AWITC 2013 – Workshop W24

Refrigeration management for batch cold stabilisation

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Outline

- Batch cold stabilisation - definition
- Tank insulation
- Pull-down vs. holding cooling requirements
- Pre-cooling next wine using stabilised wine
- Night-time cooling
- Tank agitation
- Brine temperature

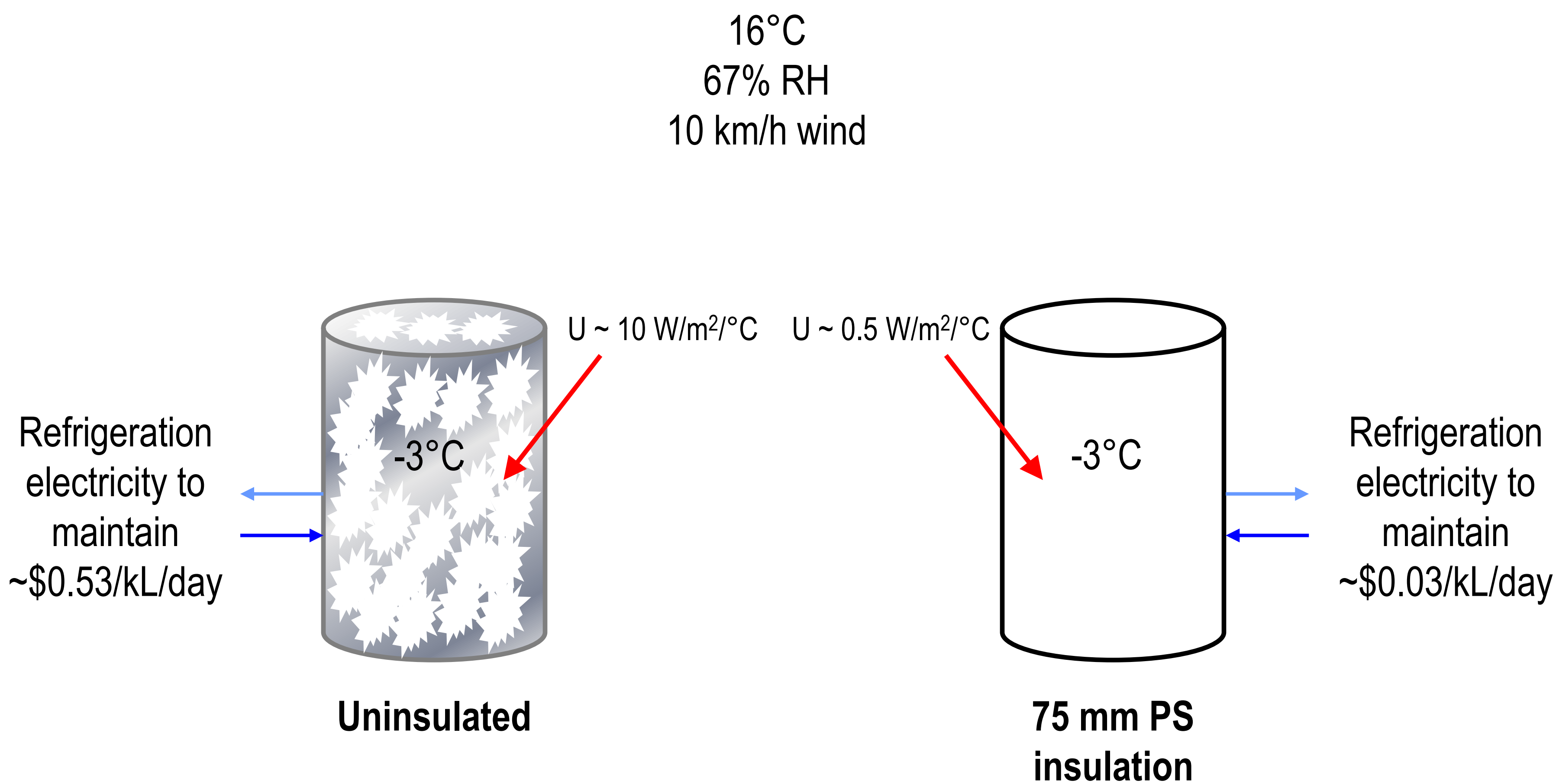
Batch cold stabilisation

- Chilling wine to precipitate out potassium bitartrate in-tank so that it won't precipitate in-bottle
  - Sometimes seeded with potassium bitartrate crystals so that the crystallisation process is not as reliant on natural nucleation and can therefore happen more quickly

Tank insulation

- Particularly important for cold stabilisation because of the low wine temperature relative to the ambient temperature
- Large savings in refrigeration electricity
- May struggle to reach low wine temperatures needed for cold stabilisation without it

Tank insulation – order of magnitude calcs



Key assumptions: COP_{+brine}: 1.5, Electricity: $0.15/kWh, 100 kL tank, L/D: 2.

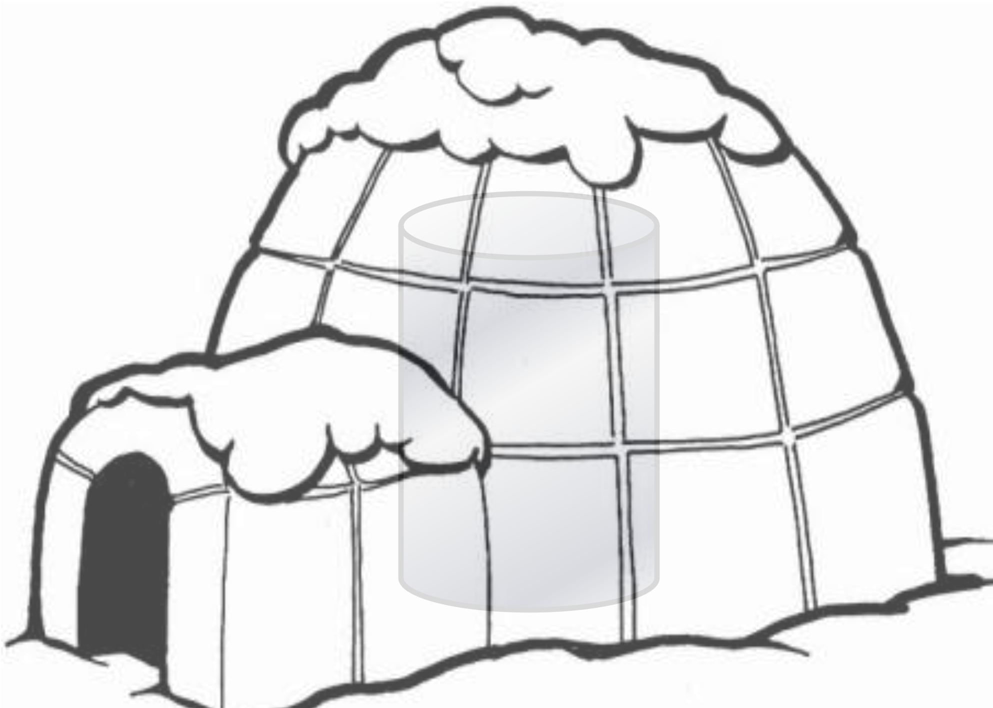
Note: Overall heat transfer coefficient for an uninsulated tank is very dependent on the film coefficients. Literature correlations have been used for estimates.

Tank insulation – ice?

- As soon as there is condensation and ice formation on the tank, the heat gain and therefore refrigeration electricity use increase significantly
- It is true that as the ice grows it will provide some insulating effect and the overall heat transfer coefficient will gradually decrease

But would need 4 m of ice to reduce the overall heat transfer coefficient to that achieved using just 75 mm of polystyrene insulation!

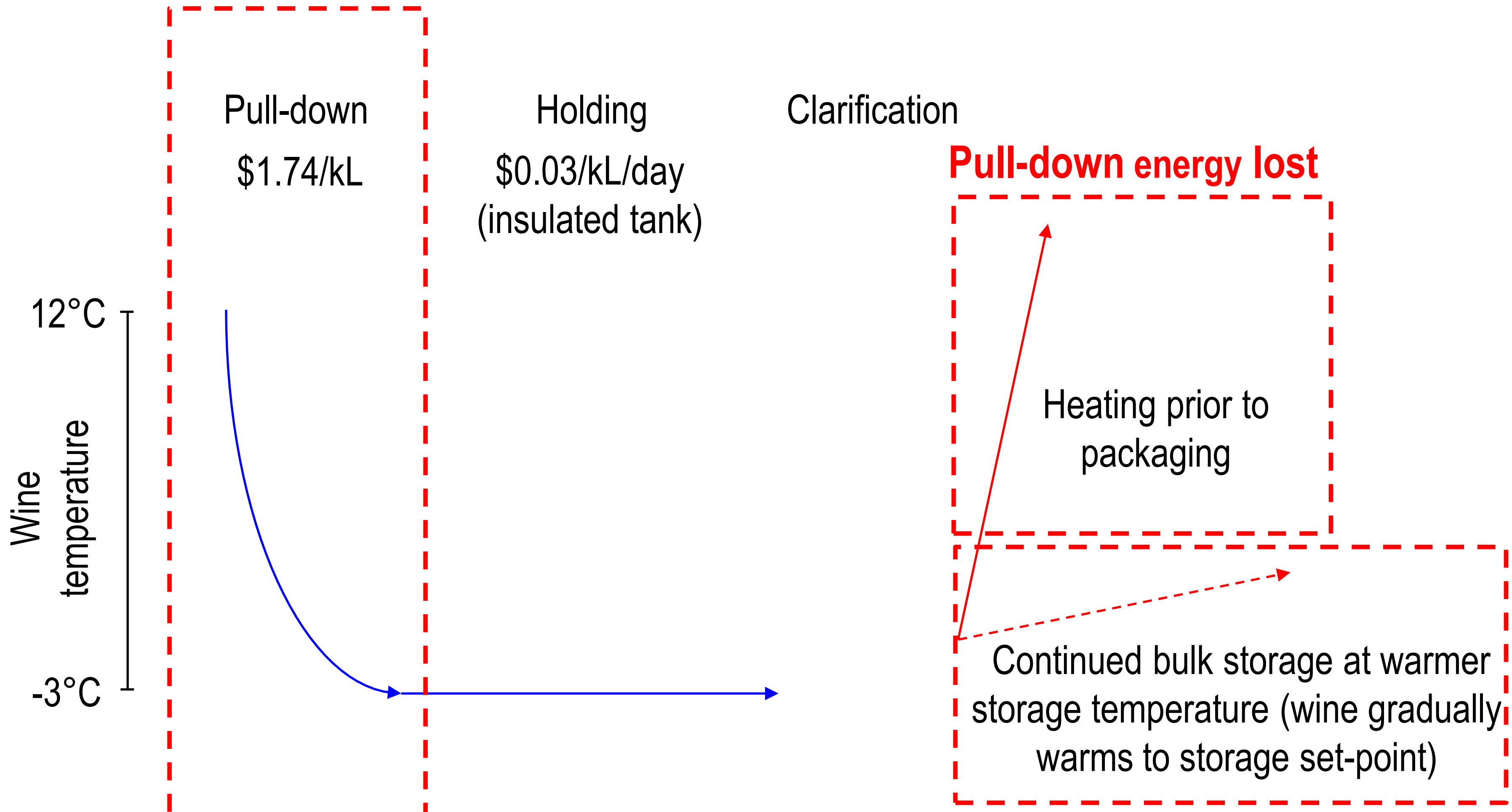
With 4 m of ice, the increased surface area would result in refrigeration electricity consumption 4 x that when using 75 mm of polystyrene insulation!



Technical qualification: Igloos are initially made from snow bricks not ice. There will be some ice formation after the inside melts slightly, but snow still makes up the bulk. Snow is a better insulator than ice.

Pull-down vs. holding cooling

The energy (and money) is in reducing the temperature of the wine



Pull-down energy not completely lost – potentially avoids refrigeration needed for storage

Note: Only refrigeration electricity cost included. Calculations based on assumptions from previous slides. Pull-down estimate considers wine temperature drop only.

Pre-cooling next wine to be cold stabilised

- Use cold stabilised wine to pull-down the next wine requiring cold stabilisation (refrigeration plant then only needs to provide the last little bit of pull-down)
  - Typically performed using a plate heat exchanger (more effective than a tube-in-tube heat exchanger)
- Electricity savings will not be as large if the wine finishing cold stabilisation would otherwise have been allowed to warm naturally to normal storage temperatures
- Can be a scheduling challenge
- This 'cool' recovery process is automated in most continuous packaged tartrate crystallisation systems (incoming wine cooled by the same exiting wine)

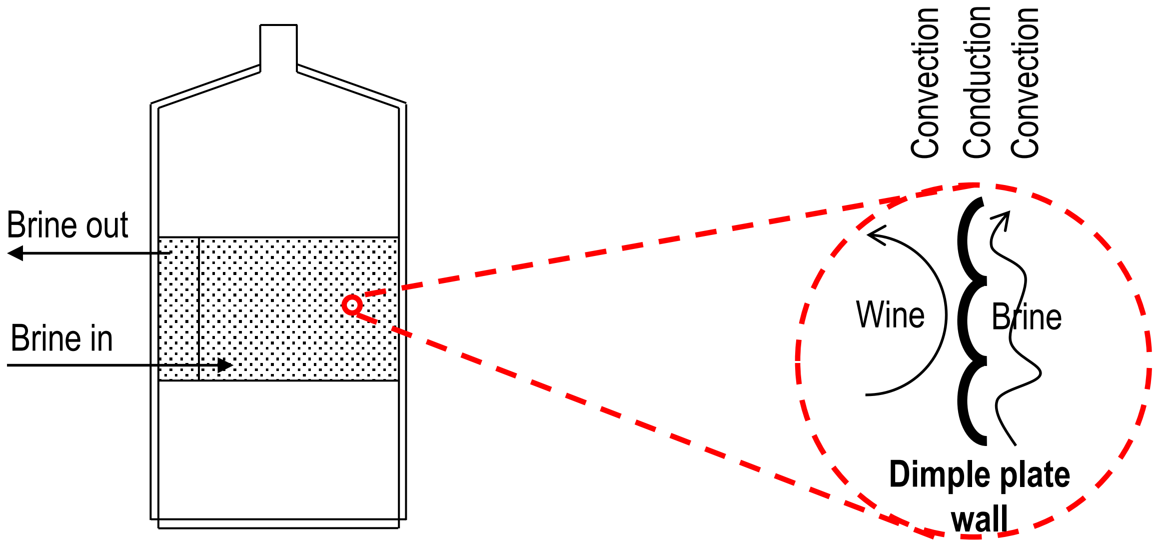
Plate heat exchanger

Night-time cooling

- Night-time electricity is usually charged on a significantly cheaper off-peak tariff
- Refrigeration plants can also operate more efficiently at night (if the head pressure is allowed to float)
- Try and shift as much electricity use as possible to night-time
  - For cold stabilisation, the pull-down cooling is the dominant refrigeration load, so try and get as much of this as possible happening at night
  - When purchasing/modifying temperature control systems, consider systems that allow automation of this load shifting process

Tank agitation - cooling jacket heat transfer

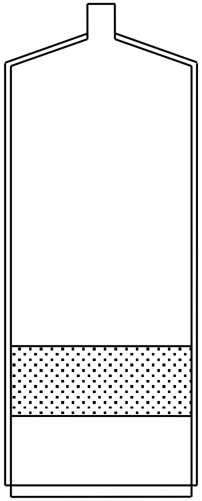
- Poor cooling rates are achieved by in-tank cooling relative to using external heat exchangers
  - Agitation level and therefore convection coefficients are relatively low
  - Brine-wine temperature differential (driving force) decreases considerably as the wine gets to lower temperatures
  – But, it is easy! Just adjust the tank set-point and you are done
- Tank agitation when brine is flowing is important to maximise the cooling rate and minimise electricity use for brine pumping
  – Tank agitation increases the wine side convection coefficient considerably



Tank agitation - stratification and ice formation

- Tank agitation also avoids temperature stratification induced by low cooling jackets on tanks
  - Stratification reduces heat transfer even further by reducing the temperature differential between the brine and the wine next to the tank jacket (cooler wine at the bottom is next to the cold brine, if tank was mixed, the wine next to the jacket would be warmer)

Tank with low cooling jacket – even more important that agitation is used!

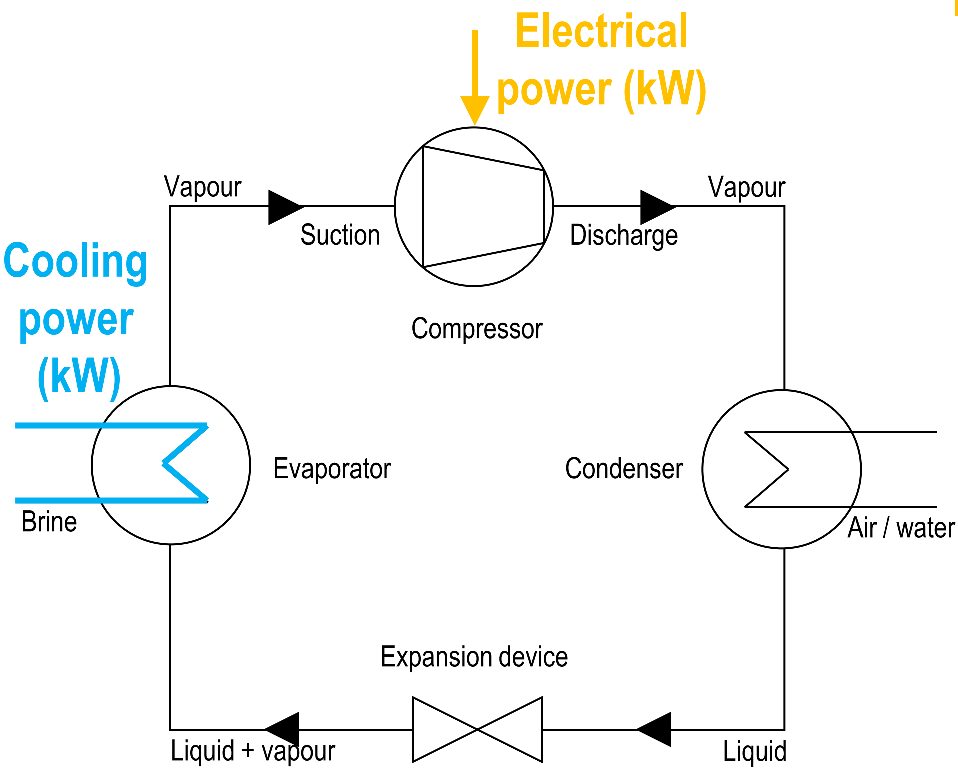


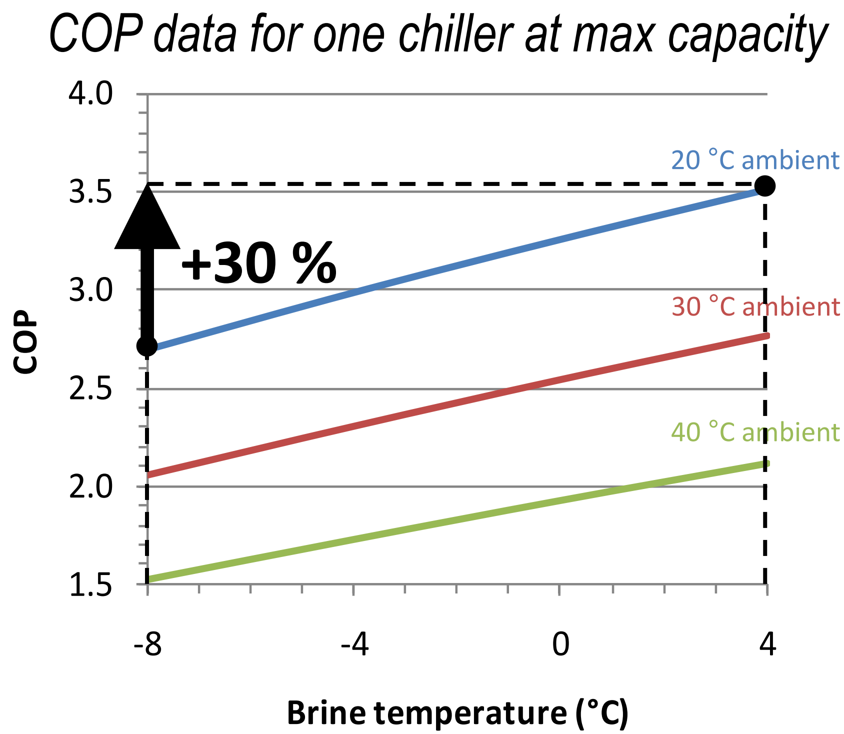
Ice sitting in the bottom of an emptied tank after cold stabilisation without the agitator on (ice damaged the tank door)

- Tank agitation also minimises wine ice formation, which in addition to resulting in very poor heat transfer can also damage tank fittings

Brine temperature and refrigeration plant efficiency

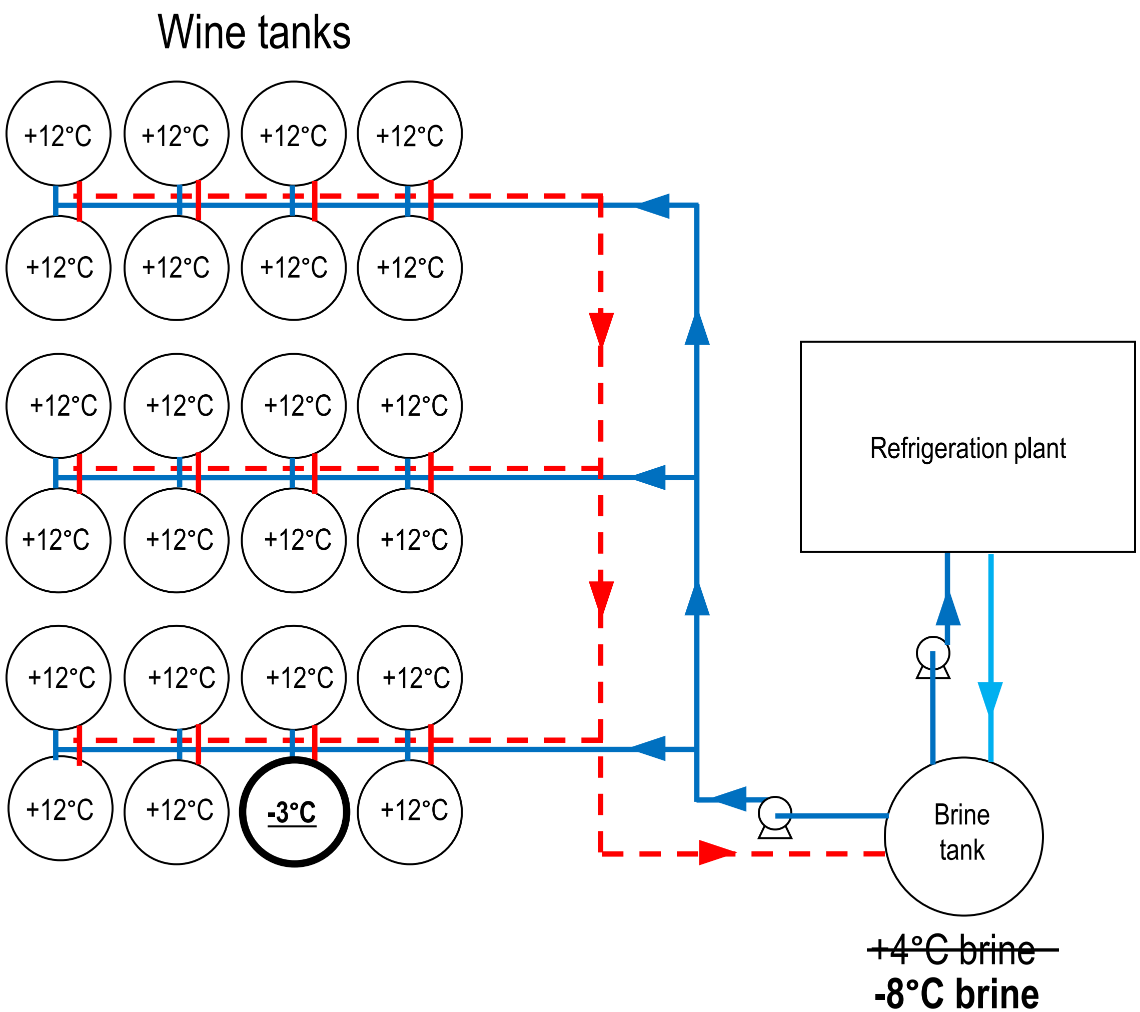
$$COP = \frac{\text{Cooling power (kW)}}{\text{Electrical power (kW)}}$$





Warmer brine ⟶ More energy efficient refrigeration plant

Brine reticulation loop & scheduling



- Brine temperature dictated by the coldest tank on the reticulation loop (need to have a negative temperature differential between the brine and wine)
- When one tank is being cold stabilised, a much colder brine has to be used
- Could cold stabilisation operations be scheduled to occur in specific periods so warmer brine can be used the rest of the time? (may not be practical)
- When purchasing/modifying temperature control system, consider having it automatically set the brine temperature based on the lowest wine temperature (at least this adjusts the brine temperature up when there are no tanks being cold stabilised)

Summary

- Use insulated tanks for cold stabilisation
- Consider pre-cooling next wine using stabilised wine
- Try and maximise the amount of pull-down cooling occurring at night-time
- Agitate tanks to improve rate of cooling
- Schedule cold stabilisation operations to occur in blocks (if practical) and use warmer brines at other times

Thank you for your attention
Please see booklet in workshop pack