# COOLING WITH CHP

**Presenters – Edy Chiarotto**

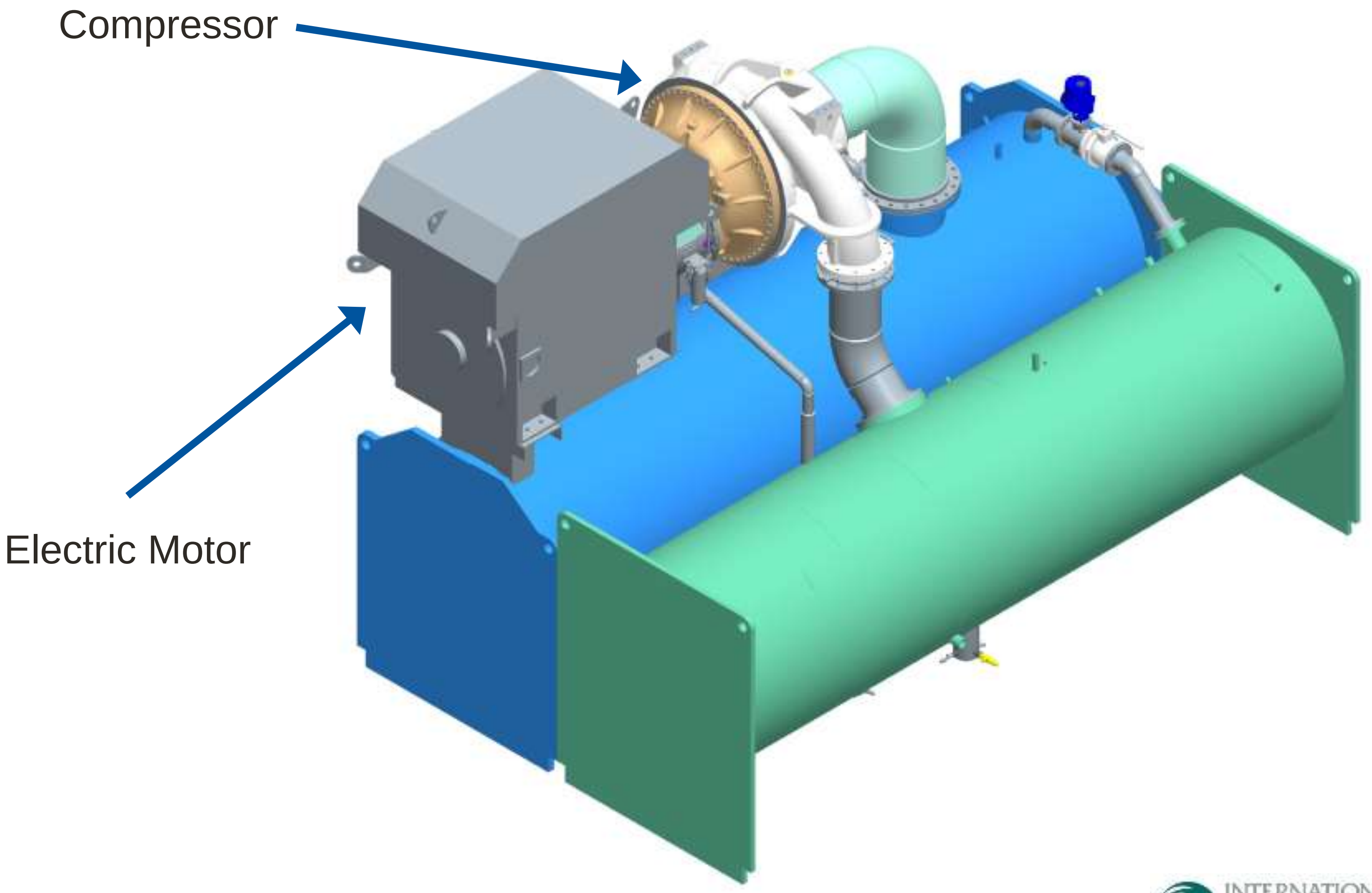
**December 2015**

INTERNATIONAL DISTRICT ENERGY ASSOCIATION

# Agenda

- Basics
- Range
- Operating Schematic
- Performance
- Real-World Applications
- Recap

# Electric Motor Driven Centrifugal Chiller



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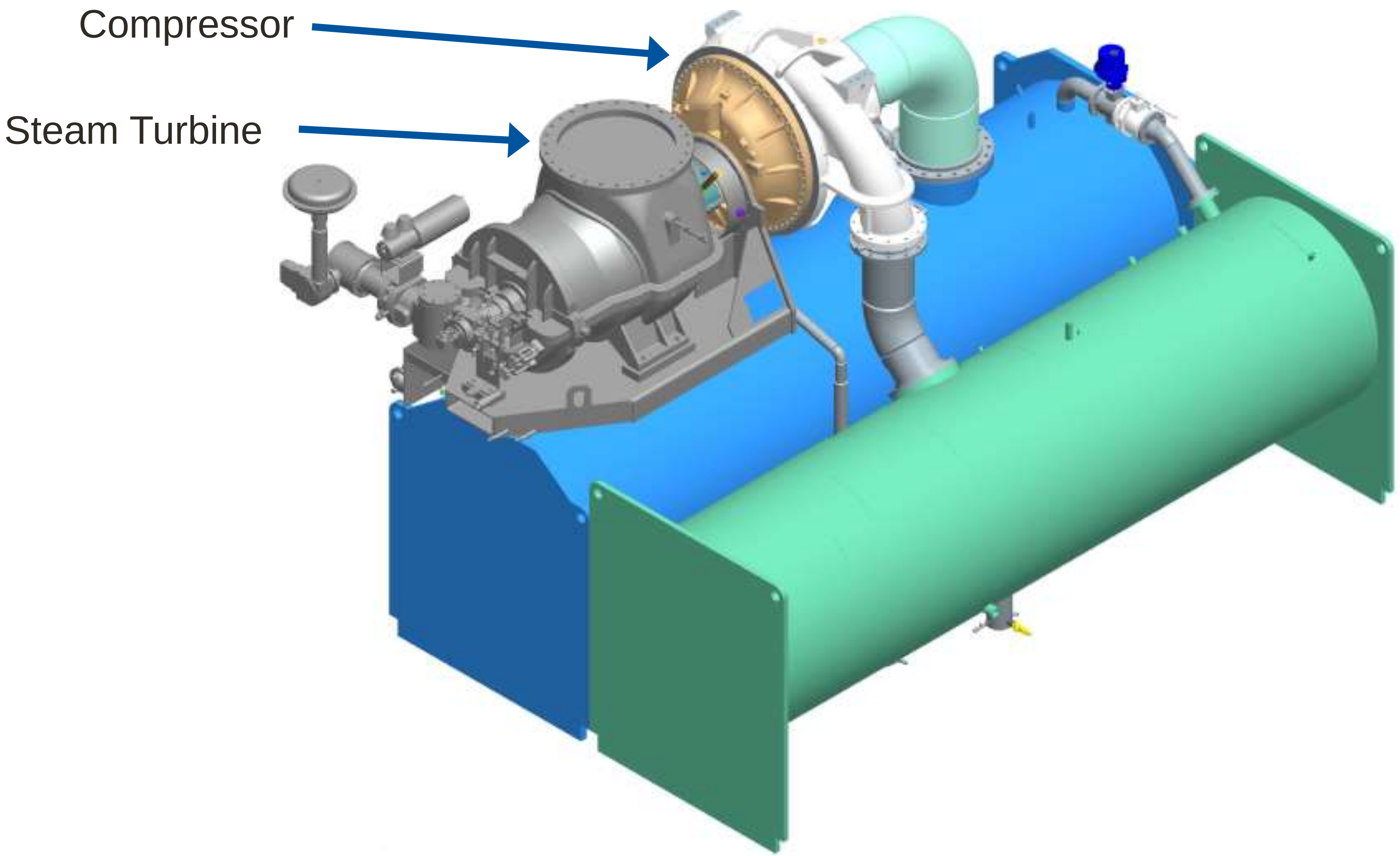




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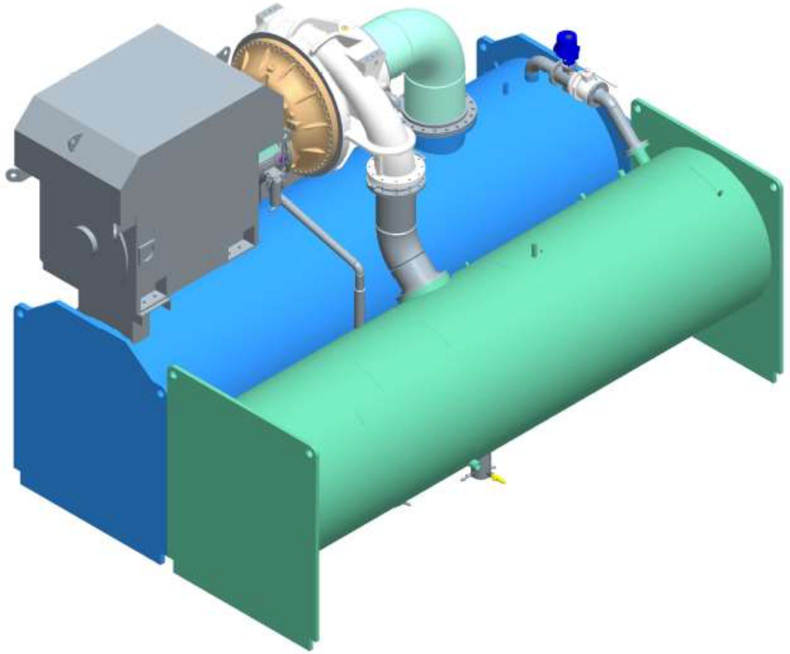
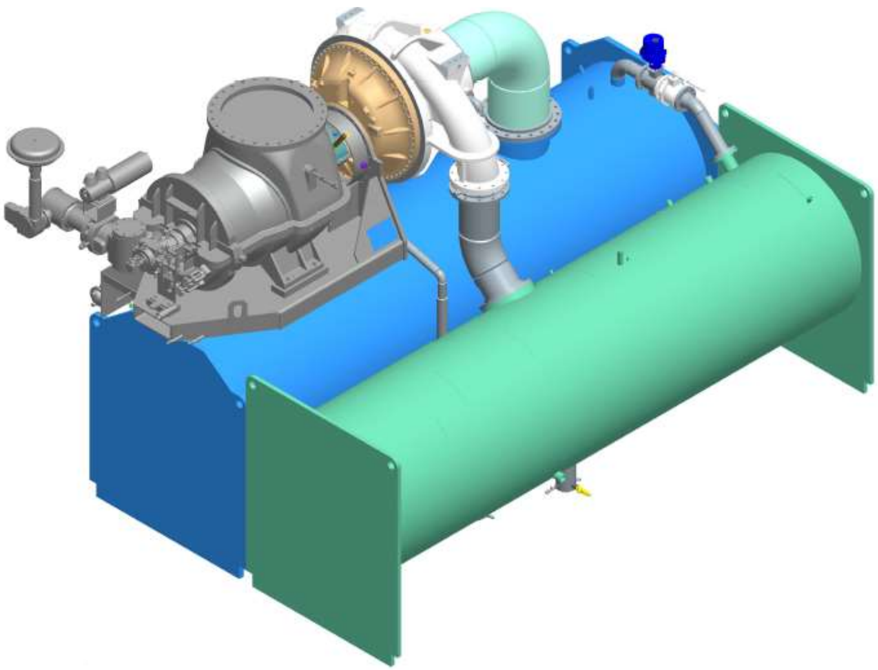
# Electric Drive vs. Steam Drive

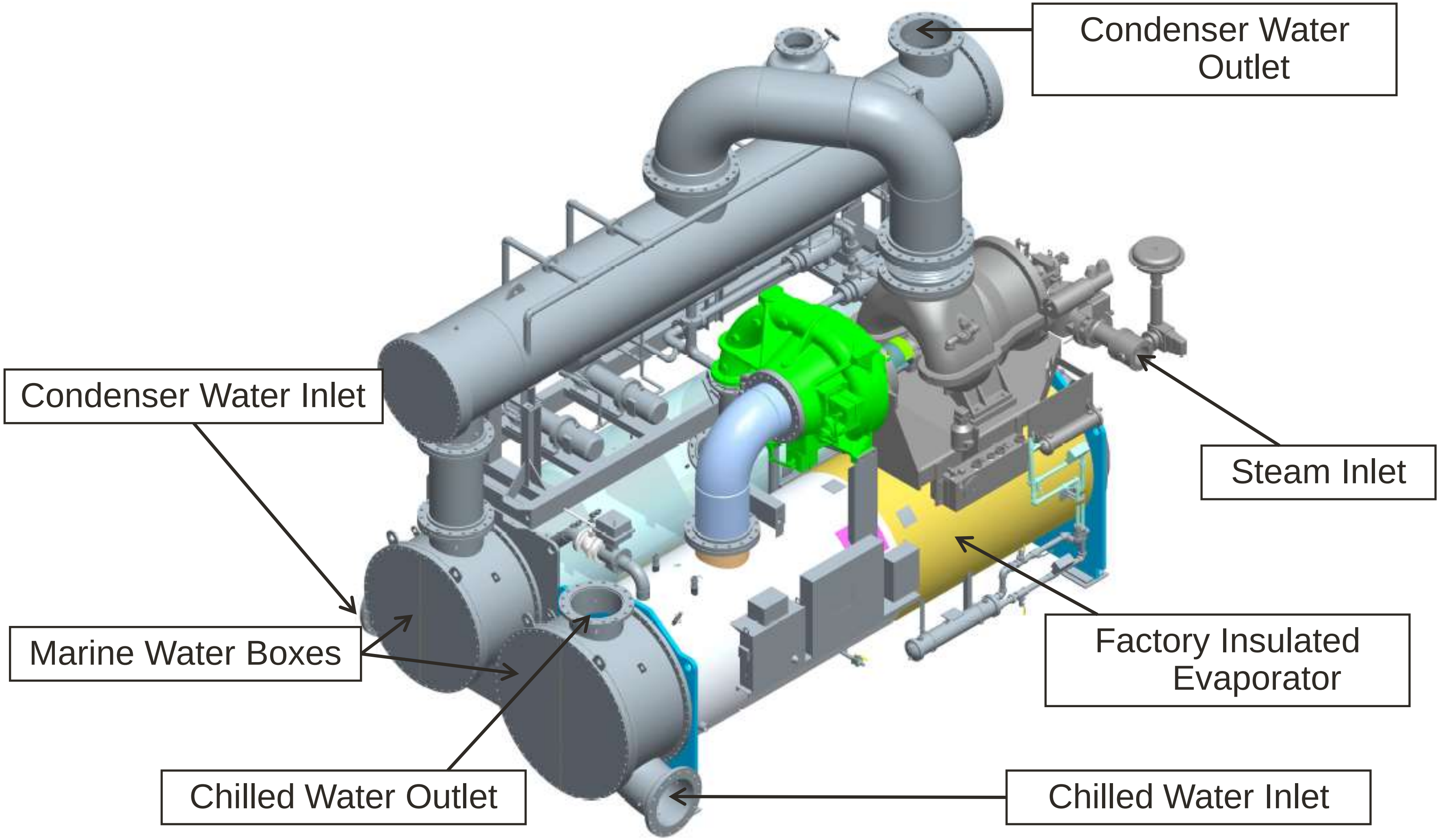


Electric Drive



Steam Turbine Drive

# Key Components



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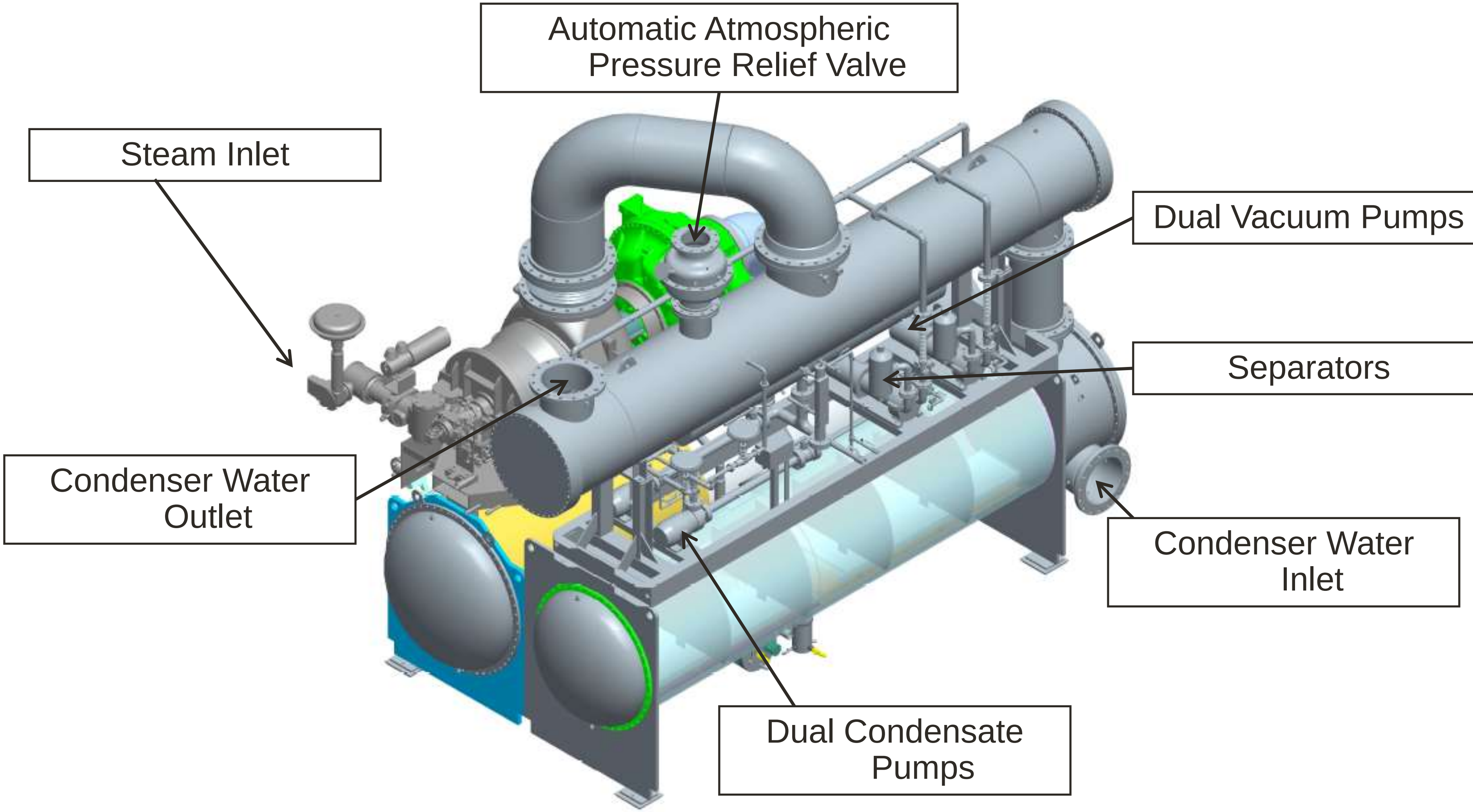




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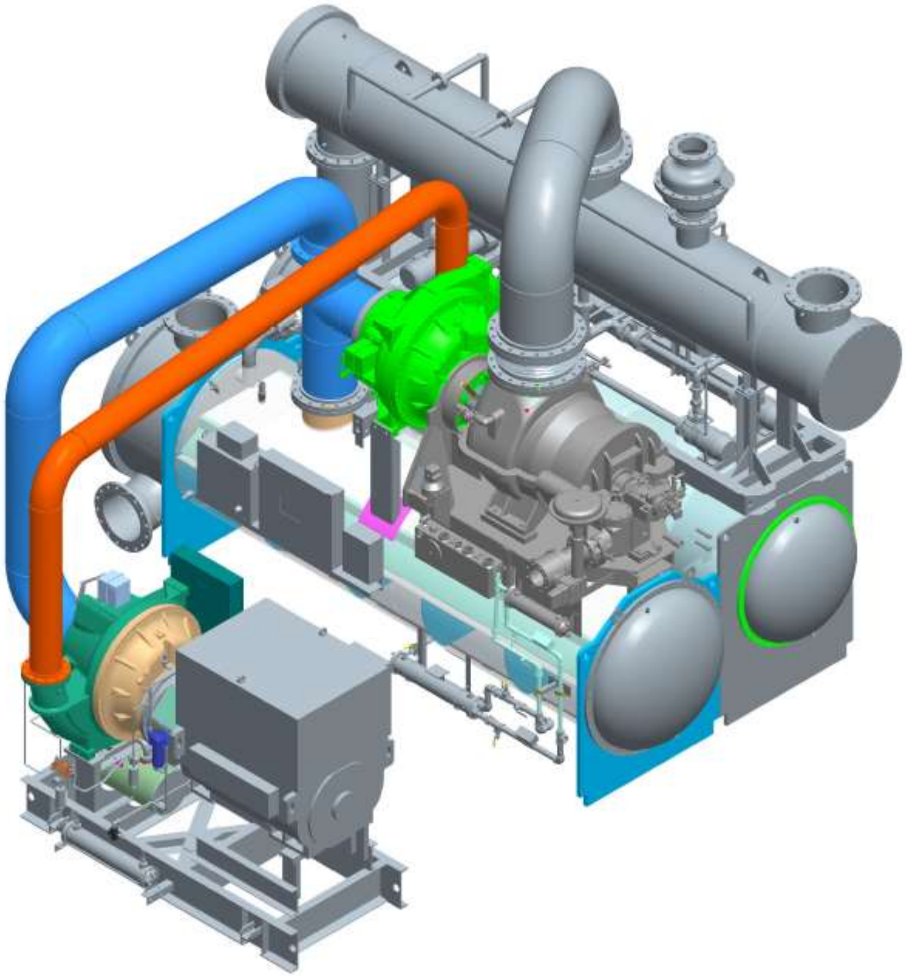
# Steam Turbine with Parallel Electric Drive





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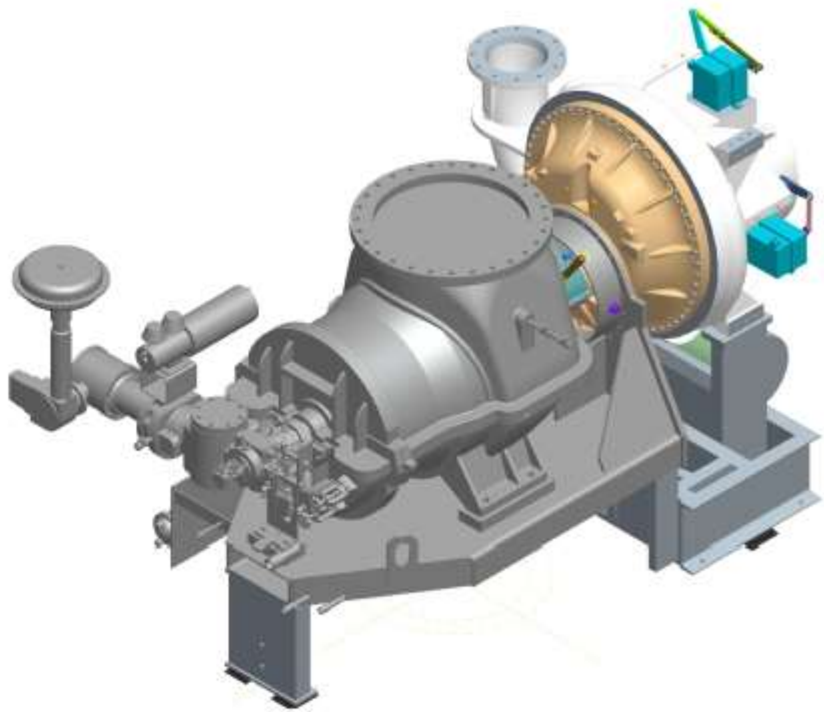
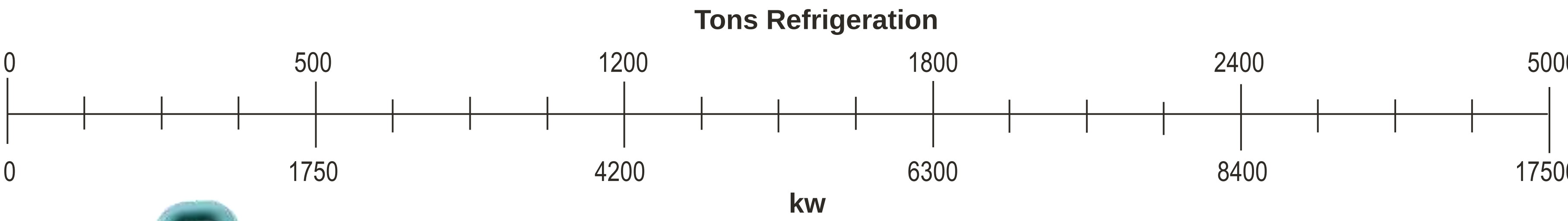
# Floor Mounted Steam Turbine



# Product Range




**500 - 5000 Tons**



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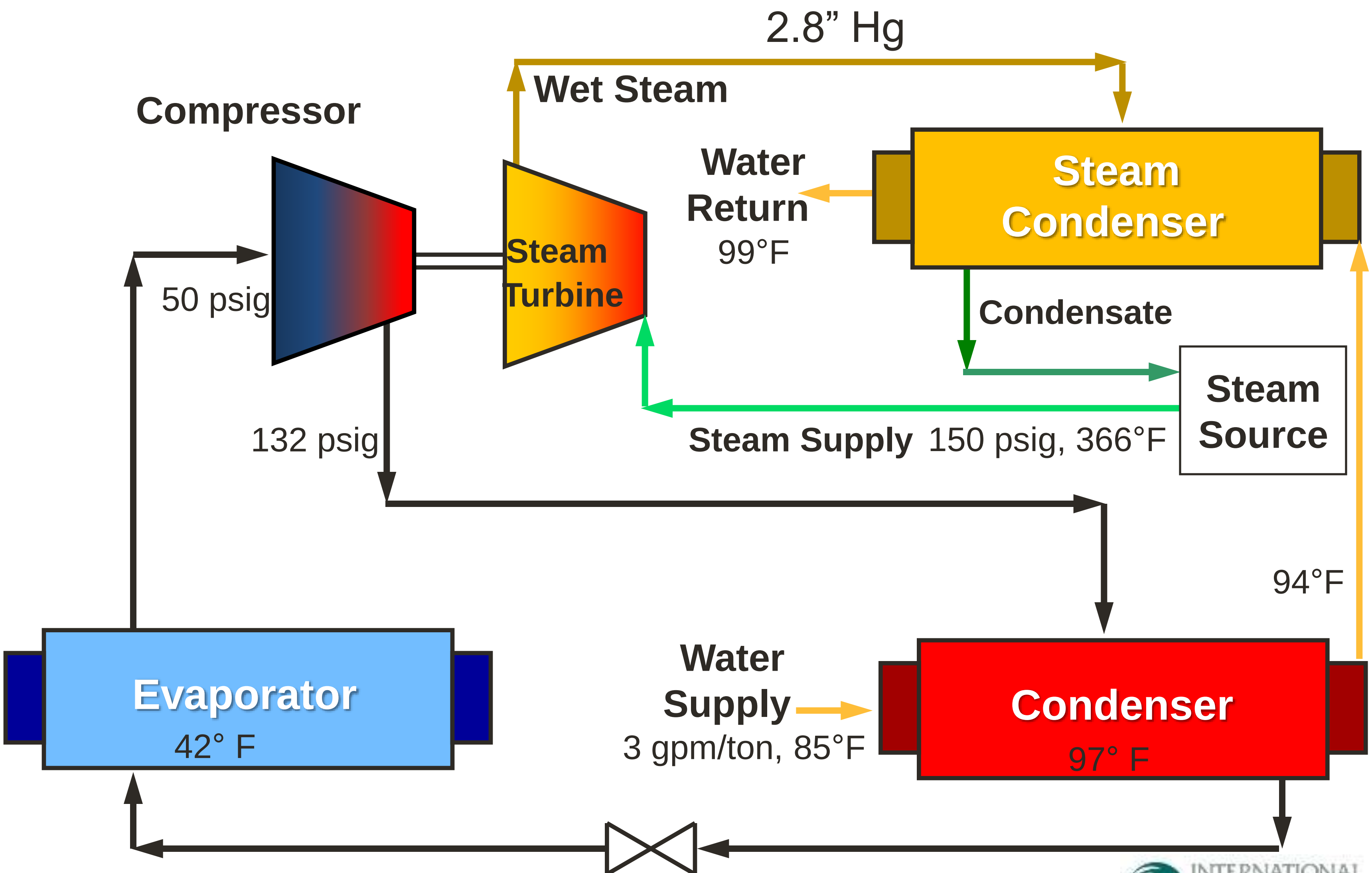
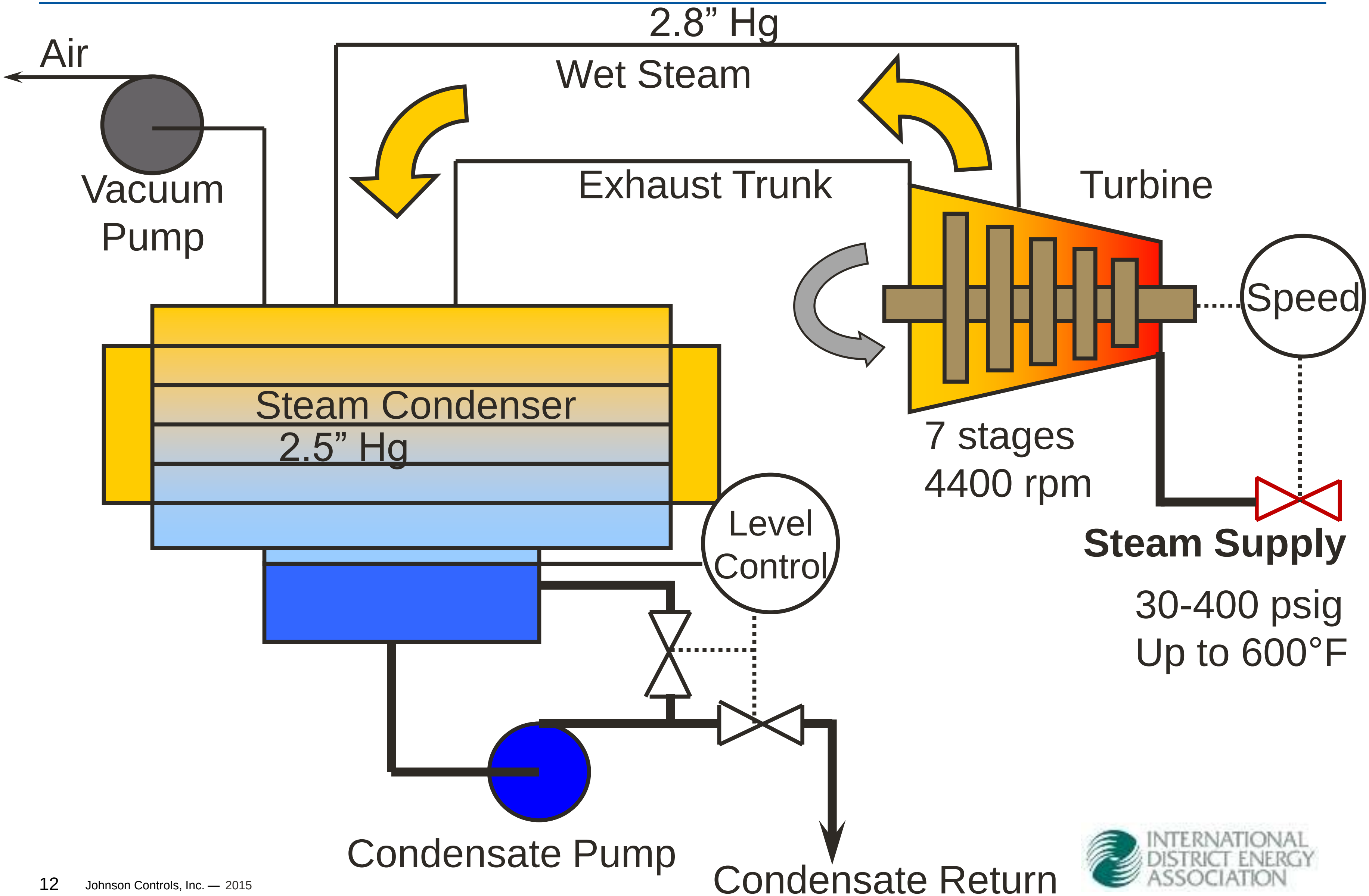
# Typical Schematic – 2000 Tons



# Steam System



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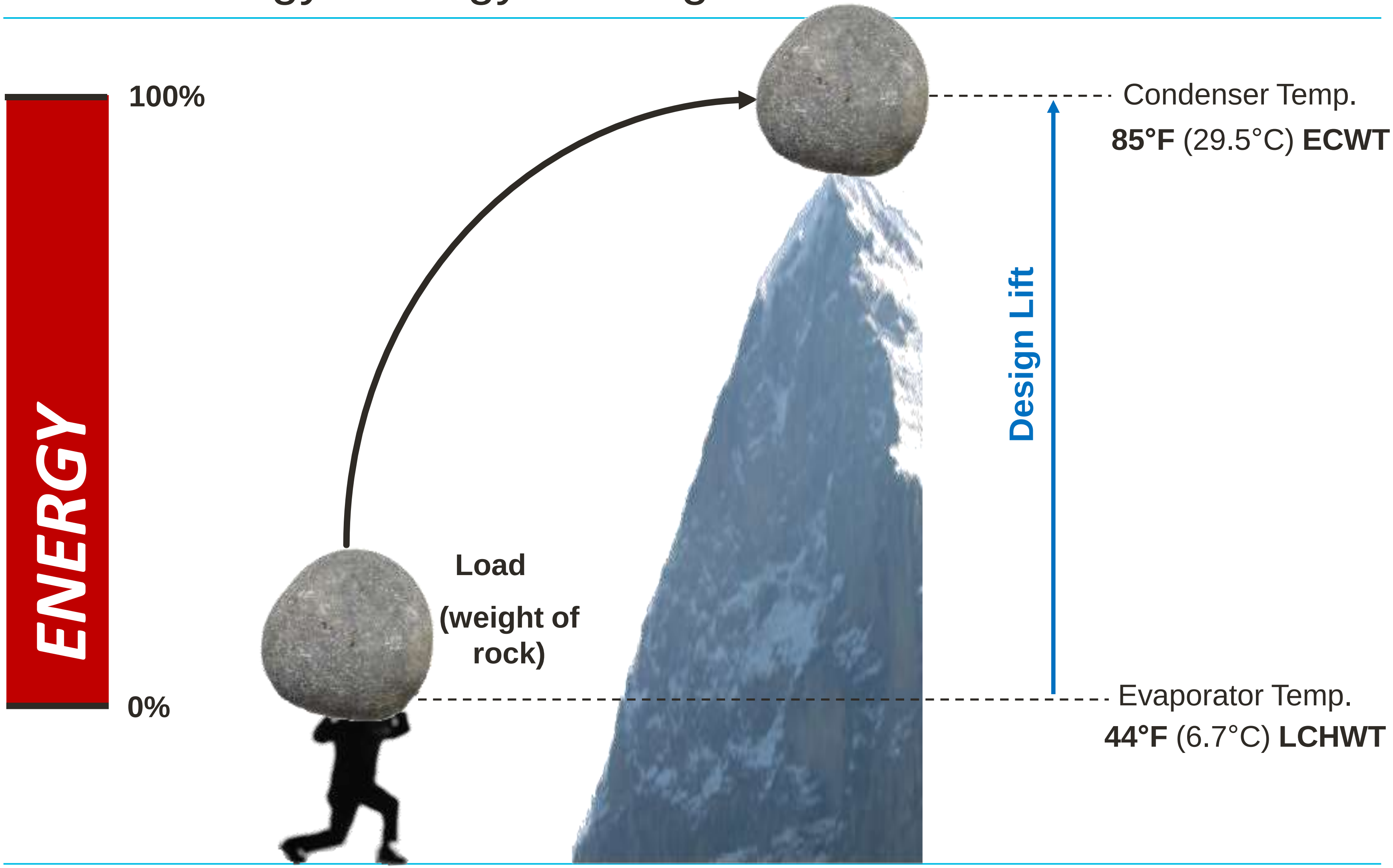
# NPLV/IPLV Formula

$$\text{IPLV/NPLV} = \frac{1}{(.01/A) + (.42/B) + (.45/C) + (.12/D)}$$

**A = KW/Ton @ 100% Load @ 85.0 °F ECWT or 95.0 °F EDB**
**B = KW/Ton @ 75% Load @ 75.0 °F ECWT or 80.0 °F EDB**
**C = KW/Ton @ 50% Load @ 65.0 °F ECWT or 65.0 °F EDB**
**D = KW/Ton @ 25% Load @ 65.0 °F ECWT or 55.0 °F EDB**

# Chiller Energy Analogy – Design Point



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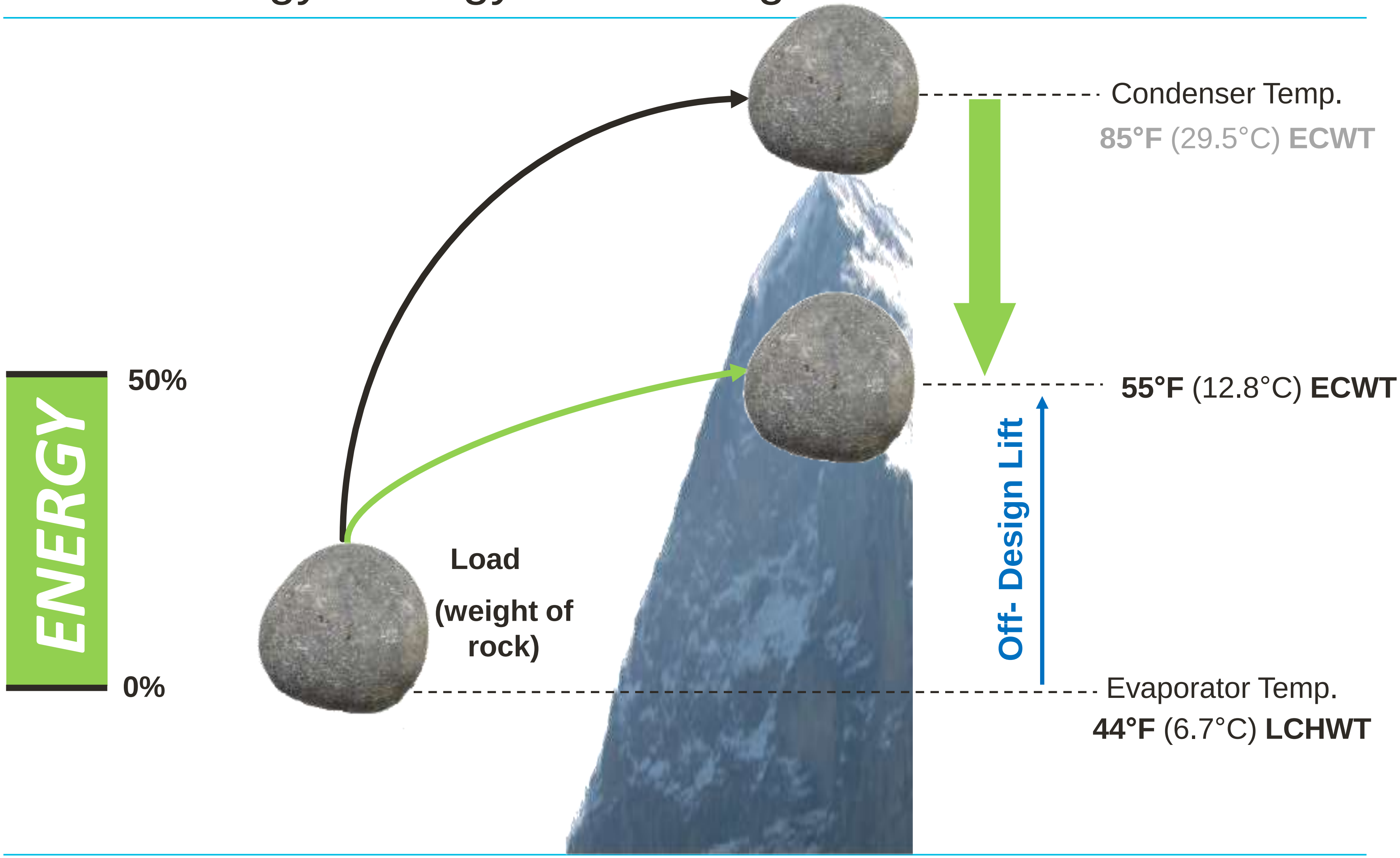
# Chiller Energy Analogy – Off-Design



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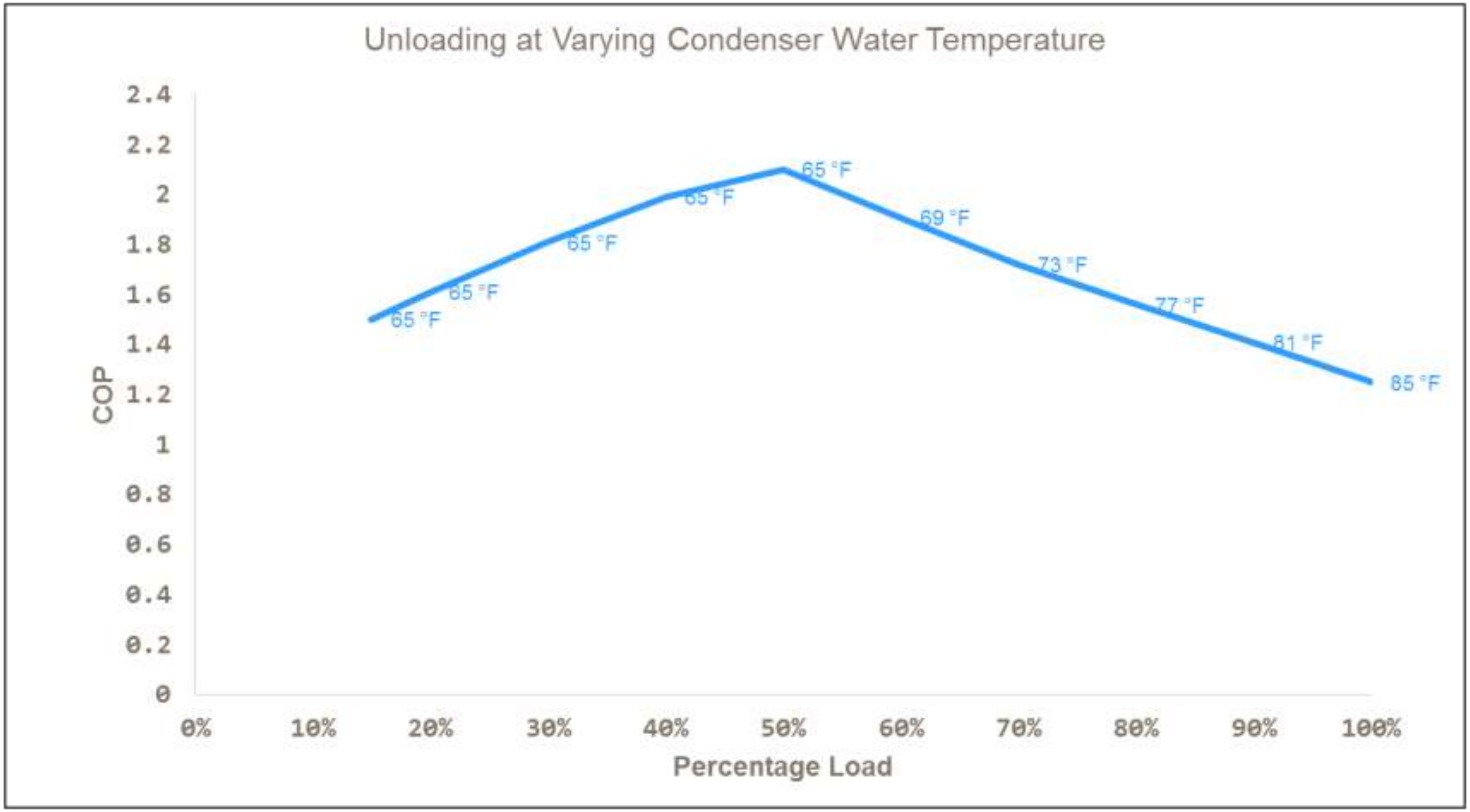
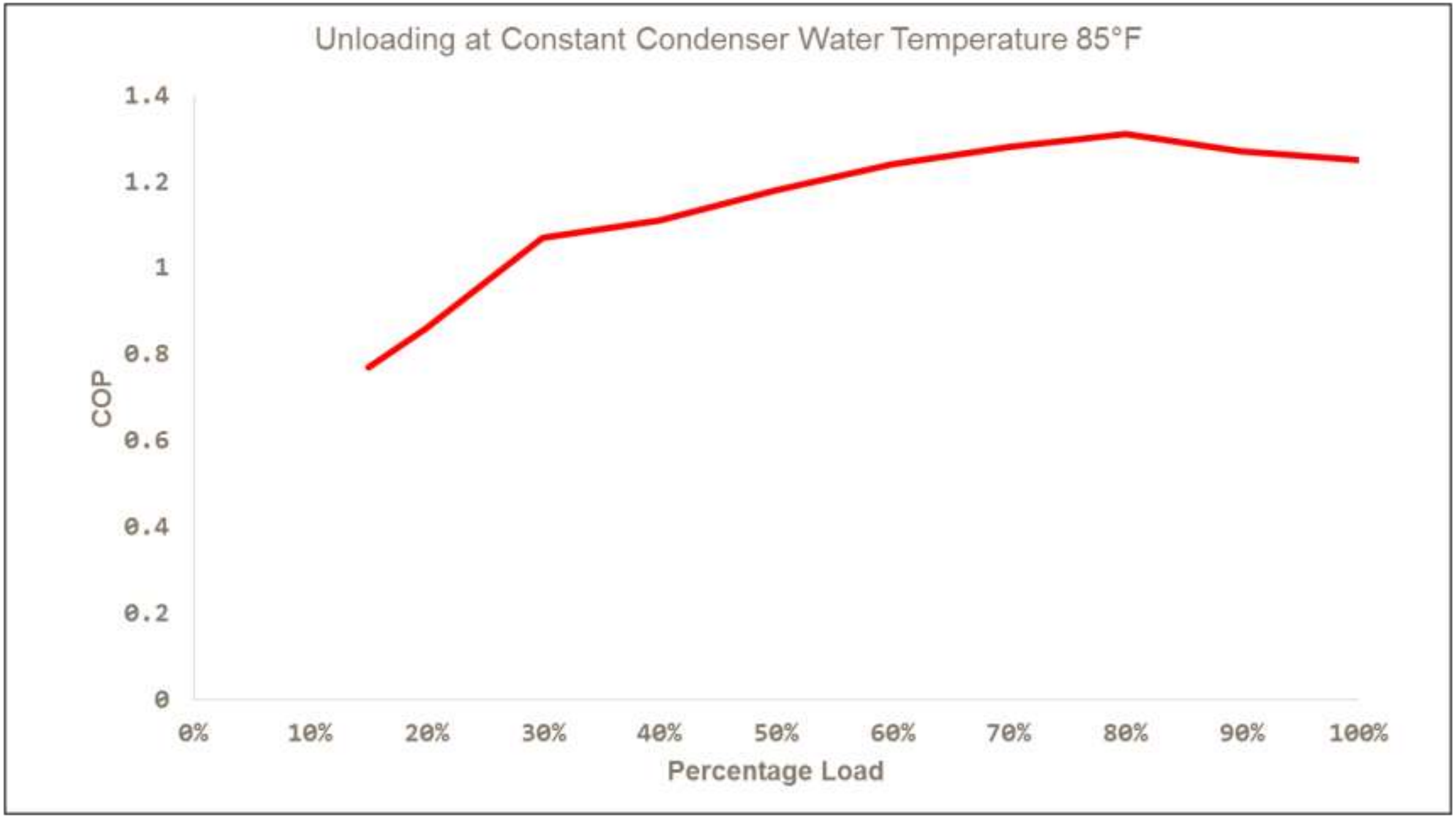
# Unloading Per AHRI



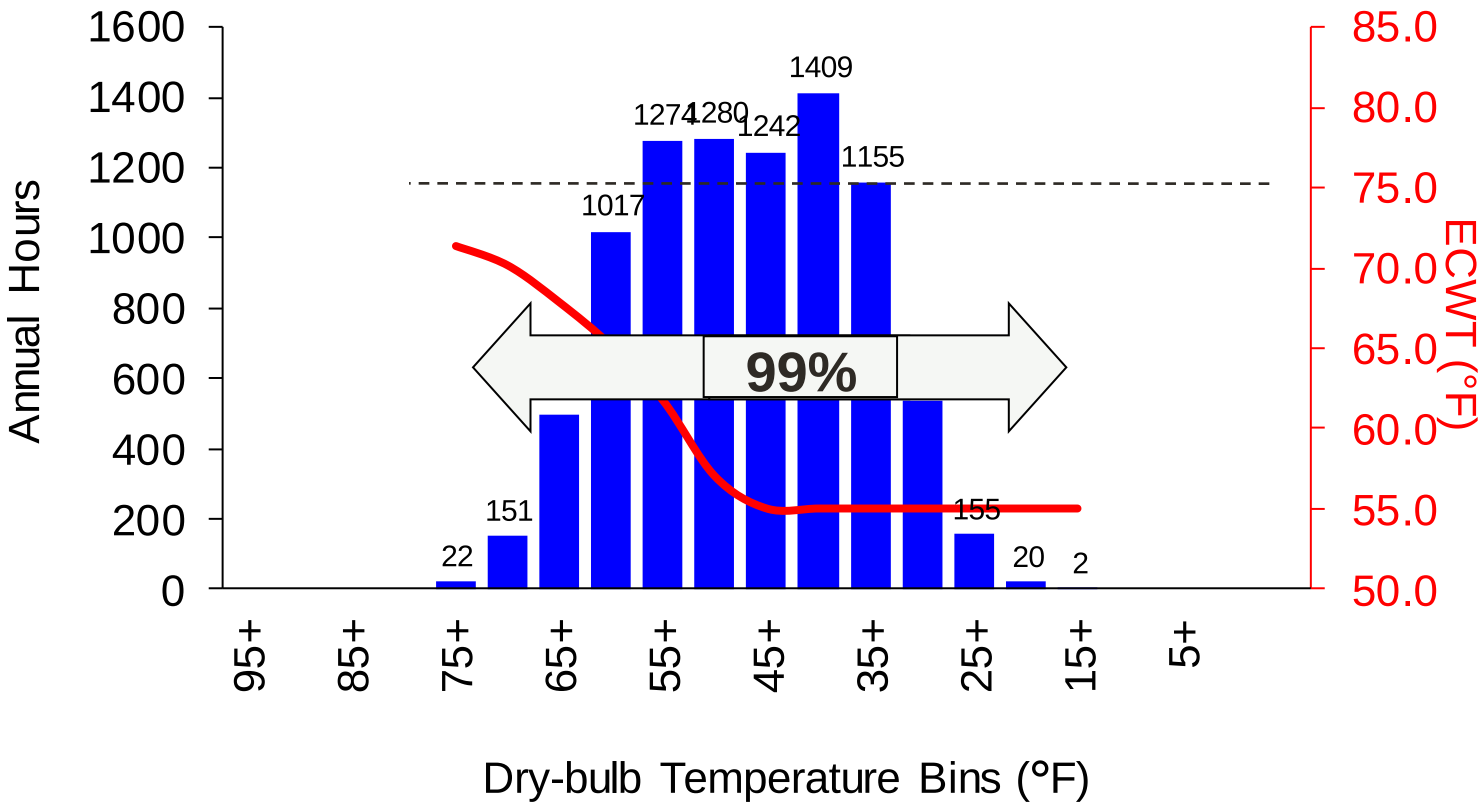

ECWT – entering condenser water temperature, COP – coefficient of performance

# Unloading with Constant ECWT (85°F)




ECWT – entering condenser water temperature, COP – coefficient of performance

# Vancouver Weather (ASHRAE CWEC Weather)




Note: ECWT = Avg WB + 8 approach



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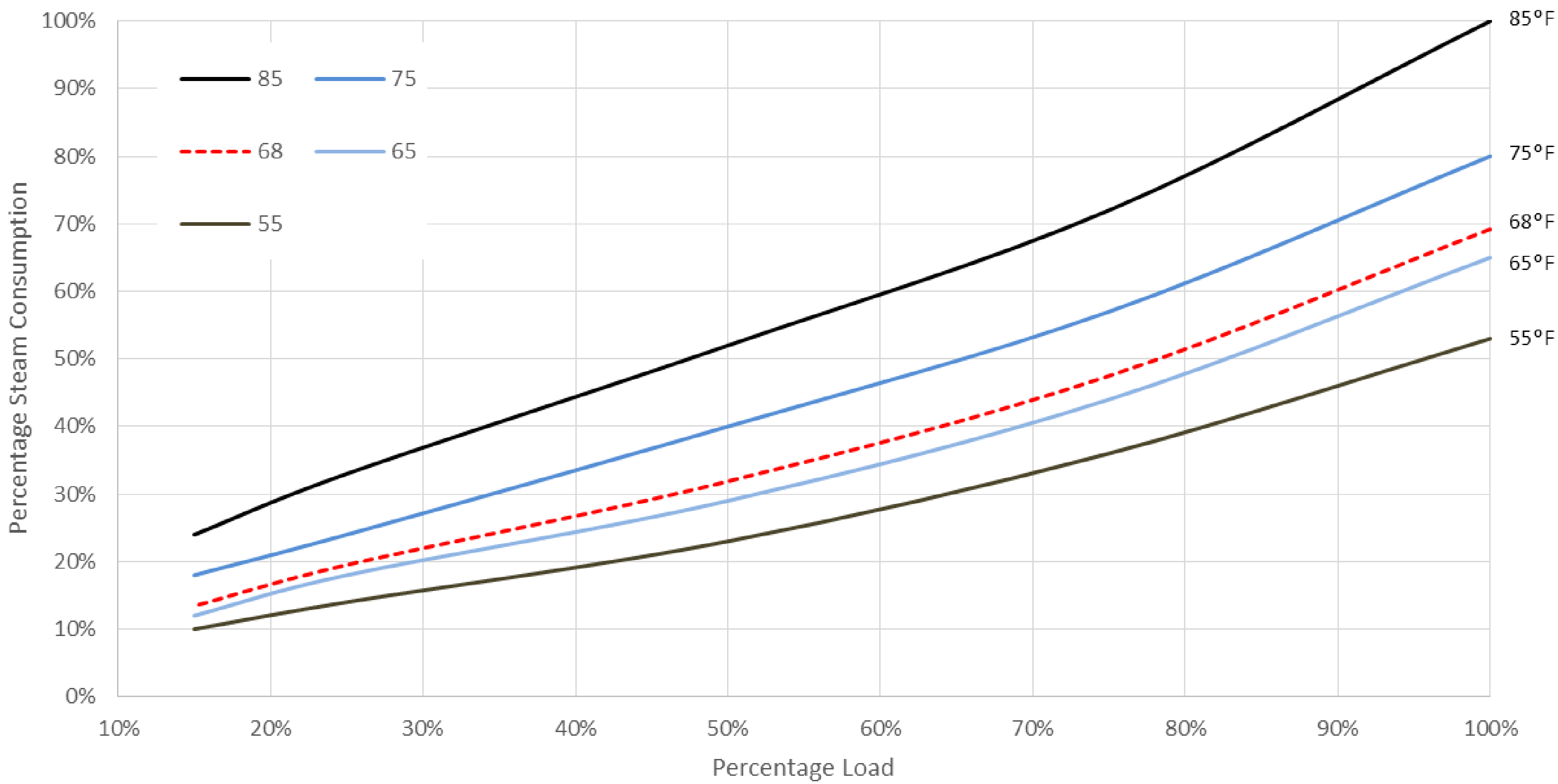
# Very Good




ECWT – entering condenser water temperature, COP – coefficient of performance

# Achieving 20% Higher Capacity
# With Lower ECWT with a typical 3000 Ton Chiller

| ECWT Deg F | % Design Load | % Steam Rate of Design |
|---|---|---|
| 85 | 100 | 100 |
| 80 | 105% | 97 |
| 75 | 110% | 95 |
| 70 | 115% | 94 |
| 65 | 118% | 91.3 |
| 60 | 121% | 91.6 |
| 55 | 123% | 92.5 |

Perhaps shut off a chiller in the plant room

ECWT – entering condenser water temperature, COP – coefficient of performance



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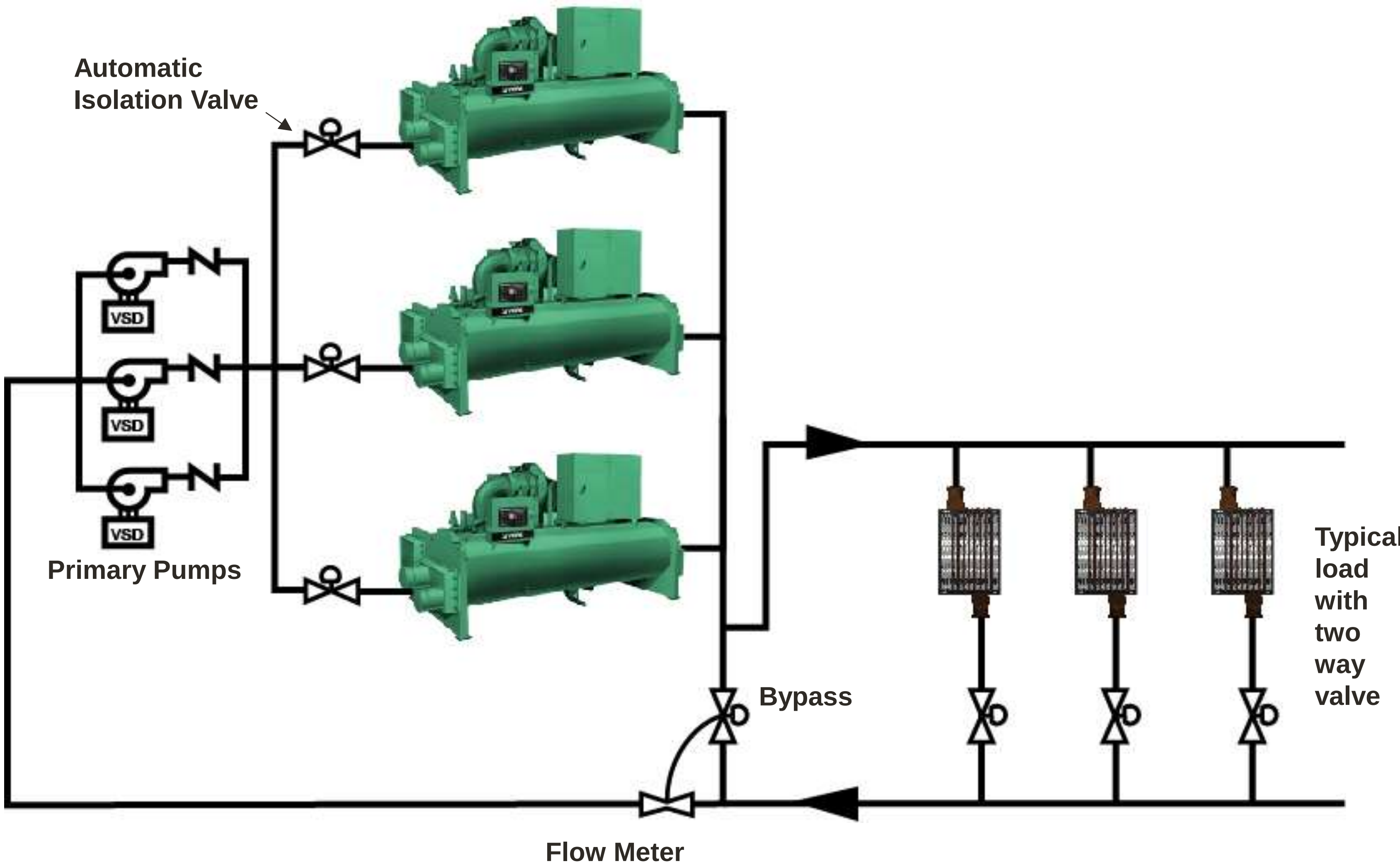
# Variable Primary Flow



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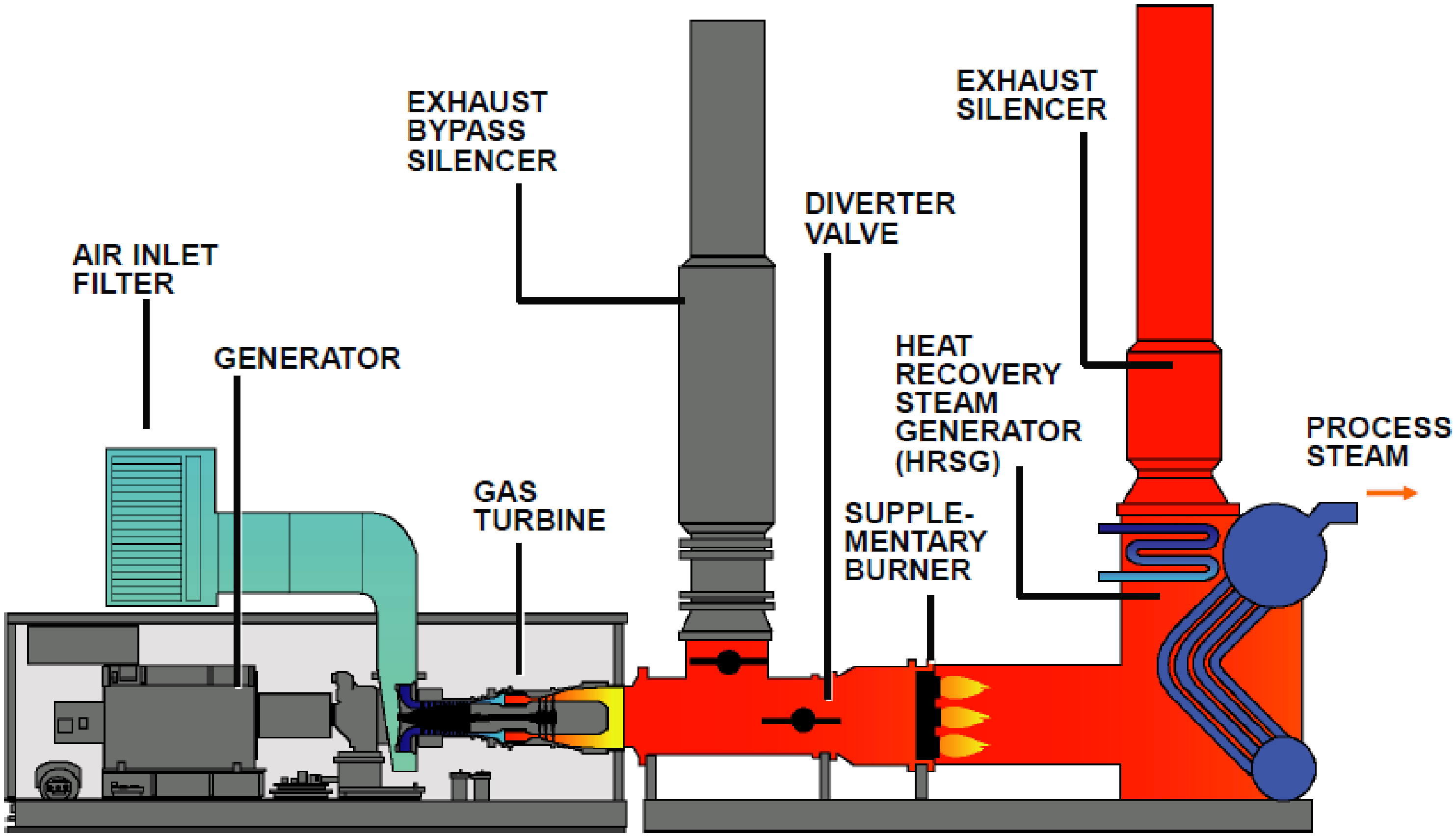
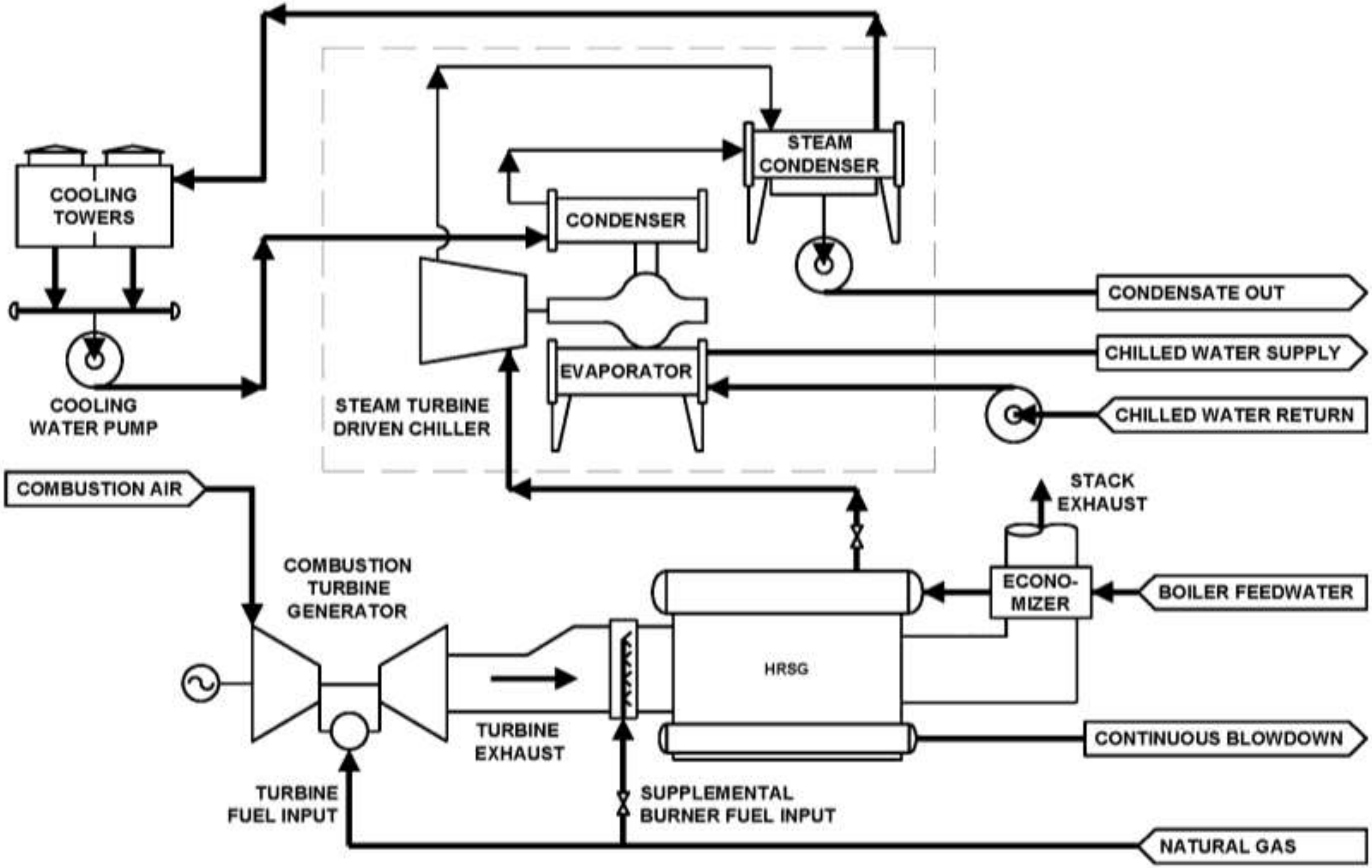
# Typical Combustion Turbine CHP



# Typical CHP System




**Source CEM Engineering**



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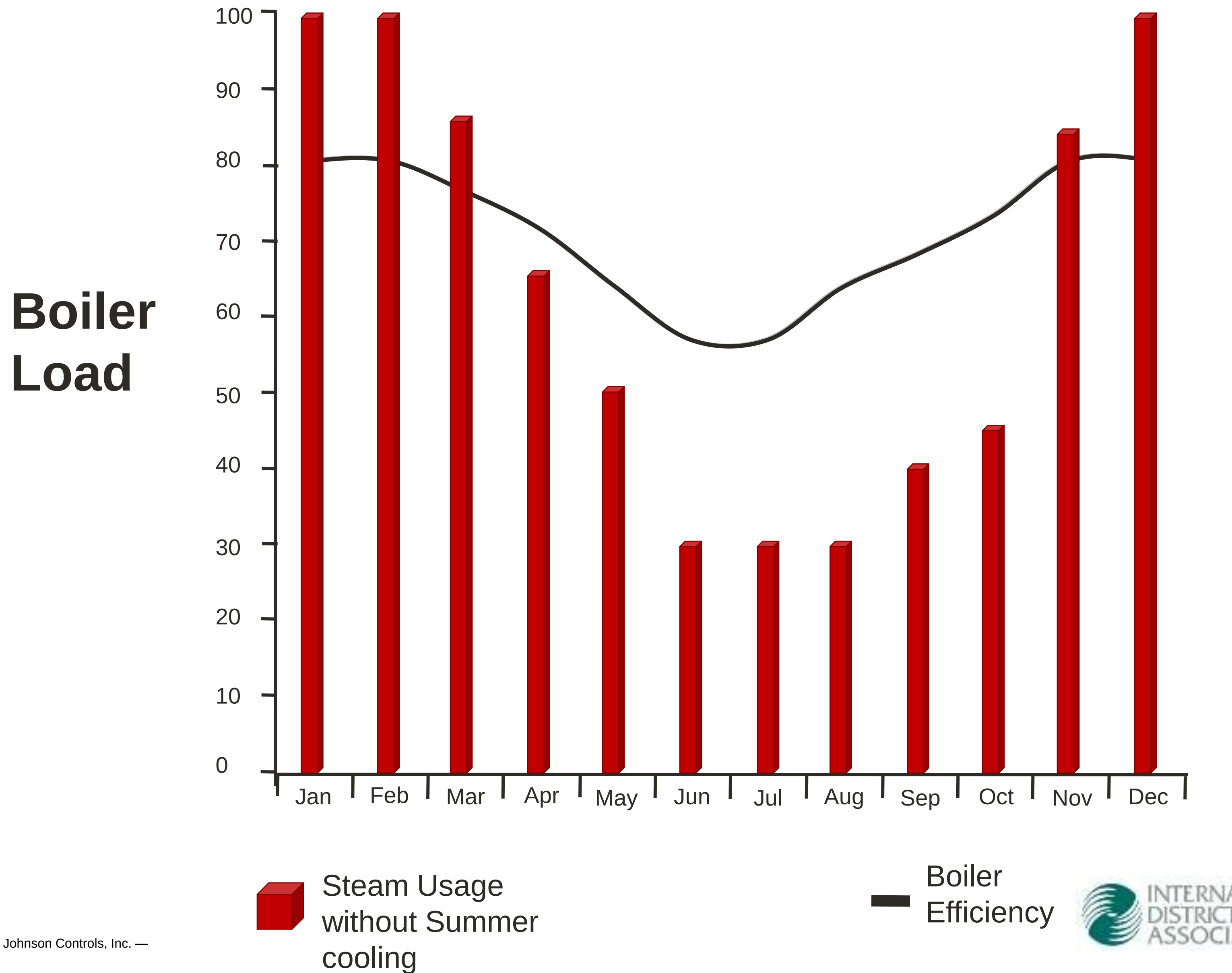
# Seasonal Steam Usage- Without Summer Cooling



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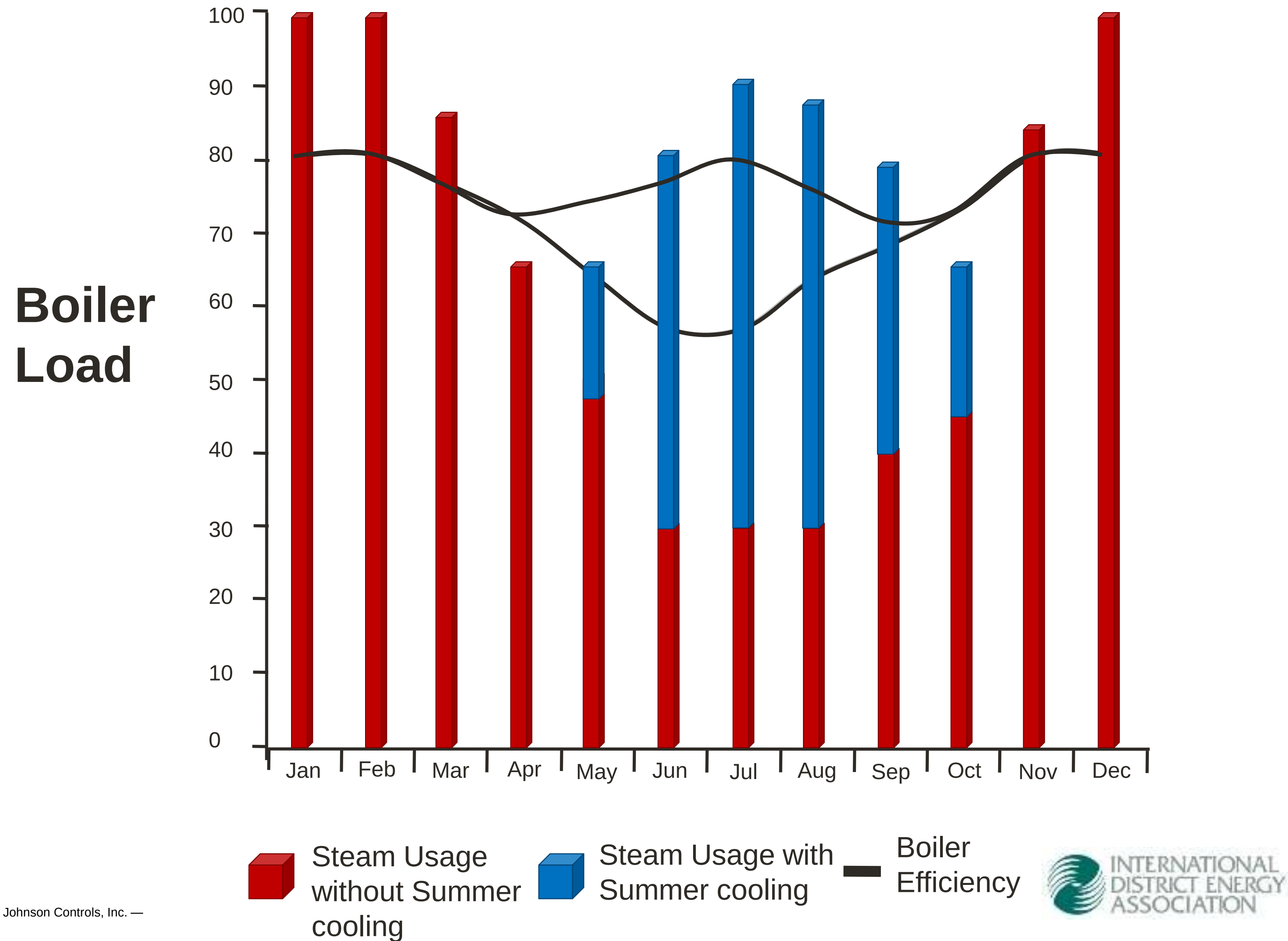

# Keele Campus Overview

- Founded in March 1959, and is now Canada's third-largest university
- Over 55,000 students and growing fast
- Over 7,000 employees
- Single largest campus in Canada
- 8,000,000 sq. ft.
- 21MW electrical peak load (and growing with new Life Sciences Building, Stadium and Lassonde School of Engineering building)
- Over 12,000 tons of centralized chillers for air conditioning
- Prime opportunity for peak shaving

# Energy Management Overview

- **Central Utilities:**
  - Generates high pressure steam (250psi, 1,724kPa) for heating and 5$^{o}$C chilled water for cooling,
  - Delivers these by way of underground service tunnels to mechanical rooms of each building for distribution to the various heating, ventilating, and air conditioning (HVAC) units within the building
  - Generate and distribute power through 10 megawatt co-generation plant and associated 13,800 volt electrical distribution system.

# Energy Management Overview

- **Historical Operating Budget - $25 million (almost $70,000/day, $0.80/sec)**
  - Natural Gas 35%
  - Electricity 40%
  - Water 10%
  - Oil – backup <1%
  - Maintenance and Operations 15%

# New Tri-generation Steam Turbine Chiller Project

- Board of Governors approved of $5,000,000 budget to engineer, procure and install a 3,000 ton tri-generation steam turbine driven chiller in the Keele Campus Central Utilities Building

- This project has several attributes which independently substantiate the concept;
  - Reduced energy consumption and associated environmental stewardship (reducing annual electrical consumption by 5,231,000 kWh and peak consumption by 2MW, over 4,000 tons of $CO_2$ avoided assuming imported coal fired peaking generation, twice the capacity and efficiency, part load efficiency almost 4 x better during start up testing)
  - Requirement for Incremental Peak Cooling Capacity – various new buildings
  - Minimization of Imported Power and reducing cost of purchased electricity Investment Business Case and Incentive Timeliness (<8 year payback, with an electricity saving of $523,101/year, incentive over $1,030,000 on electricity, $44,000 on natural gas)
  - Modernization and reliability – replaces very inefficient and obsolete 1964 unit
  - Infrastructure Cost Avoidance – electrical sub-stations, new chillers

# CHP Steam Driven Chiller Recap

- Lower operating cost than electric drive chillers and 2 stage absorption chillers.
- Utilize lower entering condenser water temperature to improve efficiency and increase capacity above design conditions.
- Improve boiler efficiency and provide cooling during summer months
- Operate with variable primary flow where this is more difficult with absorption technology.
- Wide operating range from 30 - 400 PSIG, 500 to 5000 Tons Refrigeration
- Flexible assembly configuration capabilities to meet space limitations

# Questions


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