Thermal-Electric Balance in Cooling-Only CHP Applications

Texas CHP Policy Forum and Trade Show

November 3, 2010

Bocci ENGINEERING LLC

The Problem

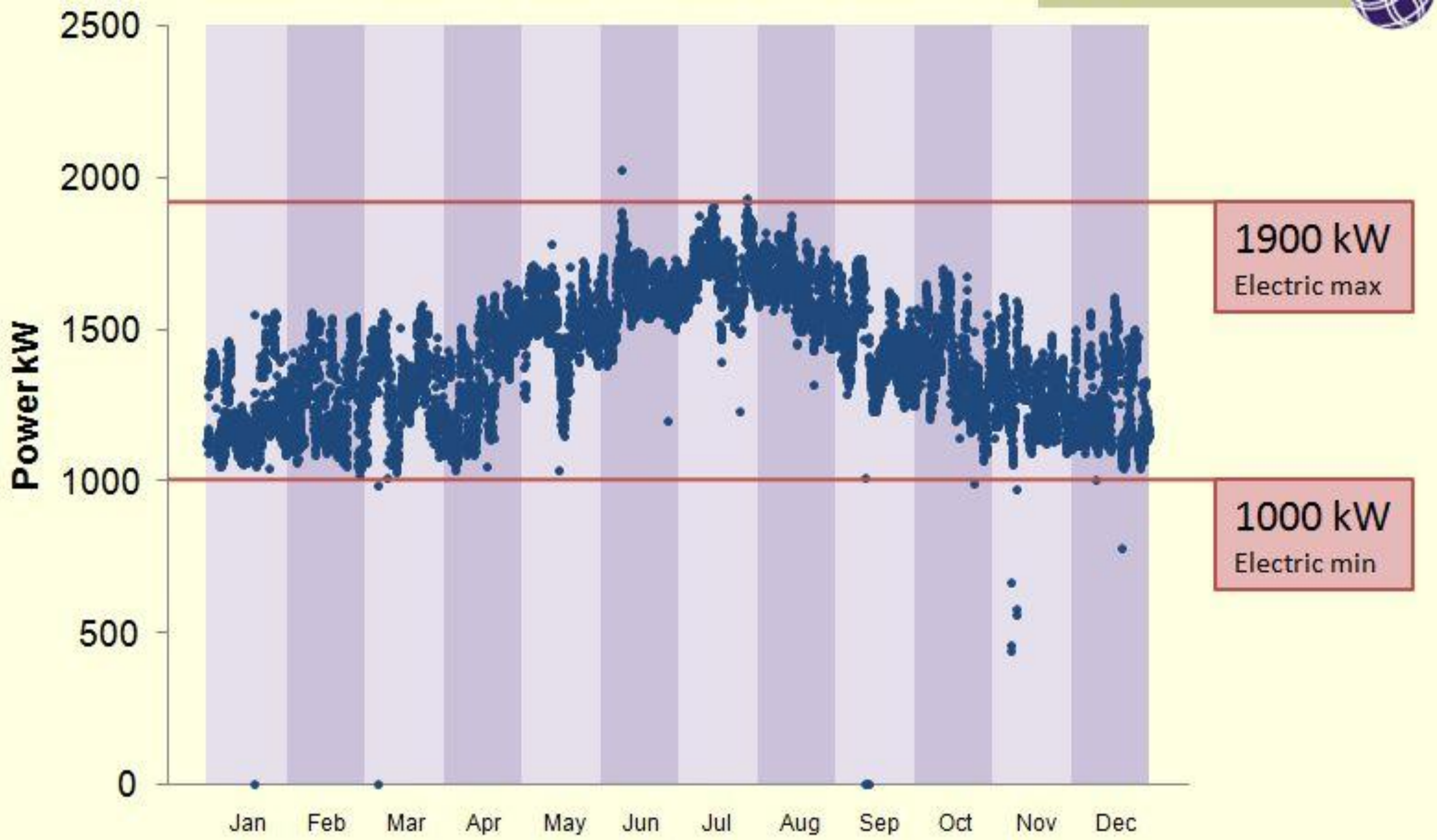
- How do we determine the optimal system configuration for a cooling-only CHP system?
  - Define your needs
  - Find your fit
  - Optimize

Bocci ENGINEERING LLC

The Process

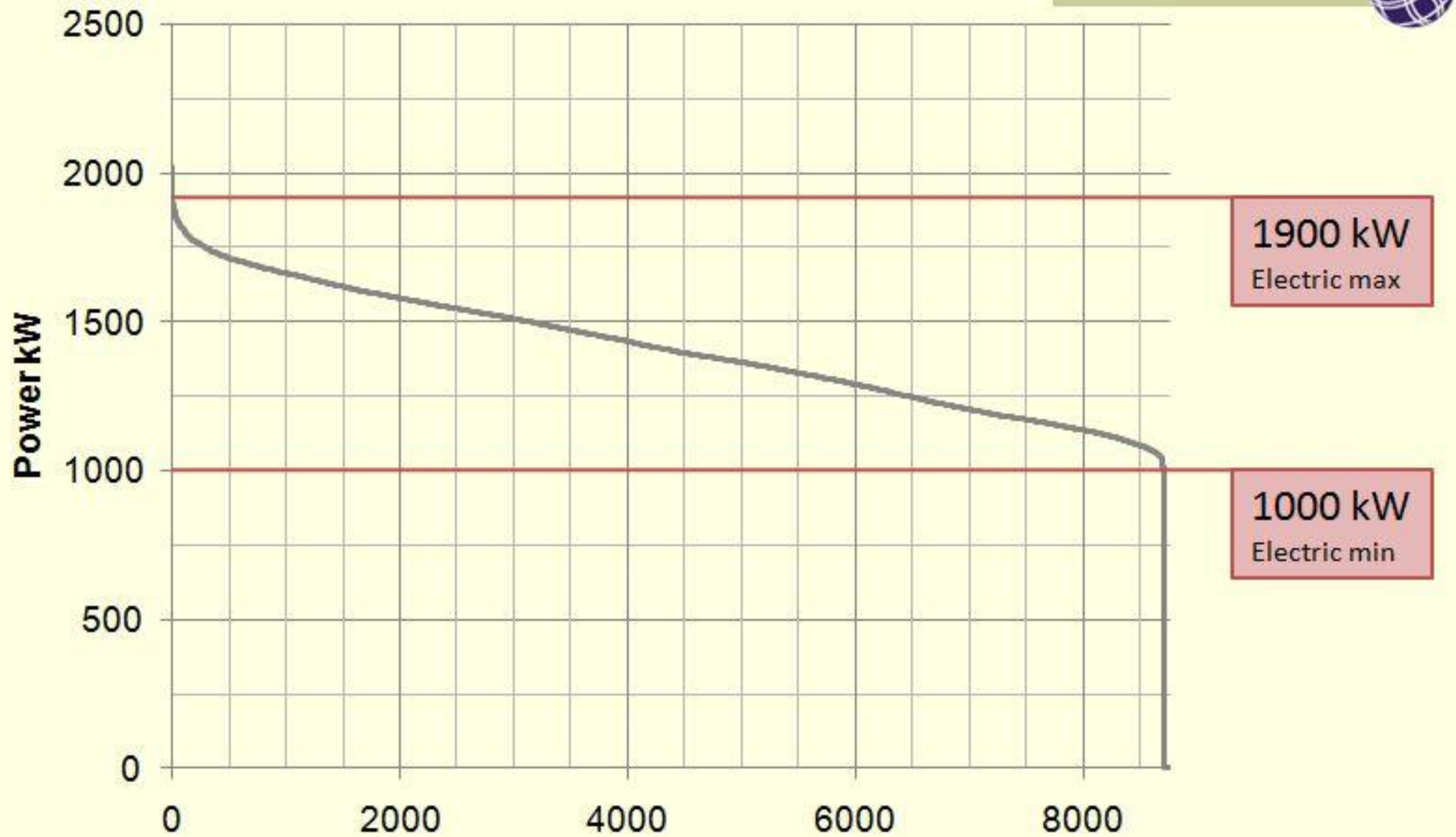
- Step 1: Evaluate electrical consumption

Step 1: Evaluate Electrical Consumption



Bocci ENGINEERING LLC

Step 1: Evaluate Electrical Consumption



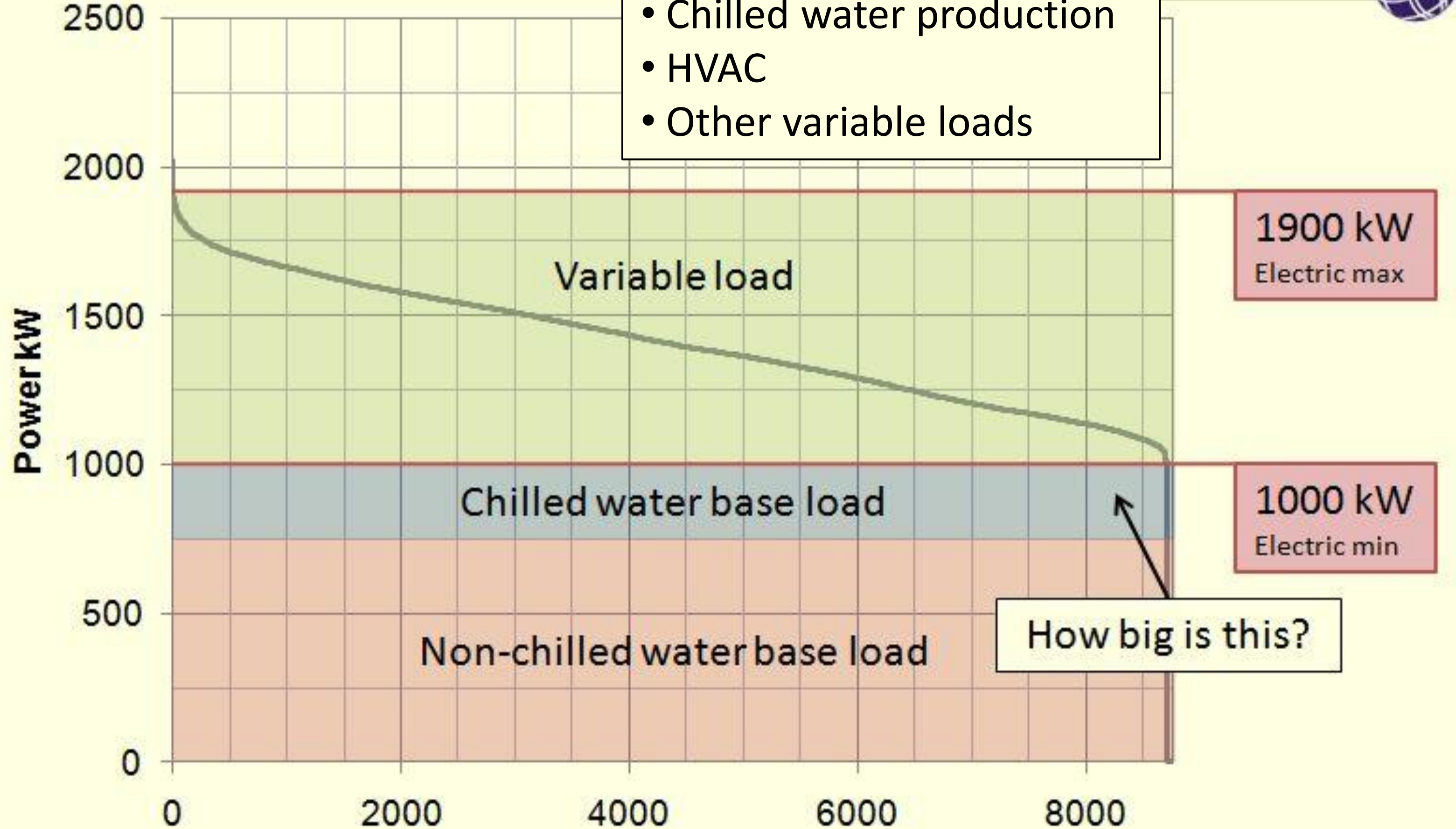
The Process

- Step 1: Evaluate electrical consumption
- Step 2: Estimate chilled water power consumption

Bocci ENGINEERING LLC

Step 2: Estimate Chilled Water Power Consumption

Components of variable load:
- Chilled water production
- HVAC
- Other variable loads



Step 2: Estimate Chilled Water Power Consumption

In an ideal world:

- Separate meters for chilled water plant
- Facility meters chilled water production (thermocouples and flow meters)

In the real world:

- Interview with facility staff

"I have two 600 ton machines and a 500 ton backup. My chillers are all on VFDs. In the winter I only need one, in the summer I run both, and once in a while I need to run my backup 500 ton unit. Even in the winter, one unit is always at least at part load."

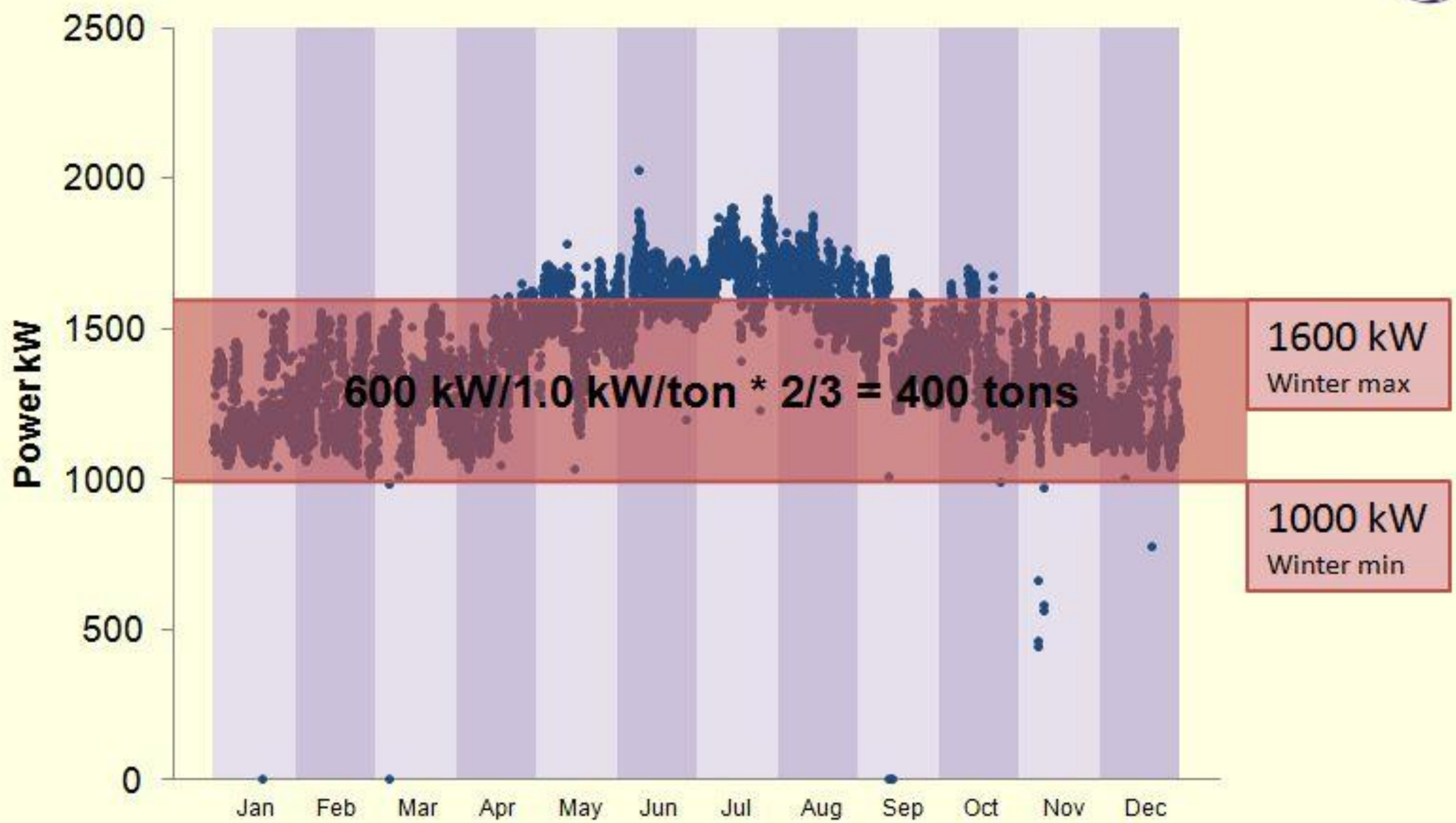
Bocci ENGINEERING LLC

Step 2: Estimate Chilled Water Power Consumption

- What else do we know?
  - Chiller model number and size
  - Size of auxiliary equipment (pumps, cooling towers, etc)
  - Single operational data point (on day of audit)
  - System configuration and control scheme (variable frequency drives, primary or secondary chilled water flow, etc.)
  - Equipment age

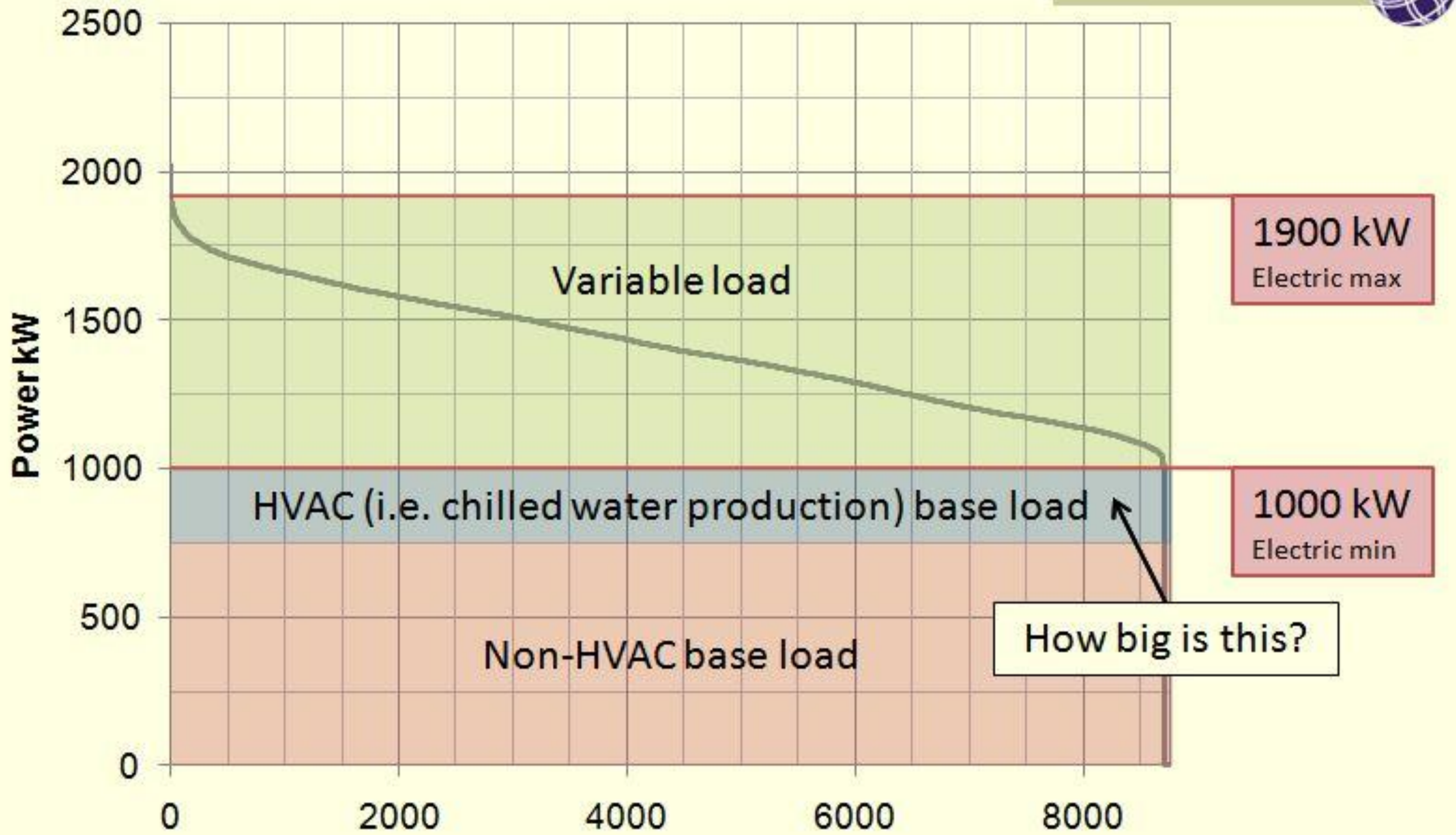
Bocci ENGINEERING LLC

Step 2: Estimate Chilled Water Power Consumption



Bocci ENGINEERING LLC

Step 2: Estimate Chilled Water Power Consumption



Step 2: Estimate Chilled Water Power Consumption

“In the winter I only need one [600 ton chiller].”

400 ton variability in winter chilled water load

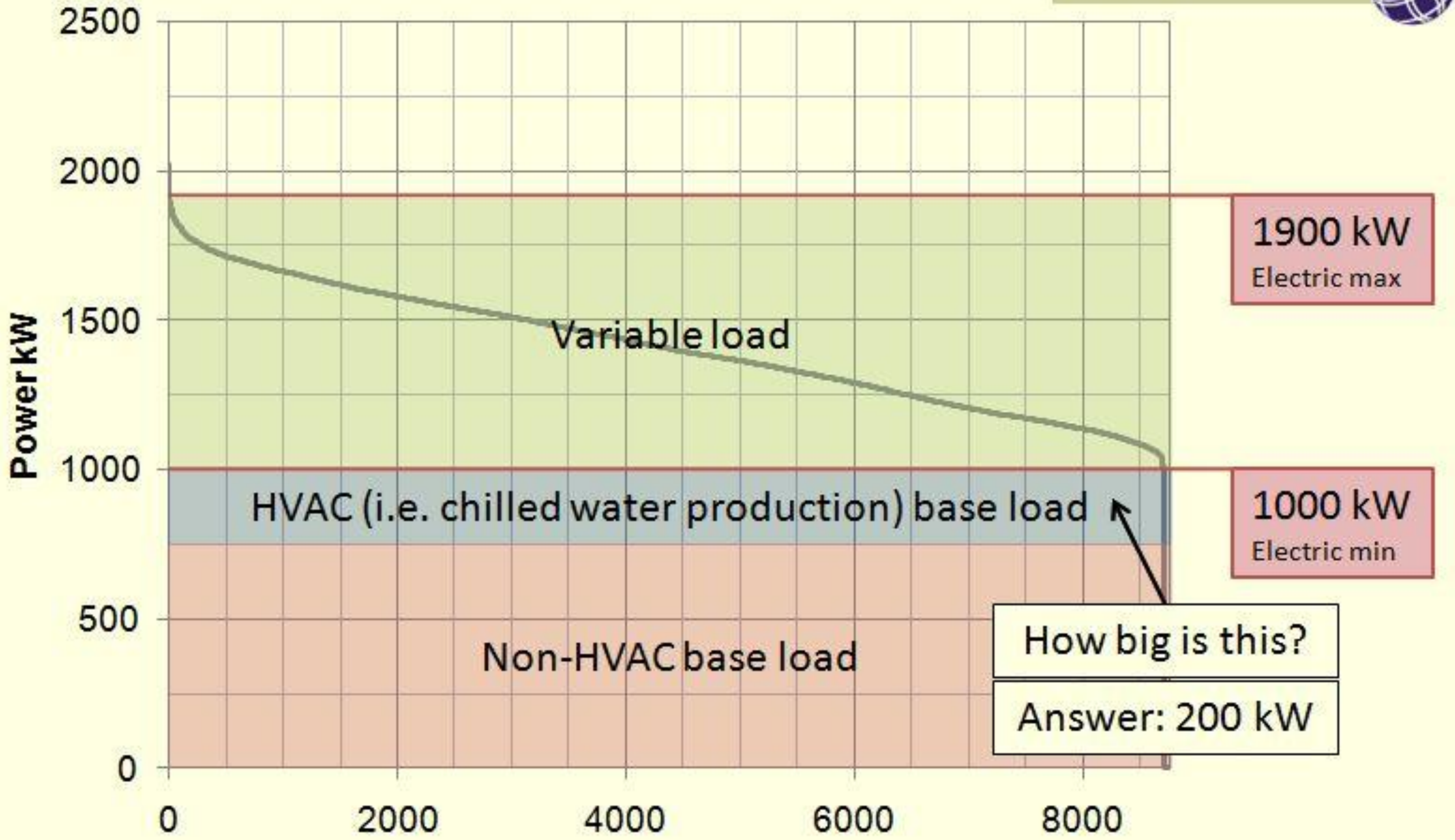
1 kW/ton system efficiency

(600 tons – 400 tons) / 1 kw/ton = **200 kW baseload**

1000 kW baseload – 200 kW = **800 kW**

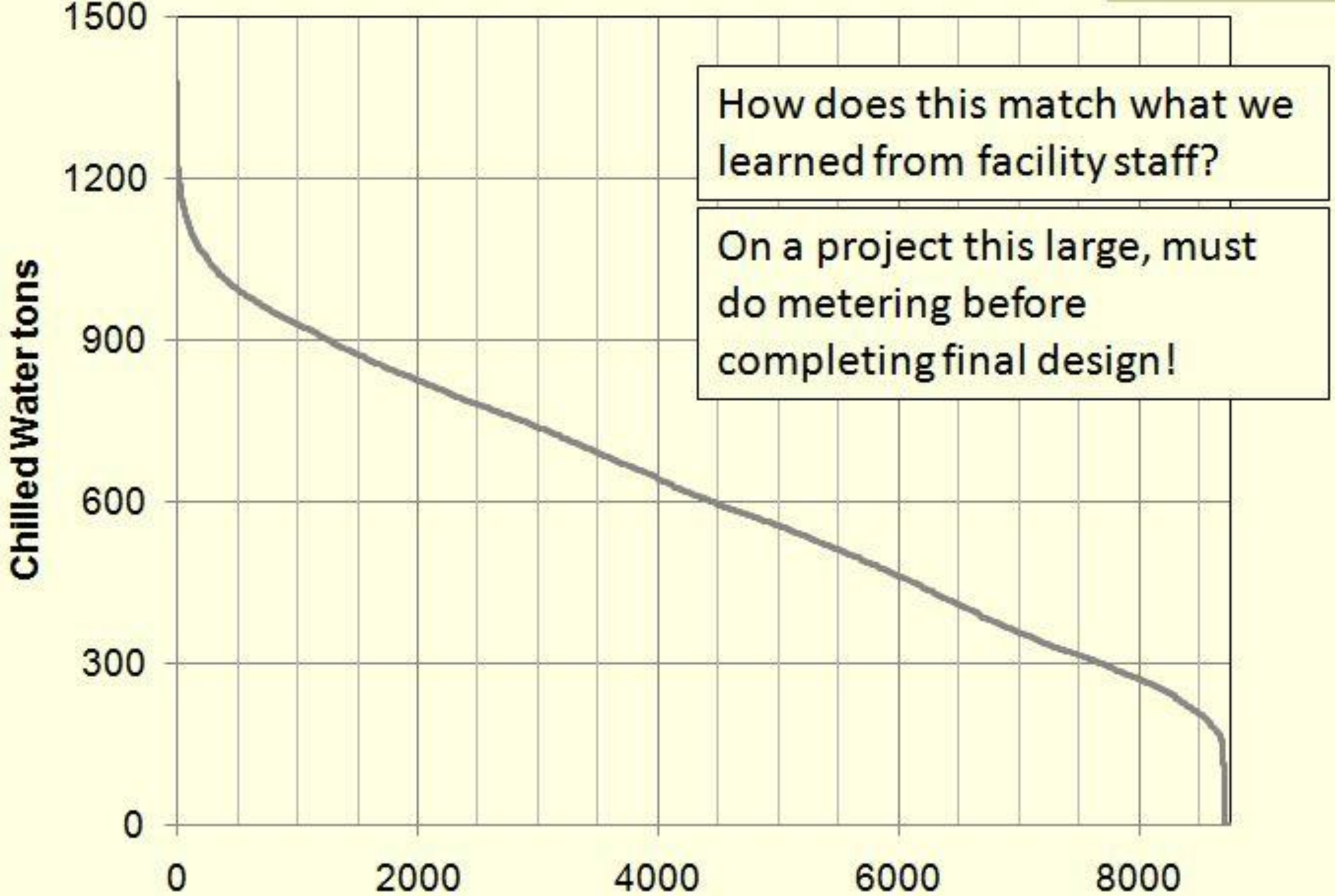
Bocci ENGINEERING LLC

Step 2: Estimate Chilled Water Power Consumption



Bocci ENGINEERING LLC

Step 2: Estimate Chilled Water Power Consumption

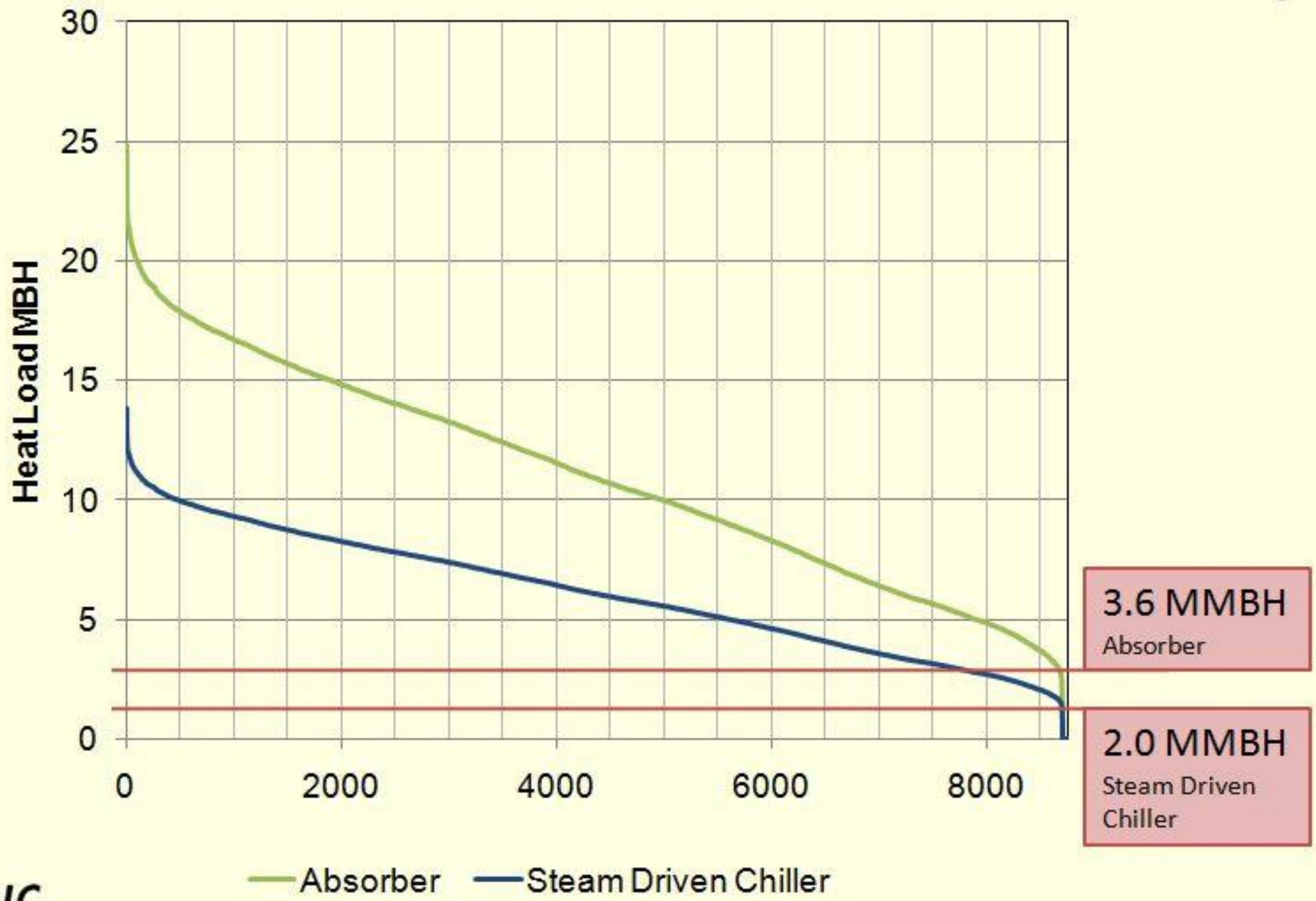


The Process

- Step 1: Evaluate electrical consumption
- Step 2: Estimate chilled water power consumption
- Step 3: Convert to a heating load

Bocci
ENGINEERING LLC

Step 3: Convert Chilled Water LDC to Heat LDC



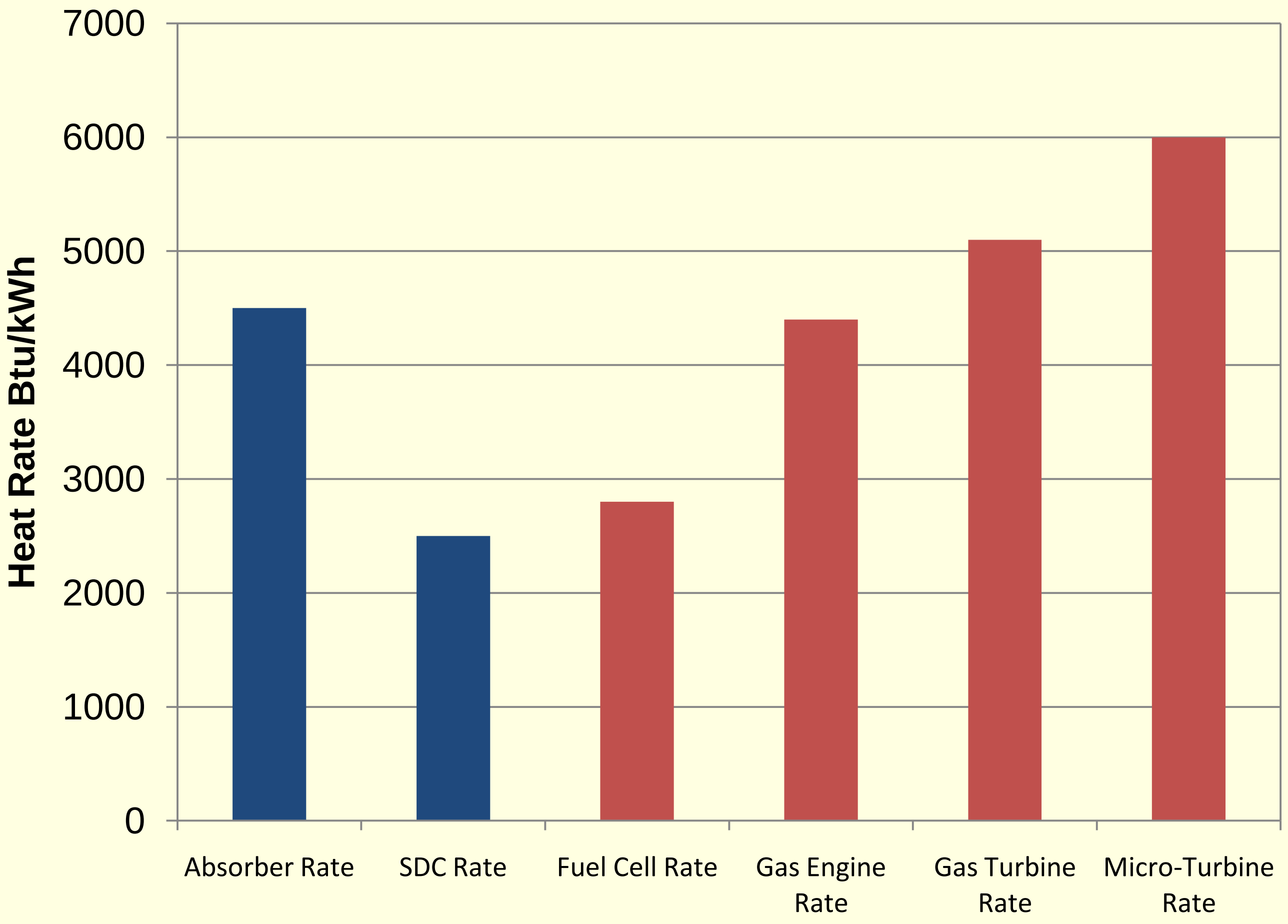
Bocci ENGINEERING LLC

The Process

- Step 1: Evaluate electrical consumption
- Step 2: Estimate chilled water power consumption
- Step 3: Convert to a heating load
- Step 4: Evaluate balance point

Bocci ENGINEERING LLC

Step 4: Evaluate Balance Point



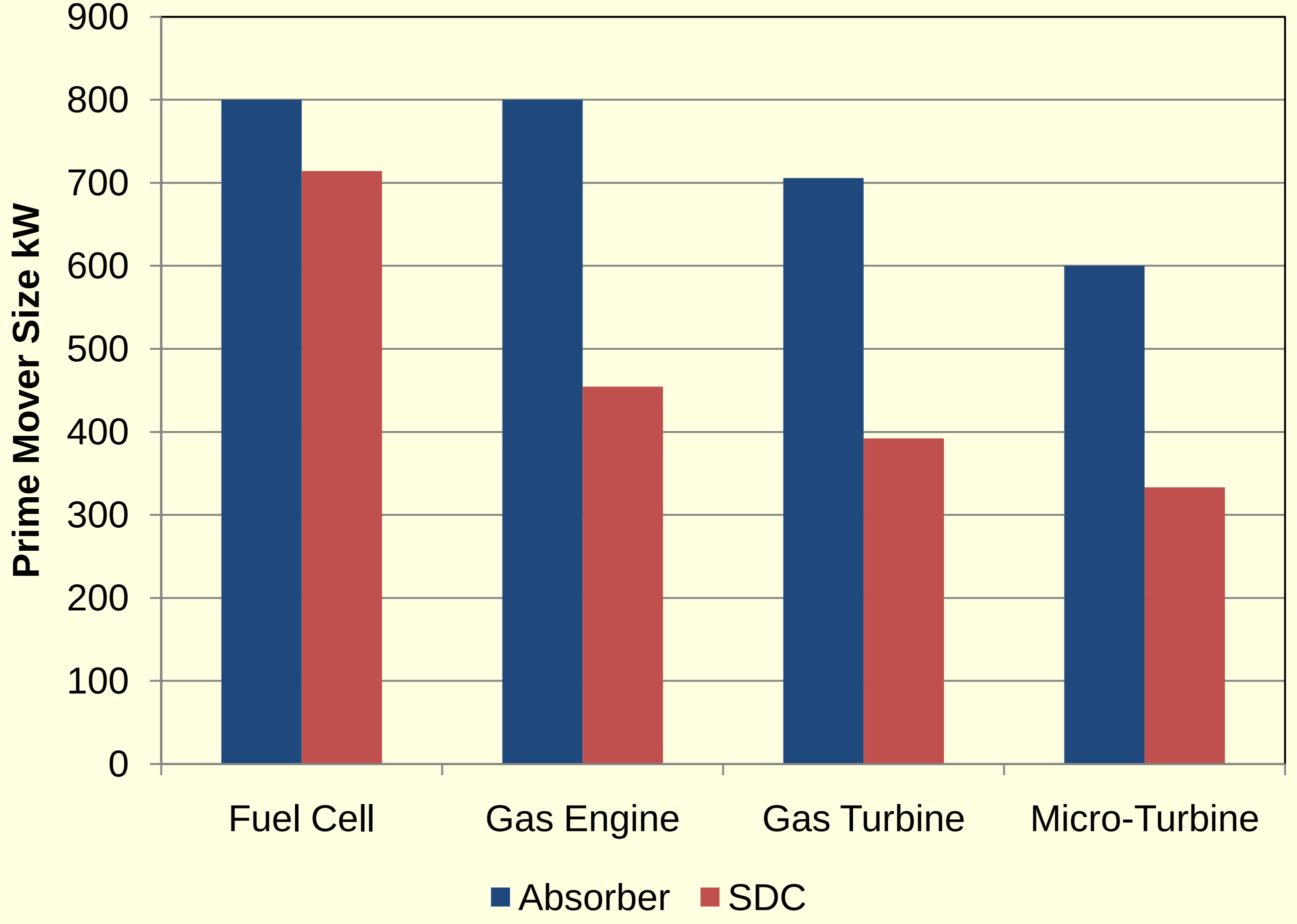
Bocci ENGINEERING LLC

Step 4: Evaluate Balance Point

If $H.R._{prime\ mover} < H.R._{load}$: Power-Limited
If $H.R._{prime\ mover} > H.R._{load}$: Thermally-Limited

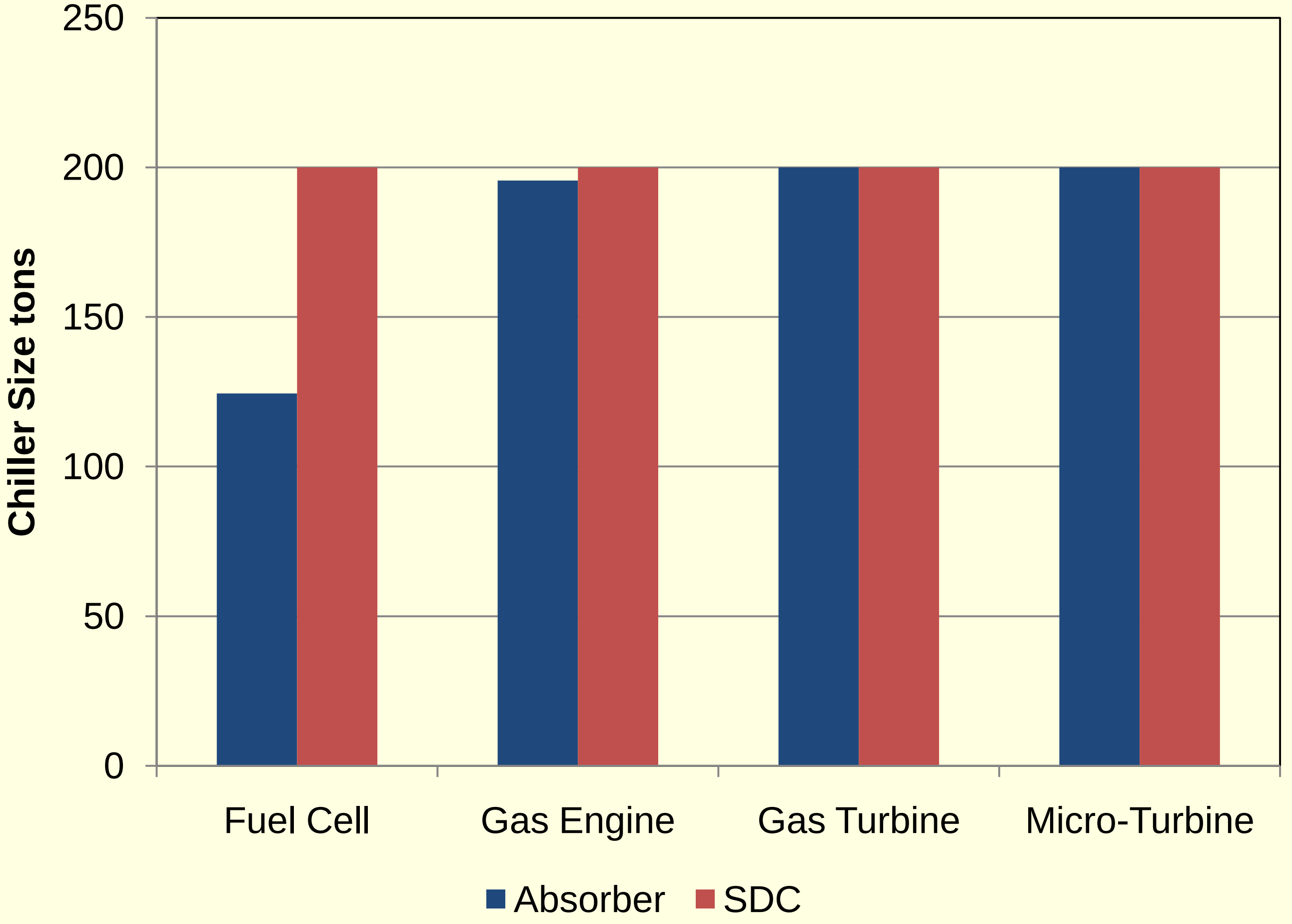
Bocci ENGINEERING LLC

Step 4: Evaluate Balance Point



Bocci ENGINEERING LLC

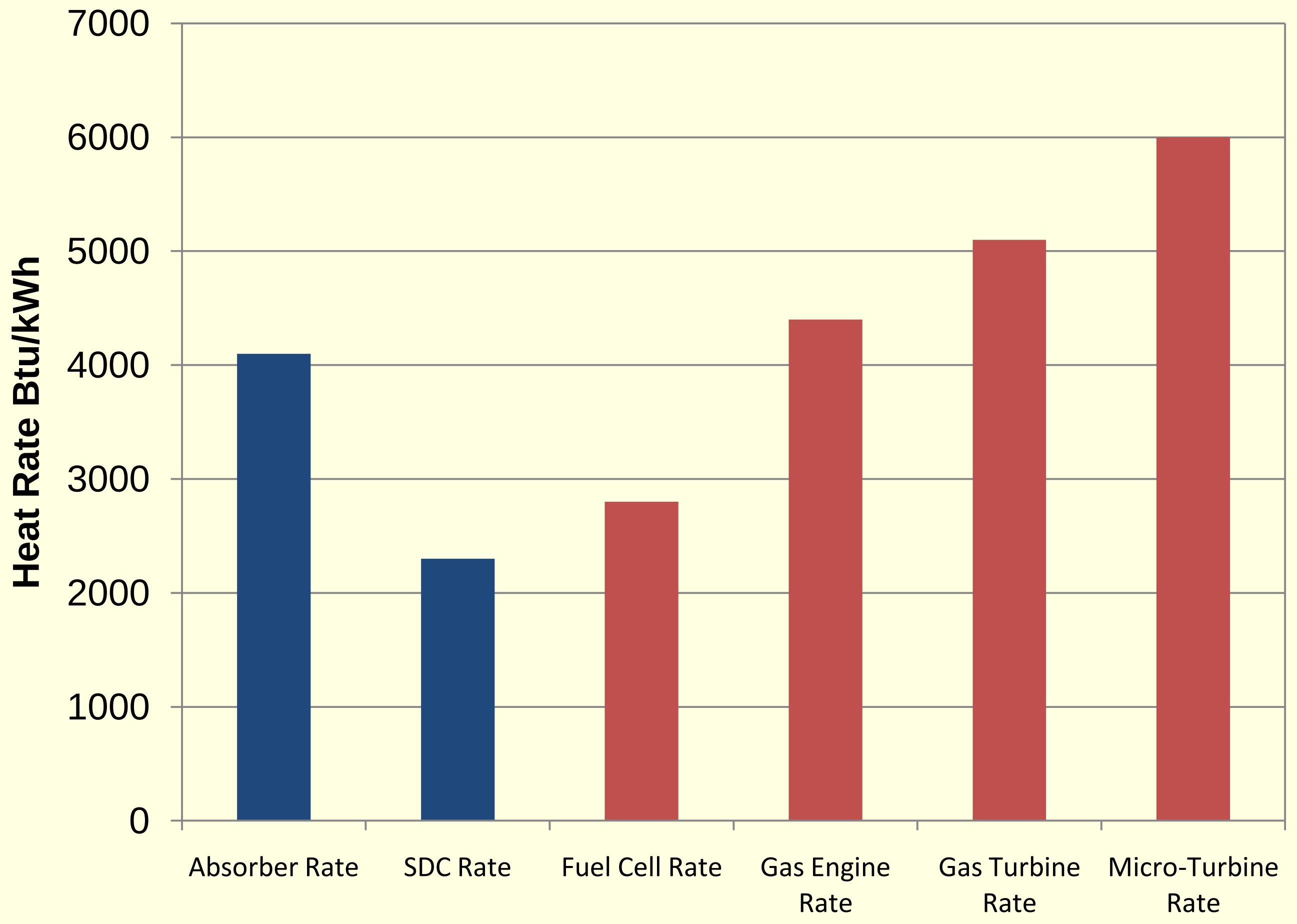
Step 4: Evaluate Balance Point



The Process

- Step 1: Evaluate electrical consumption
- Step 2: Estimate chilled water power consumption
- Step 3: Convert to a heating load
- Step 4: Evaluate balance point
- Step 5: Economics optimization

Step 6: Economics Optimization



Bocci ENGINEERING LLC

Step 6: Economics Optimization

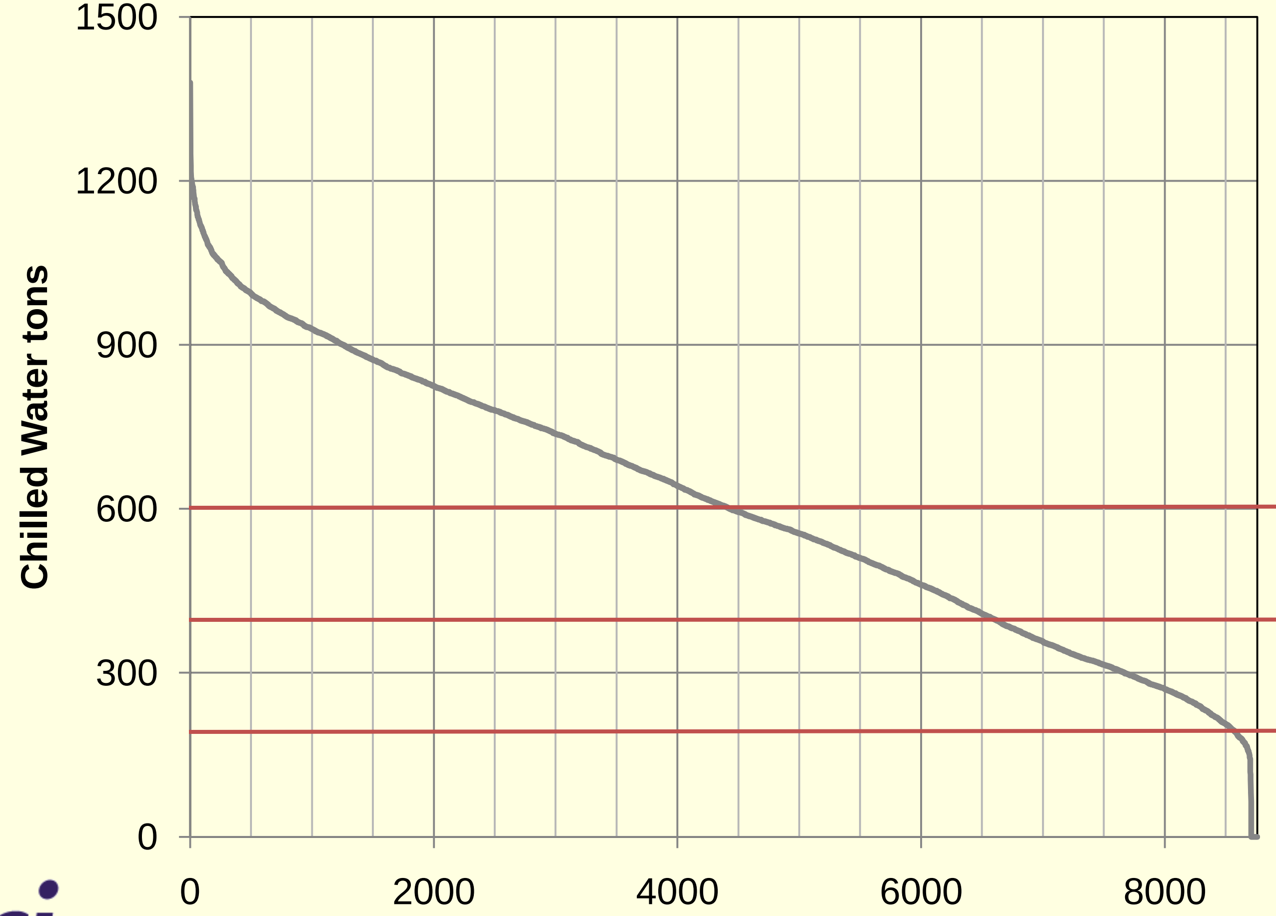
Typical cost factors:

Gas Turbine	1.0
Gas Engine	1.1
Micro Turbine	1.7
Fuel Cell	4.5

Source: Department of Energy CHP Screening Tool

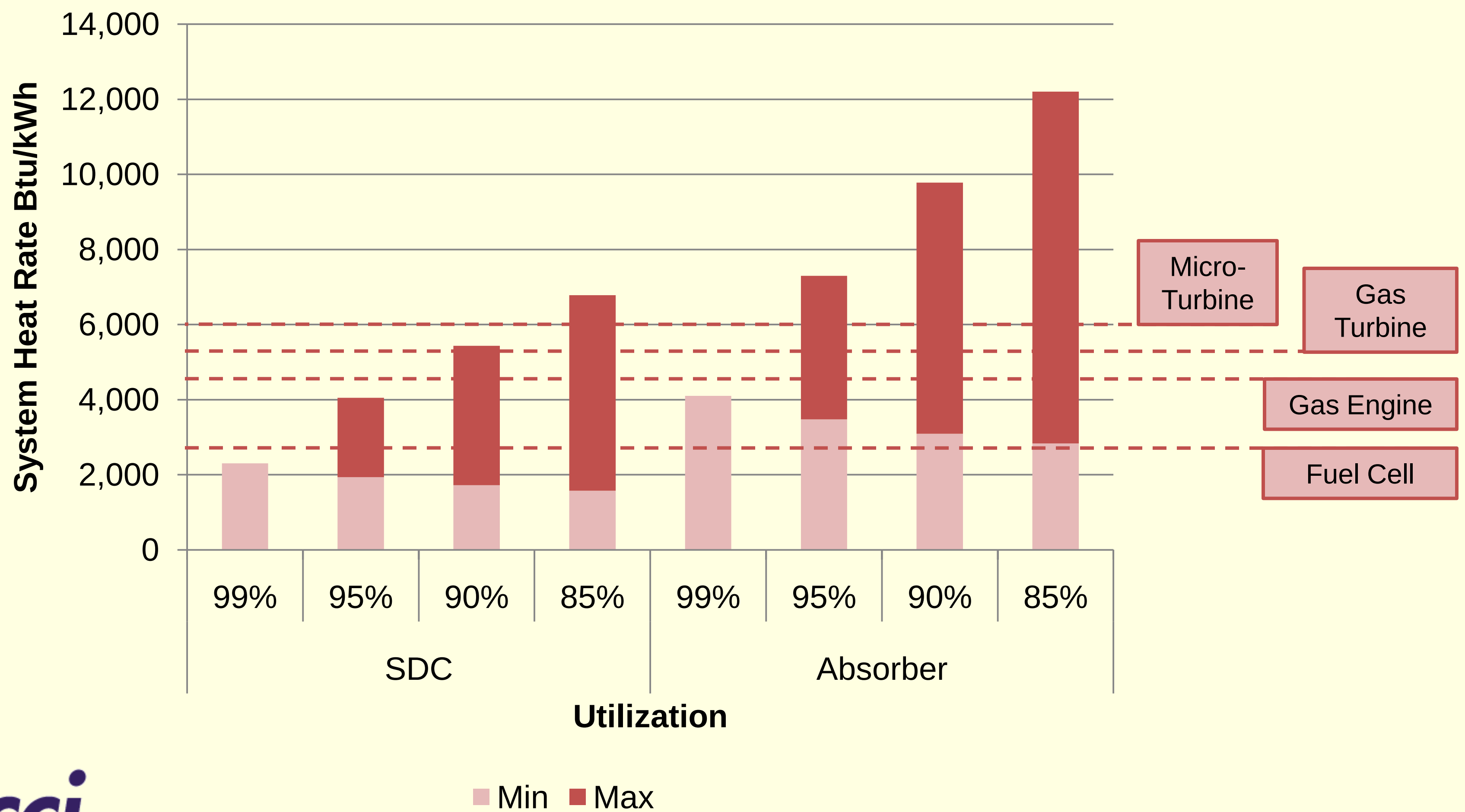
Bocci ENGINEERING LLC

Step 6: Economics Optimization



Tons	Utilization
600	83%
400	93%
200	99%

Step 6: Economics Optimization



Bocci ENGINEERING LLC

In Summary

- Determine the electrical load
- Determine the chilled water load
- Translate to a heating load
- Identify the load heat rate (i.e. balance point)
- Match and optimize with available technology

Bocci ENGINEERING LLC

Questions?