WEA Conference – June 23rd 2011

Improving Winery Refrigeration Efficiency & Opportunities for Cleaner Production

Simon Nordestgaard

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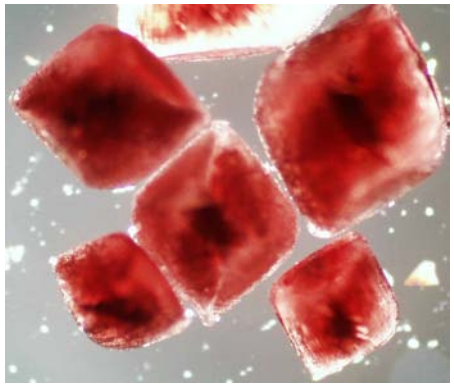
Winery Refrigeration - Uses



Cold Stabilisation

Must Chilling

Fermentation,
Storage,
White Juice Settling

Space Cooling

~50-70% Winery Electricity Use!

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Winery Refrigeration - History

- 1500s – Benefits of cold stabilisation noted.
- 1884 – Refrigeration first used in Champagne region to create cold brine baths for disgorging Champagne.
- 1890 – Cooling coils first used in Australia to lower fermentation temperature (16-20 °C water from stream or dam).
- 1900 – Refrigeration for wine treatment developed in France/Italy.
- 1932 – Refrigeration first used in Australia for cold stabilisation.
- 1950s – Refrigeration first used in Australia to control fermentation temperature (Initially pressure fermenters then other types).
- 1956 – Direct expansion chilling first used in Australia (i.e. no intermediate brine).

Sources:

White, Adamson, Rankine (1989) Refrigeration for winemakers. Winetitles.
Rankine (2004) Making good wine. Pan Macmillan.

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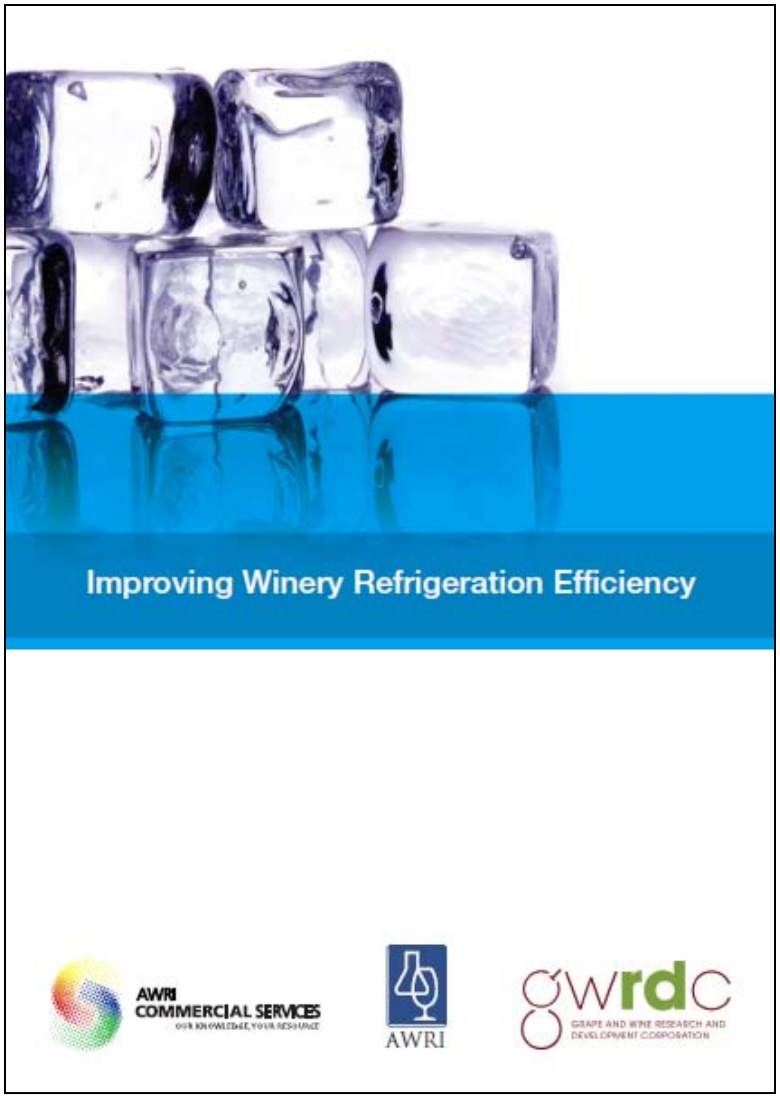
Refrigeration Handbook



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Refrigeration Handbook

1. Turning off plant / running plant infrequently.
2. Temperature rationalisation.
3. Night-time harvesting.
4. Night-time/winter scheduling.
5. Brine temperature.
6. Brine concentration.
7. Chiller to brine tank pump.
8. Brine reticulation.
9. External heat exchangers.
10. Product heat exchange.
11. Maintenance.
12. Electricity bills.
13. Auditing.
14. Reference charts.
15. Training.
16. Process control.
17. Insulation.
18. Fridge plant heat recovery.
19. Separate brine tanks.

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Winery A

- 500 tonne crush:
  - 90% Red, 10% white grapes.
  - Wine largely matured in barrels.
- Cooling system:
  - Packaged chiller with brine reticulation.
  - 10 years old.

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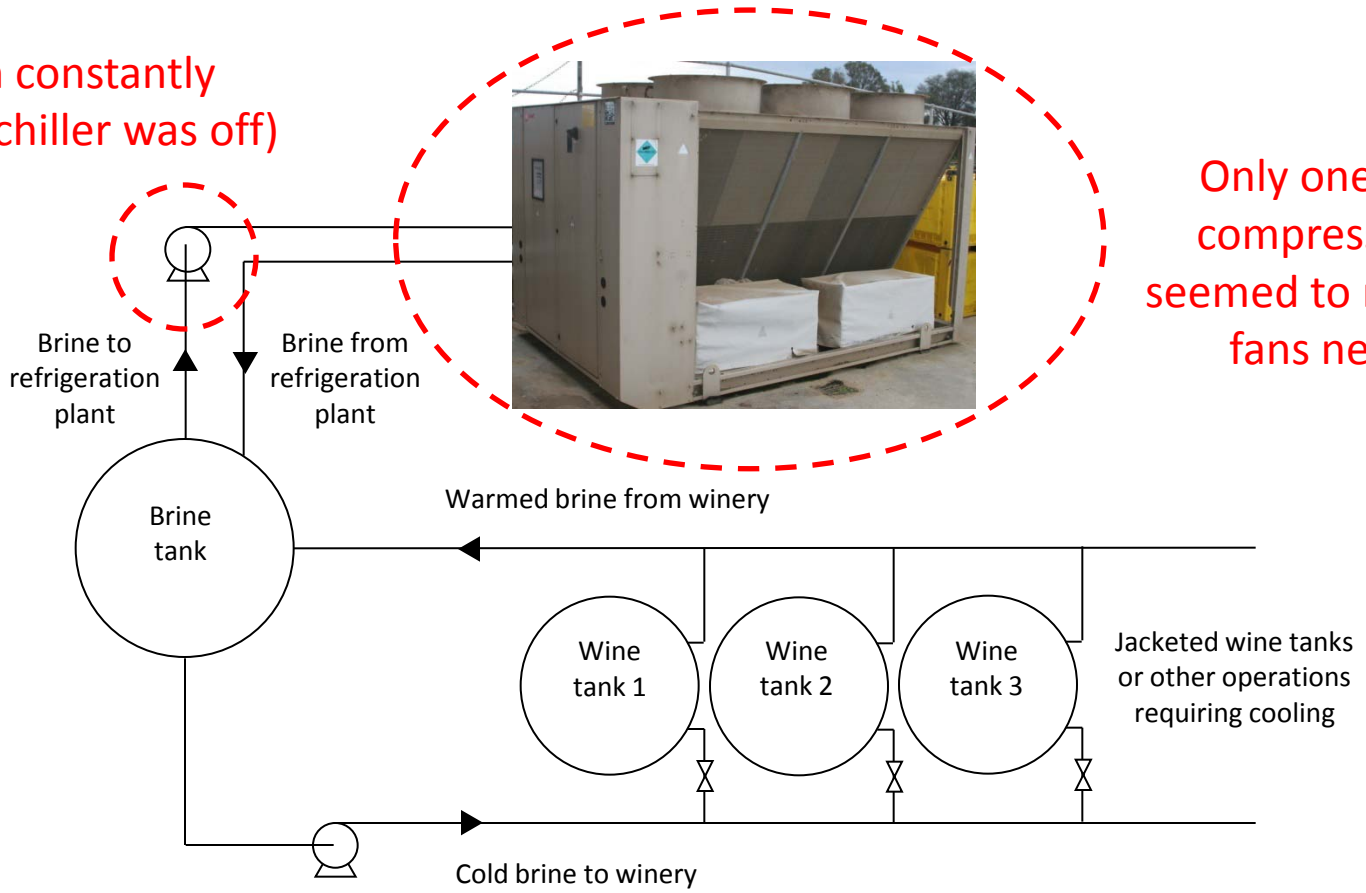
Winery A – Auditing/Maintenance

Pump ran constantly
(even when chiller was off)

Only one of the 2 compressors ever seemed to run & some fans never ran



Simplified winery brine cooling loop

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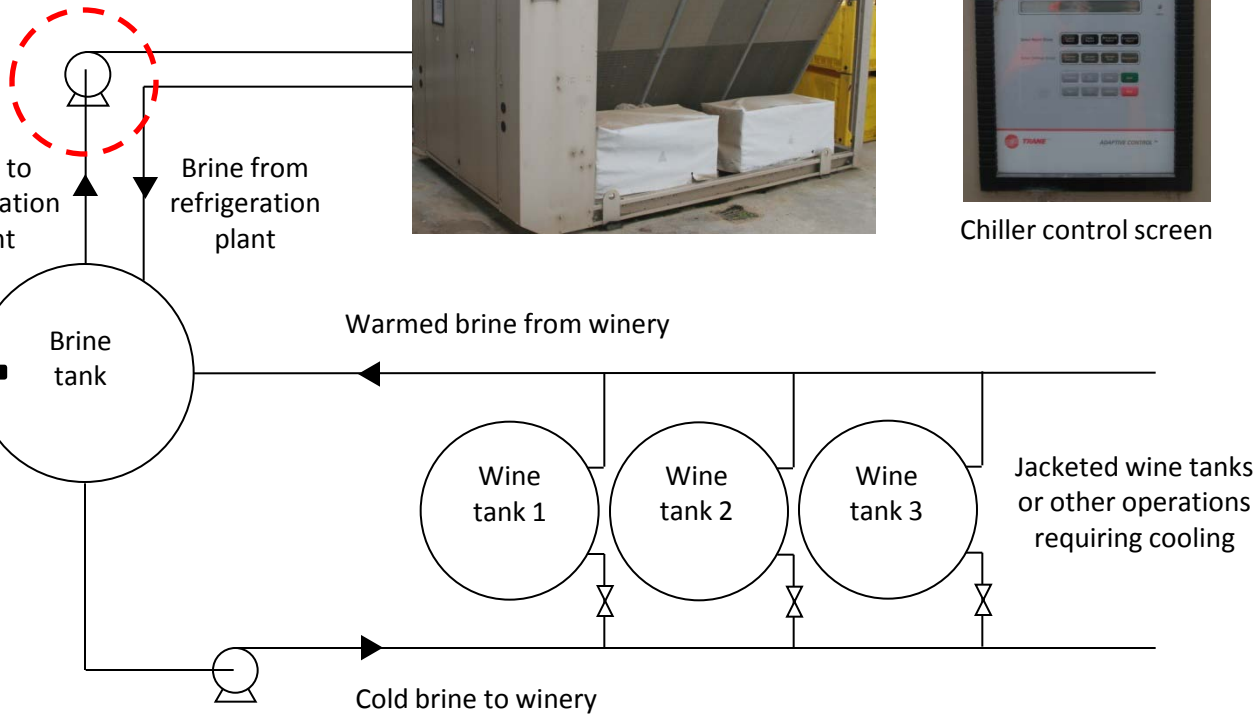
Winery A – Auditing/Maintenance

Pump ran constantly
(even when chiller was off)

Chiller control screen

Winery control panel



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Winery A – Auditing/Maintenance

Only one of the 2 compressors ever seemed to run & some fans never ran

- There had been a refrigerant leak and 1 of the 2 circuits was empty.
  - Compressor had been cutting out on low pressure error.
  - Leak repaired and circuit recharged.
  - Both circuits / compressors now running.
- Fans that had tripped were reset.

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Winery A – Stopping/Starting Plant

- Compressor oil heaters
  - May need to be kept on (or at least energised for a significant period prior to start-up).
  - Otherwise refrigerant may be absorbed in the lubricating oil and compressor may be damaged upon start-up.
- Follow manufacturer's instructions!
- Brine evaporation during shut-down
  - Consider the evaporation of freezing-point suppressant (e.g. ethanol).
  - Instead of shutting the plant down altogether it may be better to just set the brine temperature to ~10 °C to limit evaporation, and employ a wide control band such that the plant doesn't run too often.

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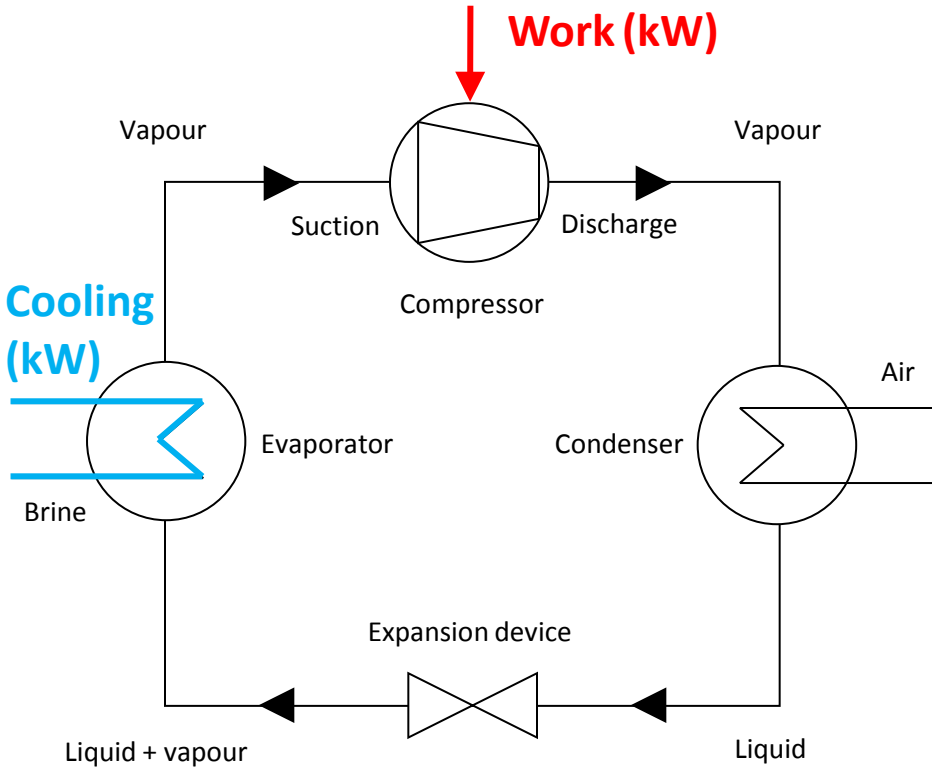
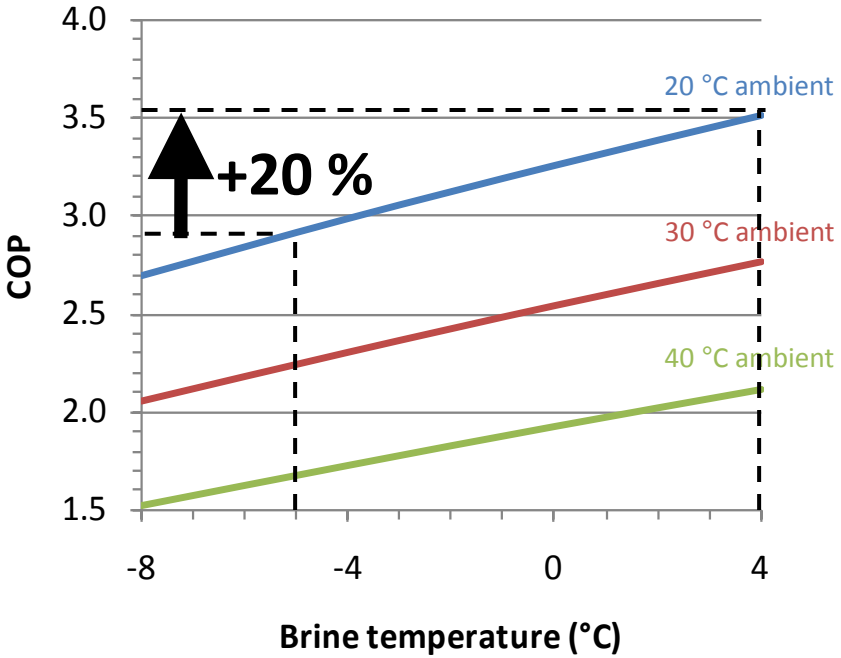
Winery A – Brine Temperature



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



- Warmer brine temperatures mean that a higher refrigerant suction pressure should generally be able to be used - leading to a higher COP.
  - verify with your specific system that when using a warmer brine setting the evaporator/suction pressure does increase .

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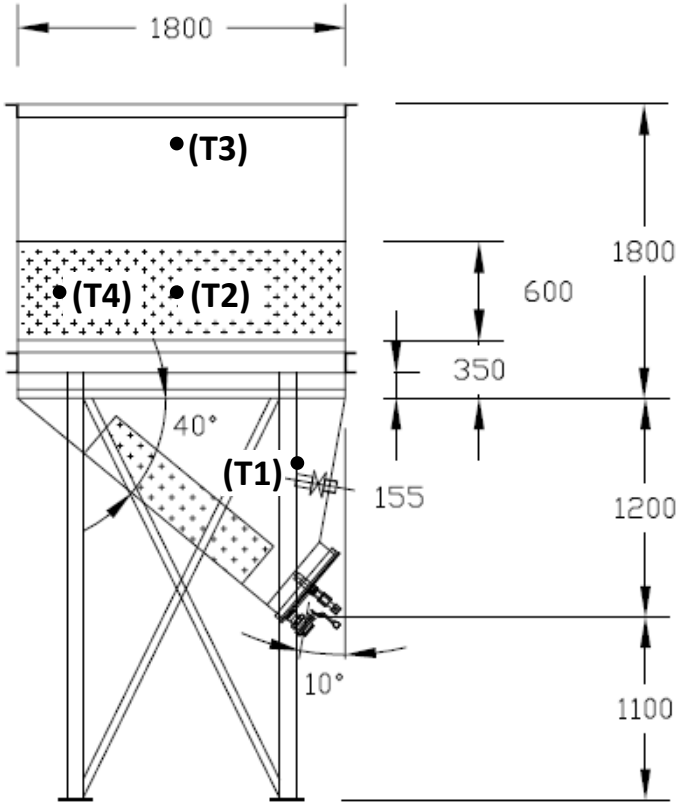
Winery A – Brine Temperature

- Preliminary trial:
  - Fermenter full of rainwater.
  - Brine: -5 °C or +4 °C (nominal).
  - Cooling: From 21 °C to 15 °C.

- Cooling slower with +4 °C brine:
  - 23% slower based on probe T1.
  - 11% slower based on probe T2.



5 tonne open-topped fermenter

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Winery A – Brine T / External HEX

- Teralba dimpled tube-in-tube heat exchanger to provide additional surface area for cooling.
  - In case the tank jackets couldn't provide enough cooling with warmer brine.

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Winery A – Brine T / External HEX

- The whole winery switched to using +4 °C brine (nominal).
- We arranged to perform and monitor 2 side-by-side fermentations with the same grapes (Malbec – 4.6 tonnes/tank).
  - One using only tank jacket cooling.
  - One using tank jacket cooling + heat exchanger cooling during pump-overs when required.

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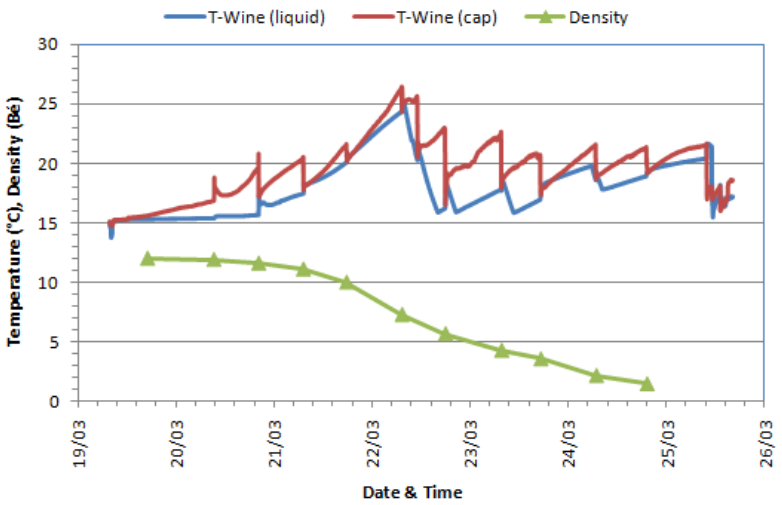
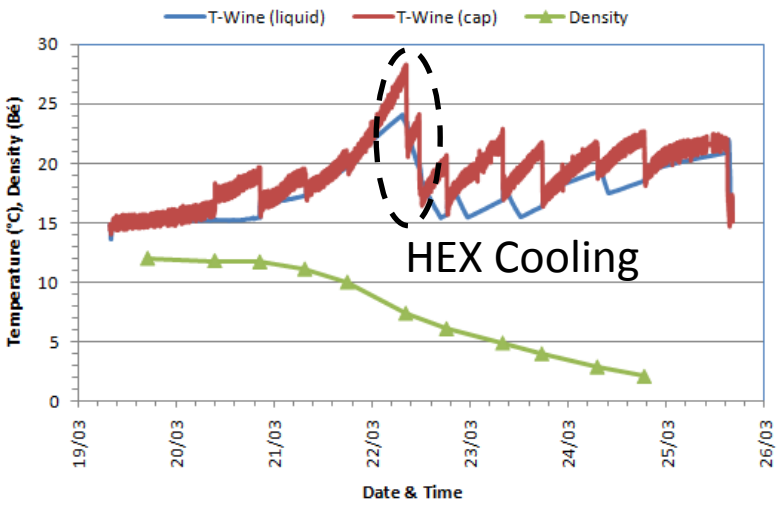
Winery A – Brine T / External HEX

(a) Tank jacket only



(b) Tank jacket + HEX on 22/03



- No real problems controlling fermentations with +4 °C brine even without heat exchanger.
  - Winery reported that it was a little bit slower getting down from the peak temperature on 22/03 than normally the case with -7 °C / -5 °C brine.
- HEX was a simple way of providing extra cooling.

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Brine Temperature Comments

- Problem operations for warmer brine temperatures (must/juice/wine temperature is getting close to the brine temperature):

		Alternatives
• Must chilling	→	Night-time harvesting / Dedicated refrigeration system
• Juice settling	→	Flotation
• Cold stabilisation	→	Electrodialysis, packaged rapid contact systems, crystallisation inhibitors (CMC, Mannoproteins, etc.)

- Generally, in terms of electricity usage is best to use as high a brine temperature as practicable for as long as practicable.
  - Schedule operations that require low brine temperatures concurrently so can keep brine warmer the rest of the time.

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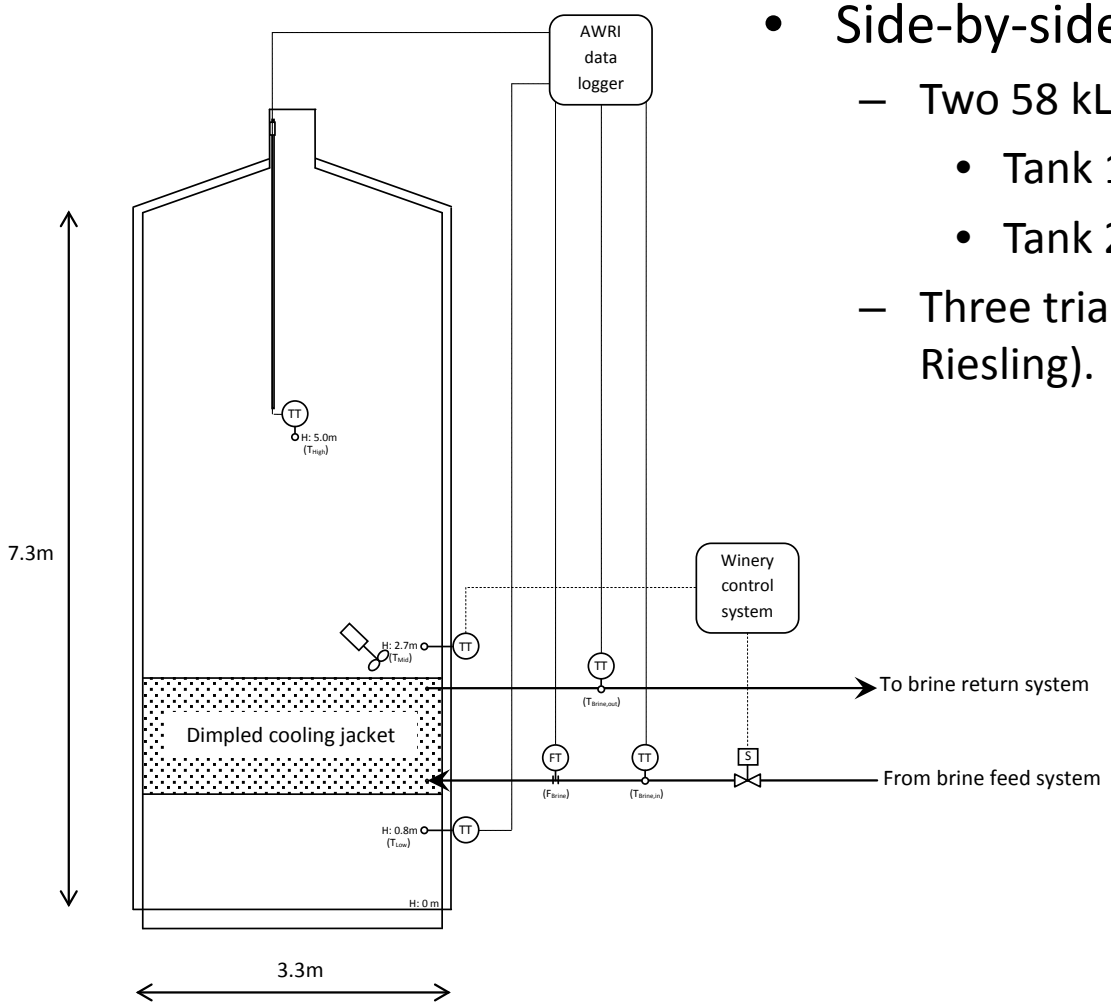
Winery B – Fermentation Temperature



- Side-by-side white fermentation trials:
  - Two 58 kL insulated tanks.
    - Tank 1: ~15 °C.
    - Tank 2: ~19 °C.
  - Three trials (Chardonnay, Semillon, Riesling).

Brine flow meters, Temp. probes

Data logger with cellular connection.

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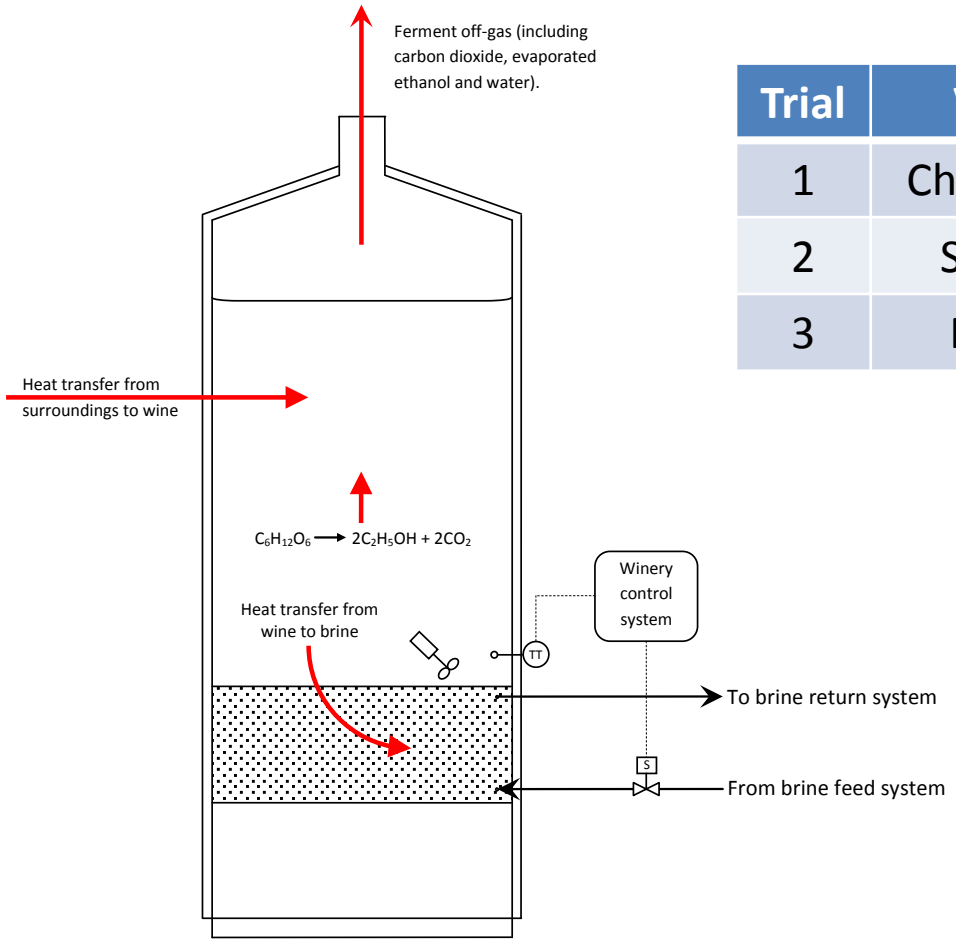
Winery B – Fermentation Temperature



*Energy removed by brine**

Trial	Variety	~15 °C	~19 °C	Δ
1	Chardonnay	91 kJ/L	91 kJ/L	0%
2	Semillon	77 kJ/L	71 kJ/L	8%
3	Riesling	81 kJ/L	78 kJ/L	4%

- Little energy savings benefit in the use of warmer fermentations (of this order of temp. difference).
  - Fermentation reaction is the key generator of heat and there are no reports that the overall energy released from this reaction differs with temperature.
  - Slightly reduced energy use was likely related to increased evaporation of ethanol and water at the warmer temperature.
- Warmer fermentation temperatures may be justified on the basis of fermentation speed in some wineries with limited fermentation tank availability.

*Corrected for sensible heat change of wine (temperature was not constant over the length of the fermentation)

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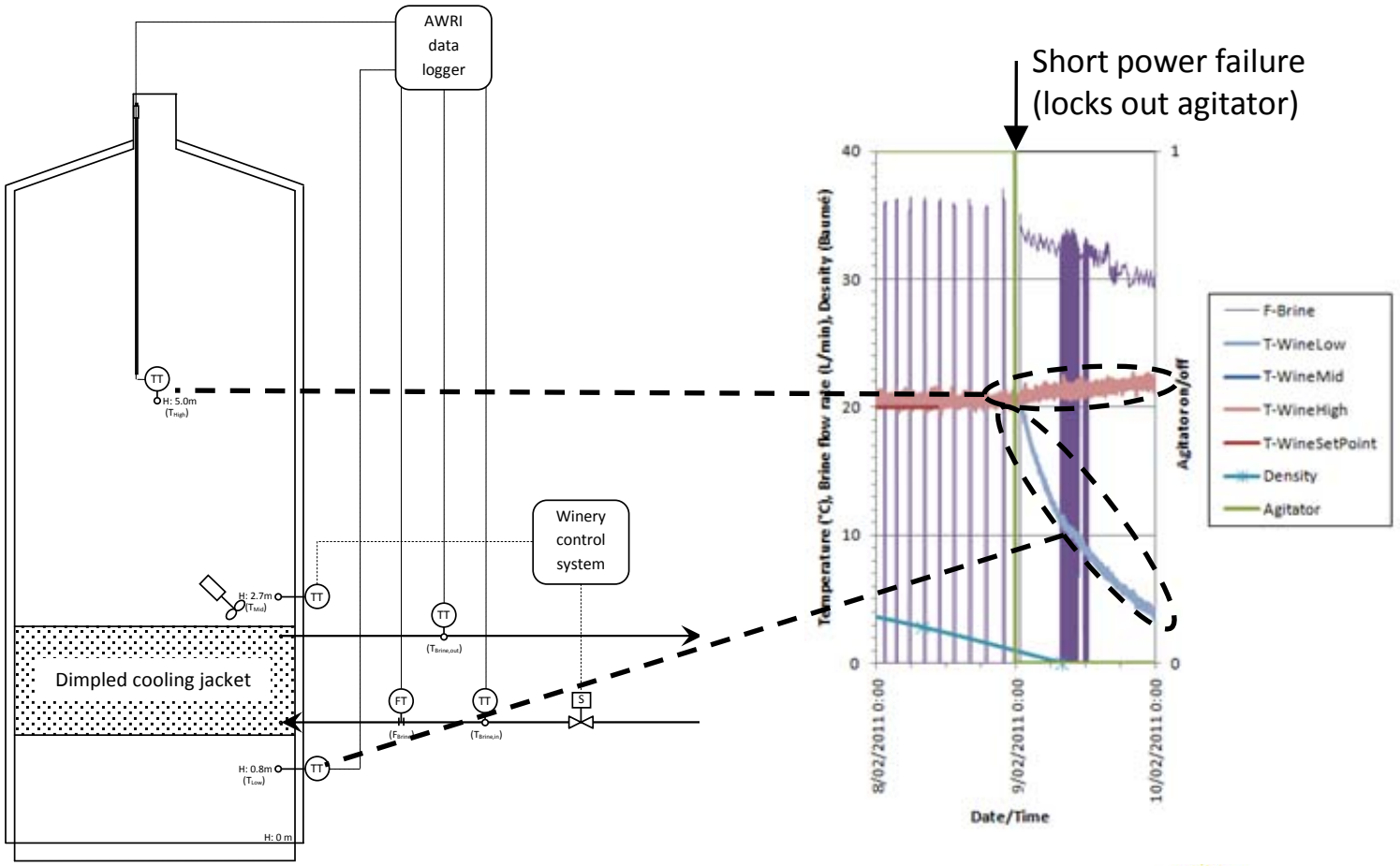
Winery B – Brine Induced Stratification



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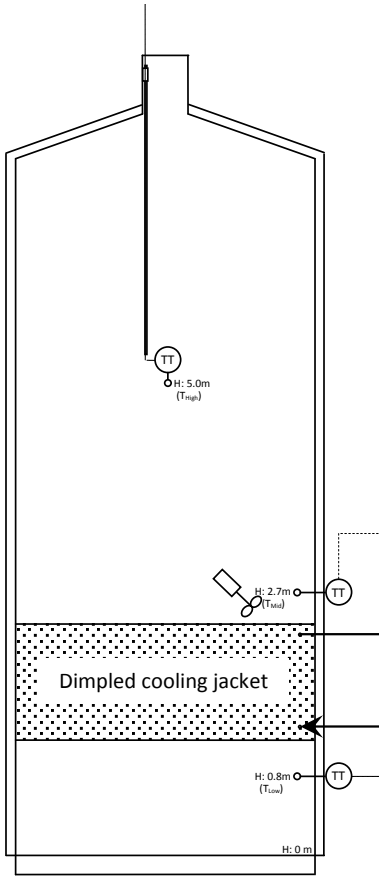
Winery B – Storage Temperature



- Same arrangement now being used for storage temperature trial.
  - Two 58 kL insulated tanks holding same Chardonnay wine.
  - Agitator on when brine is on (to prevent stratification).
  - Wine was at 10 °C prior to going into tanks on 17th March.
  - Average ambient temperature since 17th March : 11.5 °C.

*Preliminary results**

Tank	Set-point (°C)	Pull-down cost (/kL)	Maintenance cost (/kL/month)
1	5	$0.50	$0.40
2	15	$0.00	$0.00

*Experiment is ongoing. Assumptions: $0.15/kW.hr, Aggregate COP:1.5.

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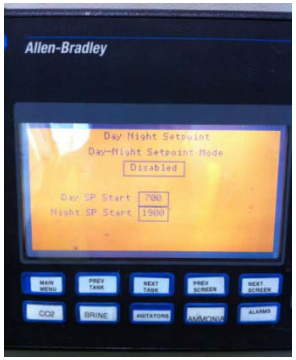
Winery B – Floating Temperatures

Tank Farm



Control Screen

Power Logger

- Trial investigating using different day-time and night-time (i.e. floating) tank set-points.
  - Fridge plant servicing 24 × 10kL tanks.
  - Monitor and compare power usage with floating versus constant tank set-points.
  - Modifications have been made to the control system to accommodate this and track the results.
  - Starting trial shortly.

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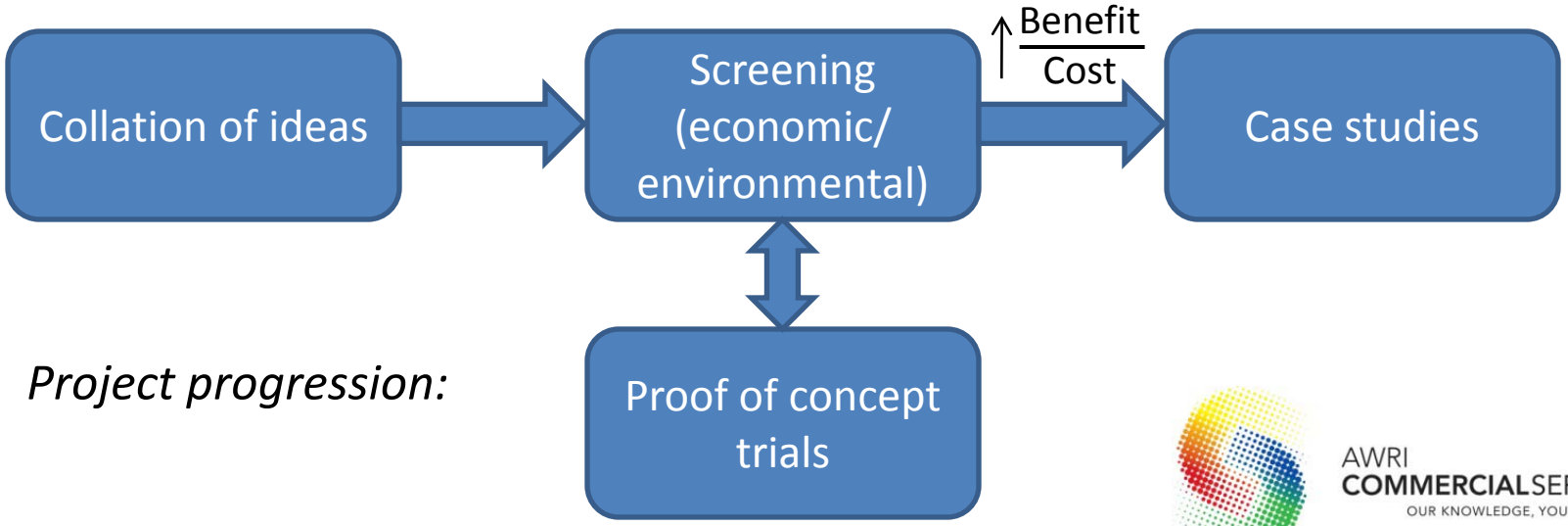
Opportunities For Cleaner Production

- Evaluation of winery technologies/practices which can positively impact winery waste streams, e.g. technologies which may reduce:
  - Wastewater volume.
  - Wastewater pollutant load.
  - Wastewater treatment costs.



Project progression:

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Opportunities For Cleaner Production

(1) Transfers:

- Reuse of must push-water.
- Ice pigging.
- Improving transfer practices (e.g. Pumping speed).
- Improving cut-outs.
- Minimising transfers (e.g. Improved scheduling, cylindricoconical tank usage, ullage management).
- Diverting rainwater from entering wastewater sumps.

(2) Cleaning:

- Chemical evaluation (e.g. NaOH vs. KOH).
- Efficacy of heating cleaning solutions.
- Reuse of cleaning chemicals (mobile and fixed-line).
  - Methods for determination of disposal/top-up.
- Disposal methods for spent-material (e.g. General wastewater, segregated wastewater, off-site processing).
- Barrel cleaning techniques.
- Clean or not clean? (Does it need to be cleaned)

(3) Solids separation:

- Cross-flow lees filtration.
- Wet vacuum.
- Advanced settling tanks.
- Juice flotation.
- Must solids separation (e.g. Static basket screens, trommel screens).
- Prevention of marc leaching by rainwater (e.g. Marc bay roofing).

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Acknowledgements

- Australian grapegrowers and winemakers, the Australian Government and the Grape and Wine Research and Development Corporation for funding.
- Winery A and Winery B for allowing us to perform the *refrigeration* case studies at their sites.
- All the wineries who have offered input so far into the *cleaner production* project.

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