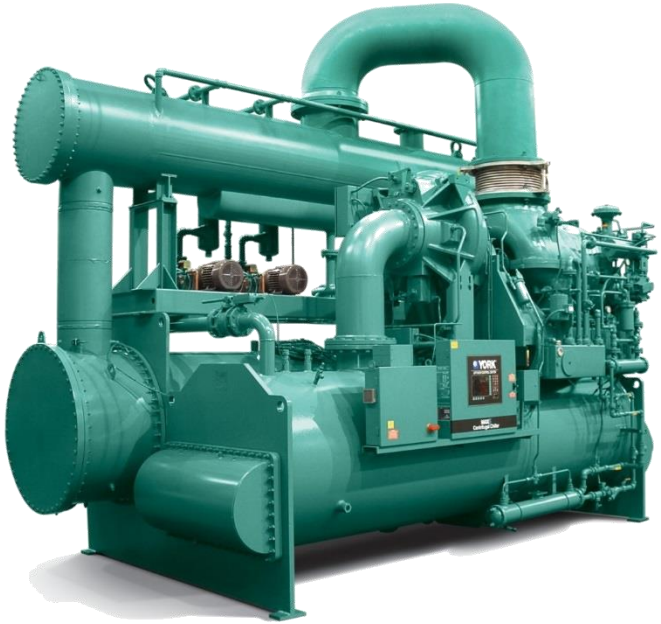


STEAM TURBINE CENTRIFUGAL CHILLERS

Presenters - Joe Brillhart and Rajesh Dixit

Toronto, Canada

September 10th, 2015

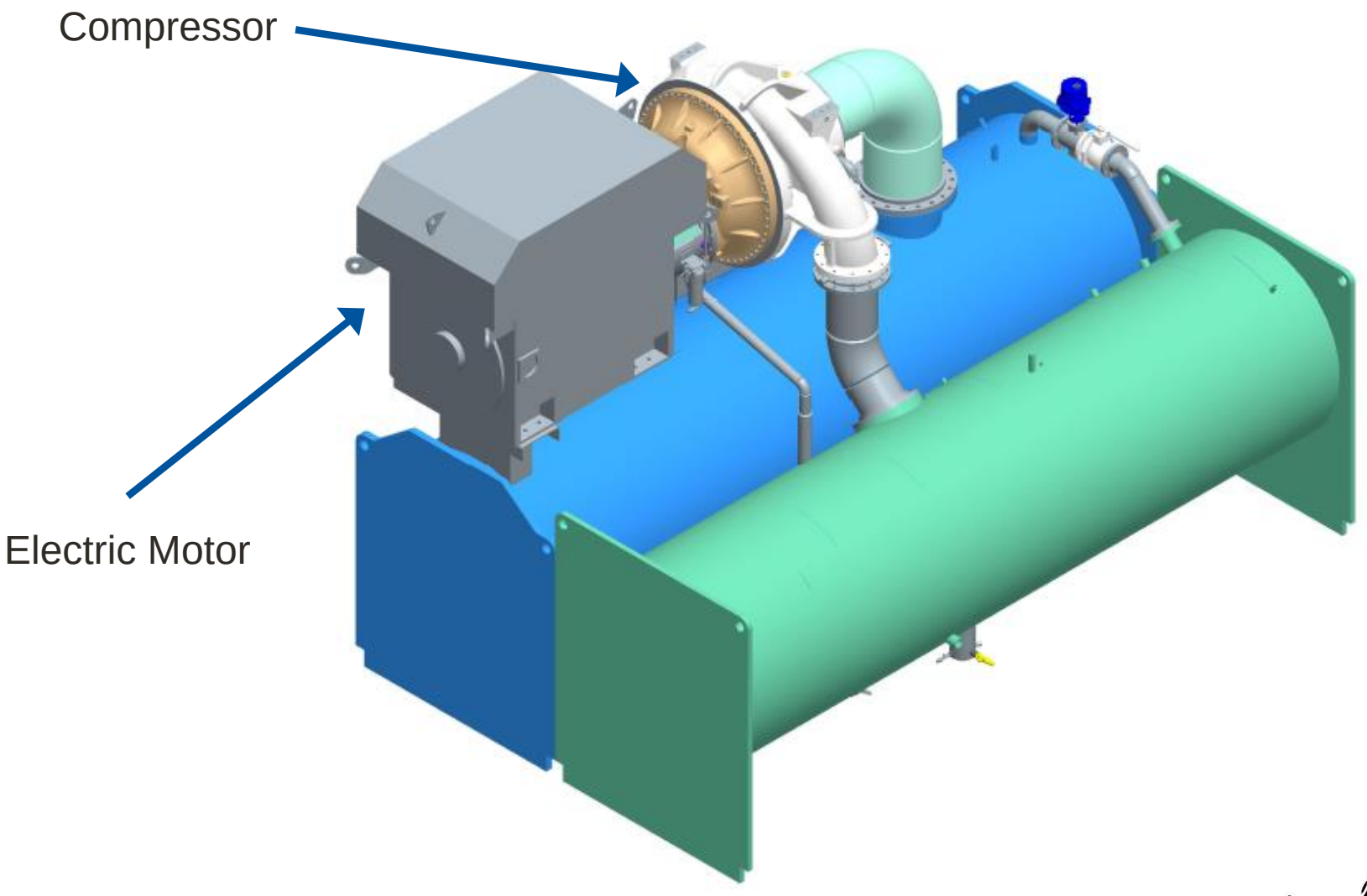
YORK®

Johnson Controls

Agenda

- Basics
- Range
- Illustration & Features
- Performance
- Real-World Applications
- Recap

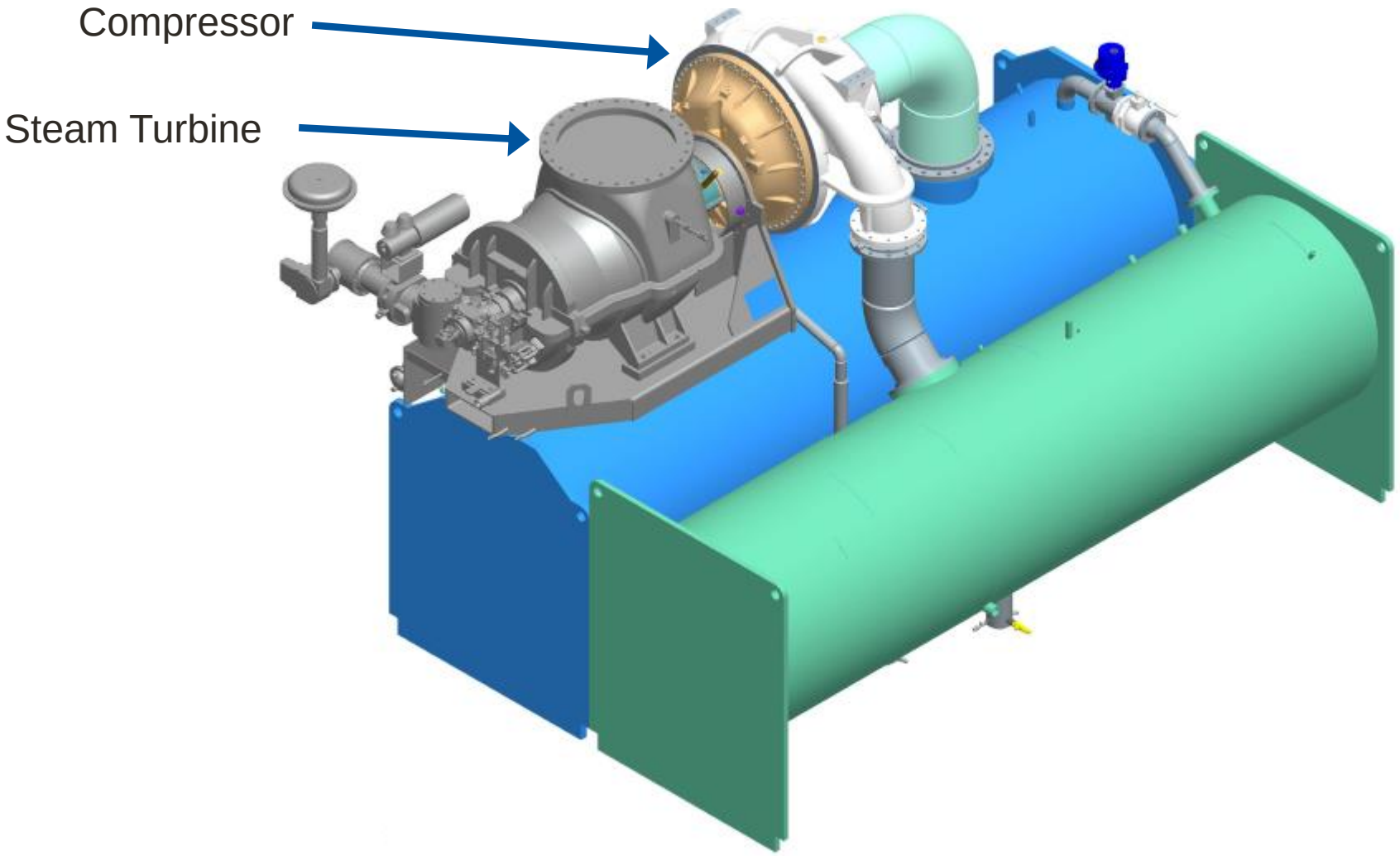
Electric Motor Driven Centrifugal Chiller



YORK – Electric Motor Driven Centrifugal Chiller

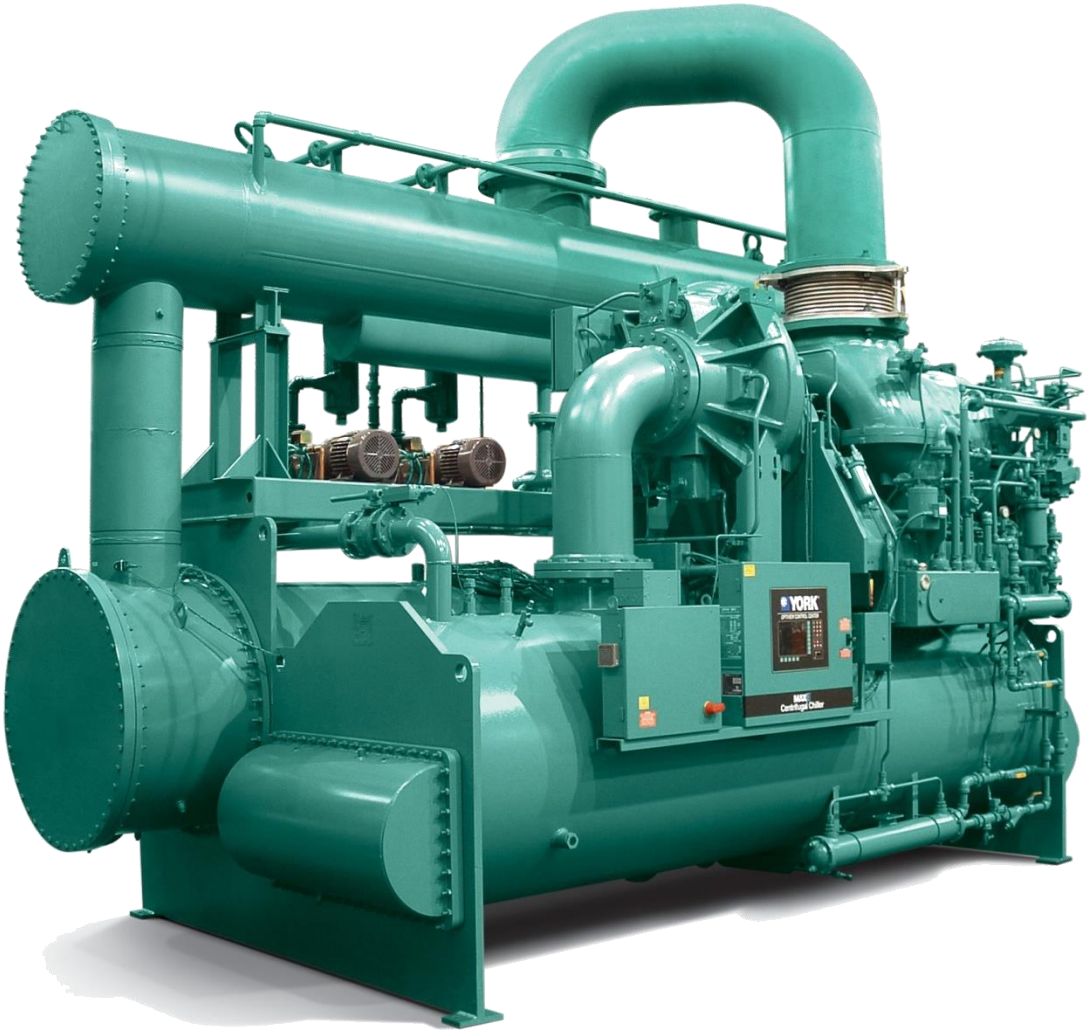
- YK Chiller
- Open Drive
- R-134a

Electric Motor Driven Centrifugal Chiller

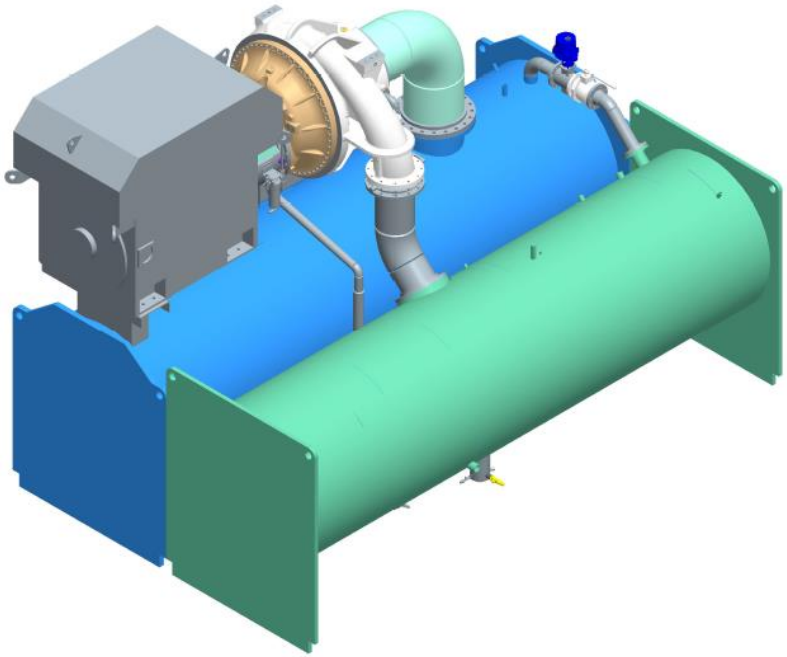


YORK – Steam Turbine Driven Centrifugal Chiller

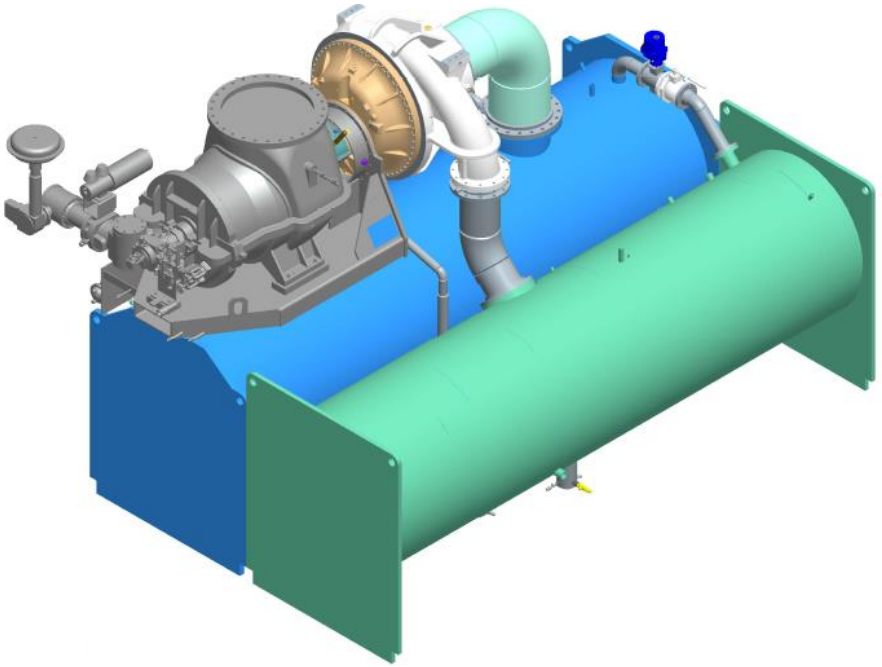
- YST Chiller
- Open Drive
- R-134a



Electric Drive vs. Steam Drive

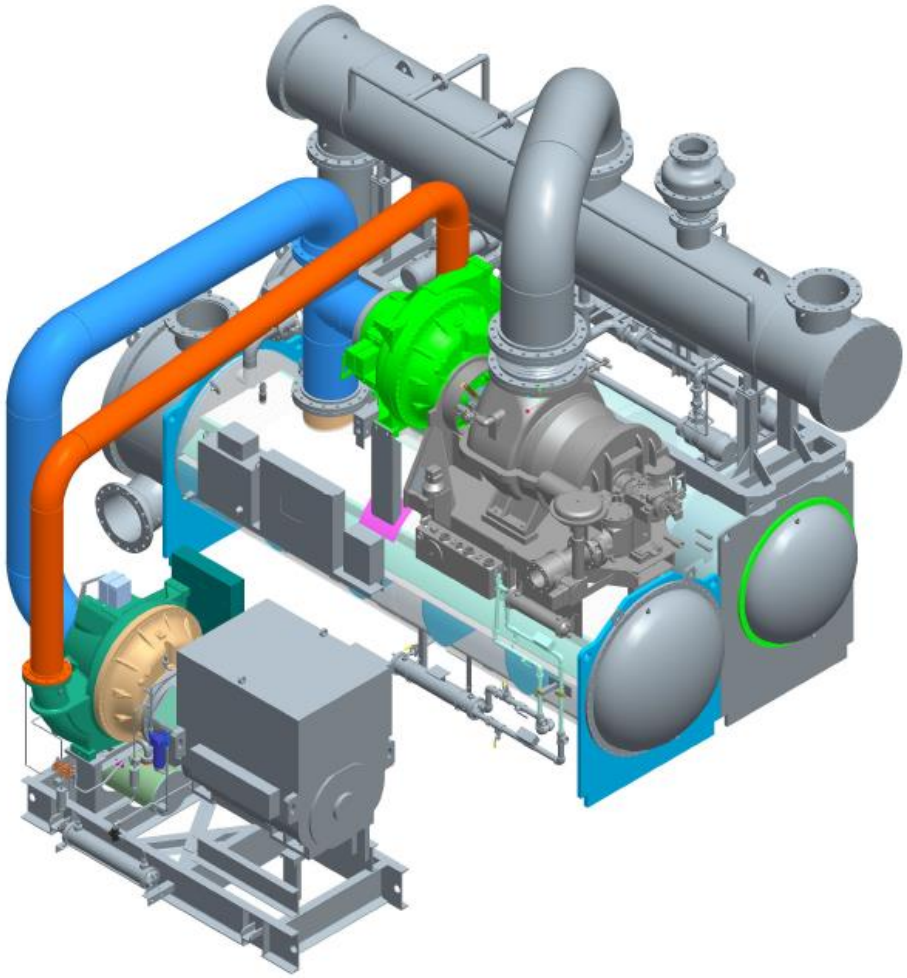


Electric Drive (YK)

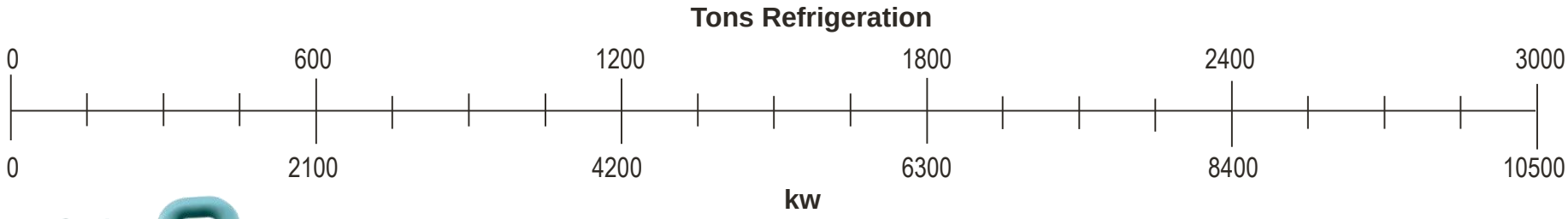


Steam Turbine Drive (YST)

Steam Turbine with Parallel Electric Drive

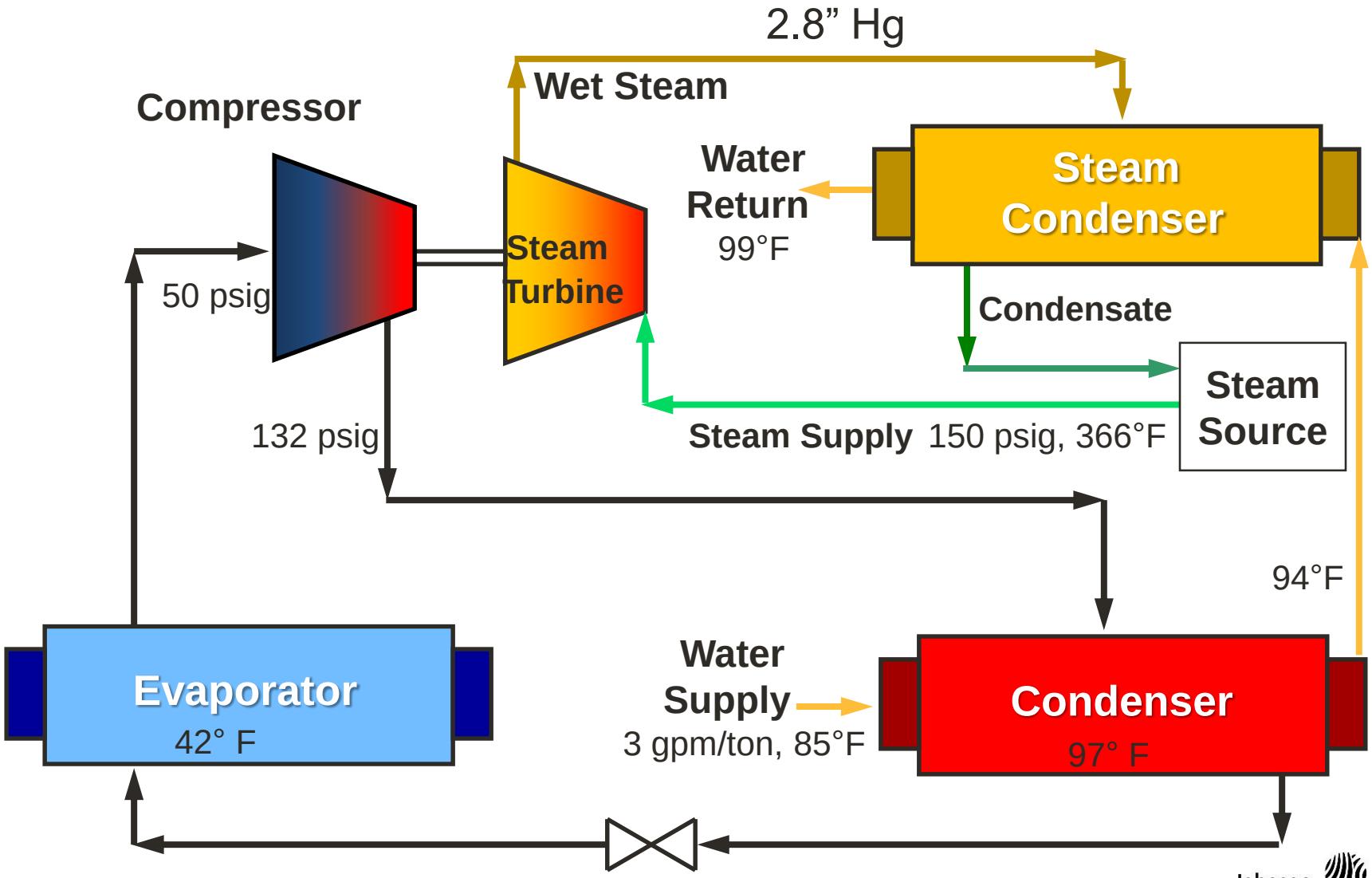


Product Range

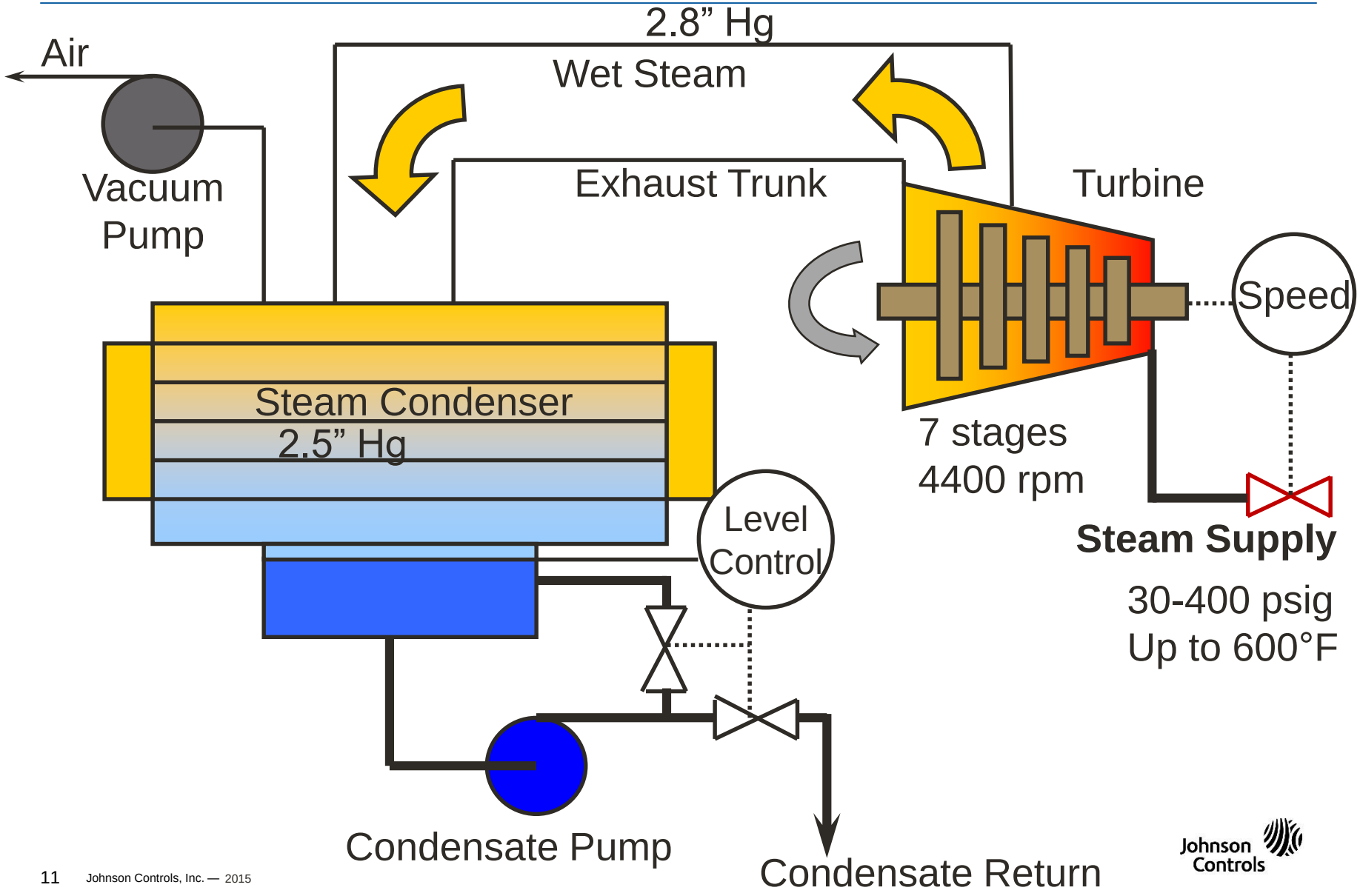


600 - 2800 Tons

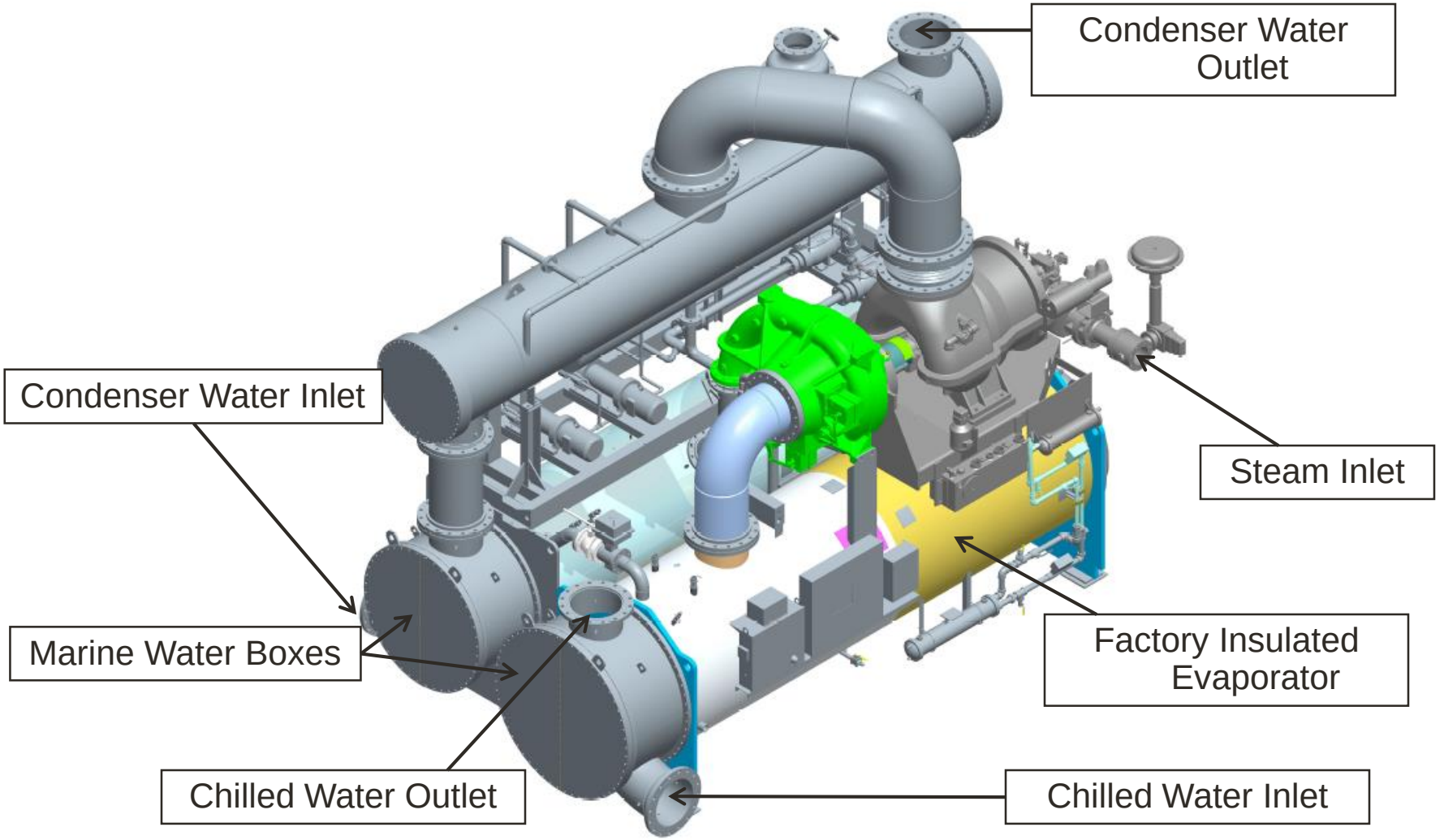
Typical Schematic – 2000 Tons



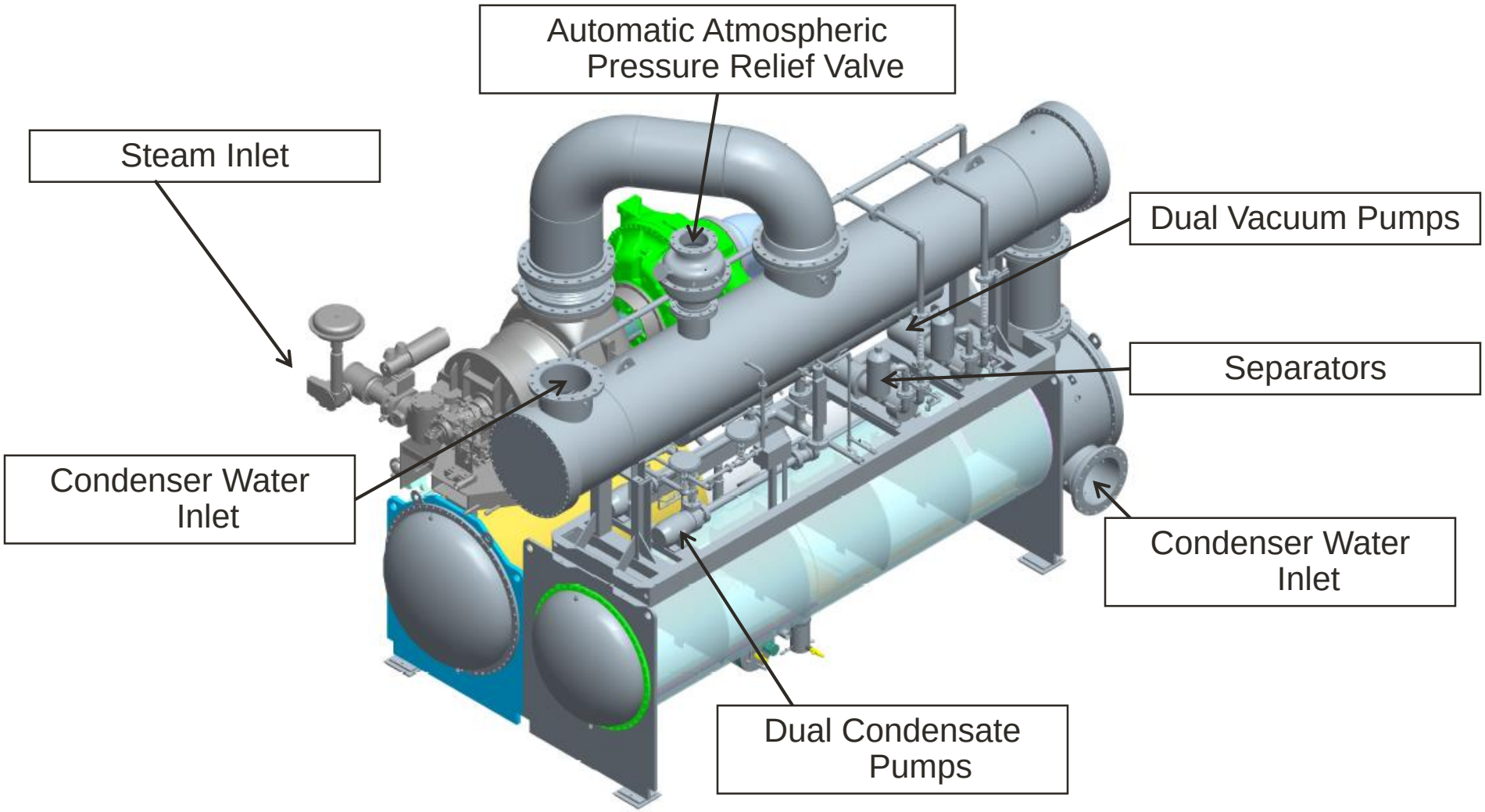
Steam System



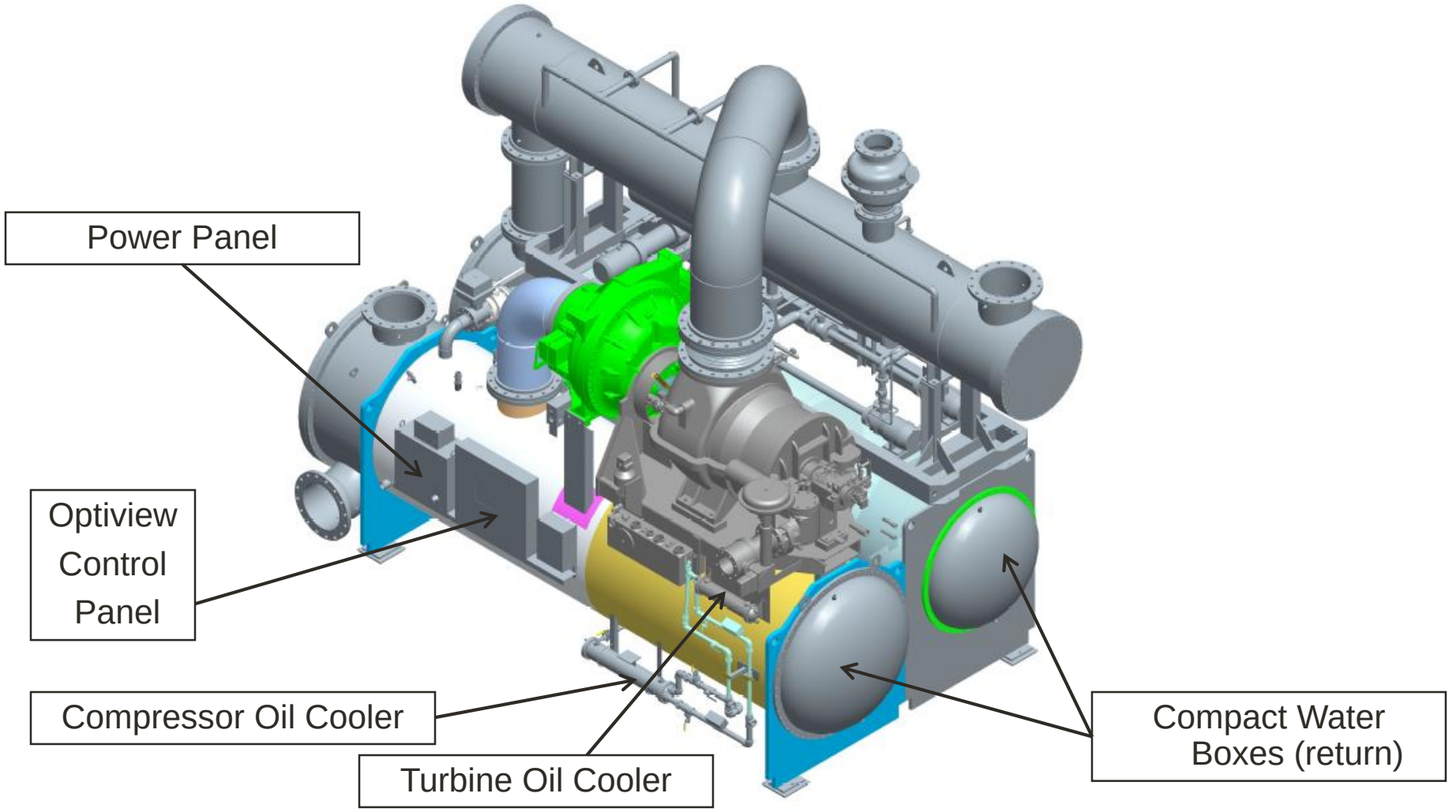
Key Components



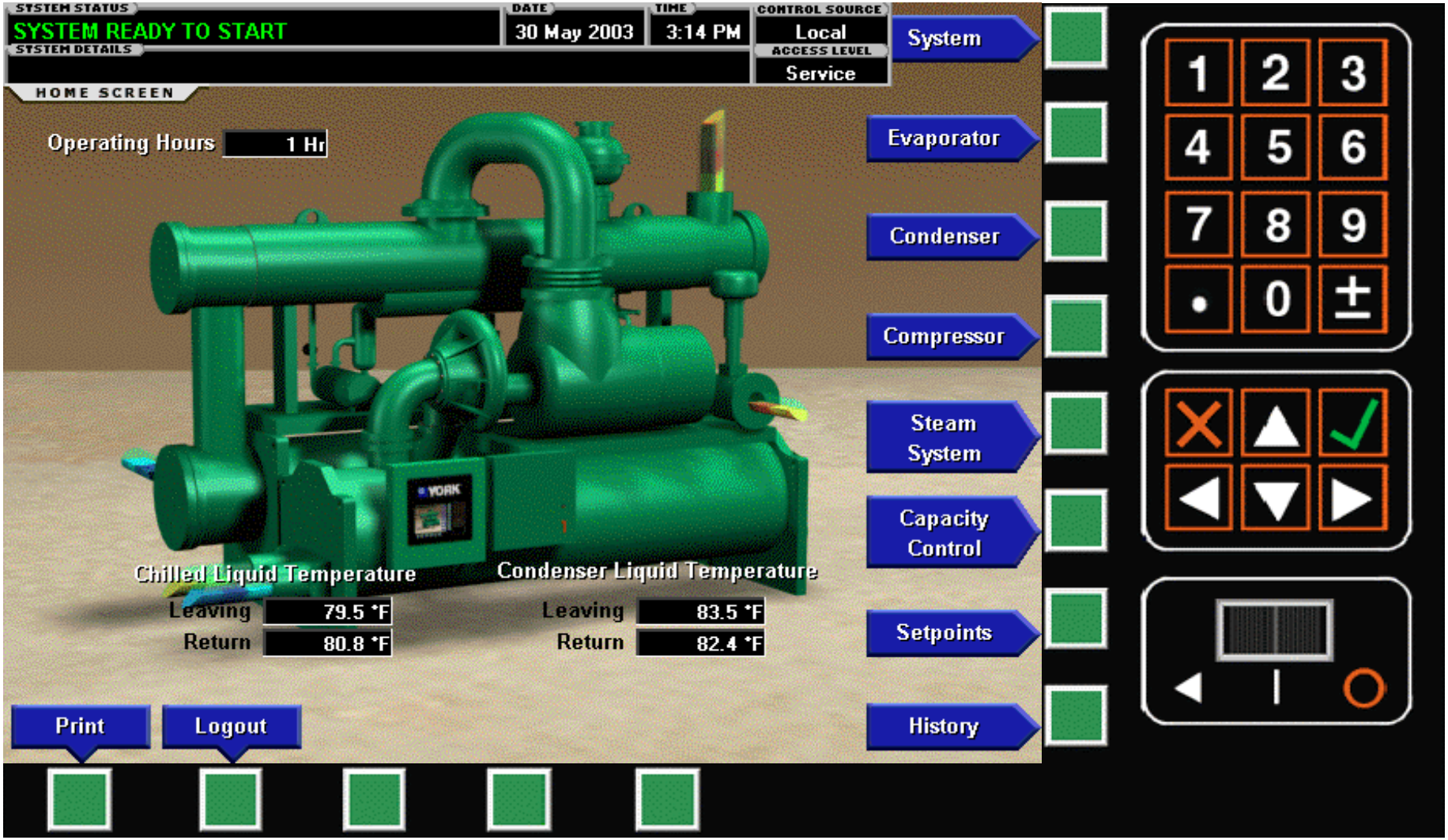
Key Components



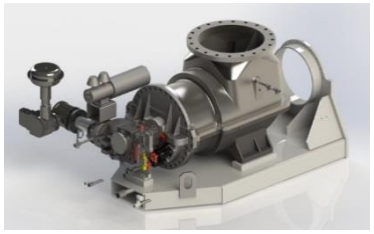
Key Components



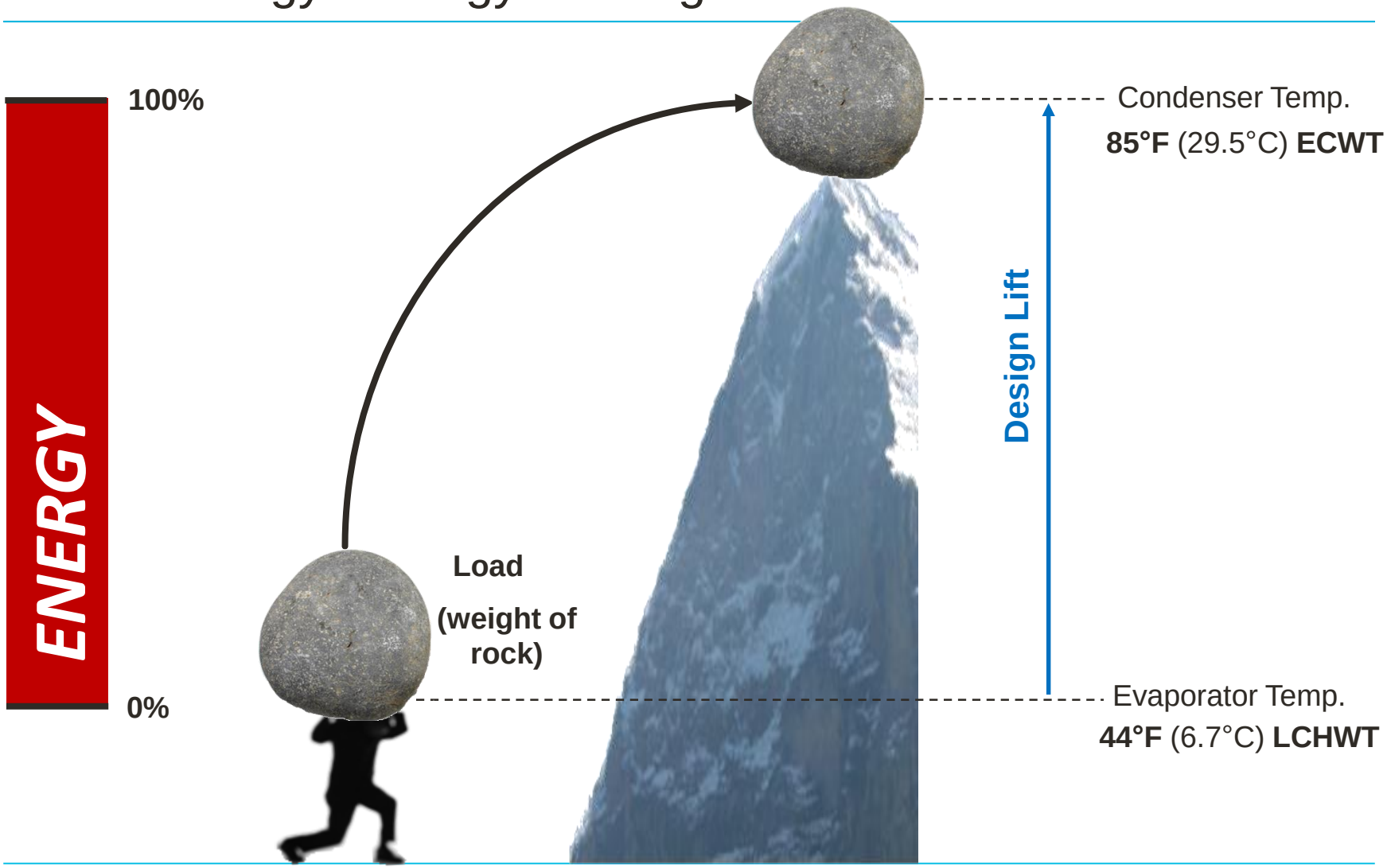
State-of-the-art Control Panel – Automatic Start



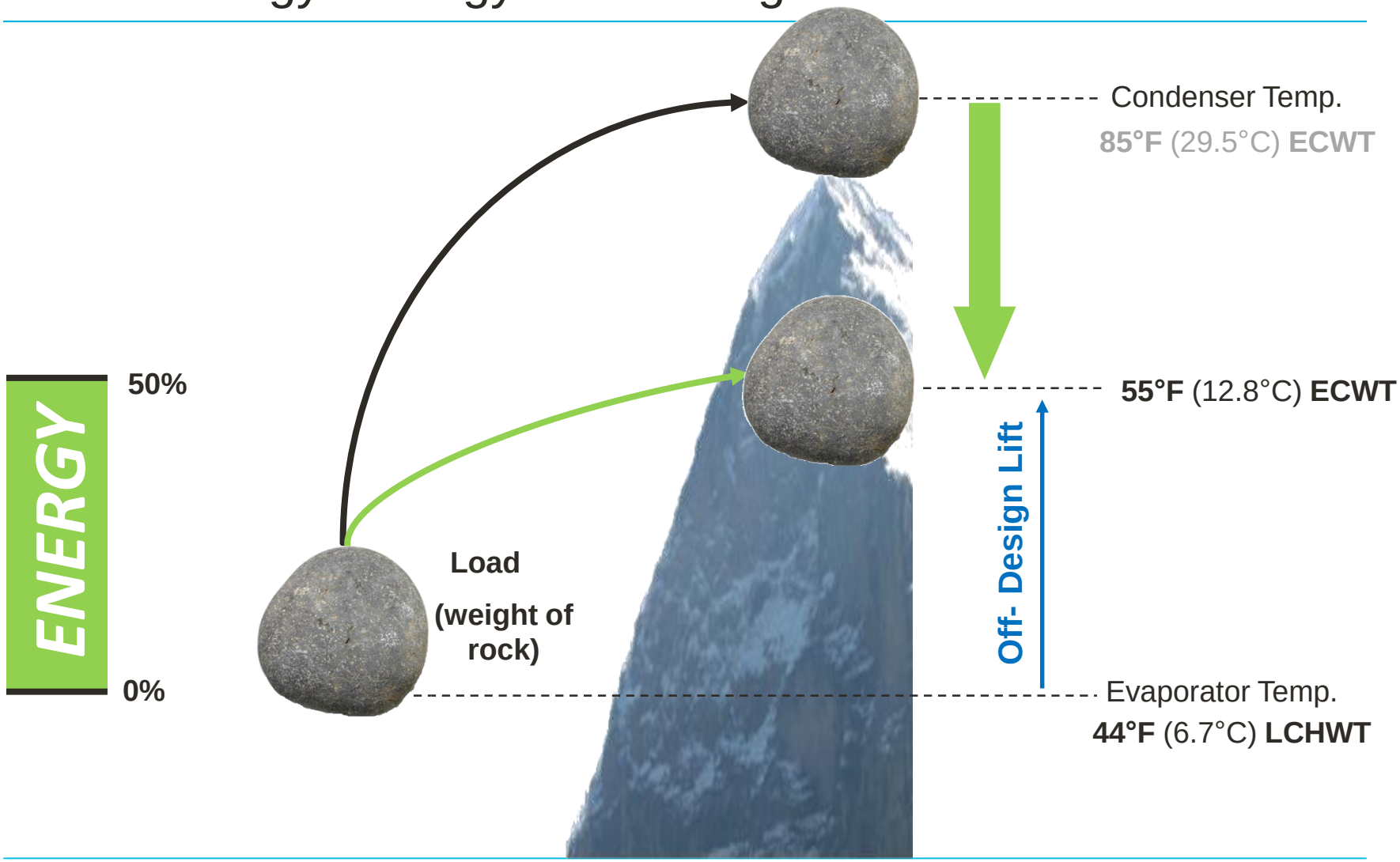
High Efficiency Multi-Stage Steam Turbine Dresser-Rand (Murray)



Chiller Energy Analogy – Design Point



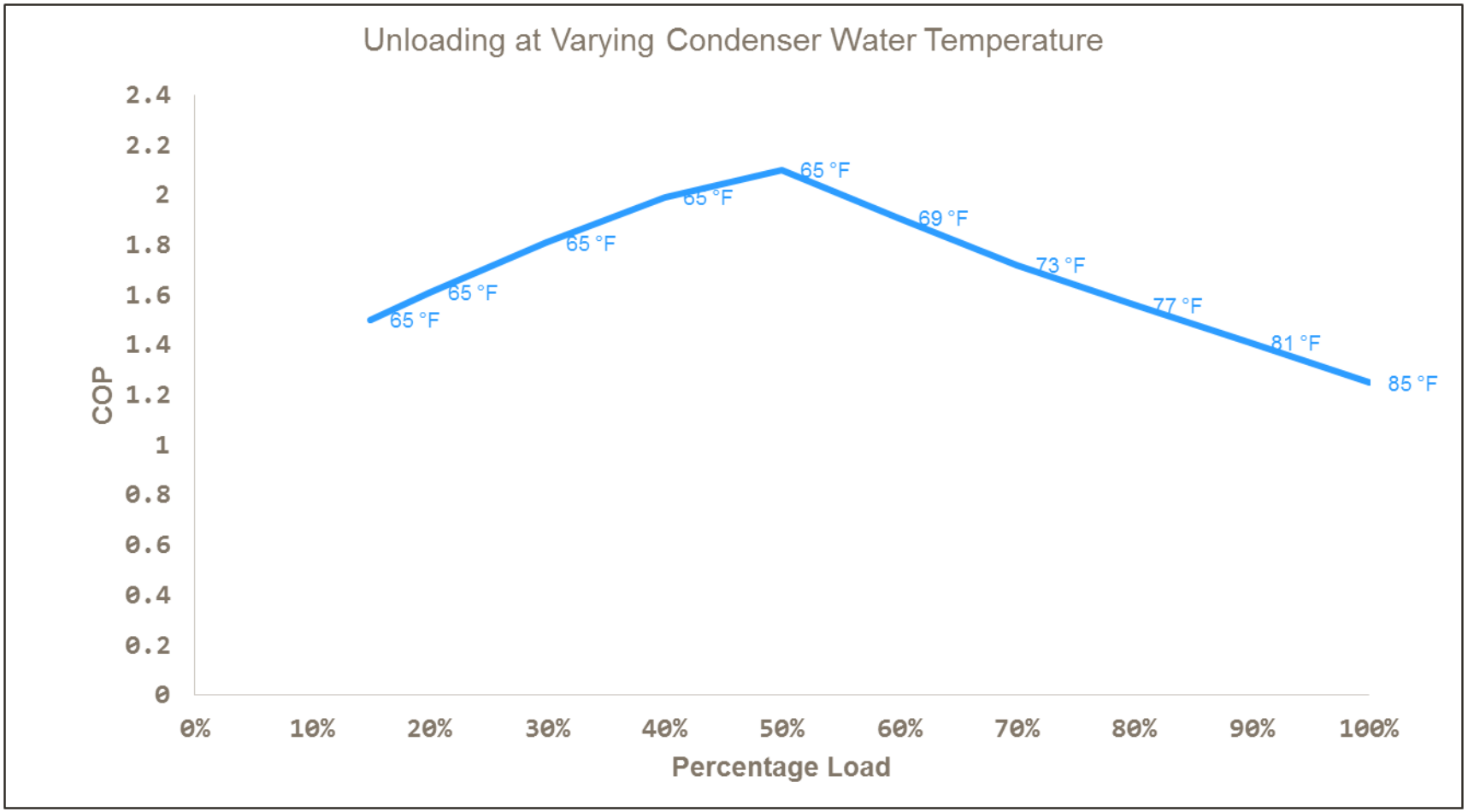
Chiller Energy Analogy – Off-Design



Typical Performance – AHRI Conditions 120 psig, 350° F steam

Parameter	Unit of Measure-ment	I	II	III	IV	V	VI	VII
Cooling Capacity	Tons	600	900	1100	1300	1600	2000	2800
Design Steam Rate	lb/hr/ton	9.6	9.3	9	8.8	8.7	8.9	8.6
Off-Design Steam Rate	lb/hr/ton	6.5	6.4	6.1	5.9	5.8	6	5.7

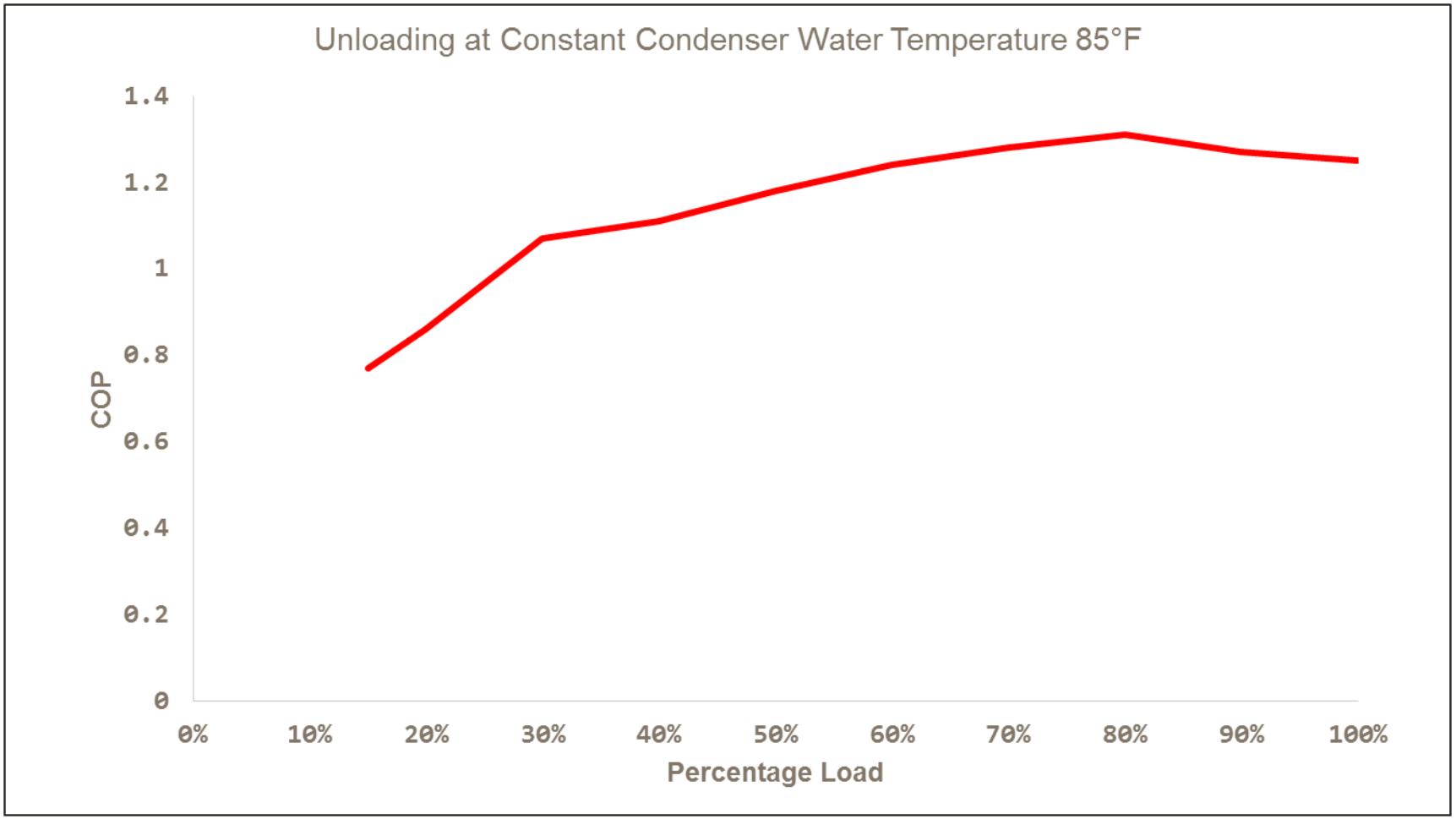
Unloading Per AHRI



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

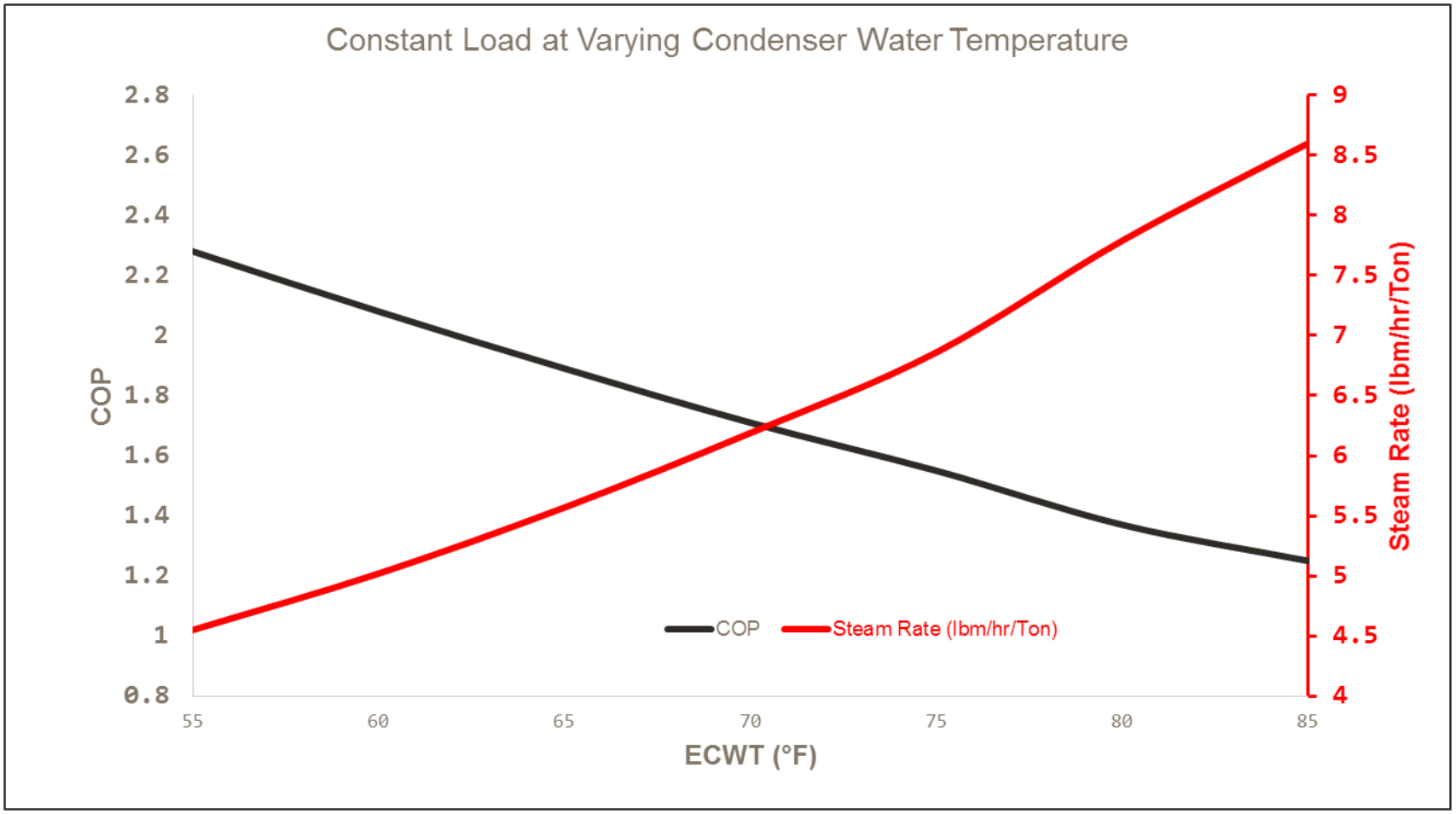
NPLV (as COP): 1.85

Unloading with Constant ECWT (85°F)



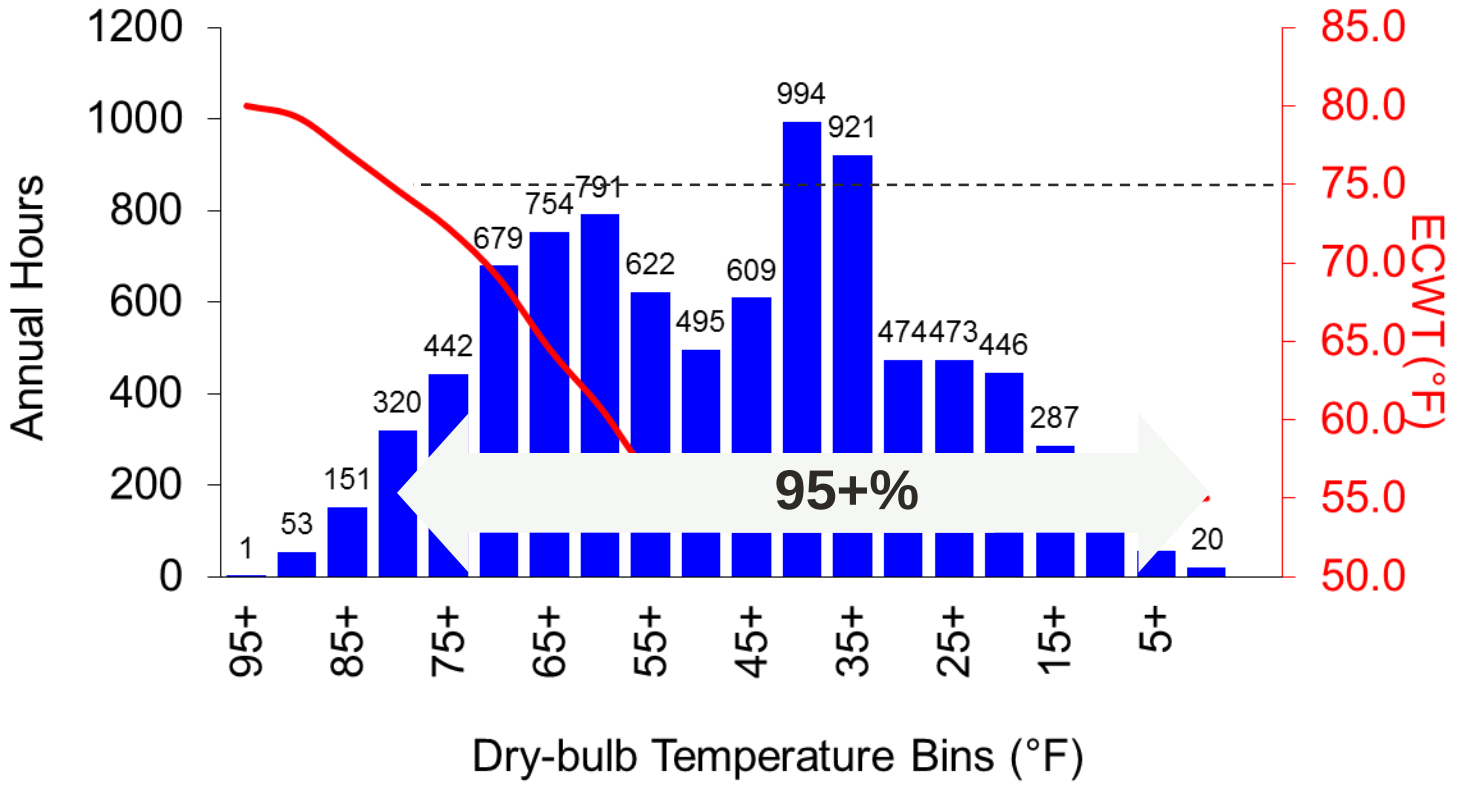
ECWT – entering condenser water temperature, COP – coefficient of performance

Constant load at varying condenser water temp



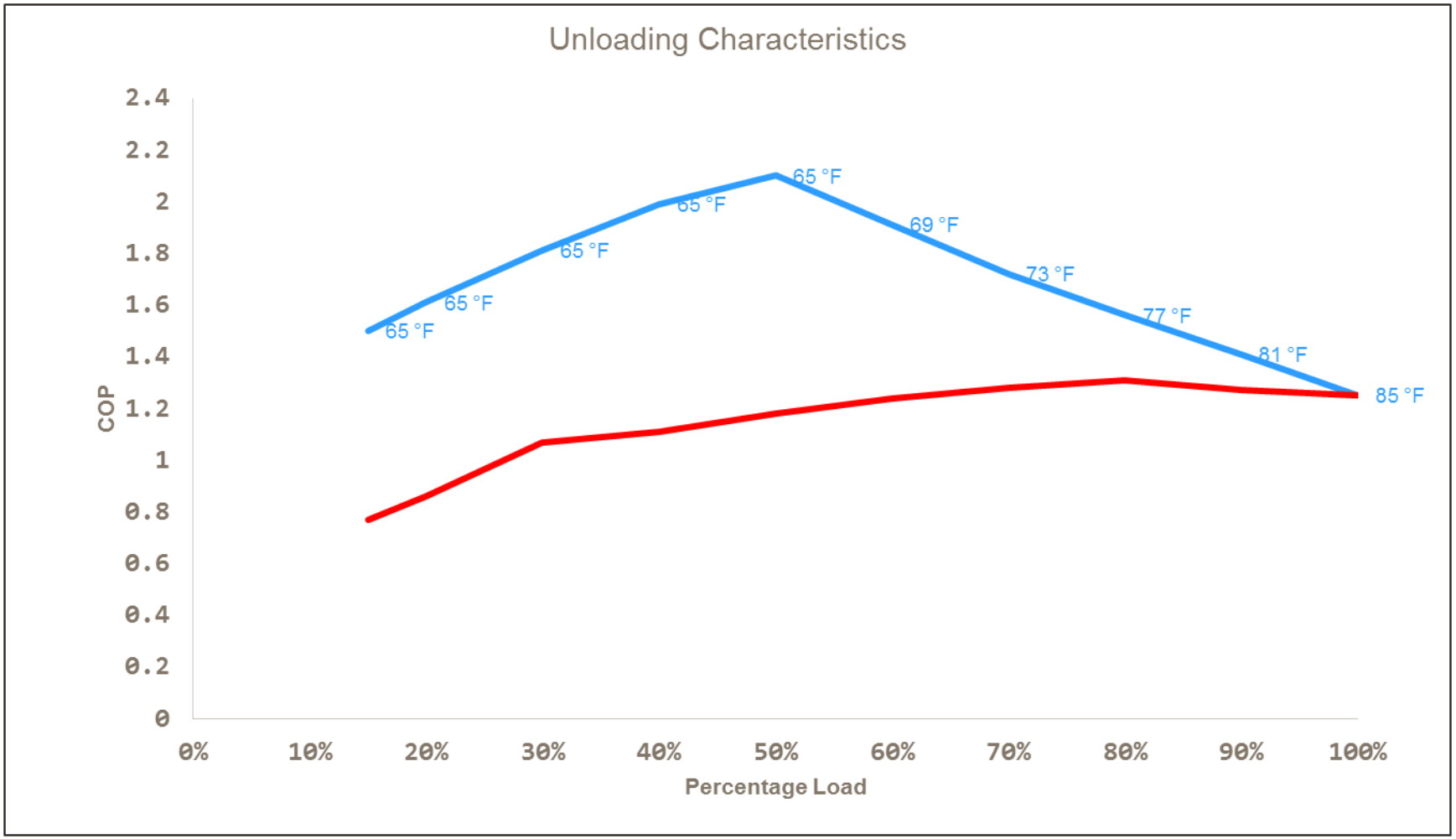
ECWT – entering condenser water temperature, COP – coefficient of performance

Toronto Weather (ASHRAE CWEC Weather)



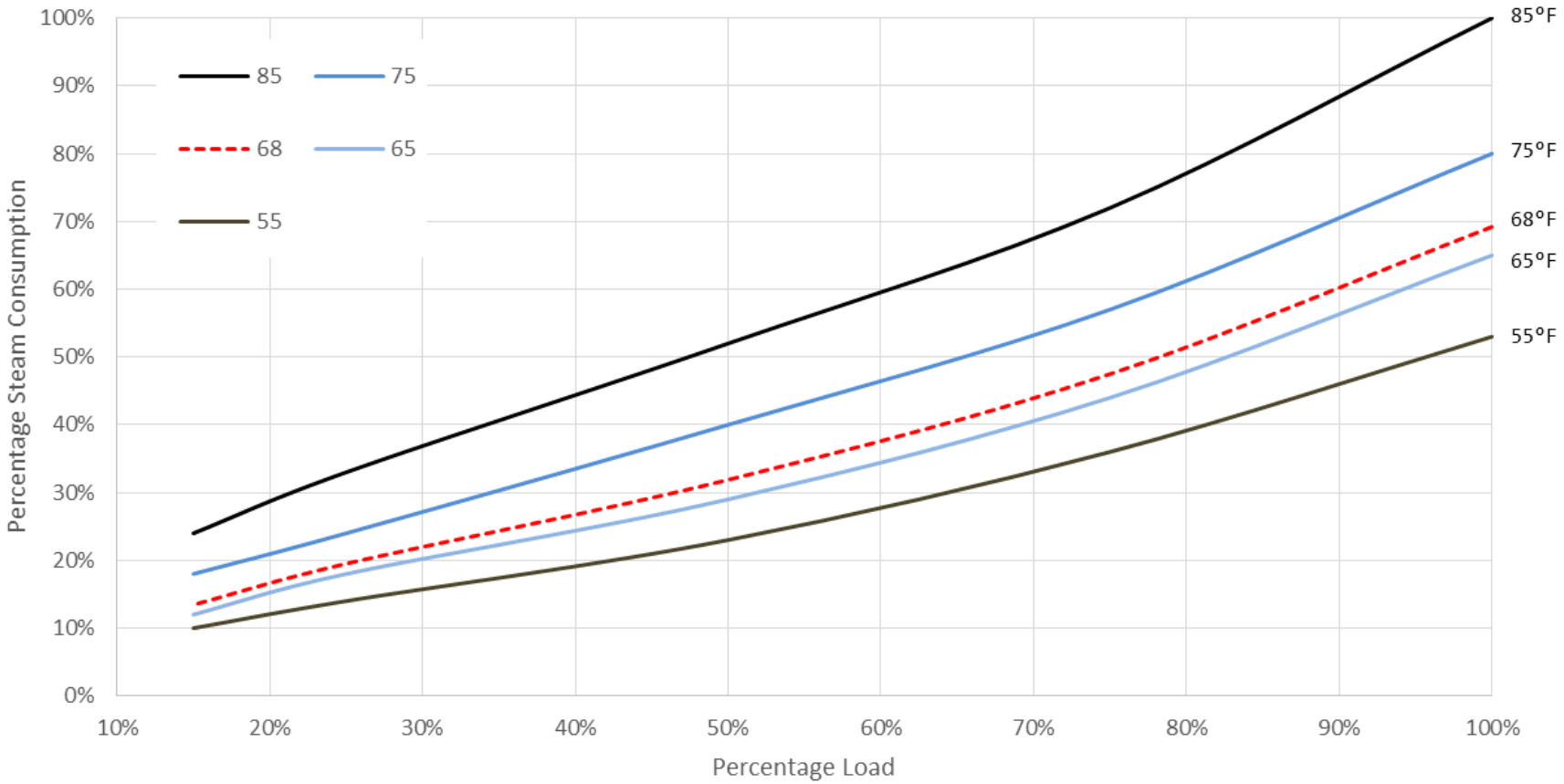
Note: ECWT = Avg WB + 8 approach

Full (Constant) Load at Different ECWT



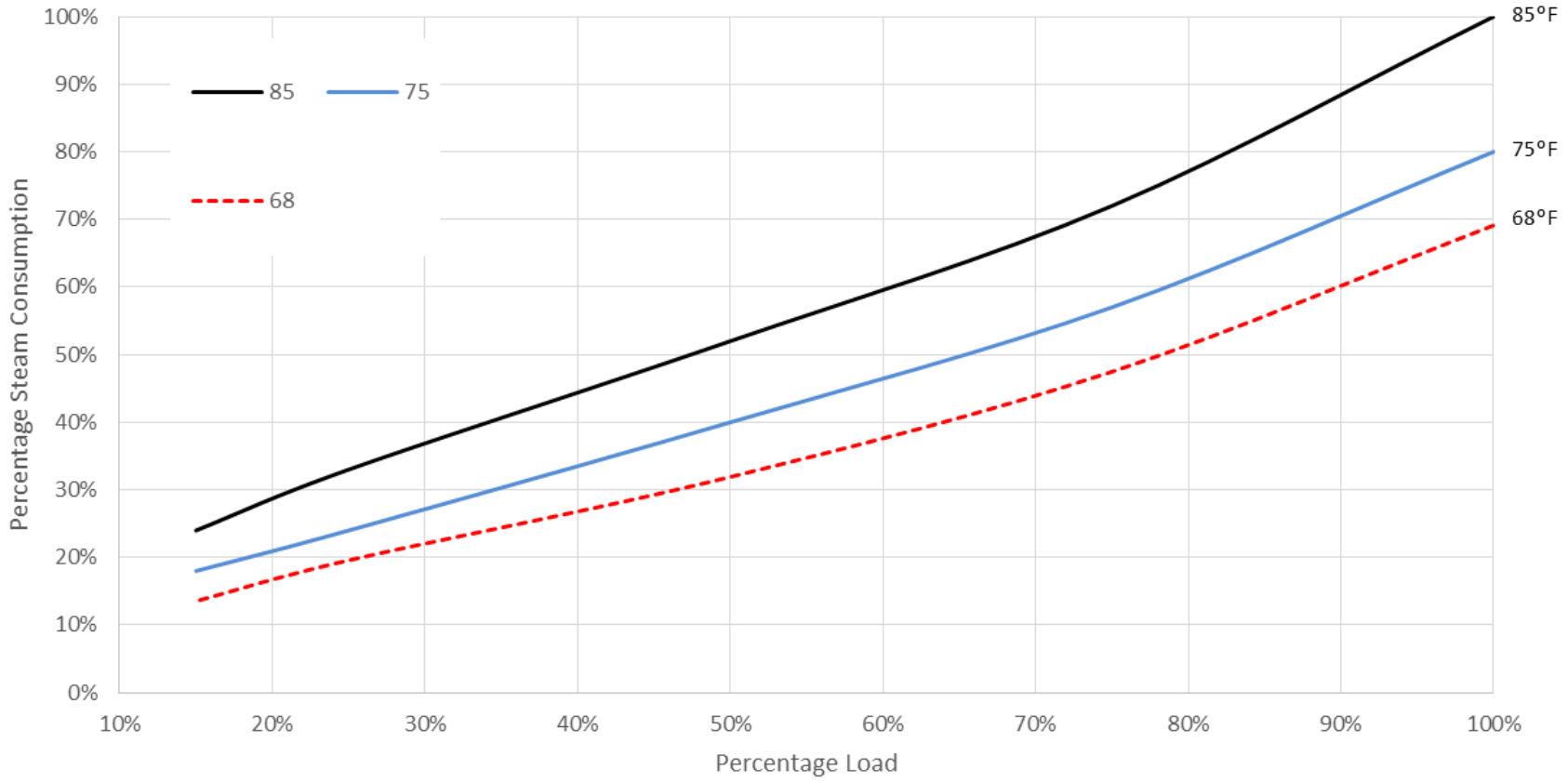
ECWT – entering condenser water temperature, COP – coefficient of performance

Very Good



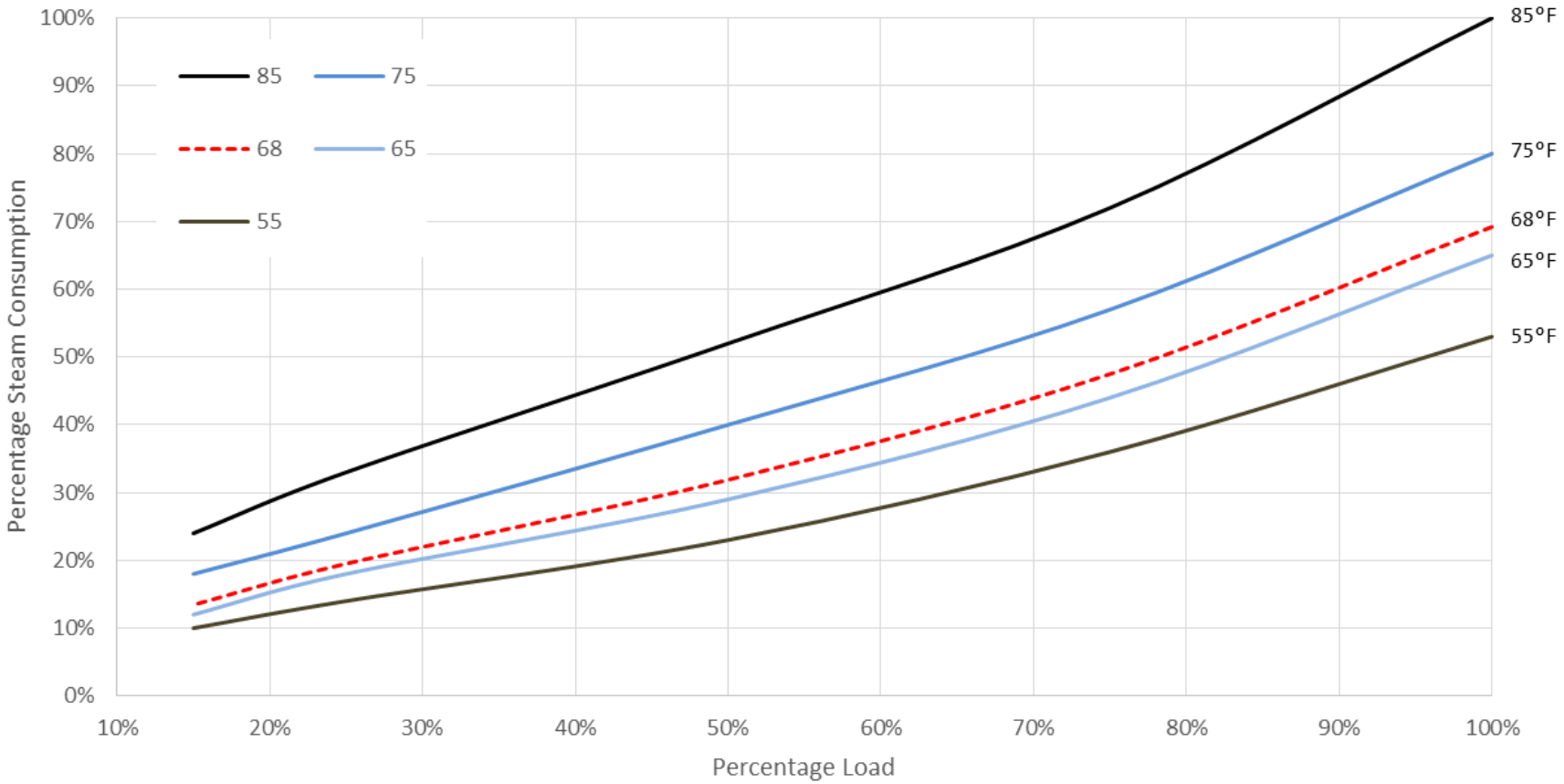
ECWT – entering condenser water temperature, COP – coefficient of performance

Good



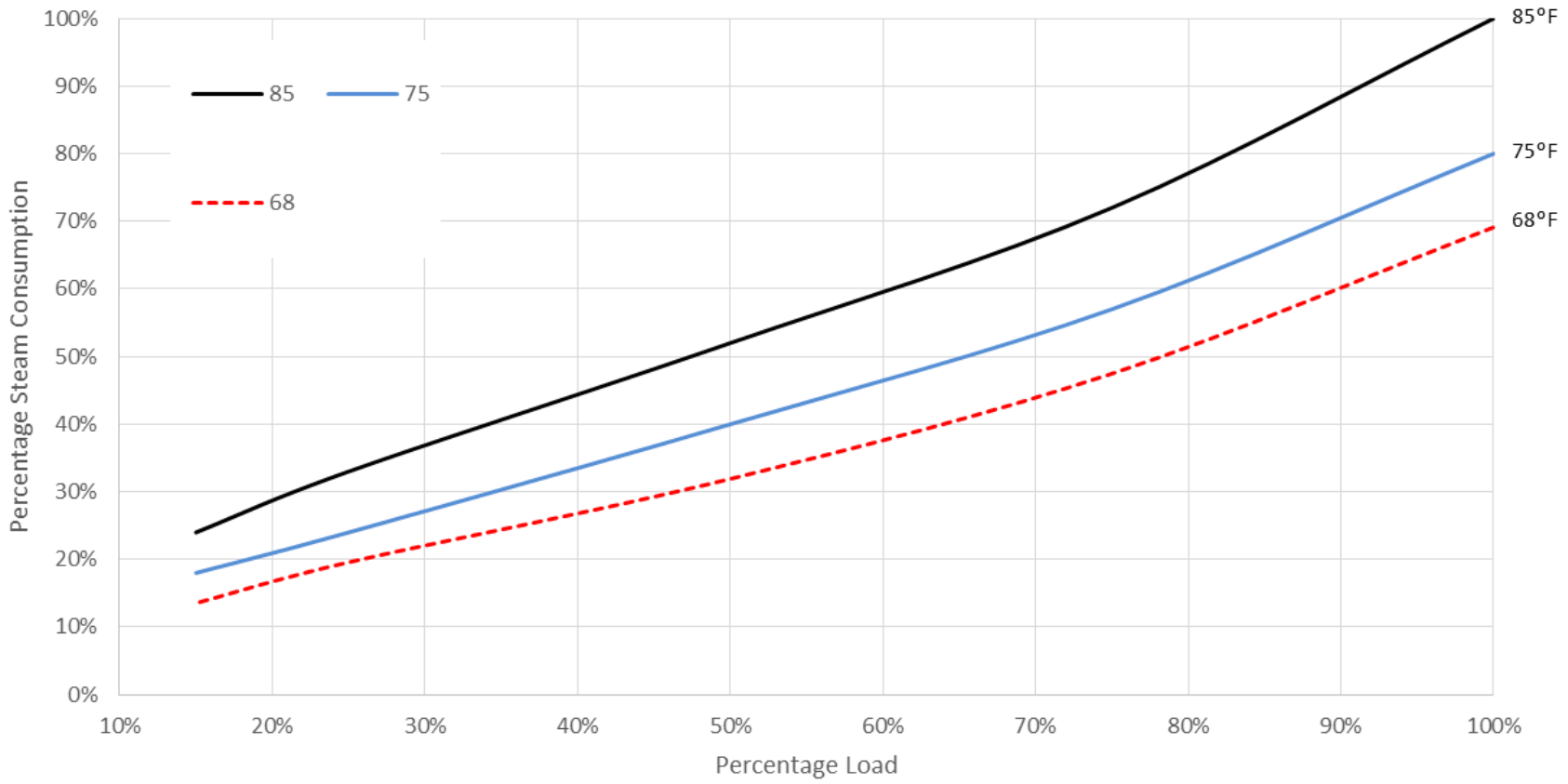
ECWT – entering condenser water temperature, COP – coefficient of performance

Very Good



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

Good



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

Achieving 20% Higher Capacity With Lower ECWT

ECWT Deg F	Load Tons	% Design Load	Steam Consumption lb/hr	% Steam Rate of Design
85	2800	100	24,090	100
80	2940	105%	23,361	97
75	3080	110%	22,854	95
70	3220	115%	22,628	94
65	3310	118%	21,995	91.3
60	3382	121%	22,073	91.6
55	3453	123%	22,280	92.5

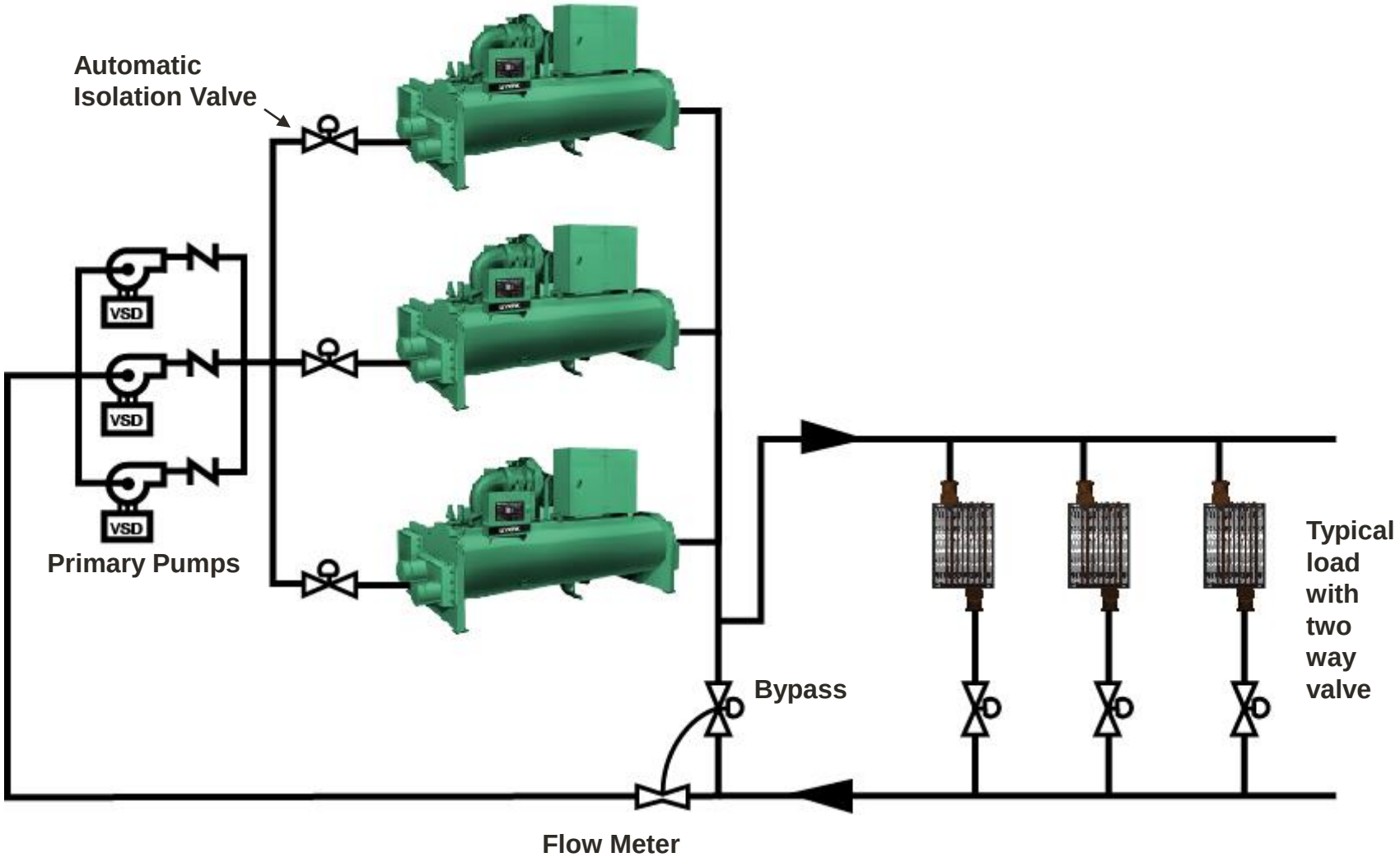
Perhaps shut off a chiller in the plant room

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

1000 Tons With Lower Steam Pressure

Steam supply pressure psig	Steam rate lb/hr/ton	Steam inlet size inches	Steam outlet size inches
93	10	4	20
30	12.9	8	24
26	13.3	8	24

Variable Primary Flow



YORKcalc – Annual Energy Cost

- Toronto, Ontario
- 8,760 hours
- Electric usage rate $ 0.10 per kWh
- Electric demand $ 5 per KW
- Steam cost $ 7 per 1,000 lb
- Natural gas $ 0.65 per therm
- 2800 tons cooling capacity
- Electric centrifugal chiller 0.576 kW/ton (minimum ECWT 58°F)
- Steam turbine chiller 8.6 lb/hr/ton (minimum ECWT 58°F)
- Two-stage steam absorption chiller 7.6 lb/hr/ton (minimum ECWT 68°F)

YORKcalc – Annual Energy Cost – 2800 Tons

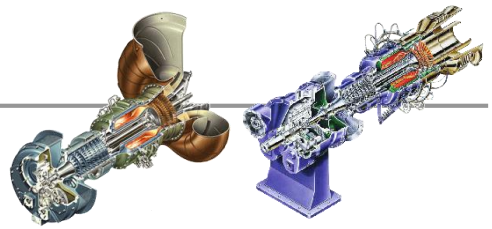
	Electric Centrifugal Chiller Variable Speed Drive	Steam Turbine Centrifugal Chiller Variable Speed	Two Stage Steam Absorption Chiller
Chiller Cost of Operation	$ 320,523	$ 274,014	$ 469,685
Plant Cost of Operation	$ 612,107	$ 580,593	$ 784,412

Applications

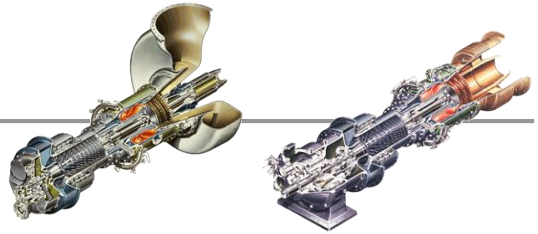
- 200+ Chillers – 300,000+ Tons Installed
- Common Applications
  - Commercial Office Buildings
    - District Steam
    - Footprint / Rigging, Access
  - Process Applications
    - Pharmaceuticals
    - Electronics manufacturing
  - Medical Centers
    - Heating, Food Service, Sterilization, Laundry Services
  - Higher Education
    - Steam Heating, Food Services
  - Hybrid Plants / Hybrid Chillers
  - District Steam & CoGen Chiller Plants

Solar Gas Turbine Families

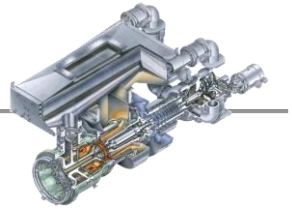
Saturn 20
1590 hp/1210 kWE
(Over 5000 Units)



Centaur 40 & 50
4700-6130 hp
3515-4600 kWE
(Over 3570 Units)

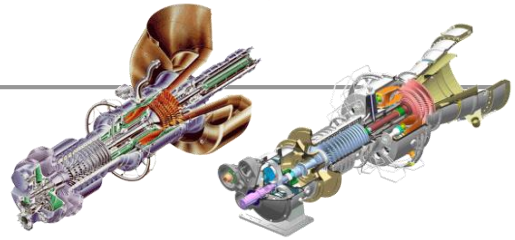


Mercury 50
4600 kWe
(Over 80 Units)

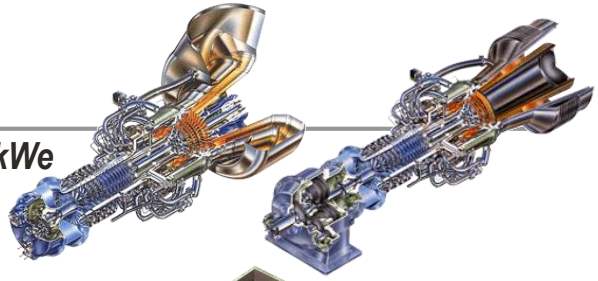


Taurus 60
7700 hp/5670 kWe
(Over 1840 Units)

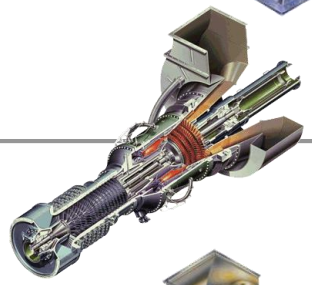
Taurus 65
6300 kWe
(Over 25 Units)



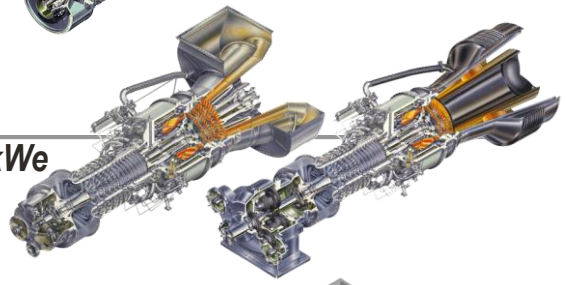
Taurus 70
10,915 hp / 7965 kWe
(Over 700 Units)



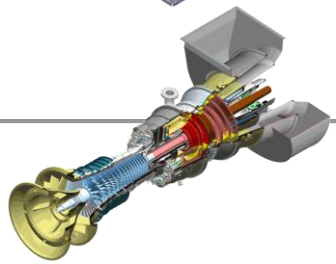
Mars 90 & 100
13,220 – 15,900 hp
9450 – 11,350 kWe
(Over 1200 Units)



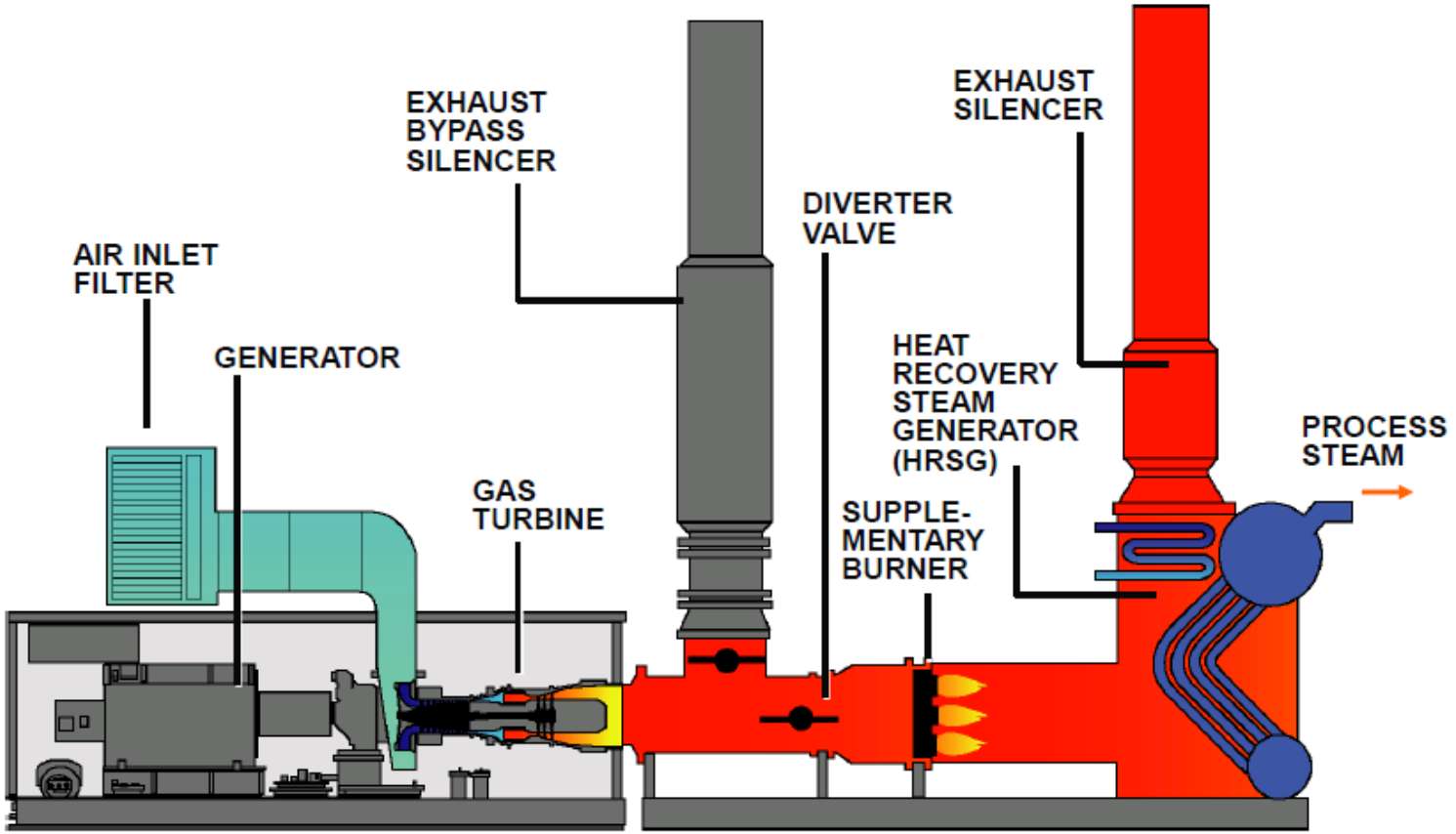
Titan 130
20,500 hp / 15,000 kWe
(Over 690 Units)



Titan 250
30,000 hp / 21,745 kWe
(20 Units and Growing)

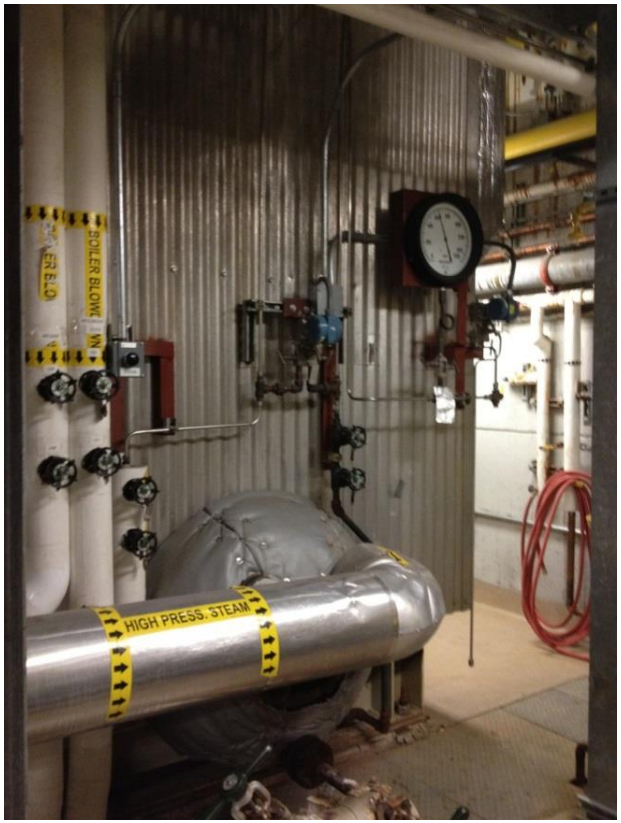


Typical Combustion Turbine CHP



Source: Solar Turbines

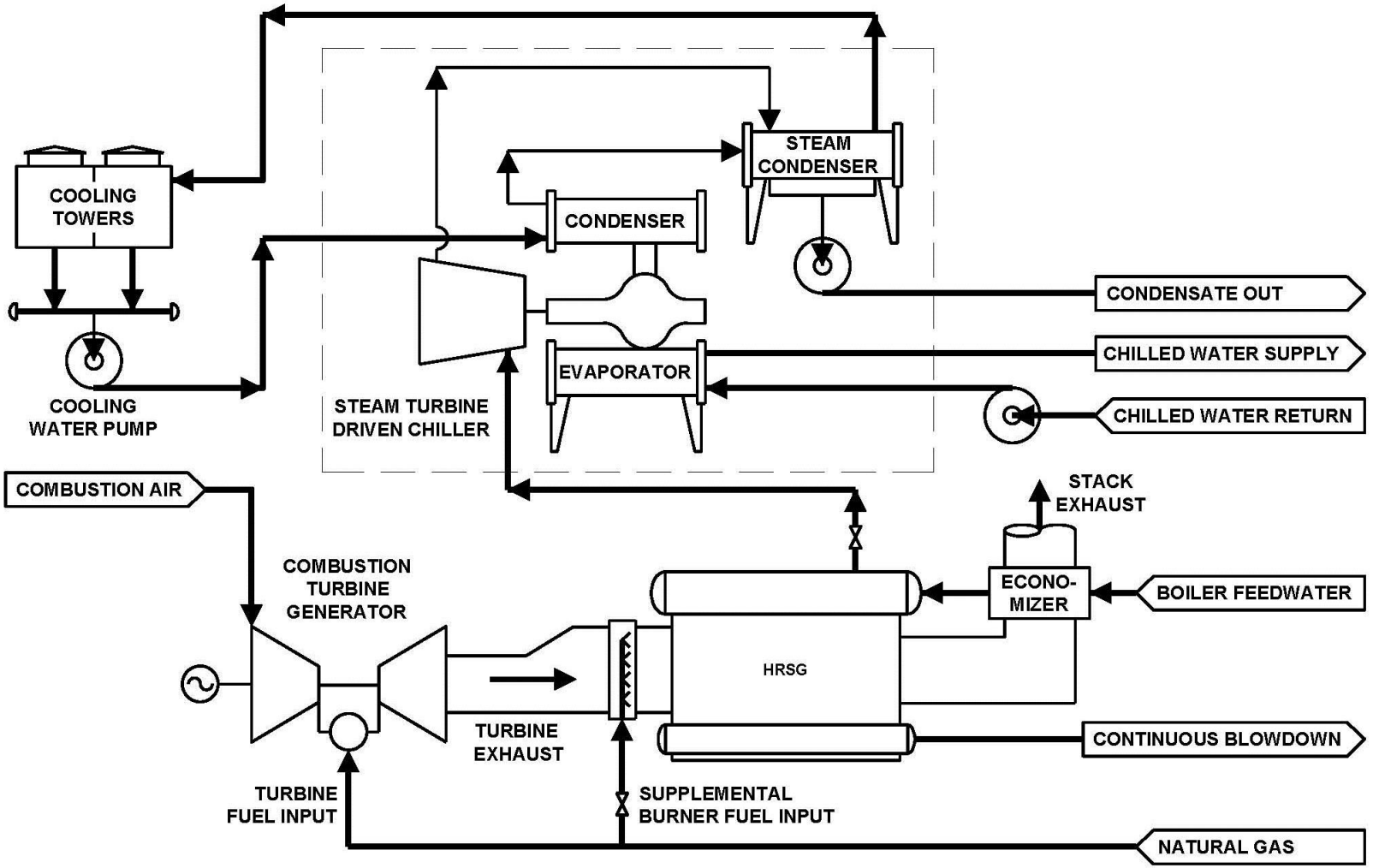
NYU Turbine Inlet Air Cooling Solar Turbines – 2 x Taurus 60, HRSG



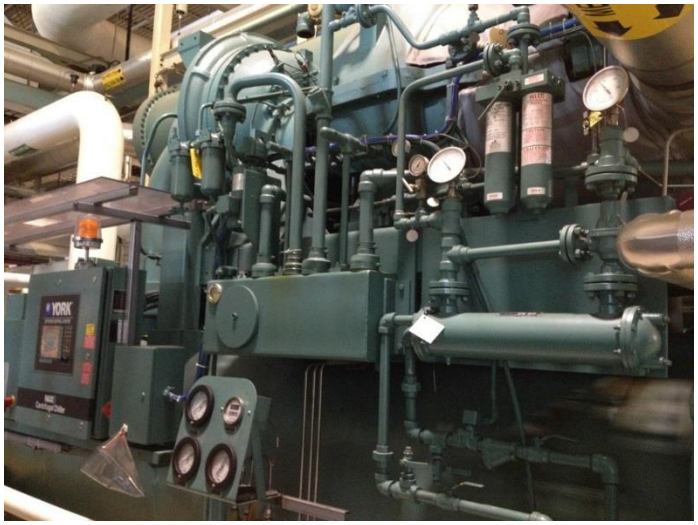
NYU Turbine Inlet Air Cooling

York University, Canada
2 x Taurus 60 with Supplemental Firing

Toyota Motor Manufacturing Company, Canada
2 x Centaur 50 with Supplemental Firing



Greater Toronto Airport Authority 2 x 2000 Tons



UCONN, CT
4 x 2100 Tons, 3 x Taurus 70

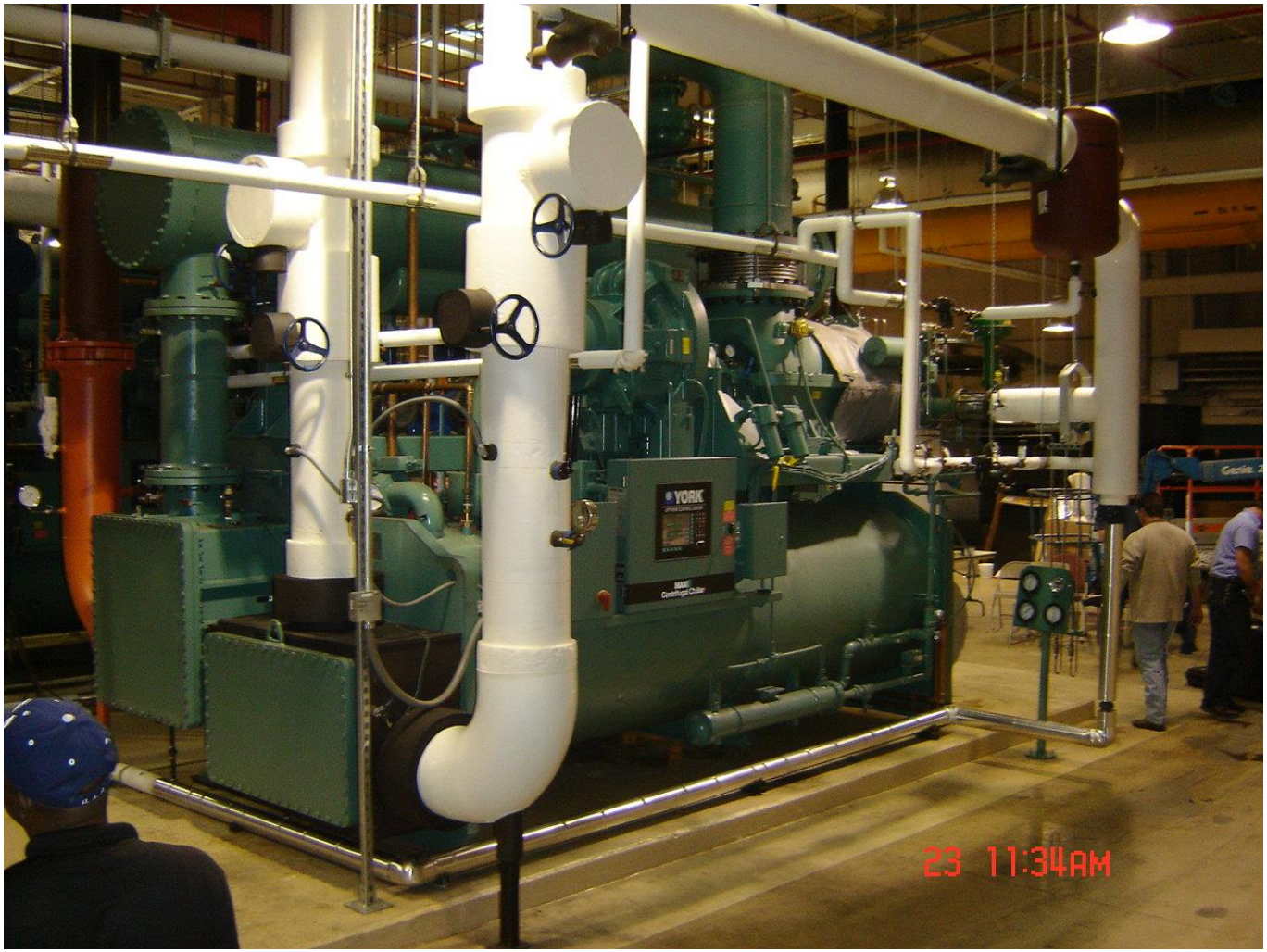
University of Missouri Hospital
1750 Tons, 40 psig Low Pressure Steam

NASA Houston, TX
3 x 2000 Tons, 400 psig High Pressure Steam

Henry Ford Health System
2 x 2800 Tons

Vanderbilt University, TN
2 x 1500 Tons

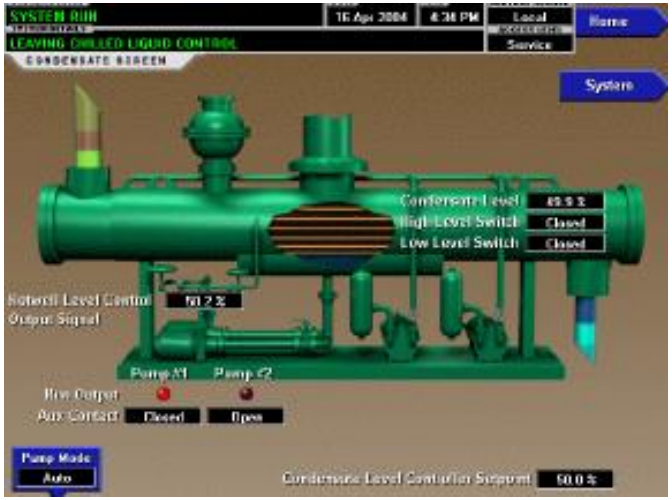
VA Dallas, TX
2 x 1000 Tons



VA Dallas, TX
2 x 1000 Tons

VA Dallas, TX
2 x 1000 Tons

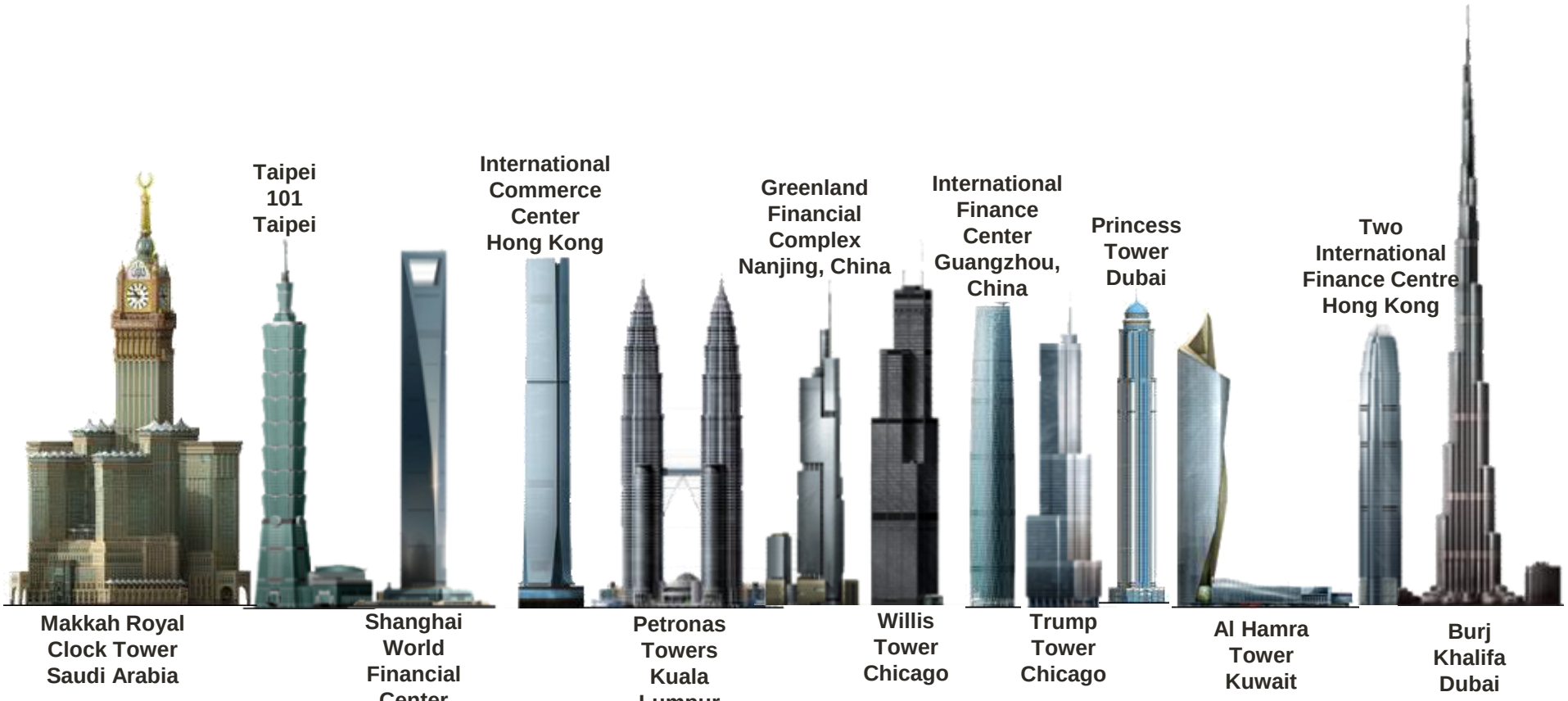
Sunnybrook Health Sciences, Canada



Empire State Building

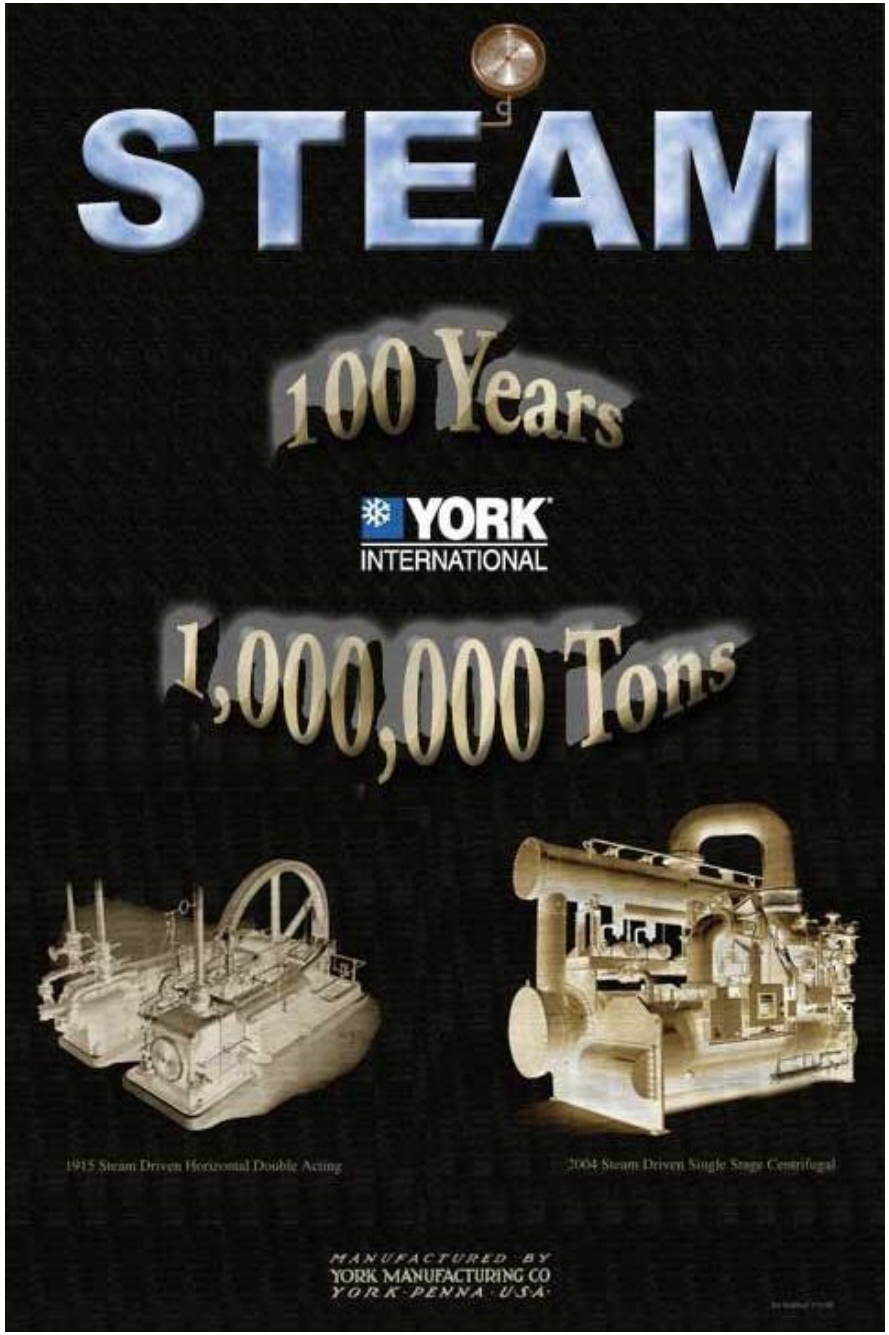
- 1294 tons - 1951 (vintage shells)
- 750 tons - 1993
- 2000 tons - 1993

No Matter the Size, Complexity, or Location



Recap

- Made in the USA
- Factory Assembled, Completely Integrated
- Superior off-design performance
- Wider operational flexibility
- Strong track record
- Long life
- Local service and parts



YORK®

Johnson Controls

Steam Driven Mechanical Heat Pump (YDST)
100 MW Heating Capacity