Diversification of sustainable energy sources for process heat, using digital simulation

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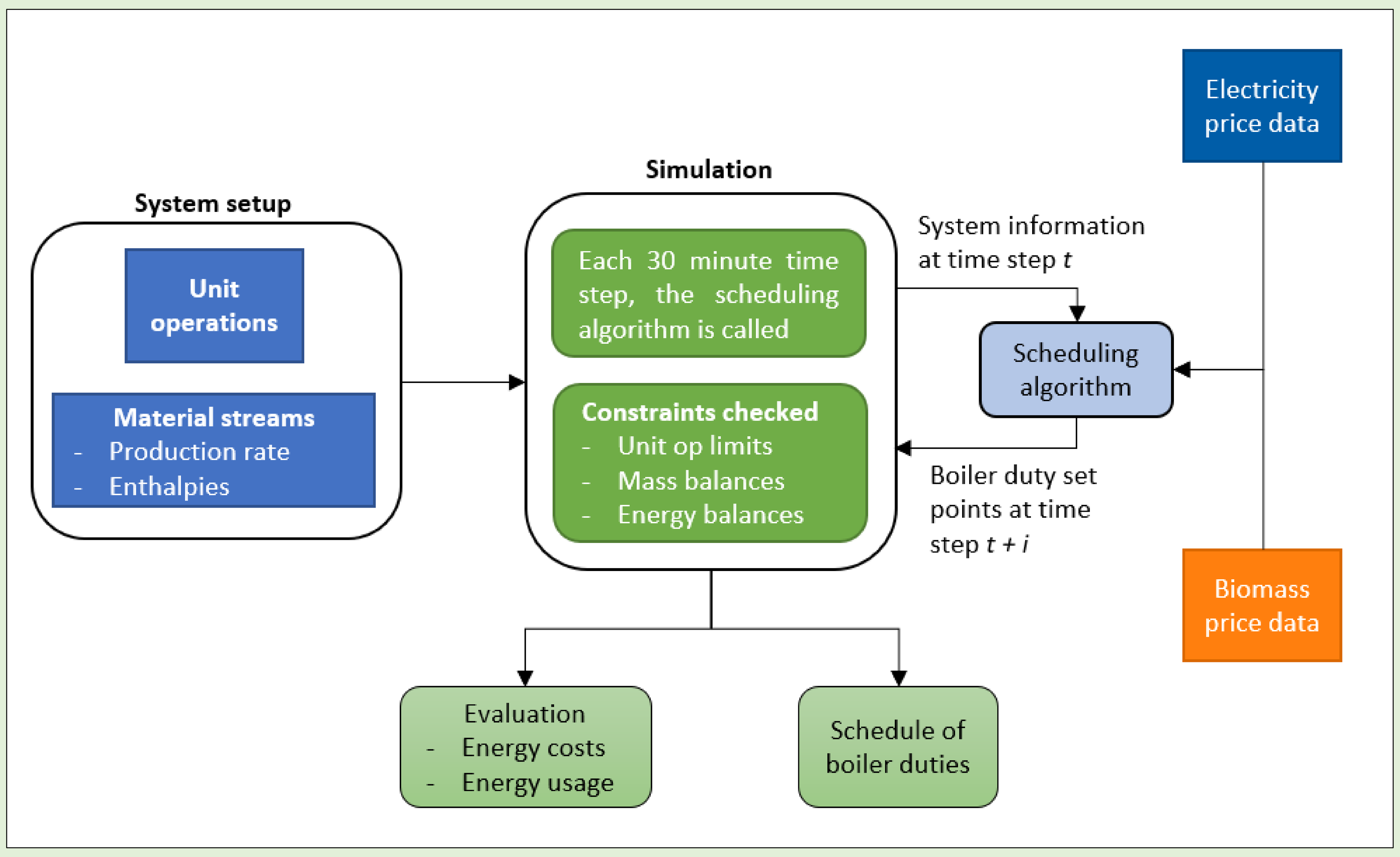
Background

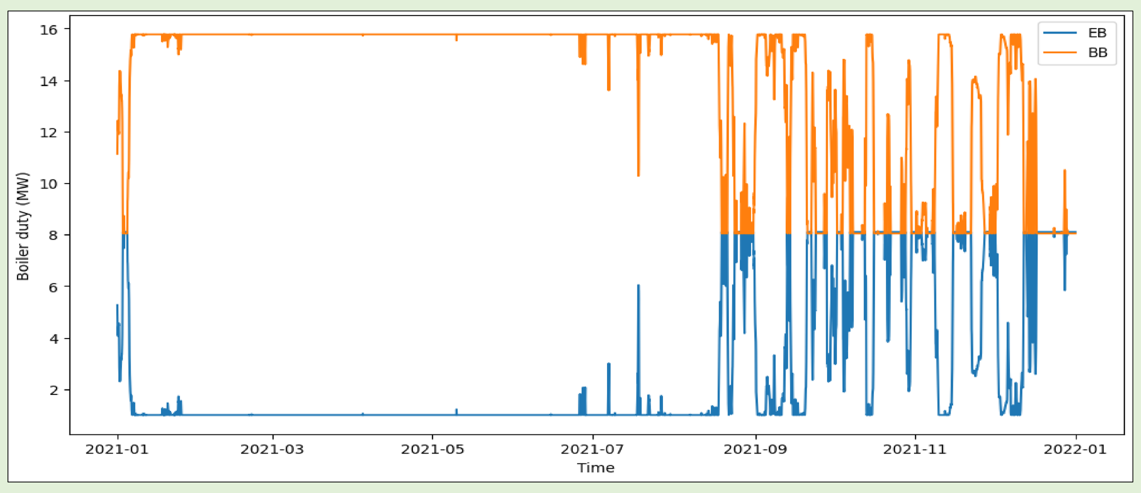
To address climate change, the industrial sector must transition to more sustainable practices, including decarbonisation of process heat. New Zealand's grid is already significantly integrated with renewable energy sources, incentivising electrification as a sustainable approach

Renewable energy sources typically suffer from intermittency, influencing grid supply and electricity costs. This is problematic for industrial systems requiring constant energy input. A potential solution is **hybrid utility systems**, where a combination of energy sources are used to meet demand, in a dynamic balance.

Modelling framework



Operations



Decision support

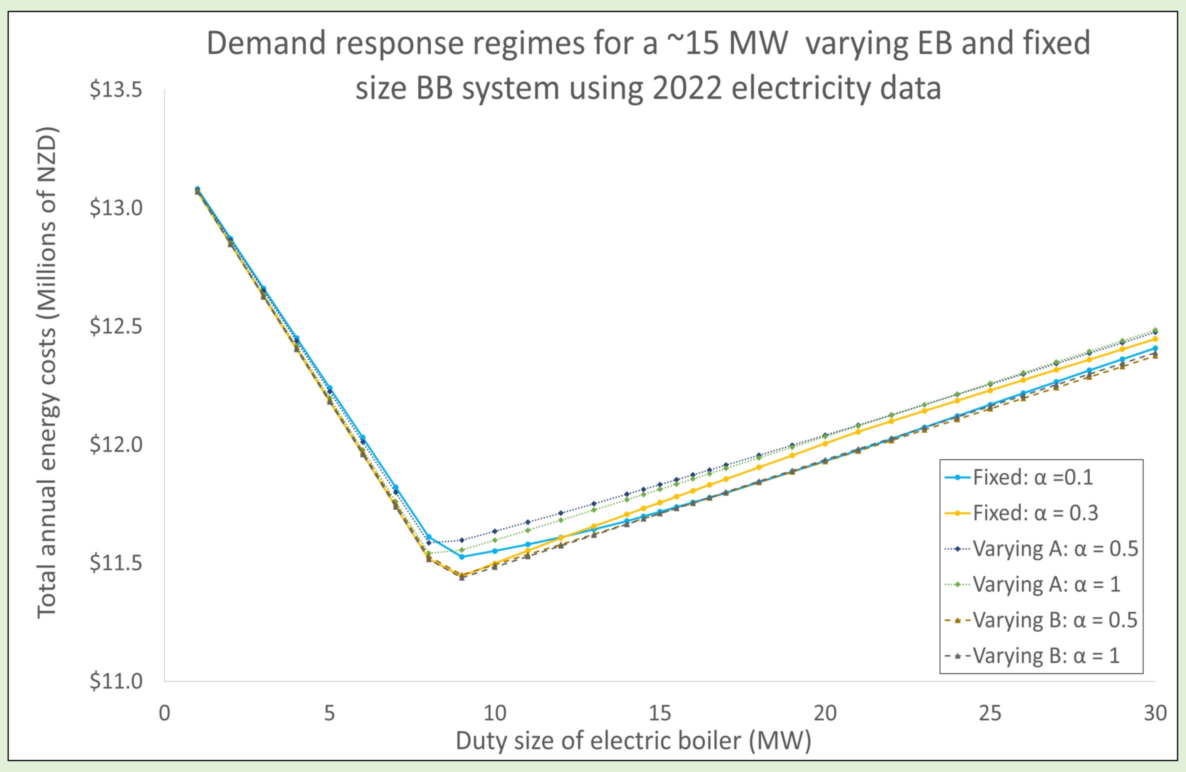
This graphical output displays the ideal schedule of set points for the duty of the boilers, based on the conditions provided to the algorithm.

Demand response regimes

Regime	Mathematical representation
Fixed magnitude	$EB\ duty_{t+i} = \alpha EB\ duty_t$
Varying magnitude A	$EB\ duty_{t+i} = (1 - \alpha \dfrac{Electricity\ price_i}{Biomass\ price} + \alpha) EB\ duty_t$
Varying magnitude B	$EB\ duty_{t+i} = (\dfrac{Biomass\ price}{Electricity\ price_i})^{\alpha} EB\ duty_t$

- **Fixed:** $0.1 \leq \alpha \leq 0.4$
- **Varying:** $0.1 \leq \alpha \leq 2$

Regimes with larger fixed duty change and where duty change was based on the ratio of prices exhibited better performance, due to greater responsiveness to volatile changes in the electricity market.



Conclusions

- Hybrid systems with minimal cost reduce energy costs by 13-15%, compared with BB only systems.
- Configurations with a smaller EB and fully sized BB perform best.
- Demand response regimes with larger magnitudes tend to perform best.

Aims

- Examine which hybrid utility system configuration and sizing results in minimal energy costs.
- Determine which demand response regime is best across the scenarios considered.

System

Hybrid utility system

Electric boiler (EB)
- High efficiency (98-99%)
- Demand response with grid when advantageous

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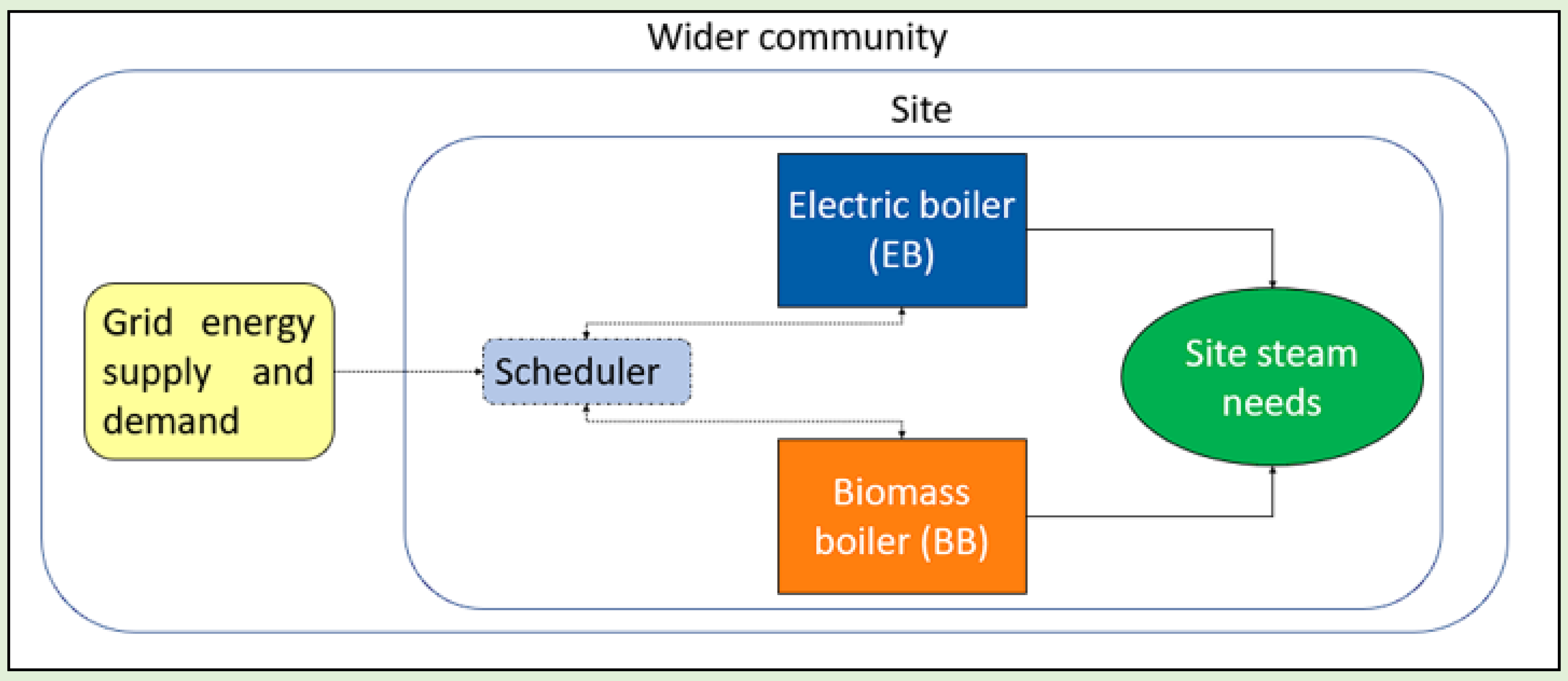
Biomass boiler (BB)
- On-site secure supply
- Provides stability, mitigating electricity market volatility

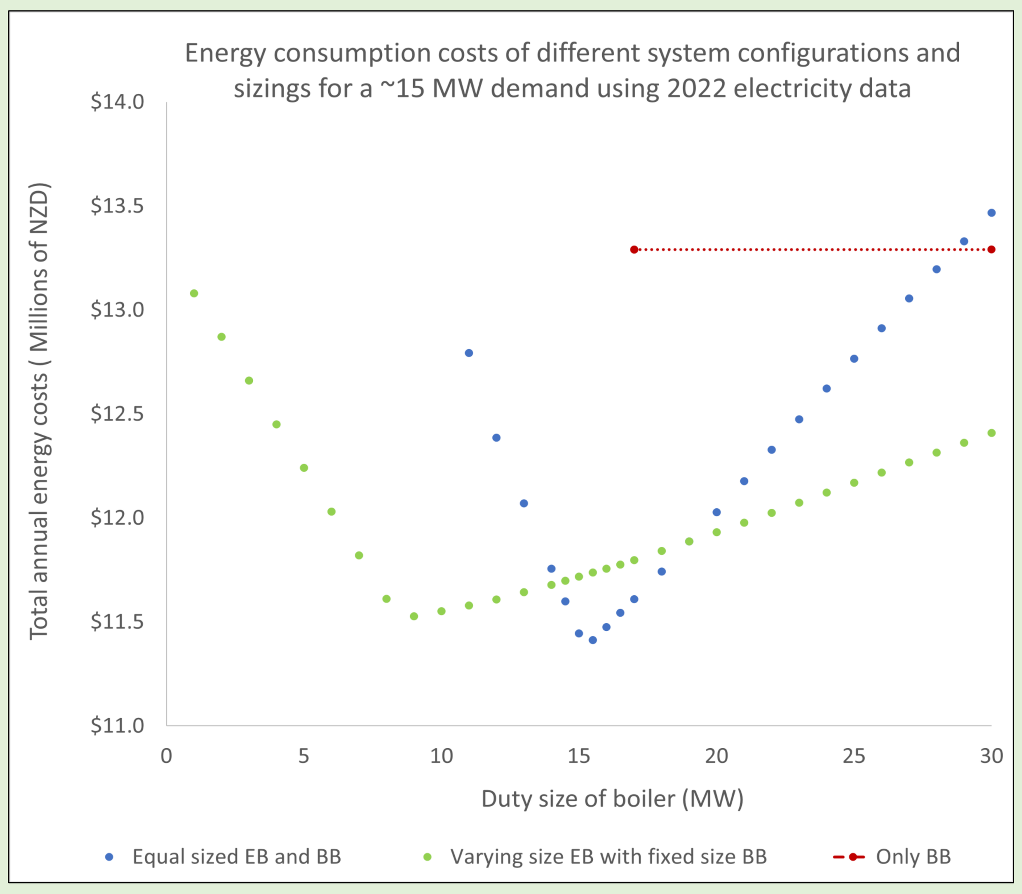


Design and retrofit

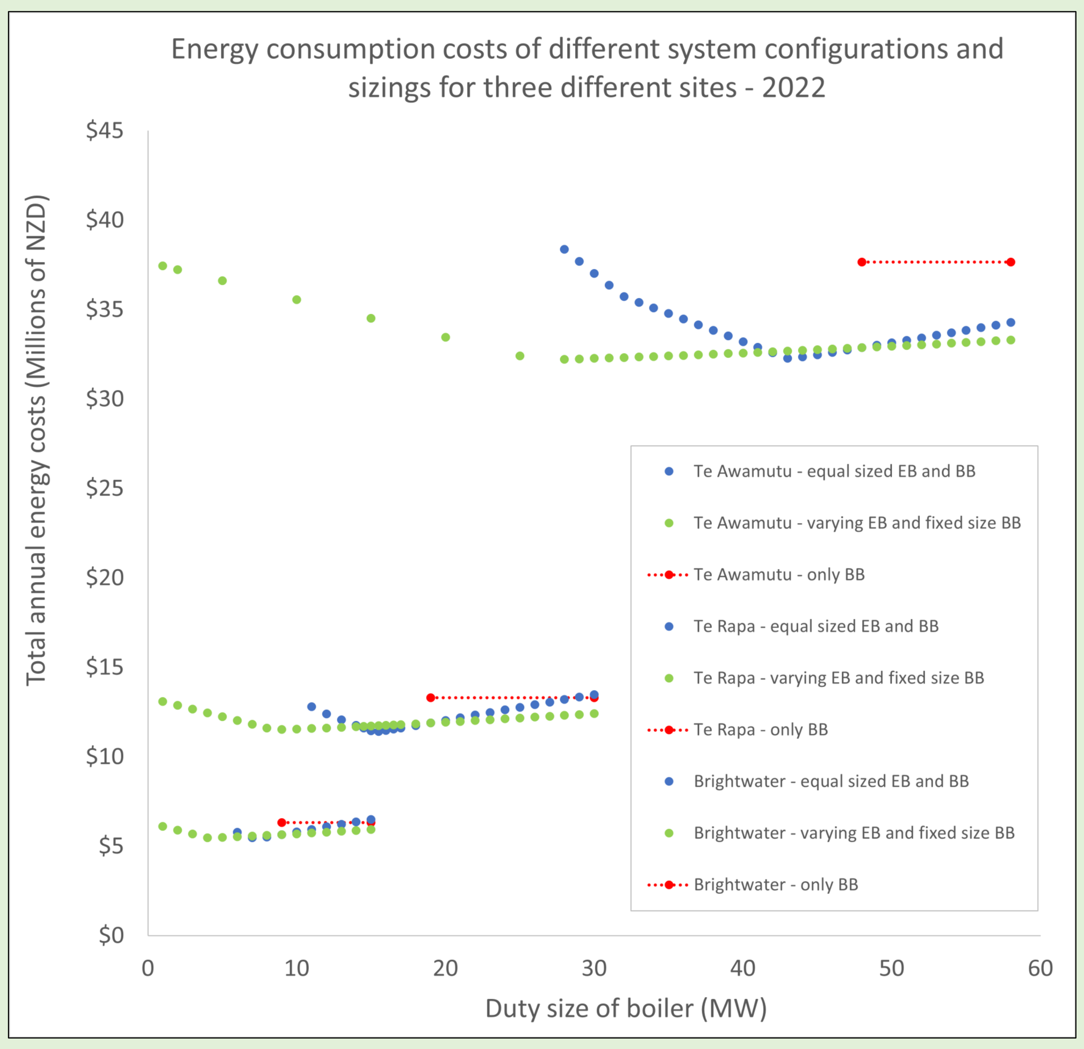
Configuration and sizing of system

The costs of a system with only a BB act as a reference, indicating the savings from the hybrid system configurations.

Optimum values for boiler size can be seen across both configuration styles, with the equal sized configuration having the lower minima but higher capital costs.



Site size and heat demand



Site	Demand
Te Rapa	15 MW
Te Awamutu	40 MW
Brightwater	7 MW

Greater site demands show greater energy cost savings when adding on an EB of the same size.

The minima of the equal sized configuration for Te Awamutu and Brightwater are greater than their varying EB configuration counterparts.

Extensions underway

- Techno-economic assessment
- On-site renewable generation
- Value of storage
- Seasonal production demand
- Environmental assessment
- Optimisation