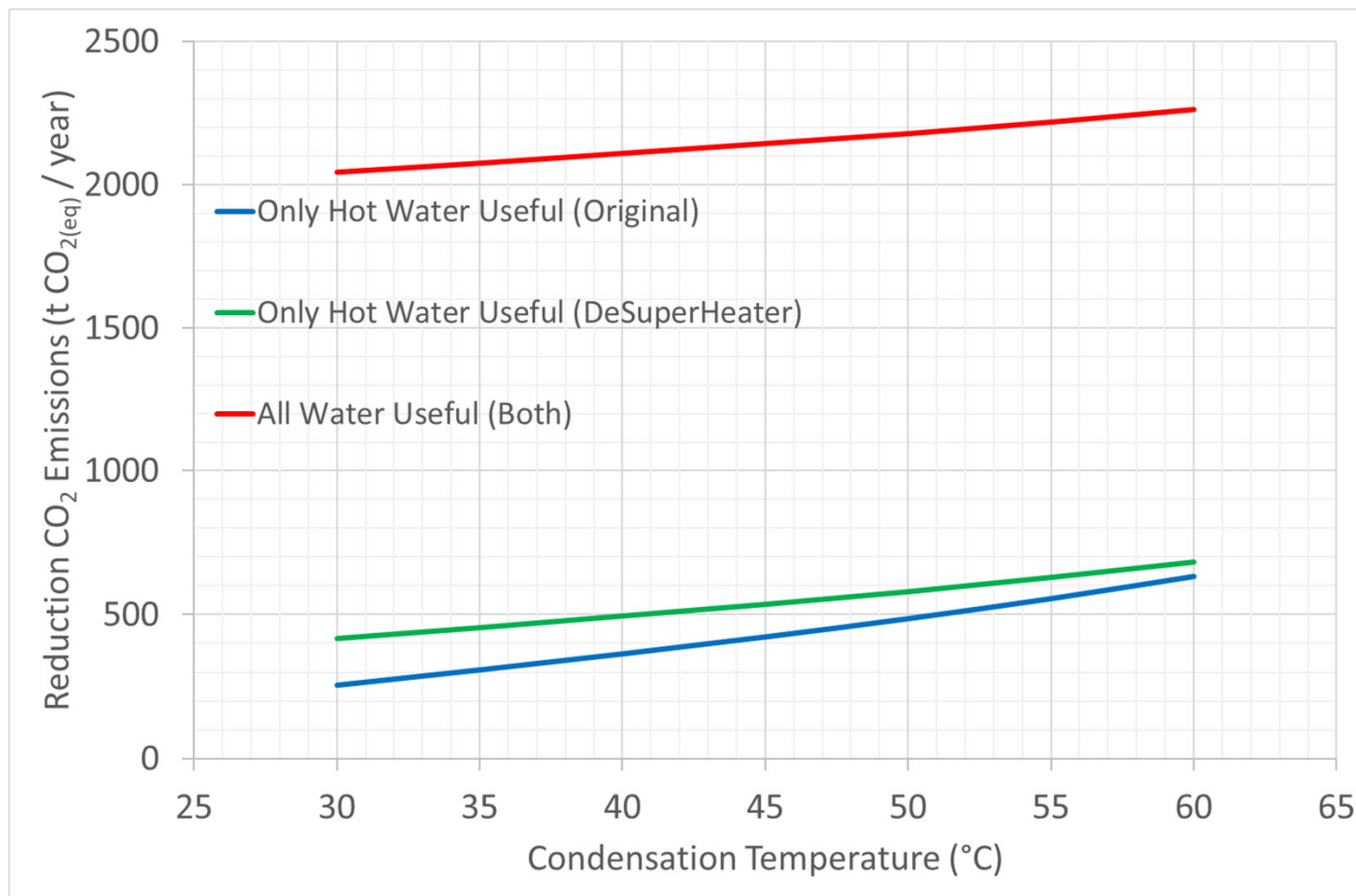


Assume
operating 4000
hour per year.

Elect.
emissions:
100 g CO₂/kWh

Gas emissions:
195 g CO₂/kWh
Boiler efficiency
= 85%

Reduction in CO₂ emissions: replacing coal heating



Assume
operating 4000
hour per year.

Elect.
emissions:
100 g CO₂/kWh

Coal emissions:
334 g CO₂/kWh
Boiler efficiency
= 80%

Conclusions

- Heat recovery reduces the total energy cost of cooling and heating *if* there is a use for the heat on site.
- Increasing Discharge Pressure increases amount of high value water heating from heat recovery.
- Increasing Discharge Pressure also increases electricity cost to run compressor.
- Heat is available from the oil cooler, de-superheater and condenser.
- Utilizing the de-superheater is an advantage, but there is relatively less benefit at high discharge pressures (if heat is also being captured in the oil cooler).
- More opportunities may be available by installing a heatpump utilising the rejected heat.