Appita

Driving Decarbonisation in Process Heat

Pulp, Paper and Packaging Sector
Renewable Heat Study

Supported by the Australian Industry Renewable Heat Accelerator & A2EP and delivered in partnership with

Northmore Gordon

Before We begin

Participation

All participants are muted. Please use the **Raise Hand** feature if you wish to speak and we will unmute you when prompted.

Submitting Questions

Please submit questions at any time using the **Q&A** panel (not Chat). A brief posting delay may occur.

Q&A

We will address questions throughout the session as time permits and hold a dedicated Q&A at the end of the presentation.

Agenda

Renewable Heat Study

Process Heat Technologies

Pathways

Q&A

Workshop

Appita FutureProof 2026 Conference 25-26 March

Renewable Heat Workshop

Date: 26th March
Venue: Hyatt Place, Essendon Fields, VIC
Room: Atrium

For more information visit appita.com.

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Renewable Heat Technologies

August 2025

Our Scope

- Preparation, information gathering
- Webinar on renewable heat technologies and the path to renewable heat
- Industry workshop at conference to identify priority areas for development of process heat options in the pulp and paper industry
- Develop 3 high level case studies of the priority areas identified in the workshop
- Provide a report outlining the above plus indicating potential revenue from environmental certificates or grants that could help fund early implementations

Certificate Schemes - Over $150M total to clients
Paper industry – $750,000, $2.5M in the pipeline

	NSW - ESC	VIC - VEEC	Fed - ACCU
Current Price	$23	$80	$37
Minimum saving	500 MWh elect 2,000 GJ gas	200 MWh elect 1,500 GJ gas	2,500 tpa$CO_{2\text{-}e}$
Locations	Single Address	Single Address	Multiple
Revenue	10 years in year 1	10 years in year 1	Annual for 7 years

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Workshop Outline

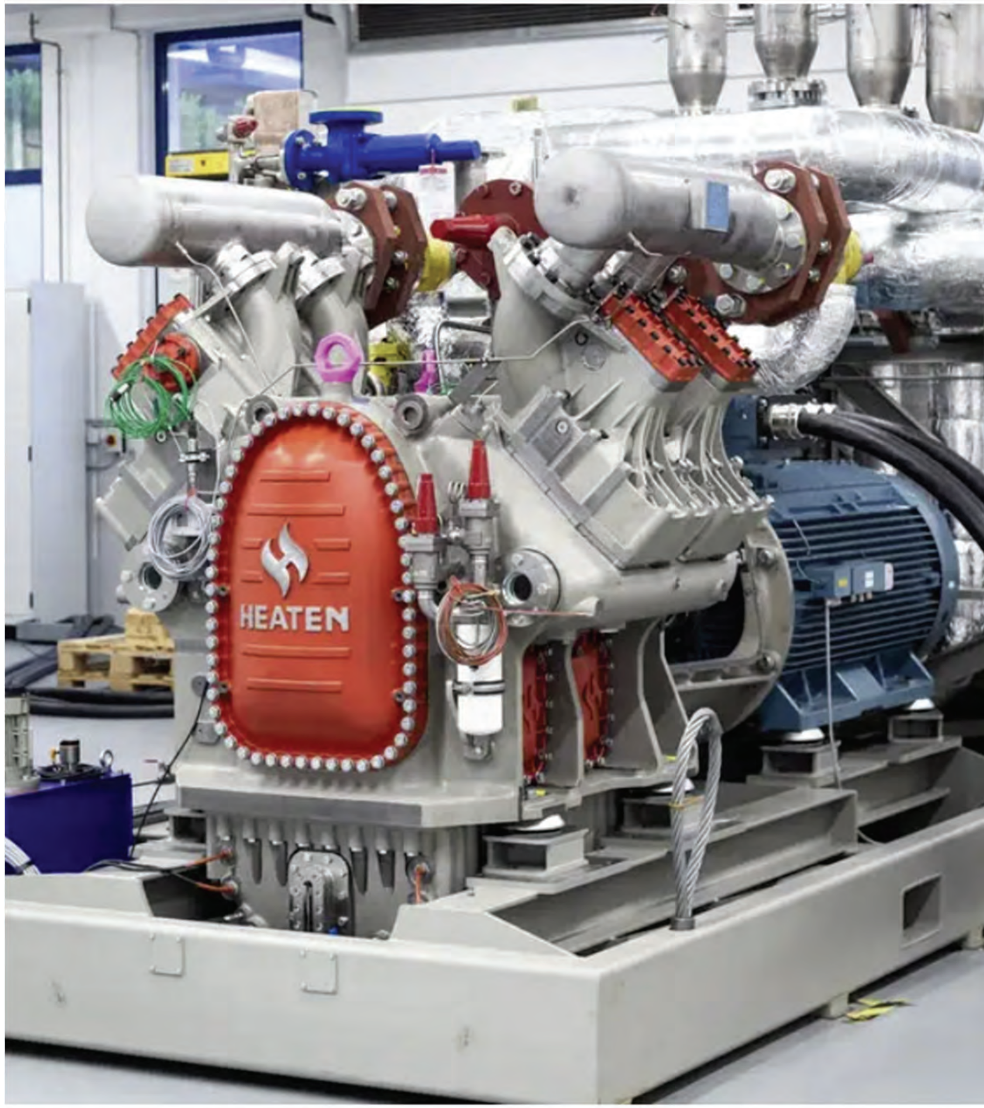
Time	Section	Description
1:30 pm – 1:40 pm	Welcome, Context & Introduction	Overview of the Renewable Process Heat Study, why industry input matters, and how the workshop will shape case studies and investment pathways.
1:40 pm – 2:05 pm	Mapping Heat Use Across the Industry	Collaborative exercise to identify major heat sources/sinks and construct a representative “typical site” heat profile.
2:05 pm – 2:20 pm	Understanding Heat Levels and Demand	Discussion of temperature levels, steam/air flows, pressure characteristics and where heat is concentrated or dissipated.
2:20 pm – 2:30 pm	Visualising the Heat Landscape	Presentation of an aggregated heat map and process schematic to guide opportunity identification.
2:30 pm – 3:10 pm	Opportunities for Heat Recovery	An interactive session exploring where direct or enhanced heat recovery could be applied or improved.
3:10 pm – 3:30 pm	Afternoon Tea	
3:30 pm – 3:50 pm	Technologies That Enable Heat Recovery	Overview of options including heat exchangers, MVR, condensate recovery and integration approaches.
3:50 pm – 4:20 pm	Pathways for Partial Electrification	Industry-led discussion on where electrification might be viable today and which technologies (heat pumps, electric boilers, hybrid systems) could be applied in the near term, based on site constraints and grid considerations.
4:20 pm – 4:40 pm	Completing the Renewable Heat Journey	Exploration of technologies that could support fully renewable heat supply, including low-carbon steam production, bioenergy options and emerging electrification solutions for high-temperature processes.
4:40 pm – 5:00 pm	Prioritising Opportunities & Selecting Case Study Themes	Participants rank each opportunity by indicative scale, cost and implementation difficulty, then work toward consensus on the three priority themes to be developed into detailed case studies for the Renewable Process Heat Study.
5:00 pm – 5:05 pm	Wrap-Up & Next Steps	Summary of key insights and confirmation of next steps for the Appita–Northmore Gordon study, including follow-up engagement and data collection.

Heat Pump (Rankine Cycle)

- Highly efficient for low– to medium-temperature lift (<50°C lift),
- Where waste heat is available can provide up to 180°C
- Usually involves a secondary heating fluid for air heat sources and sinks
- Can be paired with Mechanical Vapour Recompression for steam generation.
- Integration complexity and tariff structures can be a barrier.
- Refrigerants HFC, HFO, ammonia, CO2, HC

Heat Pump COP

- Ambient air sourced heat pumps are available to heat up to 180°C but COP is very low, <2.0
- Typical industrial COP range: 4 -6 for low–medium temperature lift systems



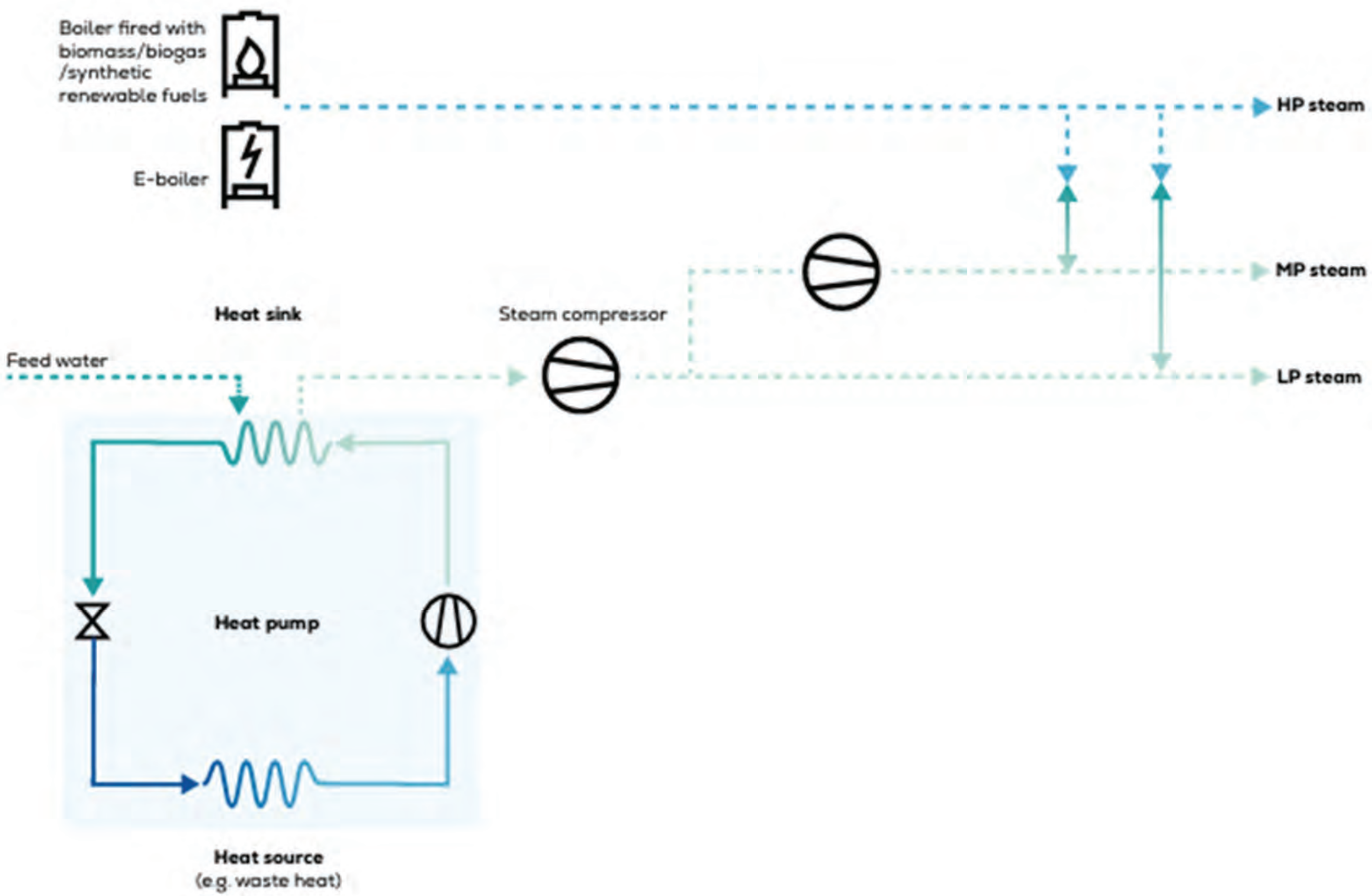
Stirling Engine Heat Pumps

- **Rankine cycle heat pumps:**
- Use latent heat of vapourisation to move heat.
- Refrigerant and system must be designed for specific circumstances to operate optimally.
- **Stirling engine heat pumps:**
- Use gas (helium) expansion and contraction only.
- Have a wider operating range than Rankine cycle heat pumps, and maintain COP across that range (for same temperature lift)
- Still in commercialization stage and hideously expensive

Mechanical Vapour Recompression

- Compress a vapour stream, e.g. LP or flash steam to increase its pressure and temperature using a centrifugal compressor.
- MVR in a closed loop system has a COP slightly less than 1!!
- The COP only increases if it enables use of waste heat vapour streams that can't otherwise be used.
- Being marketed for steam production in the pulp and paper industry

Mechanical Vapour Recompression



Electric Boiler (+BESS)

- Straightforward replacement for gas boilers; high technical readiness.
- COP less than 1!
- High operating cost under standard Australian tariffs—economics only improve with BTM renewable electricity, dynamic tariffs, or storage.
- BESS improves viability by shifting load to low-cost periods and reducing demand charges.
- Usually requires additional electricity supply capacity to be installed

Electric resistance heating

- Resistive heating element – potential option for direct heating of process/ product. (Corrugator hot bed)
- COP < 1
- Good control, low maintenance and absence of emissions from combustion
- High operating cost under standard Australian tariffs—economics only improve with renewable electricity, dynamic tariffs, or storage.
- BESS improves viability by shifting load to low-cost periods and reducing demand charges.
- Often requires additional electricity supply capacity to be installed

Electromagenetic heating

- Use electromagnetic waves to heat the target indirectly.
- Accurate delivery of energy to the point of need
- Microwave, Dielectric, Infrared, Induction, Ultraviolet
- High operating cost under standard Australian tariffs—economics improve with renewable electricity, dynamic tariffs, or storage.
- BESS improves viability by shifting load to low-cost periods and reducing demand charges.
- Often requires additional electricity supply capacity to be installed

Electric Thermal Energy Storage (eTES)

- Stores heat from electricity during low-tariff periods
- Can generate steam or heat other transfer fluids (e.g. thermal oil).
- Usually most cost effective for partial gas replacement, not 100%
- Enables integration with renewables
- Requires additional electricity supply capacity to be installed

Hydrogen

- Hydrogen as a gas replacement for boiler or furnace, has a very high flame temperature making NO_x emissions a problem.
- Hydrogen can be used to generate electricity in a fuel cell, but this will always be way more expensive than simple storage of electricity
- No matter how you frame it, renewable hydrogen will always be more expensive than renewable electricity as a heat source

Biomass/ Biogas/ Biomethane

- Commercially mature for continuous process heat; widely deployed globally.
- High capex and site impacts for biomass: fuel storage, handling equipment, completely different boiler technology.
- Biogas is great if you have a waste stream to use in a digester
- Biomethane from the gas network will be a future option but looking like a higher cost than natural gas at this stage.

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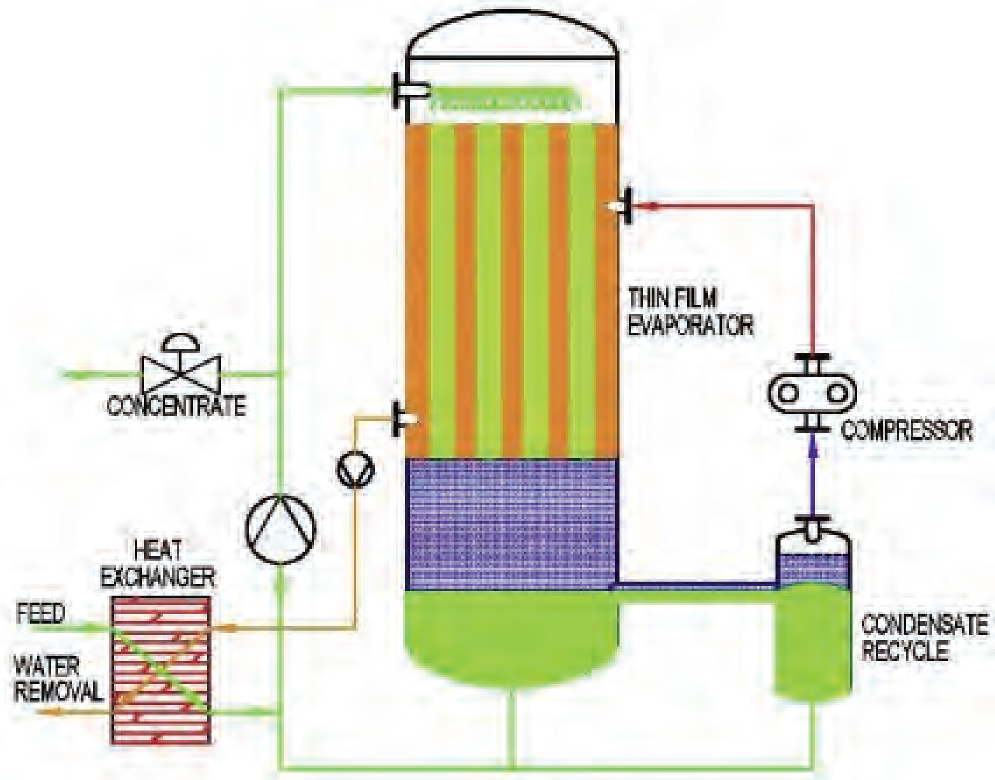
Industry Specific Examples

Mechanical Vapour Recompression

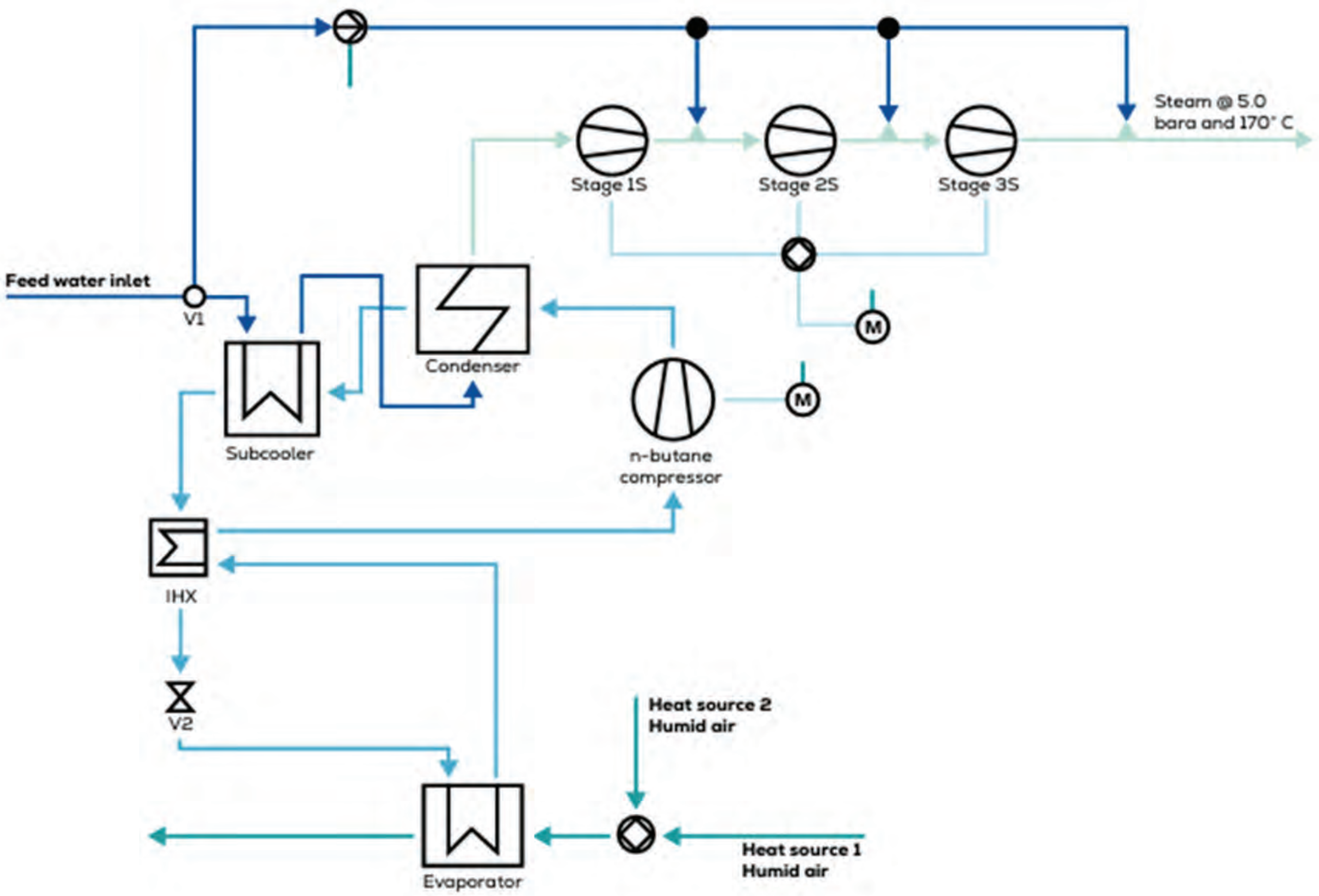
- Suppliers in Europe are offering MVR and heat pump for heat recovery to produce steam in paper mills
- In the dairy industry they are very effective in open loop configuration on thin film evaporators – no equivalent in paper industry.
- Typically 5C to 10C temp rise per stage
- Up to 8 blowers in series are used.

Mechanical Vapour Recompression



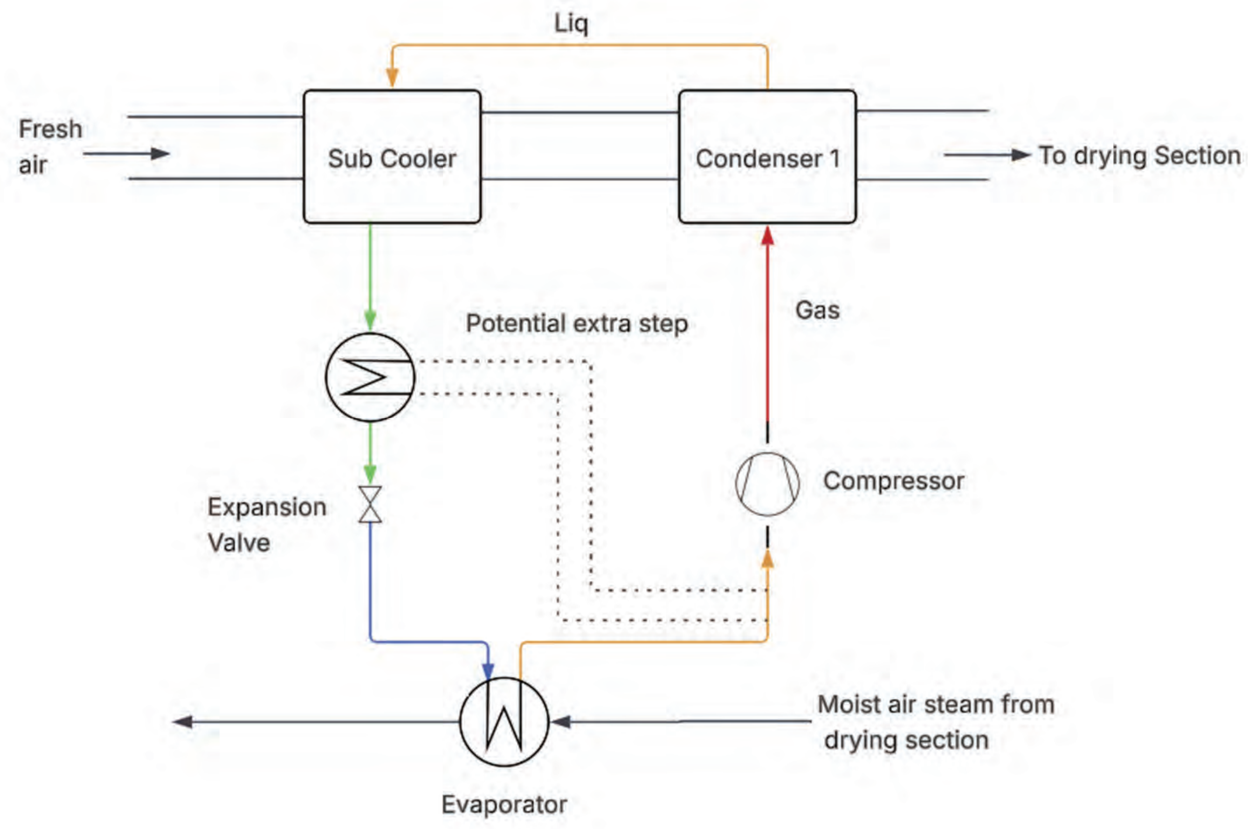
Mechanical Vapour Recompression

- This system designed for a paper mill might achieve a COP of just over **2**



MVR Alternative

- This heat pump system designed for the same heating duty will achieve a COP of **5 to 6**
- **2.5 to 3 times lower electricity cost than the MVR option being marketed currently**



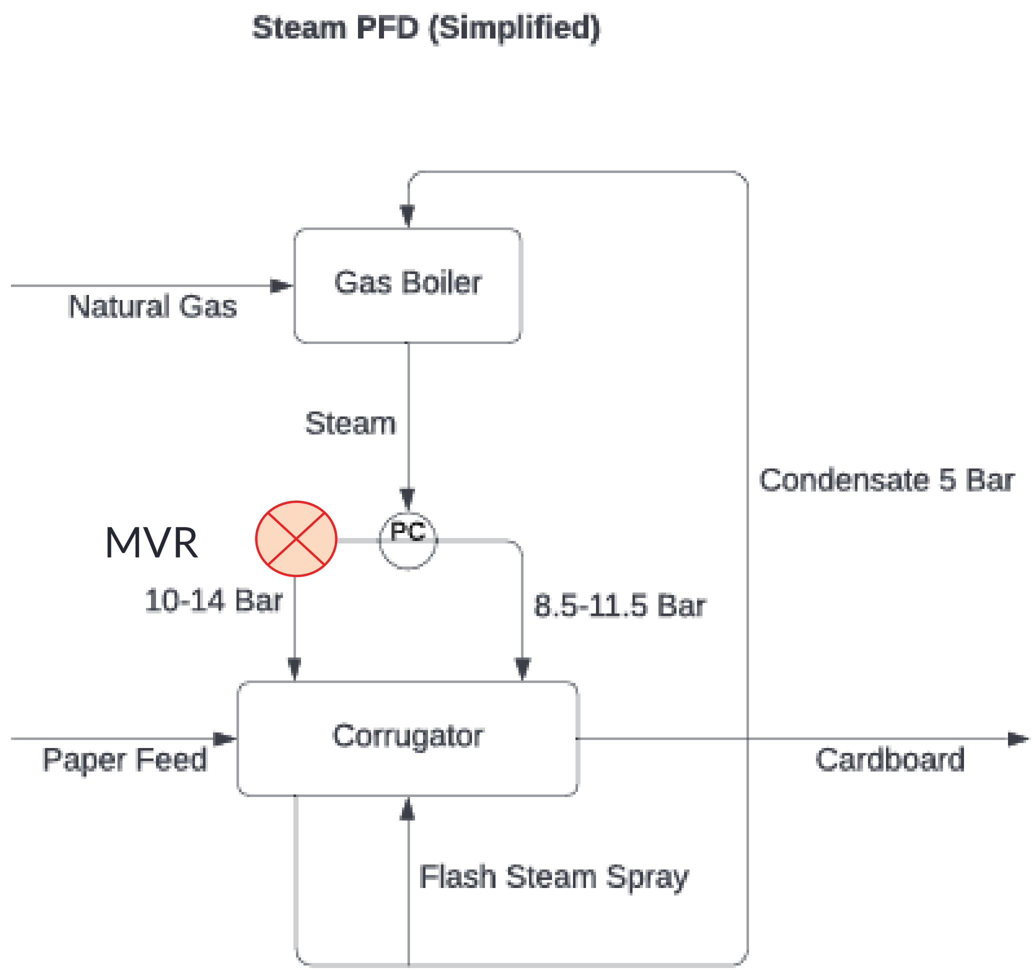
*Note, this diagram doesn't show secondary heating fluid loops which are usual for large heat pump systems

Drying Cans

- Heat with internal electric resistance heating that is stationary, similar to the existing steam supply approach
  - No steam system losses, so some gain in system heat efficiency
  - COP below 1
  - Ok if your aim is simply electrification, can add BESS
- Use MVR to boost LP steam generated from NG or biogas
  - Steam system losses remain the same
  - COP below 1
  - No ability to minimize peak demand charge

Mechanical Vapour Recompression

No different to putting in an electric boiler with separate feed pump for HP steam



Drying Cans

- Have an eboiler specifically for drying cans (with heat pumps for drying air)
    - COP below 1
    - Ok if your aim is simply electrification, can add BESS to minimize peak demand charges
- eTES for drying cans
    - Steam system losses remain the same
    - COP below 1
    - Minimizes peak demand charge without BESS

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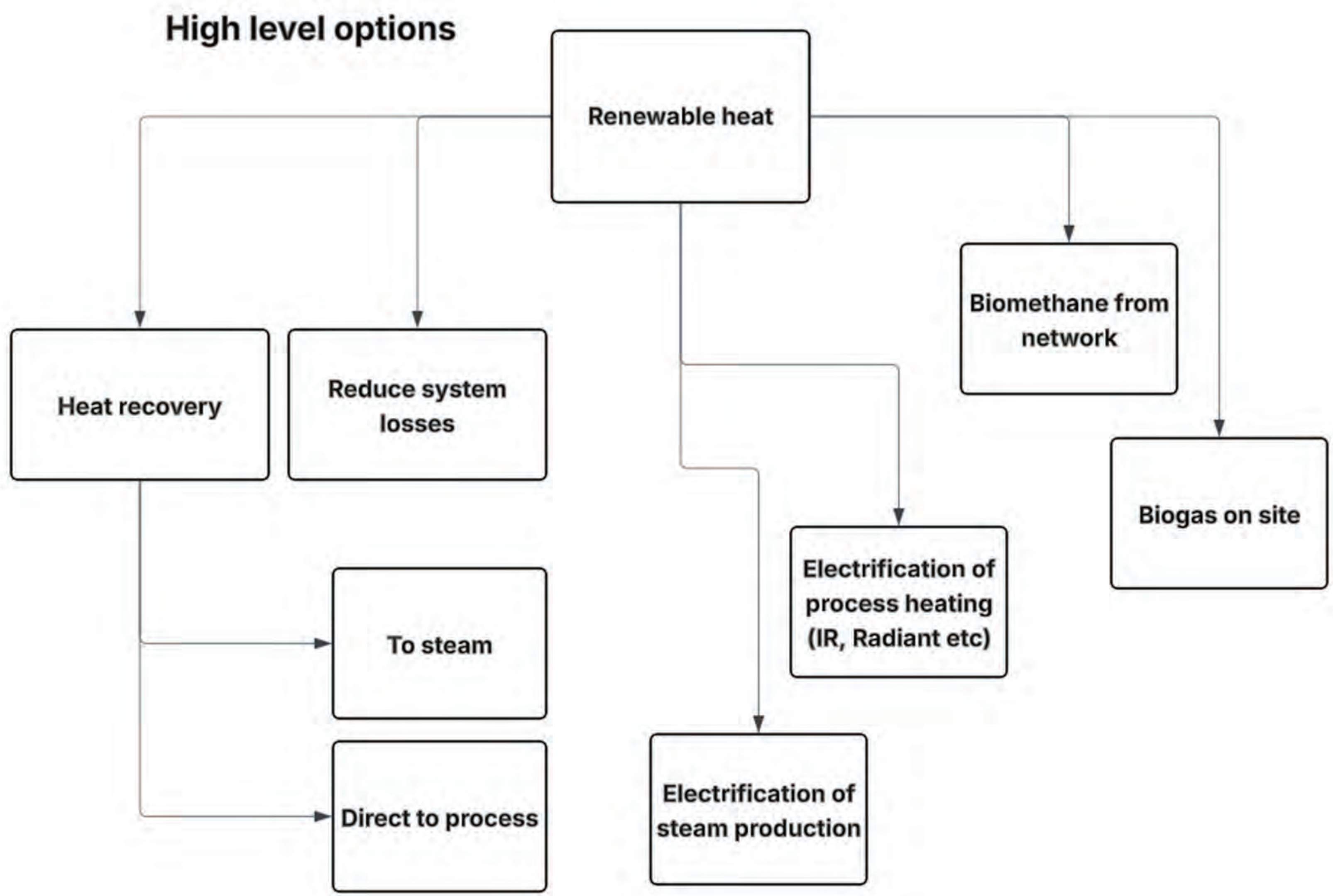
Renewable Heat Pathways

August 2025

Pathway



High level options
Renewable heat
Heat recovery
Reduce system losses
To steam
Direct to process
Biomethane from network
Biogas on site
Electrification of process heating (IR, Radiant etc)
Electrification of steam production

Efficiency first

Reducing the heat demand per unit of production is nearly always the most cost-effective way to reduce carbon emissions

- Minimise heat losses (steam leaks etc)
- Maximise heat recovery in boiler systems *and* processes (use enhanced heat recovery)
- Maximise use of biogas as a heating fuel rather than generating electricity (reduces capex for alternative heating options)
- Try to use heat rejection from chillers and air compressors if possible

The importance of COP

- With a COP of 1 (e.g. eboiler, microwave, resistance, IR), operating cost for heating is roughly $42* per GJ.
- Using a heat pump with a COP of 5 (waste heat) the operating cost for heating is roughly **$8.30 per GJ**
- Paper mill direct heat recovery replacement (already getting some heat for free) –
  - COP estimate of 6 from an example
  - effective COP of 3.1 (after allowing for existing heat recovery)
  - operating cost for heating is roughly **$13.60 per GJ**

* Assuming a $150/MWh electricity cost

Mechanical Vapour Recompression – COP

- MVR alone has a COP slightly less than 1!!
- The COP only increases if it enables use of waste heat vapour streams that can’t otherwise be used.
- In the dairy industry they are very effective in open loop configuration on surface film evaporators – no equivalent in paper industry.
- MVR steam boosting (closed loop) for drying cans (maybe) v drying air (not ideal)

Electrification considerations

- Electric options to enhance heat recovery
- COP
- Tariff structure – HV/ LV, demand charges etc
- BTM renewable electricity
- Energy storage