SNAPSHOT

SUPERHEATED STEAM SYSTEMS FOR TURBINE GENERATION AND THEIR APPLICABILITY TO THE RED MEAT PROCESSING INDUSTRY

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Project Description

This report investigated the feasibility of superheated steam power generation in Australian red meat processing facilities. A range of technologies including condensing turbines, extraction turbines, back pressure turbines (BPTs), economizers, concentrated solar thermal (CST) and a range of fuels (coal, natural gas, woodchip, biomass, biogas, LPG) were considered.

The technology found to be most technically and economically viable, back pressure turbines, is summarized in Figure 1 below.

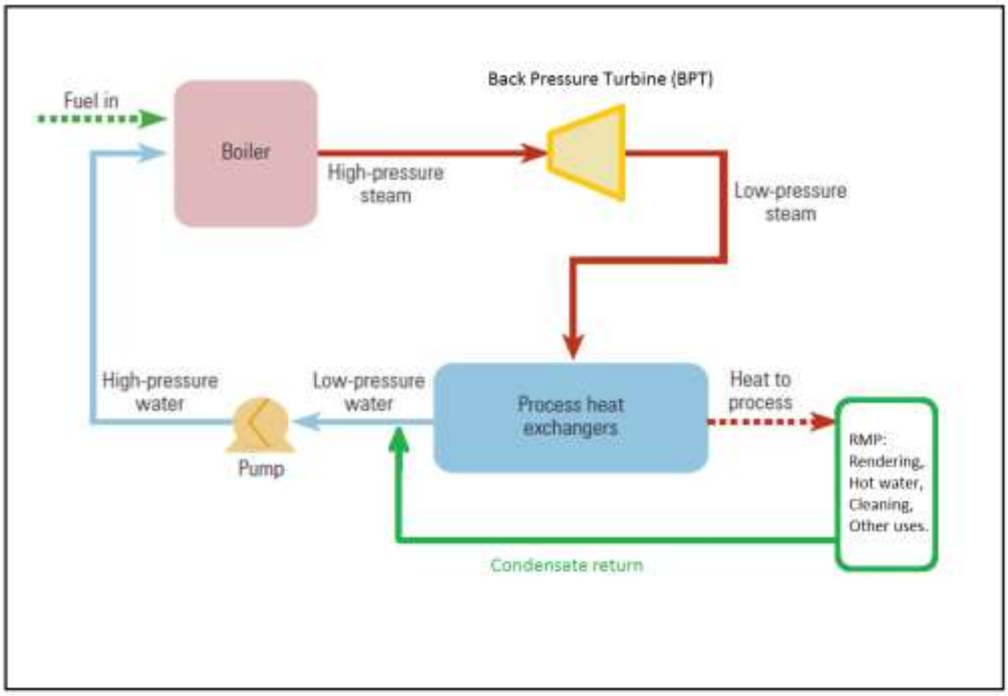

Figure 1: Schematic of a back pressure turbine (BPT) coupled to a typical Red Meat Processor (RMP) plant steam system[1].

[1] Adapted from "*Typical Thermal Plant Schematic", Casten, S, 2005, Recycling Waste Pressure into Electricity, Turbosteam Corp.*

Project Content

The analysis was completed for a “typical” red meat process facility which processes 625 head of cattle per day[2], running a 2 shift per day roster, 250 days per annum operation. The key assumptions made for the cost-benefit analysis were:

	Assumption	Information / Reference
1	Natural gas price $12 / GJ. Coal at $4.37 Woodchip at $4.17 (air dried hardwood chip)	Approximate median commercial rates (east coast Australia)
2	Electricity – $ 0.18 / kWh Network Charge: $ 262.308 kVA/year	Approximate commercial retail rates for power from the grid
	Largescale Generation Certificates (LGCs) for Renewable Energy at $60 / MWh	Approximate rates for long term contracts. Spot price was at $79.10 at 30 June 2017[3].
3	Steam provided to RMP at 6 barg pressure at a rate of 5 tonnes per hour (tph)	Mass and energy balance result for a “typical” facility based on industry data.
4	All power from BPT consumed onsite (up to 2661 kWe of power can be consumed during operating hours hence no requirement for exporting to the grid)	
5	Two scenarios were run for equipment procurement: [1] New boiler i.e. full capital cost of a new 24 barg boiler and BPT. [2] Boiler replacing an end of life boiler (i.e. additional capital for generating high pressure steam at 24 barg (rather than 6 barg) and BPT. For both scenarios, 5 tph 24 barg steam expanded in a BPT with an exhaust pressure of 6 barg is estimated to generate 130 kW of electrical power (130 kWe).	
6	No indexing (CPI), discounting, tax considerations or depreciation applied to future revenue / costs.	

There is no material difference in the capital cost for a new, fully installed boiler raising steam to moderate pressures of 24 barg in comparison to a boiler raising steam to 10 barg. However, retrofitting a boiler from 10 barg to 24 barg is prohibitively expensive to the point where it would be more economically viable to procure a high efficiency off-the-shelf 24 barg boiler and place the 10 barg boiler into stand-by / redundant mode. It was assumed that LGCs and Emissions Reduction Credits (at $8.274 / t CO2-e, which allows for project administration costs) were created when switching from coal or natural gas to a woodchip fired boiler with BPT.

Project Outcome

The key findings for a 1340 kW backpressure turbine are summarized in Table 1 below s the findings for generation of 130 kW of net power from high pressure steam for a “typical” 625 head per day facility operating for 2 shifts per day, 5 days per week.

Table 1: Key findings for generation of 130 kW of power via a Back Pressure Turbine (BPT)

Scenario	Fuel	Cap ex	Simple payback
New 24 barg boiler and 130 kWe BPT	Coal	$3.174 mil	Not in life of plant (39 years)
	Swapping from coal to woodchip		20 years
	Swapping from natural gas to woodchip		5 years
Replacing end of life boiler with 24 barg boiler and 130 kWe BPT	Coal	$0.975 mil	12 years
	Swapping from coal to woodchip		6 years
	Swapping from natural gas to woodchip		2 years

[2] www.mla.com.au/download/finalreports?itemId=3112, accessed 3 August 2016.
[3] http://greenmarkets.com.au/, accessed 7 July 2017.

A concentrated solar thermal (CST) plant creating 24 barg stream with a 130 kWe BPT for a "typical" red meat processing facility may deliver a 12-year payback in comparison to natural gas. However, for a regional facility paying high fringe of grid power prices or running a diesel gen set (e.g. power at $0.28 / kWh) and using a high cost fuel to raise steam (e.g. LPG at $30 / GJ) a 5-year payback could be achieved. Some remote area and regional feedlots may fit into this category. Schemes such as grants from the Australian Renewable Energy Agency (ARENA) could assist with reducing capital costs. One recommendation for CST is to monitor the technology until it becomes sufficiently mature that the Total Installed Capital is at an acceptable level to deliver the desired payback period.

Benefit for Industry

To reduce operating costs and hence maintain profit margins, the red meat industry requires:
[1] a clear plan for decoupling from internationally traded and exported energy commodities to improve business continuity,
[2] a clear plan for how RMPs can decouple from fossil fuels, and
[3] a clear plan for how RMPs can remove the risk of exposure to energy pricing via energy efficiency and on-site energy generation.
Further, the above requirements will also contribute to maintaining the @clean and green@ image of Australian red meat.

By being informed of technically and economically viable technologies, RMPs are able to make informed decisions on fuel and technology combinations in order to maintain business continuity and reduce energy price exposure.

Boilers for raising steam to moderate pressures (24 barg) with an associated backpressure turbine can provide payback periods of 5 years or less when swapping from natural gas to a biomass fuel at around $4/GJ lower heating value (LHV). The economic viability for a back pressure turbine is also reasonable when an end of life boiler is being considered for replacement or standby mode.