Design of a Biomass Cogeneration System

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PROJECT SCOPE

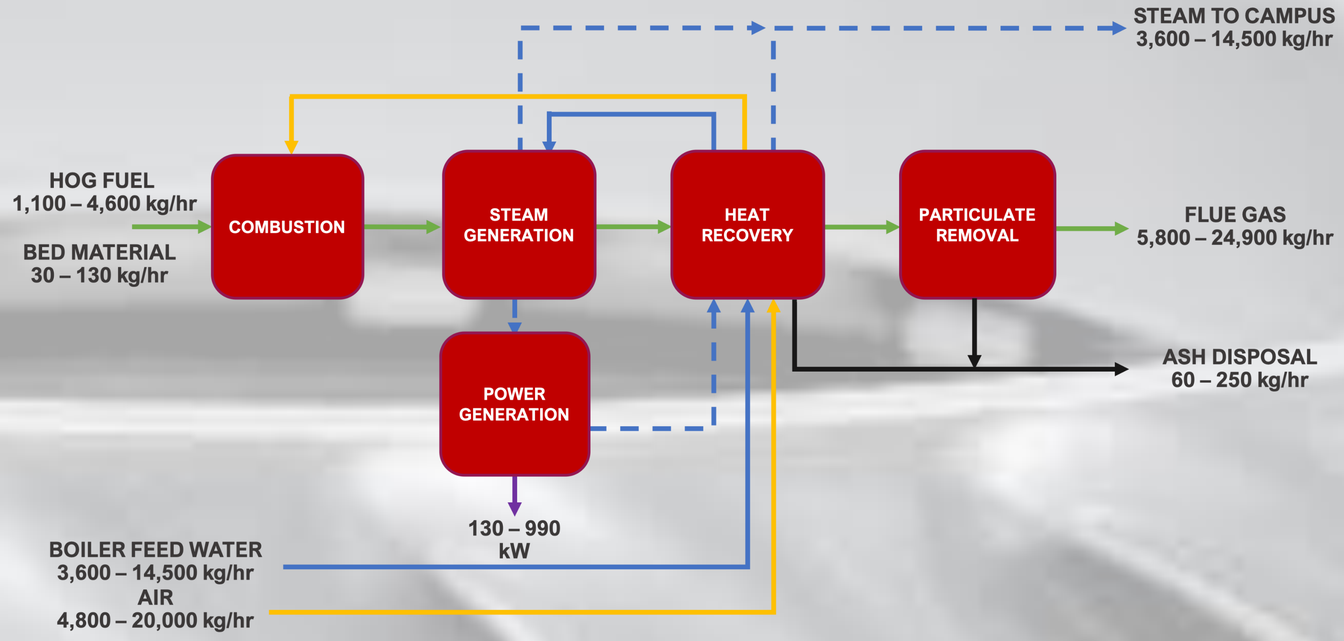
BACKGROUND

The Central Heating Plant (CHP) located at the University of New Brunswick, Fredericton Campus was built in 1970. During renovations in 1984, Boiler #1 was added as the baseload boiler and is now reaching its end of life.

OBJECTIVE

The objective of the project is to design a replacement boiler for Boiler #1. The replacement will be required to produce a minimum of 3,600 kg/hr of saturated steam at 1,480 kPa. Secondary objectives include investigating cogeneration, improving efficiency, and maintaining a low carbon footprint for the boiler.

PROPOSED DESIGN



COMBUSTION

Biomass and preheated air enter the circulating fluidized bed (CFB) boiler where they combust. The hot flue gas enters Steam Generation.

STEAM GENERATION

Steam is produced in the boiler water walls and passes through the superheater before entering the turbines.

POWER GENERATION

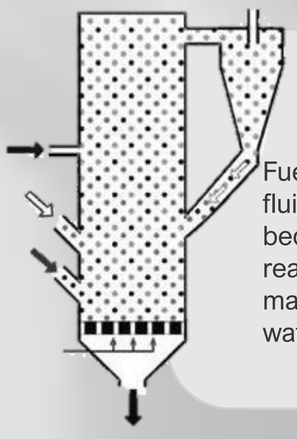
Superheated steam enters Power Generation where it splits to feed into a 3,600 kg/hr and 10,900 kg/hr turbines.

HEAT RECOVERY

Air and boiler feedwater are preheated by passing through the air preheater and economizer, respectively before entering combustion steam generation.

PARTICULATE REMOVAL

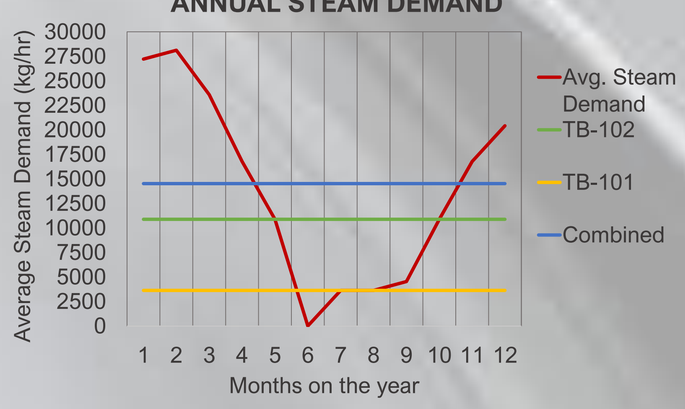
Flue gas passes through the electrostatic precipitator to remove the particulate matter before exiting the stack to the atmosphere.

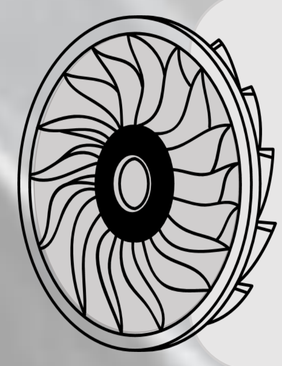


CIRCULATING FLUIDIZED BED

Fuel is combusted with air in a fluidized bed, directly in contact with bed material. The combustion reaction releases heat to the bed material which is transferred to the water walls, producing steam.

ANNUAL STEAM DEMAND



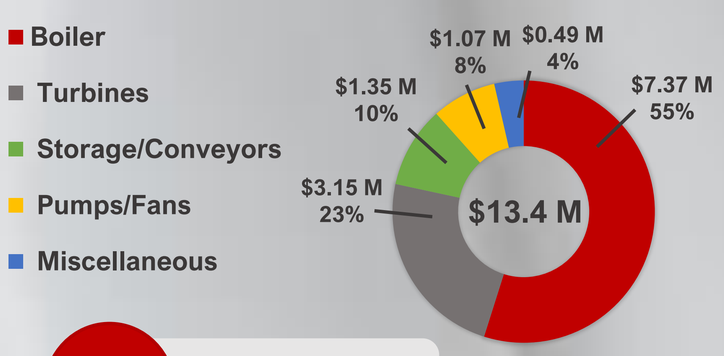


DUAL STEAM TURBINES

Two turbines were implemented to maximize the electrical power output of the system due to the seasonal variation of steam demand. Turbines TB-101 and TB-102 operate at 3,600 kg/hr and 10,900 kg/hr, respectively.

ECONOMICS

FIXED CAPITAL COST



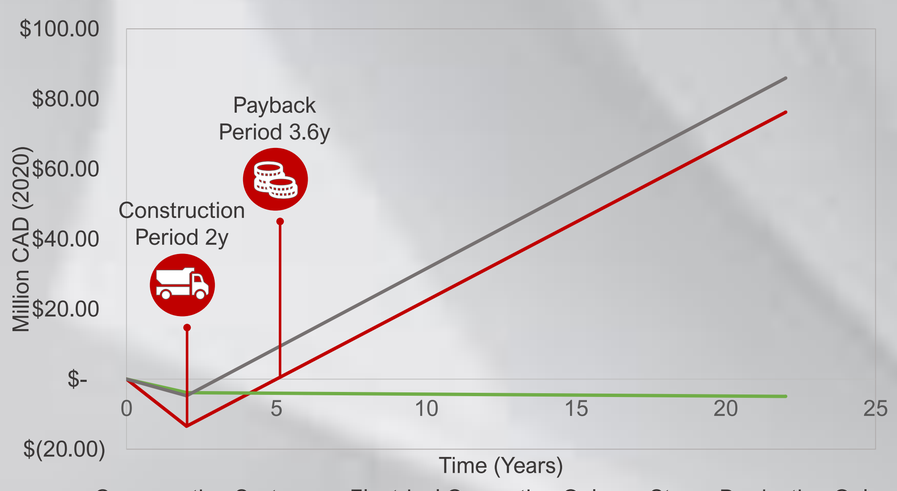
$14.1M — TOTAL CAPITAL COST

$3.8M — ANNUAL MARGIN

28% — INTERNAL RATE OF RETURN & RETURN ON INVESTMENT

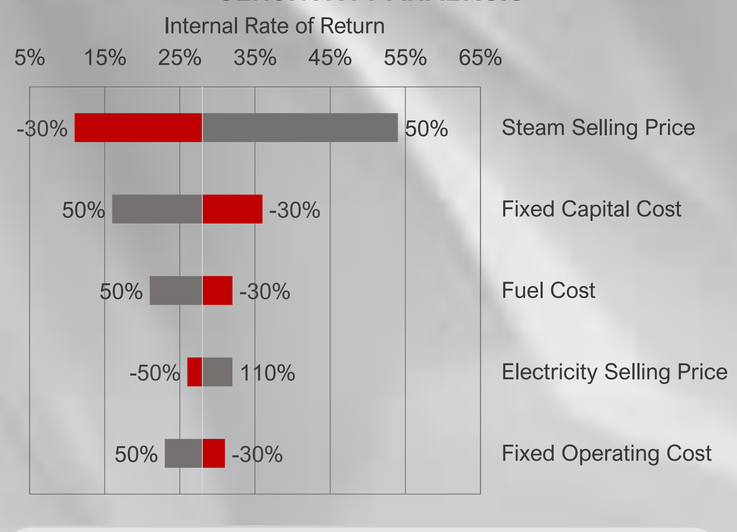
- Overall proposed design was determined to be feasible
- Steam Production Only yield greater economic benefits

NON- DISCOUNTED CUMULATIVE CASH FLOW*



* Not including labour

SENSITIVITY ANALYSIS



Variables	Values
Steam Selling Price	$35.7/1000 kg steam
Fixed Capital Cost	$13.6 M
Fuel Cost	$67/tonne of hog fuel
Electricity Selling Price	$0.0954/kWh
Fixed Operating Cost	$1.2 M

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSION

- The proposed design system efficiency increased by 16% from the current system to a value of 79%
- Hog fuel has allowed the system to have a low carbon footprint
- Electrical production determined to be not feasible

RECOMMENDATIONS

- Further investigate alternative boilers types and compare their turndown abilities
- Refrain from implementing a cogeneration system, as only producing steam is more economically viable
- Consider increasing the steam production to the maximum steam demand

ACKNOWLEDGEMENTS

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