Creating a Business Case for Industrial Heat Pumps

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ABOUT ENERGY NZ

- **Experts in Industrial Energy & Carbon Management**
- Working with businesses across New Zealand
- Emissions Reduction Roadmaps, Energy and Water Auditing, Feasibility Studies, Energy Monitoring & Targeting programmes
- Energy and Water Metering, Monitoring Systems and Dashboards for reporting/analysis
- Power Quality Auditing, Power Factor Correction Systems
- Energy project delivery, project management
- Thermal Imaging & Ultrasonic Leak Surveys
- Electrical Thermography Inspections

Why treat heat pumps differently?

- **Efficiency multiplier (COP)**
  - Moves heat to higher temperature; not a source of heat
  - Uses drastically less energy than combustion processes
  - Efficiency depends on a range of conditions

Why treat heat pumps differently?

- Efficiency multiplier (COP)
- **Interdependence with plant**
  - Reliant on the heat source
  - Output can vary with process conditions

Why treat heat pumps differently?

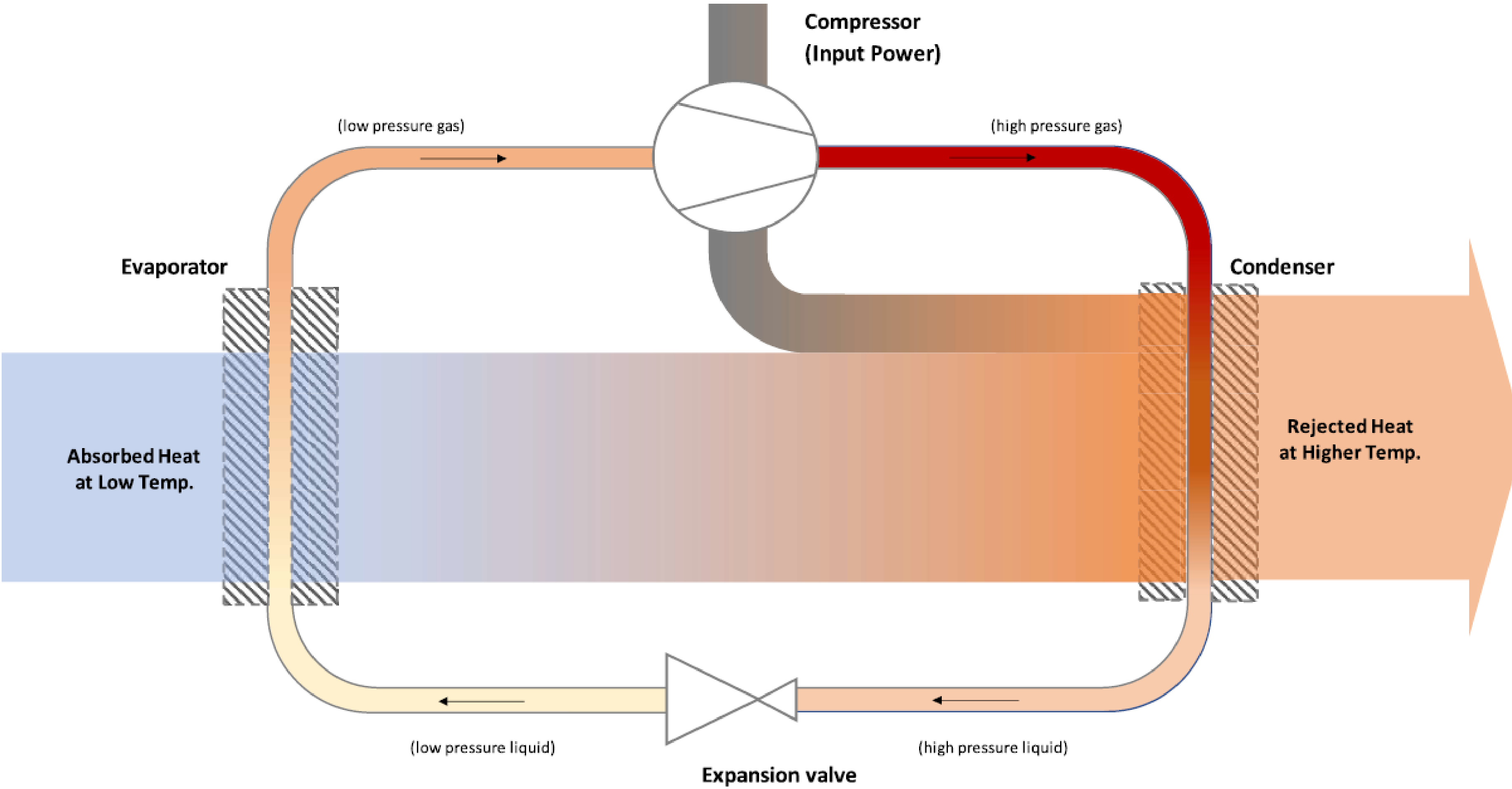
- Efficiency multiplier (COP)
- Interdependence with plant
- **Not a combustion process**
  - Avoids combustion losses
  - Max heating capacity (kW) is more of a challenge
  - Heat output may vary

How to start my business case?

- **Which heat source(s) to use?**
  - Size; power (kW) and energy (kWh or GJ)
  - Timing
  - Temperature
  - Variability

How to start my business case?

- **Which heat source(s) to use?**



How to start my business case?

- **Which heat source(s) to use?**

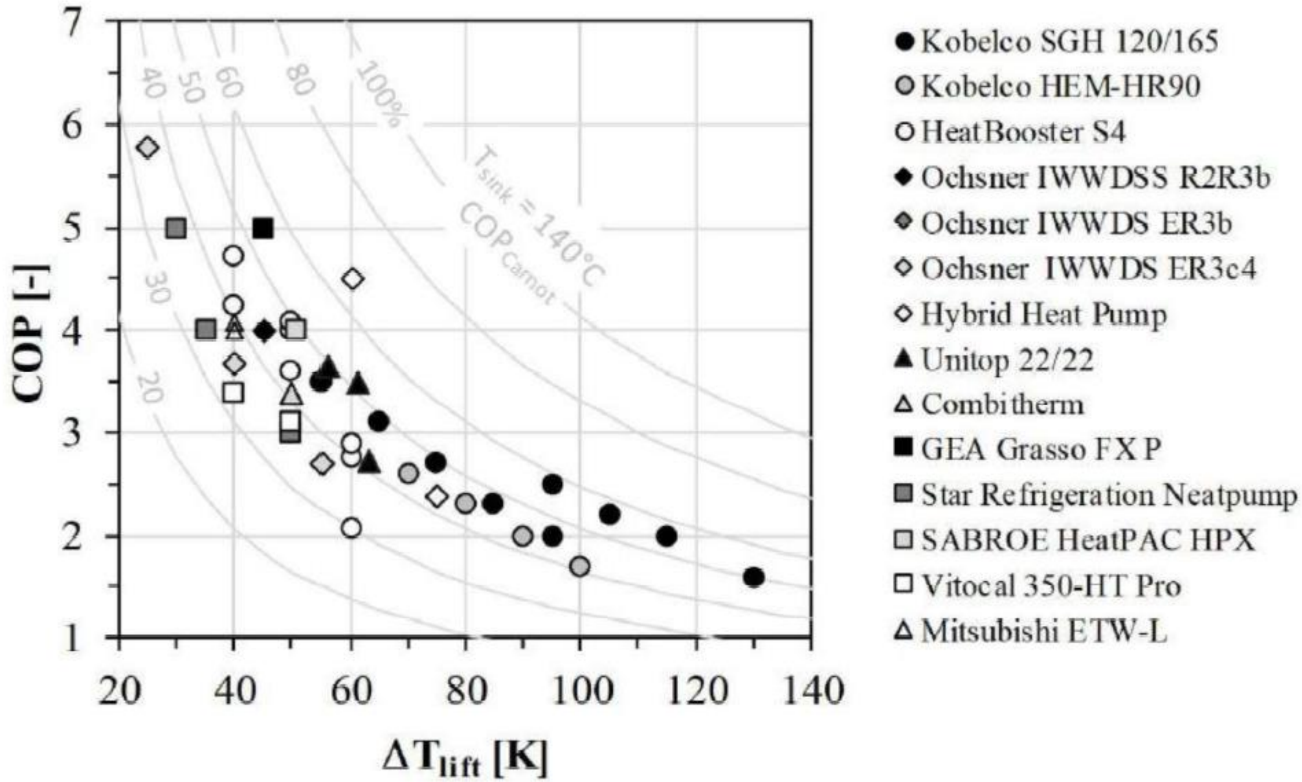


Figure 2: COP as a function of the temperature lift for various industrial HTHPs (adapted from Arpagaus *et al.*, 2017a, 2017b, 2018).

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How to start my business case?

- Which heat source(s) to use?
- **What is the demand for heating?**
  - Size – power (kW) and energy needed (kWh or GJ)
  - Timing – which processes
  - Temperatures – can you reduce?
  - Efficiency of current heating plant

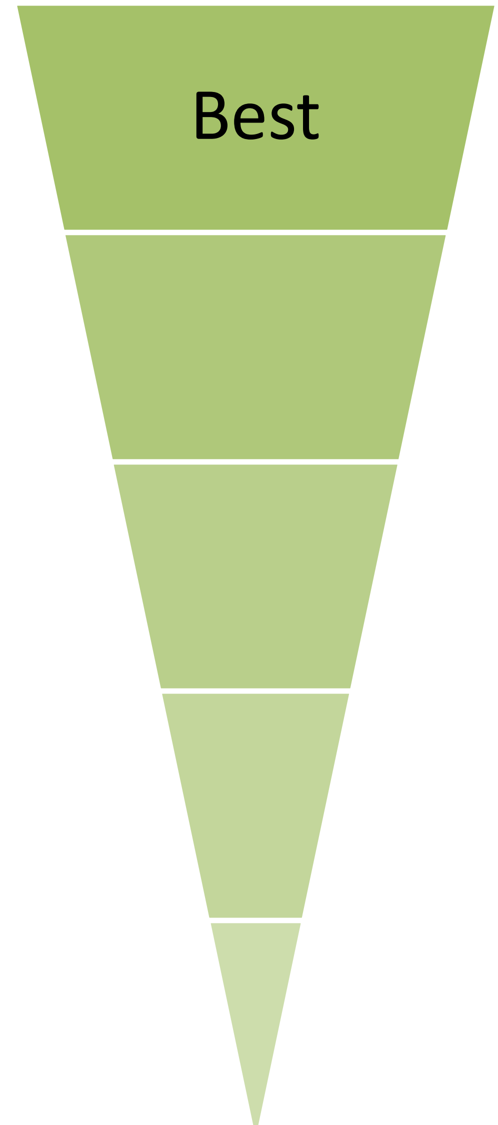
How to start my business case?

- Which heat source(s) to use?
- What is the demand for heating?
- **What do I want to achieve with a heat pump?**
  - Offsetting of fossil fuel-fired boiler load
  - Full replacement of fossil fuel-fired heating
  - Once-through water heating? Or heating a recirculating loop?
  - Heating delivery temperature

How to model performance?

- **Get the data**
  - What can you measure?
  - What needs to be estimated?
  - What causes variations in heating load?

    (during production, outside prod, daily and seasonally)



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How to model performance?

- **Get the data**
  - Example

Flowmeter?
Temperatures?

Avg. flow from
Pump curve?

Flowmeter?
Temperatures?

Avg. flow from Pump
curve? Recirc flow?

Gas/fuel meter?
Peak/Avg. kW?
Run hours?

On/off cycles and
firing rate? During
prod. & non-prod.?

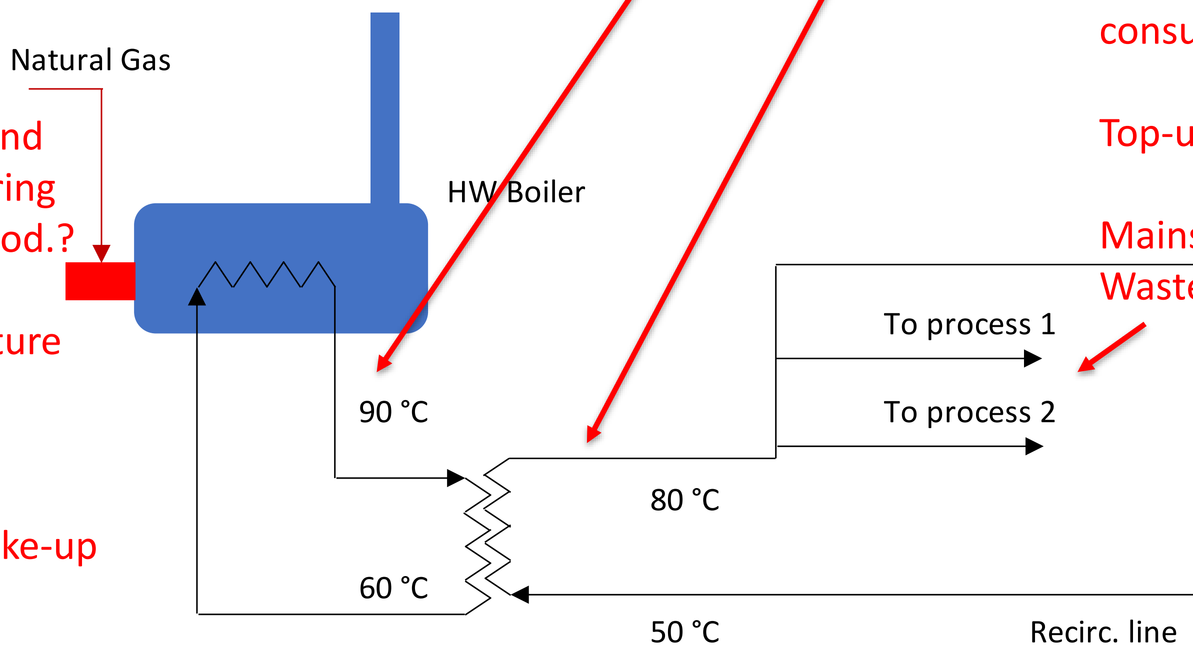
Stack temperature
logging?

Stack tests?
Blowdown, make-up
water?

Process 1&2 water
consumption?

Top-up water flow?

Mains water consumption?
Wastewater flow?



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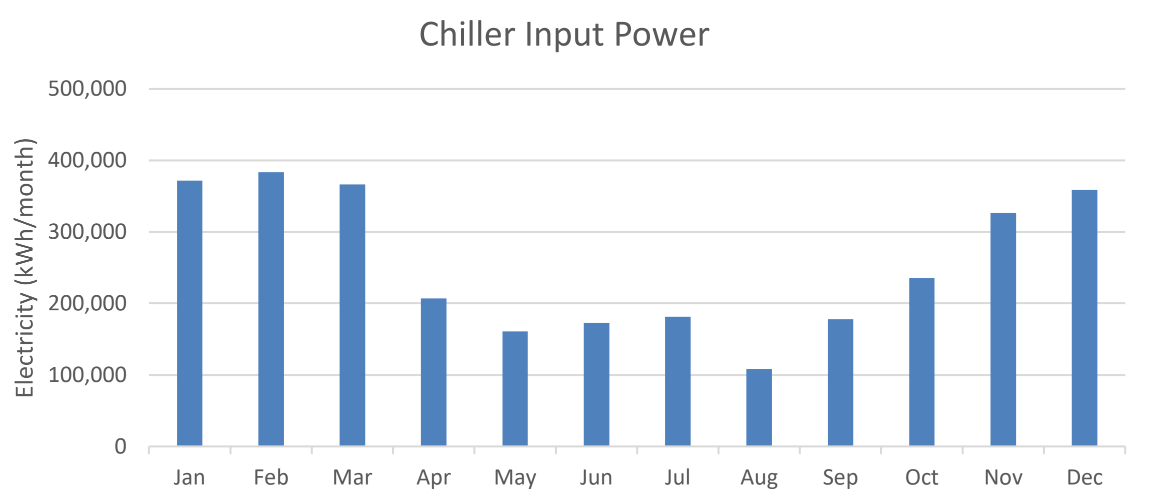
How to model performance?

- Get the data
- **Model the heat source**
  - How does it vary in size/temperature?
  - What is the hourly load profile? Daily? Weekly? Seasonal?



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How to model performance?

- Get the data
- **Model the heat source**
- **Model the heating demand**
  - How does it match the heat source?
  - What is the hourly heat load profile? Daily? Weekly? Seasonal?
  - What is the resulting heat pump demand for electricity?

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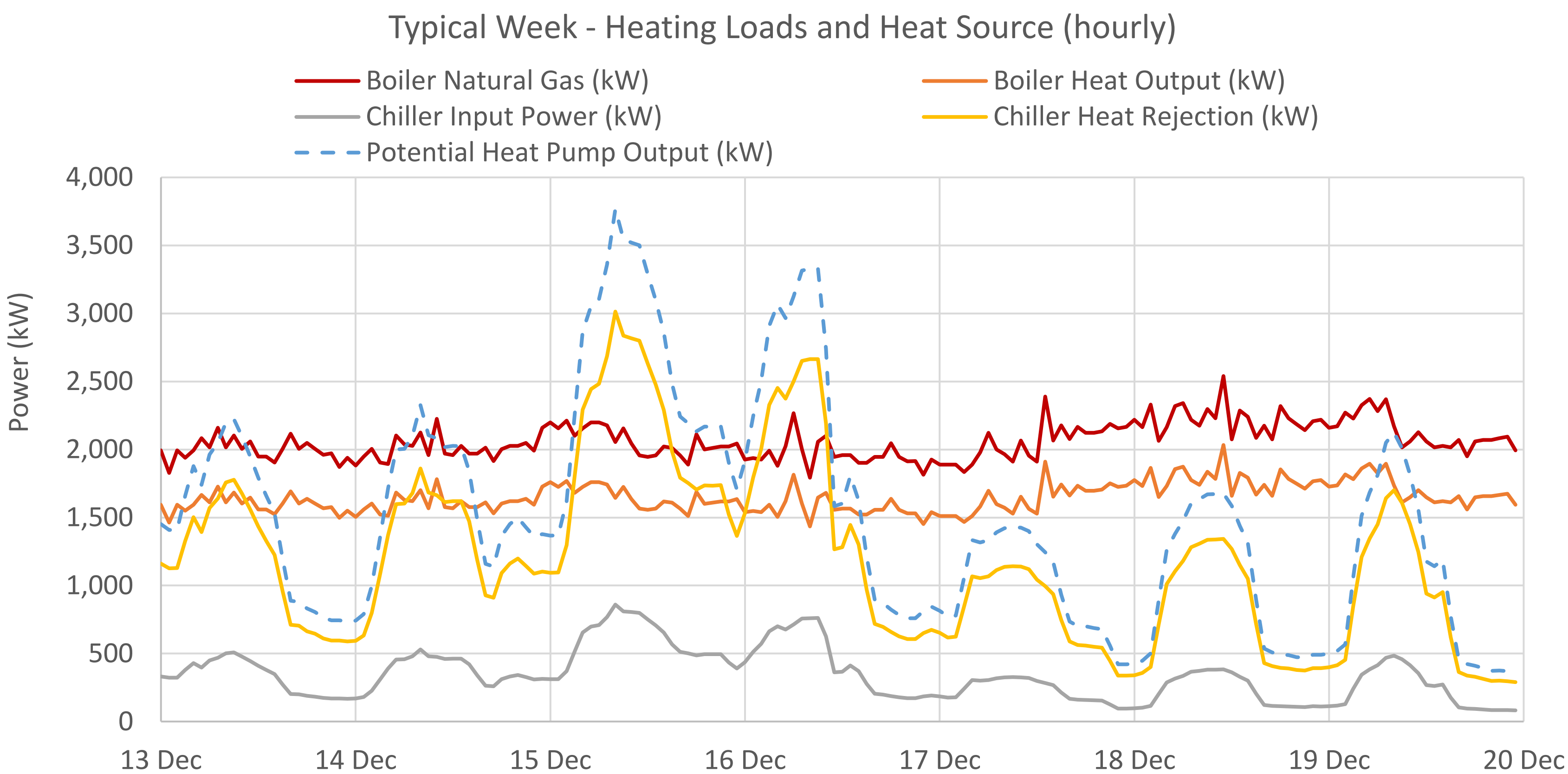
How to model performance?



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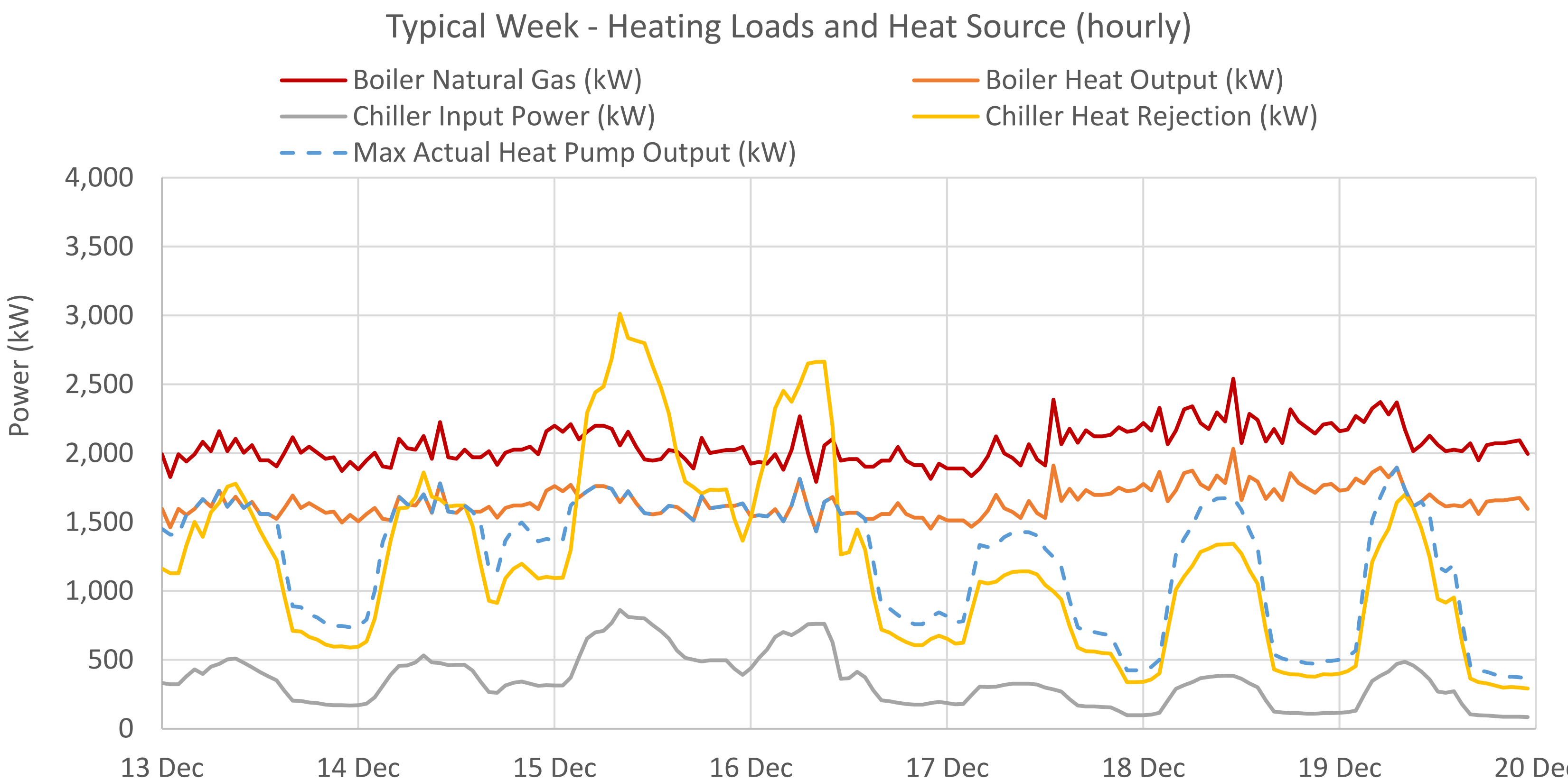
How to model performance?



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How to model performance?

- ✓ Identify heat source; temperatures, variability etc
- ✓ Get the data - modelled
- ✓ Understand the existing demand for heat, and the existing heater efficiency
- ✓ Model the heat source and the heat demand
- ✓ Set objectives and selected a heat pump (with vendors)
- ✓ Review **SNZ PAS 5210:2021 High-temperature heat pumps**

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Key metrics for business case

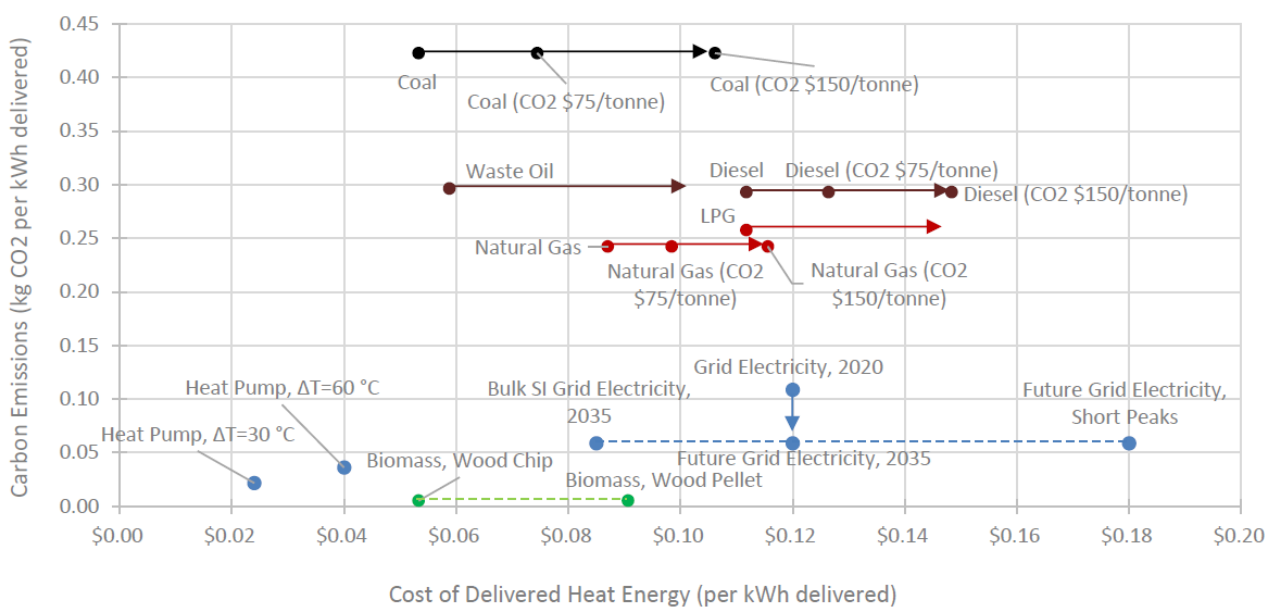
- Scope of project
  - Capacity and type of heat pump
  - Heat source and connections, demand side connections
  - Design intent of system
    (Baseload, with fired heater? Heat only, or heat + cooling? Once-through or recirc?)
  - Preheat possible?
  - Buffer storage
  - Electrical upgrades needed – new switchboard and cabling? Transformer?
  - Demand controller to limit peak loads
  - Location on site
  - Engineering; tie-ins and piping connections, pumps, instruments, valves etc
  - Is backup needed?
  - Refrigerant safety aspects
  - Refrigerant availability aspects – GWP & Montreal Protocol

Key metrics for business case

- Scope of project

- Purchased energy – before and after
  - Account for all relevant fuel cost components
  - HP will generally provide energy cost savings
  - Carbon pricing for fuels – allow low and high future estimates; communicate risks of BAU
  - Market prices (volatility) for fuels

Industrial Process Heat in New Zealand – Delivered Heat Cots vs. Emissions



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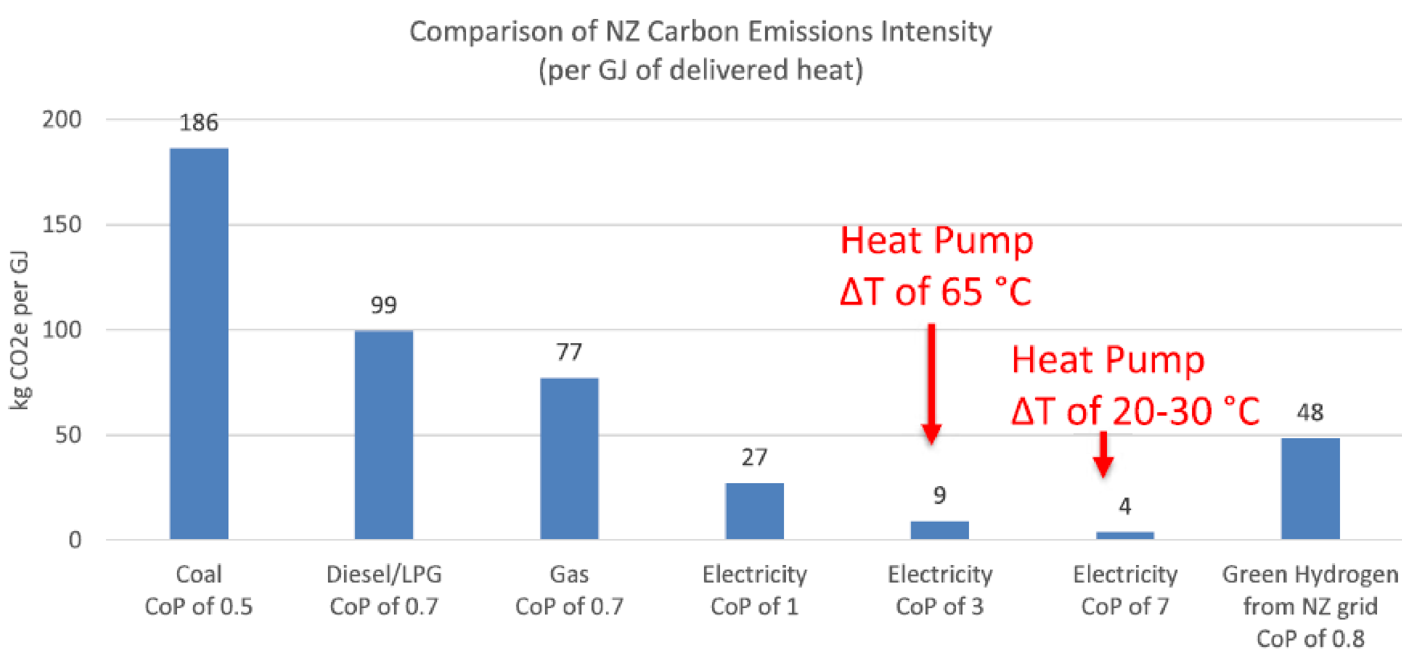
Key metrics for business case

- Scope of project
- Purchased energy – before and after
- Resulting carbon emissions
  - Typically use *Ministry for Environment* emission factors to report
  - In NZ, often 85% reduction in emissions vs. natural gas



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Key metrics for business case

- Scope of project
- Purchased energy – before and after
- Resulting carbon emissions
- Co-benefits
  - Significant progress towards business emissions targets
  - Reducing exposure to carbon pricing risk and fuel cost volatility
  - Improved process control
  - Reduced water consumption (cooling towers)
  - Reduced boiler chemicals and softening
  - Reduced peak steam loads
  - Can improve chiller efficiency
  - Can provide cooling and heating simultaneously
  - Can be a flagship project for business – marketing and reputation
  - Can dehumidify a closed process – cooling and heating same air flow

Key metrics for business case

- Scope of project
- Purchased energy – before and after
- Resulting carbon emissions
- Co-benefits
- Maintenance costs
  - Discuss with supplier
  - Similar to other refrigeration equipment
  - Note maintenance costs of existing fired heaters, both with and without heat pump

Key metrics for business case

- Scope of project
- Purchased energy – before and after
- Resulting carbon emissions
- Co-benefits
- Maintenance costs
- Avoided capital
  - Can this allow future boiler refurbishment/replacement to be avoided?
  - Or allow one boiler to be shut down?
  - Can this avoid replacement of steam piping, blowdown vessel, softeners etc?

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What’s possible

- Commercially available heat pumps:
  - **Hot water at 90 °C**, using ambient air or water/glycol 0-35 °C as heat source
    (COP = 3.0 - 5.5 depending on ΔT)
  - **Hot air at 60 - 120 °C**, using water 0-35 °C as heat source
    (COP = 5.5 – 3.0 depending on ΔT)
  - **Hot water at 95 °C**, using warm water or hot ammonia gas 25-50 °C as heat source
    (COP = 4.0 – 5.0 depending on ΔT)
  - **Hot water or steam at 110-160 °C** , using hot water or steam at 70-120 °C as heat source
    (COP = 2.0 – 4.0 depending on ΔT)
    (low production volumes – relatively new technology)

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Questions?

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