Building Efficiency

Helping people achieve

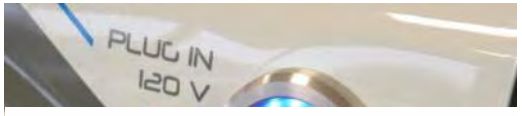
Rajesh Dixit
CIBO, Arlington VA
September 10th, 2013

Johnson Controls

Building Efficiency
Part of a $42B world-class organization – Johnson Controls

AUTOMOTIVE EXPERIENCE **$21.3B**

Supplying interiors to more than 30 million cars per year



POWER SOLUTIONS **$5.9B**

Producing 130 million vehicle batteries annually

BUILDING EFFICIENCY **$14.7B**

Optimizing building environments for more than 1 million customers

Our Vision

Creating a Comfortable, Safe and Sustainable World

Our Mission

Exceeding our Customers' Increasing Expectations

Our Values

Integrity · Customer Satisfaction
Employee Engagement · Innovation · Sustainability

Recognized as a global leader and top corporate citizen

2013 WORLD'S MOST ETHICAL COMPANIES
WWW.ETHISPHERE.COM

CR's 100 Best Corporate Citizens

Best Corporate Citizens

9	Campbell Soup Co.
10	Coca-Cola Enterprises
11	IBM Corp.
12	Walt Disney Co.
13	Spectra Energy Corp.
14	**Johnson Controls**
15	Coca-Cola Co.
16	E. I. DuPont De Nemours & Co.
17	Johnson & Johnson
18	Kimberly-Clark Corp.

FORTUNE 500

Largest American Companies

63	Safeway
64	Cisco Systems
65	Sears Holdings
66	Walt Disney
67	**Johnson Controls**
68	Morgan Stanley
69	Sysco
70	FedEx
71	Abbott Labs
72	DuPont

Forbes Global 2000

Largest Global Companies

276	Duke Energy *US*
277	Legal and General Group *UK*
278	Mitsubishi Electric *Japan*
279	Husky Energy *Canada*
280	**Johnson Controls**
281	SEB *Sweden*
282	Svenska Handelsbanken, *Sweden*
283	Sasol *South Africa*
284	Taiwan Semiconductor *Taiwan*
285	Indian Oil *India*

BDR BILLION DOLLAR ROUNDTABLE
Corporate Supply Chain Diversity

Corporate Supply Chain Diversity

AT&T
Avis Budget
Boeing
Chrysler
Dell
Ford Motor Corporation
General Motors
Honda North America
IBM
Johnson Controls
Johnson & Johnson
Kroger
Lockheed Martin
Microsoft
Procter & Gamble
Toyota Motor NA
Verizon Communications
Wal-Mart Stores

maplecroft Climate Innovation Indexes

Top Performers

1	General Electric
2	Alcoa Inc.
3	**Johnson Controls**
4	Ford Motor Co.
5	Intel Corp.
6	Hess Corp.
7	Air Products & Chemicals
8	Praxair Inc.
9	United Technologies
10	Audodesk Inc.

Johnson Controls

Building Efficiency
You may know us for this …

METASYS BY JOHNSON CONTROLS

YORK BY JOHNSON CONTROLS

Frick BY JOHNSON CONTROLS

SABROE BY JOHNSON CONTROLS

A portfolio of 2,000+ high-performance heating, cooling, refrigeration and controls products and services

HVAC Products & Controls

HVAC Equipment

Building Management Systems

Industrial & Commercial Refrigeration

Residential Heating & Controls

Service, Repair & Maintenance

Johnson Controls

Though we are so much more …
We are in the business of Building Efficiency

$14.7 billion
revenue in 2012

60,000 people
with over 5000+ energy experts including 1000+ LEED professionals

Local everywhere
7 Continents
152 Countries
697 Branches

20 million square feet
of LEED Certified facilities space for our customers

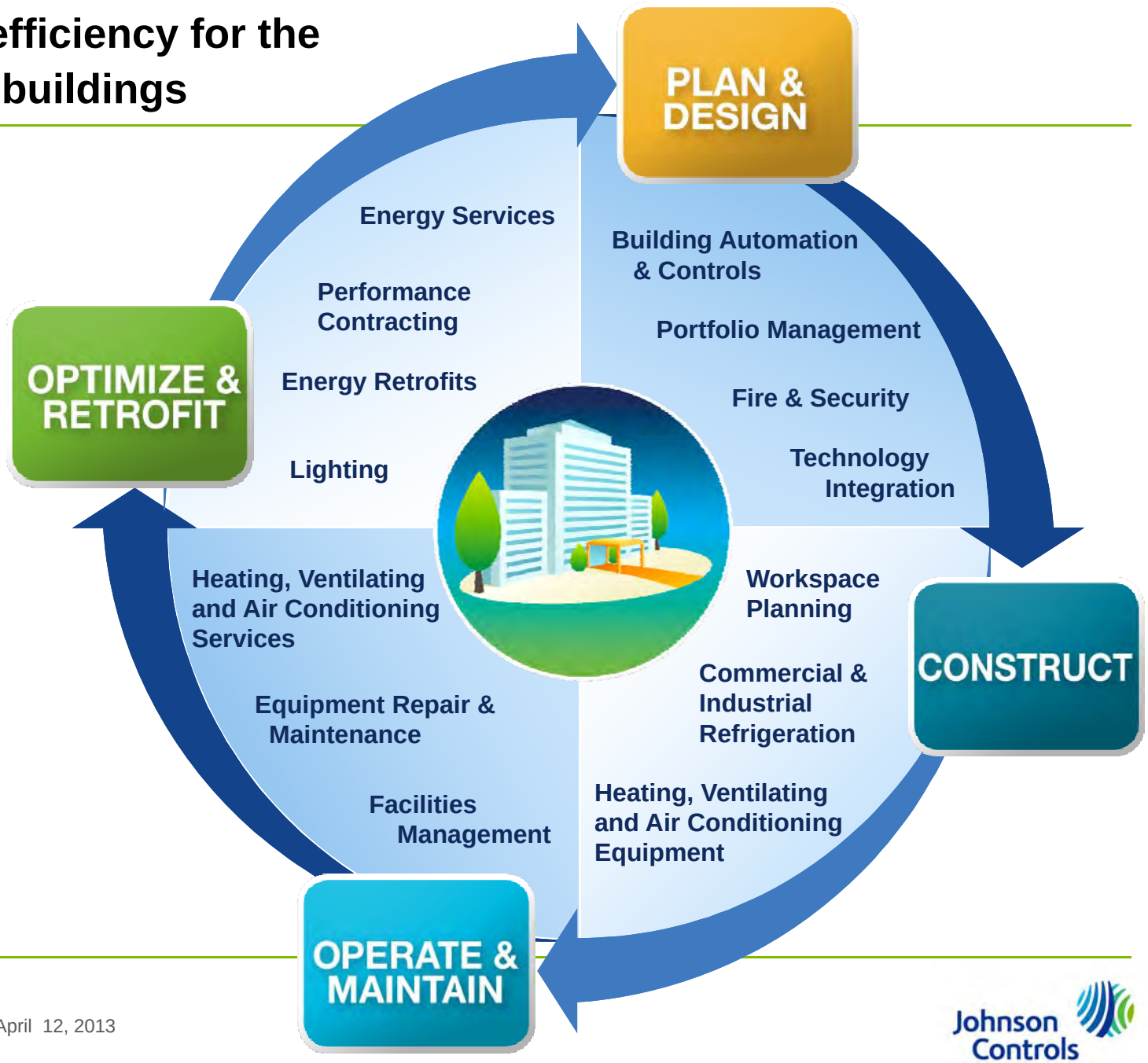
More than $7.5 billion
in savings guarantees

19 million metric tons
of greenhouse gas emissions reduced since 2000; equivalent to more than 3 million acres of pine forest

100+ renewable energy projects annually — solar, wind, geothermal

1.8 billion square feet
of real estate managed across more than 30,000 sites

We create efficiency for the life of your buildings



No matter the size, complexity or location







Residential → **Complex**



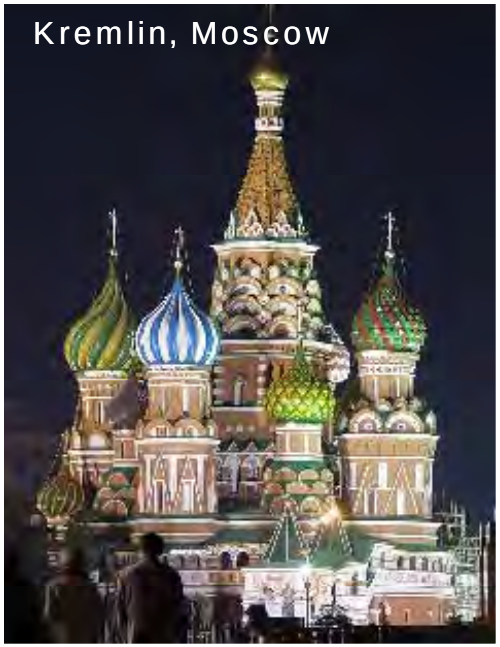


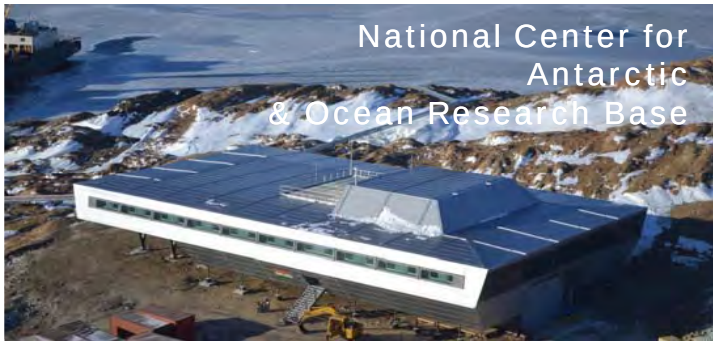


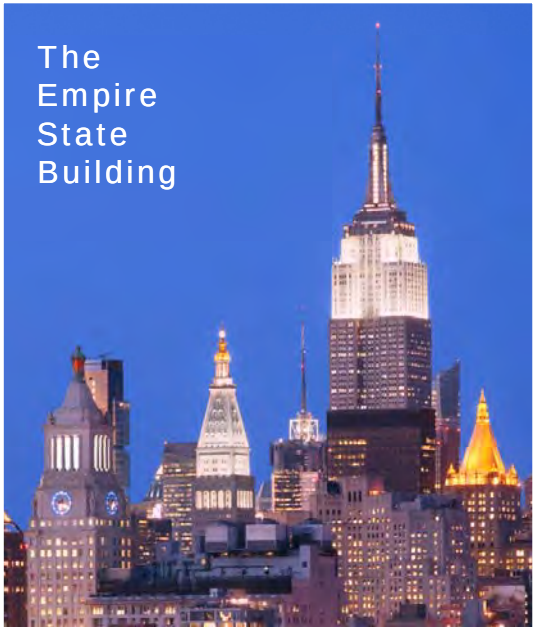
Johnson Controls

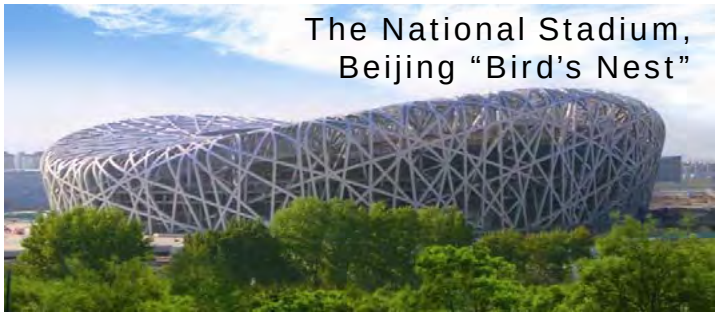
Including nearly 90% of the world's tallest buildings

And some of the most iconic spaces and places









Including our own ….
we ‘walk the talk’ when it comes to energy savings

World’s largest energy efficiency company

- 30% reduction in corporate carbon intensity between 2002 and 2008
- More than $5M energy savings in our own facilities

Johnson Controls headquarters
Largest concentration of LEED Platinum buildings on one site

We are building on more than 125 years of innovation

1885 First thermostat

1936 First fully air-conditioned office building

1958 First completely factory packaged centrifugal water-cooled chiller

1972 First mini computer system dedicated to building controls

1999 First graphic UI (user interface) panel on a chiller

2010 Johnson Controls headquarters receives LEED Platinum certification

1885 – 1910 | **1910 – 1935** | **1935 – 1960** | **1960 – 1985** | **1985 – present**

1883 First ice and refrigerating machine introduced by York

1924 Dual thermostat introduced

1956 Pneumatic control center developed

1978 First variable speed drive chiller

1990 Metasys integrates and manages multiple building systems

METASYS BY JOHNSON CONTROLS

2005 York acquisition creates largest integrated HVAC&R supplier

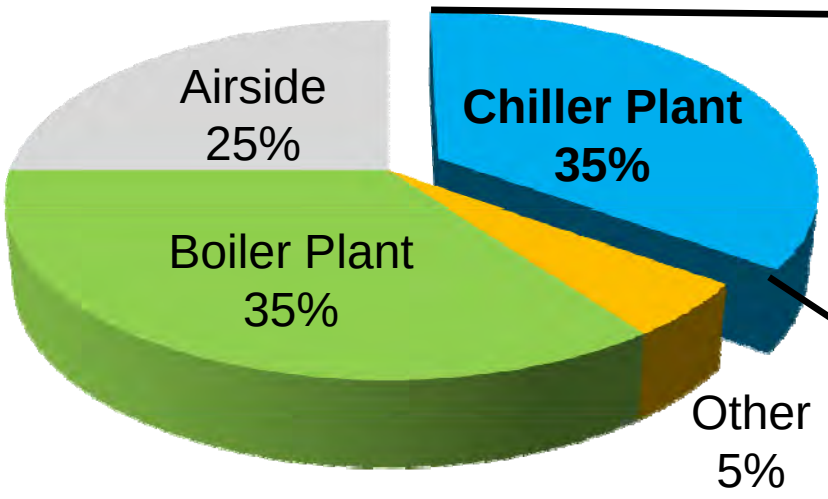
2012 An innovative approach to building efficiency

panoptix BY JOHNSON CONTROLS

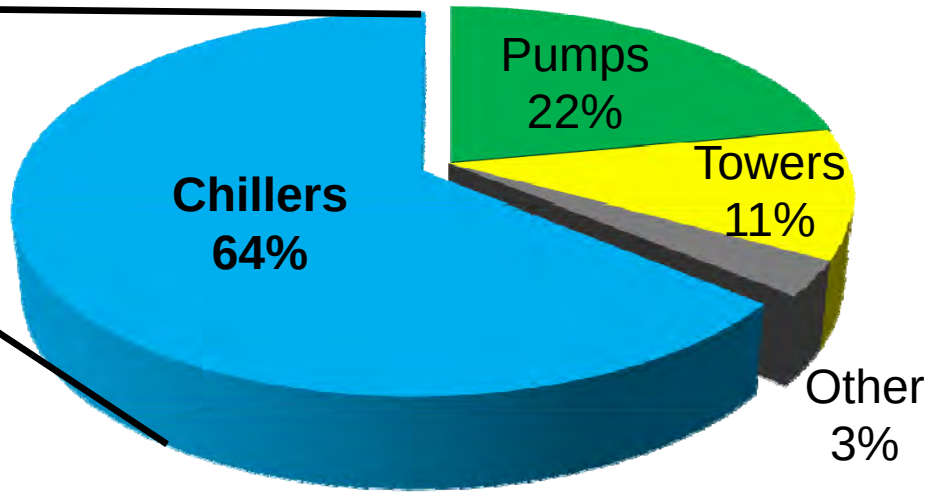
Johnson Controls

HVAC – Major Energy User

Total HVAC Energy Use for Commercial Building Utilizing Water Cooled Systems



Total Chiller Plant Energy Use



Chiller Solutions

Johnson Controls

Leading the Way- Chiller Solutions

Our Vision

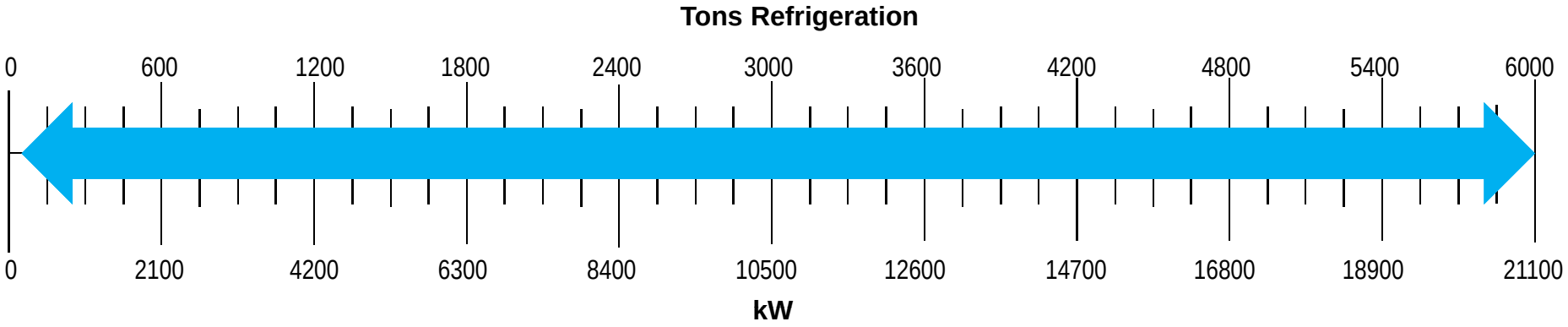
A more comfortable, safe and sustainable world

- Global chilled water solutions provider
- Most energy efficient solutions
- Widest range of offerings to meet every customer's needs

Johnson Controls

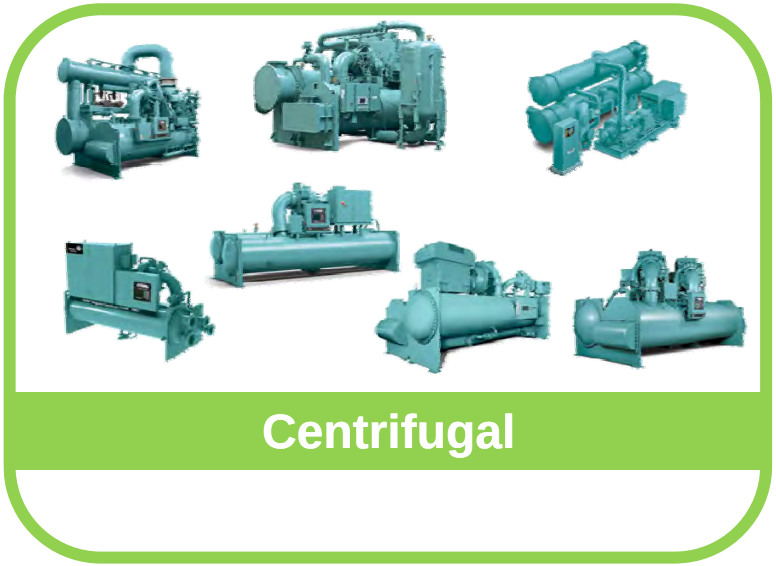
Diverse and Broad Solution Offerings

Water-Cooled



Scroll / Screw

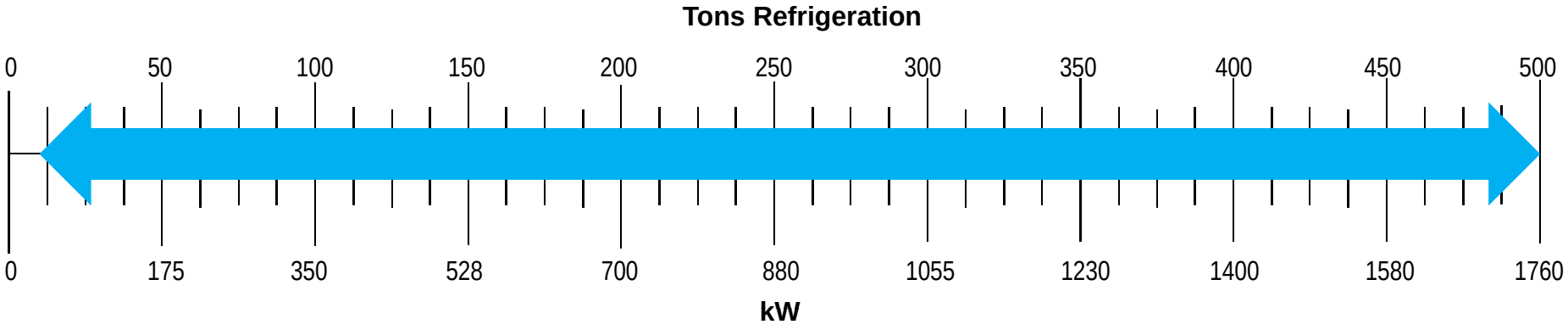
Absorption



Centrifugal

Diverse and Broad Solution Offerings

Air-Cooled Scroll & Screw Chillers



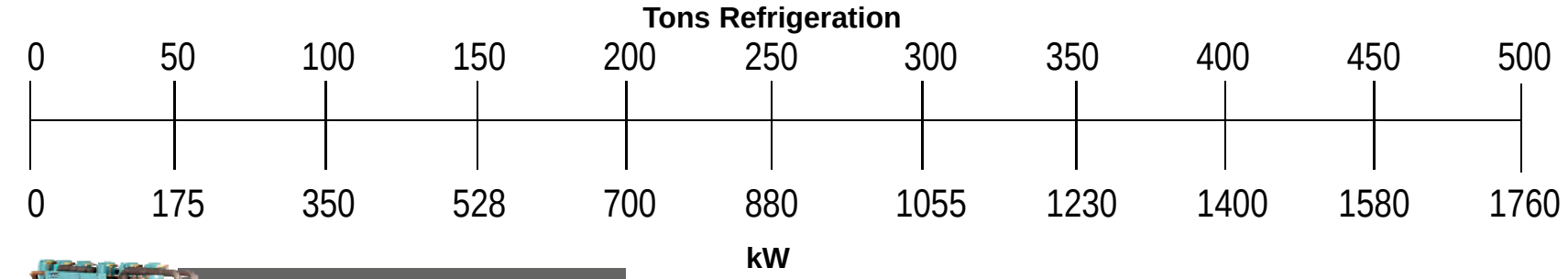
Scroll

Screw

Diverse and Broad Solution Offerings-

Water-Cooled Scroll & Screw Chillers

YORK BY JOHNSON CONTROLS



YCWL- Scroll Comps
50-200 Tons

YVWA- VSD Screw
125-300 Tons

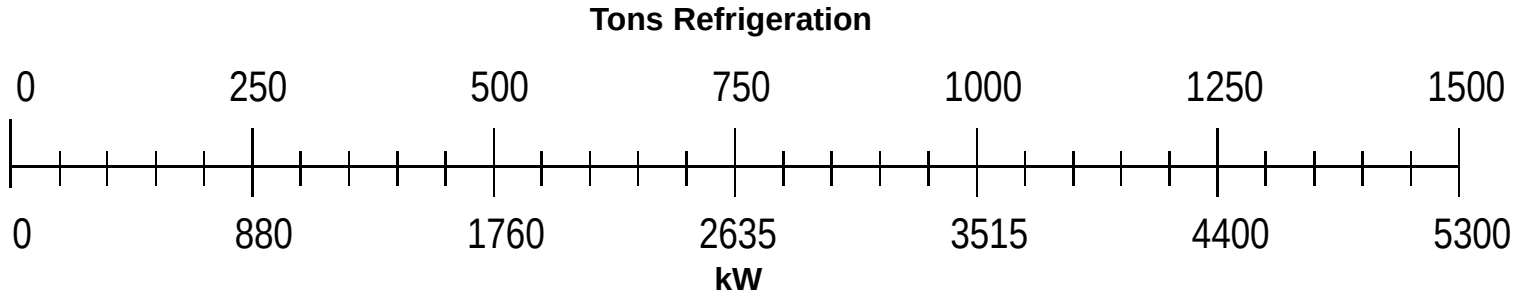
YS- Open Motor
115-430 Tons

YN- Open Motor
160-370 Tons

Johnson Controls

Diverse and Broad Solution Offerings-

Absorption Chillers



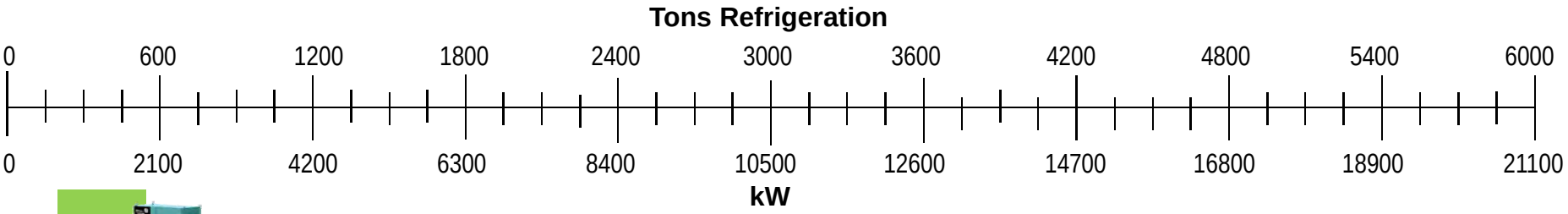
YPC- Two Stage
200-800 Tons

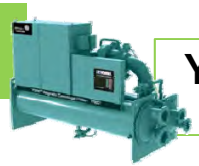
YIA- Single Stage
120-1380 Tons

Diverse and Broad Solution Offerings-

Water-Cooled Centrifugal Chillers

YORK BY JOHNSON CONTROLS





YMC² – Magnetic Compressor
215-560 Tons

YK – Single Compressor
250-3000 Tons

YK-EP – Compressors with Economizer
2500-3500 Tons

YD – Dual Compressors
2000-6000 Tons

YST – Steam Turbine
700-2800 Tons

OM – Custom Designed
3000-5500 Tons

CYK – Compound Compressors
500-2500 Tons

Johnson Controls

Environmental Leadership

The global market leader in Variable Speed Drive chillers with 30 years of experience varying compressor motor speeds

30 YEARS experience

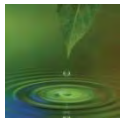
1979 Introduced OptiSpeed™ Variable Speed Drive
Delivering Unsurpassed Real World Energy

1989 First Unit Mounted Chiller Variable Speed Drive
VSD With Improved Cost and Convenience

2004 First VSD Driven Air Cooled Screw Chiller
Unmatched Real World Efficiency and Sound Levels

2005 EPA Climate Protection Award
For Pioneering VSD Chiller Technology

2010 2nd Generation VSD Air Cooled Screw Chiller



Johnson Controls

Innovation Example- Variable Speed Drive for Chillers

- Taking advantage of real world conditions
- As weather conditions and building load change, design conditions exist only 1% of the operating hours
- Applying VSD to chillers reduces energy consumption by 30%
- Globally commissioned over 10,000 VSDs

EPA's Prestigious Climate Protection Award

- YORK VSD chillers save 600,000 tons of CO_2 emissions annually

Innovation in Action

1951
Empire State Building
New York, NY

1951 Installation

- 5,300 TR (18,640 kW)
- YORK® YAC Chillers
- Electric Motor Drives

Innovation in Action

1951
Empire State Building
New York, NY

Now… Becoming one of the most energy efficient buildings in the world

- LEED Gold certification
- Retrofitting 4 existing industrial electric chillers
- Upgrading controls
- Adding variable speed drives and primary loop bypass.

2009

Energy Diversity

Gas
Absorption

Steam
Centrifugal

Electric
Centrifugal

Johnson Controls

Refrigerant Diversity-
Protecting the Atmosphere and Your Best Interests

Currently Available

HFC- 134a

Ammonia

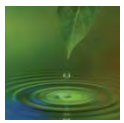
Hydrocarbon

Water

No ODP/ Low GWP Gases

Decision Criteria for Future Long Term Refrigerant Offerings

1. **Safety**
2. **Efficiency**
3. **Environmental Impact**
4. **Availability**



Conserving Water

- Water saving heat recovery solution
- Most efficient air-cooled product offerings
- Air cooled radiators available when water is not available
- Diversity in water source options
  - Fresh Water
  - Low Chloride Treated Sewage
  - High Chloride Treated Sewage
  - Brackish or Seawater

Titanium Tubing

Ceramic Coating

Delivering What is Promised

Reliable Product

- Designed for 30 year life
- Numerous installations with chiller running successfully for over 50 years
- IBC Seismic Certification
  - Only company in the industry to conduct a shaker table test
  - OSHPD Special Seismic Certification

Proven Performance

- Zero failure rate for AHRI witness performance test since inception of AHRI program

By Your Side- Customer for Life

Installation

Optimize

Maintain

Enhance/ Sustain

Design/ Re-Design

Johnson Controls

Johnson Controls


Johnson
Controls
INGENUITY WELCOME

YK Centrifugal Chiller

250 – 3000 Tons (880- 10550 kW)

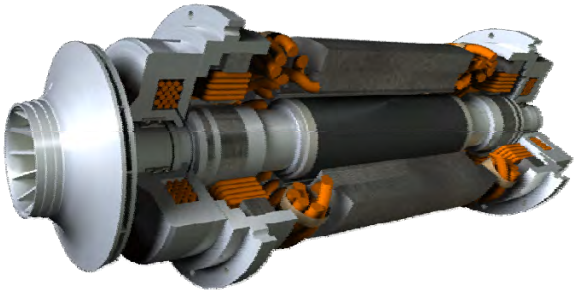
- Single Compressor
- HFC- 134a refrigerant
- 55 F Entering Condenser Water
- Great off design performance
- Open Drive
- Variable Speed Drive
- Heat Pump Capability
- Heat Recovery Capability

YK – Heat Recovery / Double Bundle

YMC² Centrifugal Chiller

215 – 380 Tons (755 - 1340 kW)

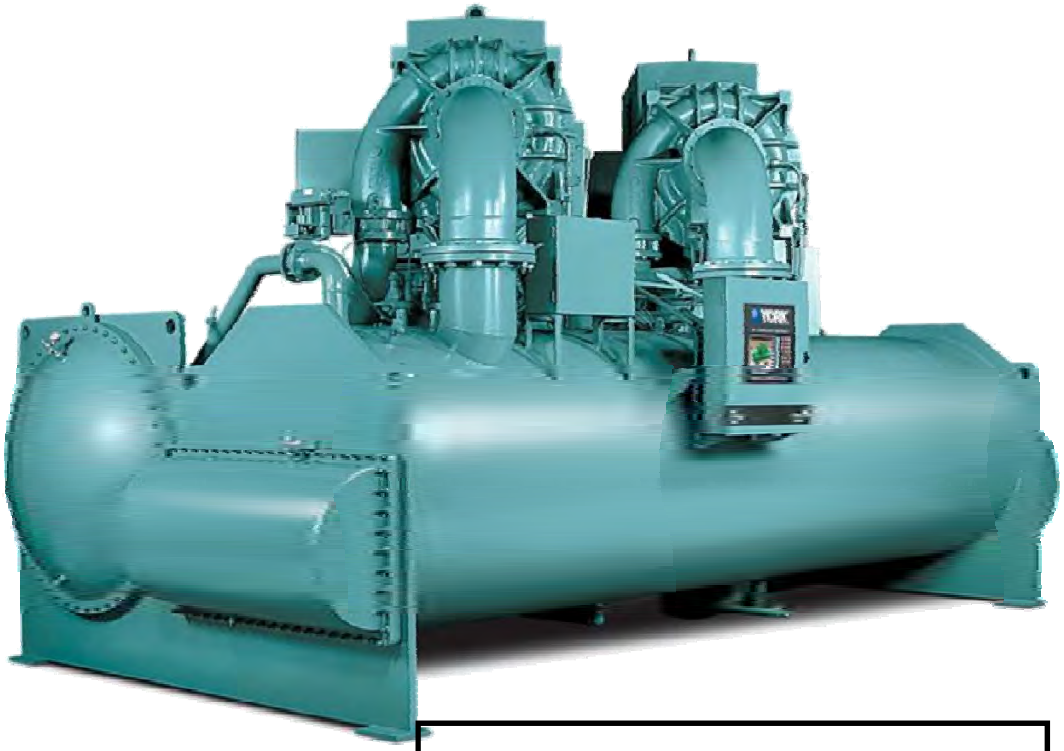
- Permanent magnet motor with active magnetic bearing technology
- HFC- 134a refrigerant
- Oil Free
- Great off design performance
- Excellent Sound Performance:73 dBA or less

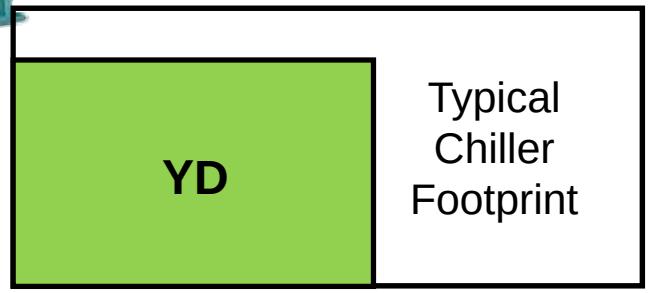


YD Centrifugal Chiller

2000 – 6000 Tons (7000- 21100 kW)

- Dual Compressors in parallel
- HFC- 134a refrigerant
- Smallest footprint per cooling ton
- Great off design performance





CYK Centrifugal Chiller

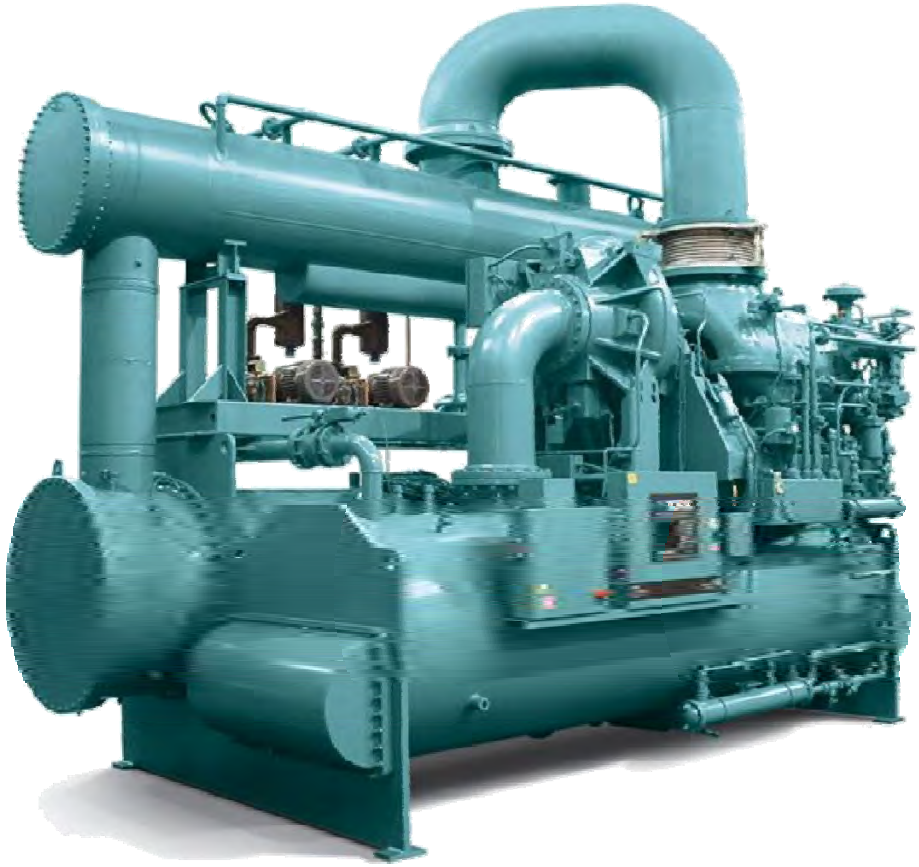
500 – 2500 Tons (1760- 8800 kW)

- Two compressors in series
- HFC- 134a refrigerant
- Single or dual evaporator
- Ideal for high lift applications
- Air- cooled radiator capability
- Ice thermal storage capability
- Low temperature process capability

YST Centrifugal Chiller

700 – 2800 Tons (2460- 9850 kW)

- Centrifugal Compressor
- Steam Turbine Drive (50-400 PSIG)
- HFC- 134a refrigerant
- Variable Speed
- Great off design performance
- 55 F Entering Condenser Water
- 3 GPM/Ton Condenser Flow
- Variable Primary Flow
- < 32 F Leaving Chilled Water
- Long life



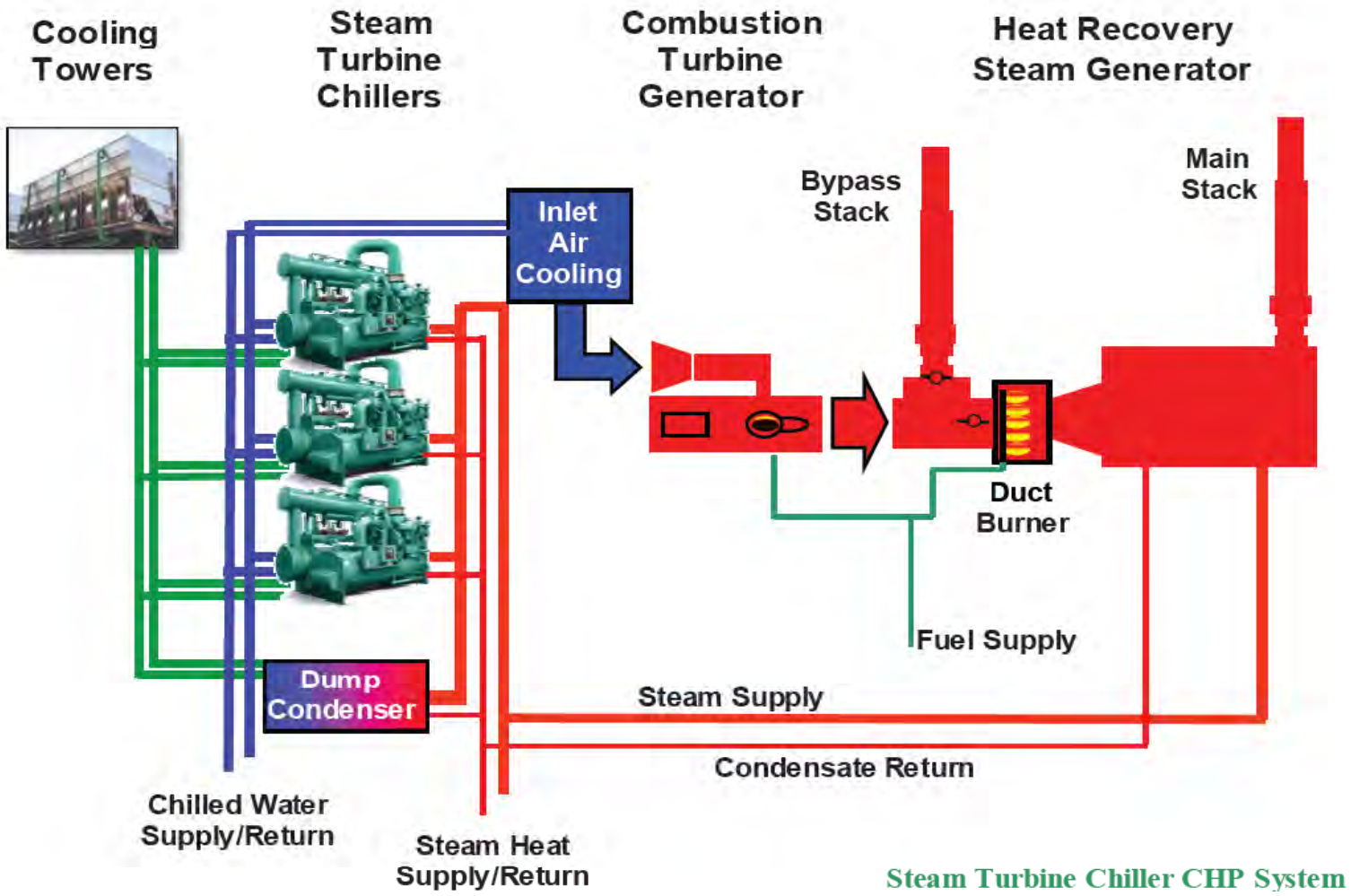
Johnson Controls

Customer Applications – YST

Installations – 160+ chillers – 260,000+ tons

- **Combined Heat and Power (CHP)**
- **Commercial Office Bldg's**
  - District Steam
  - Footprint / Rigging, Access
- **Process Applications**
  - Pharmaceuticals, Electronics manufactures
- **Medical Centers**
  - Heating, Food service, Sterilization, Laundry Services
- **Higher Education**
  - Steam heating, Food service
- **Hybrid Plants**
- **Turbine Inlet Air Cooling**

Turbine Inlet air cooling with YST

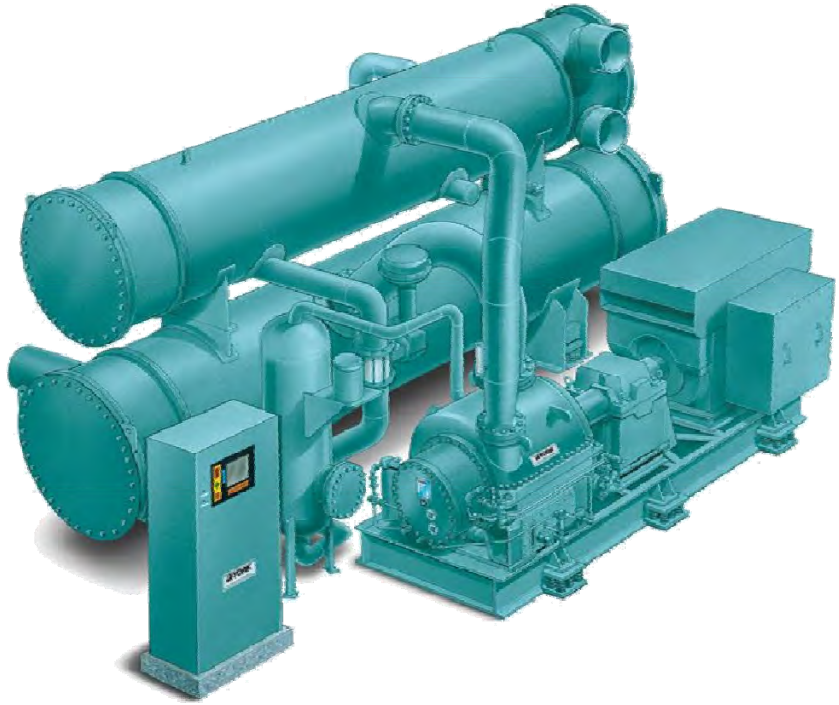


Steam Turbine Chiller CHP System

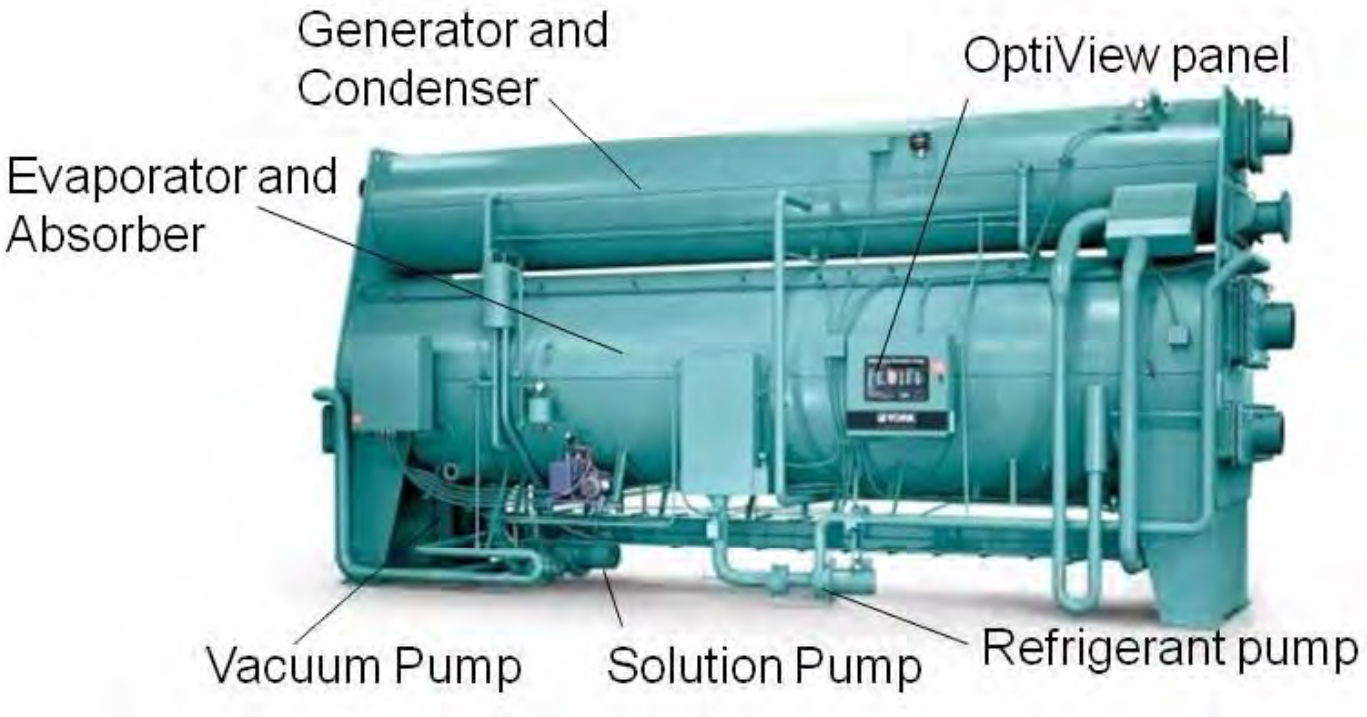
Titan OM Centrifugal Chiller

3000 – 5500 Tons (10550- 19350 kW)

- Custom designed
- Industrial Construction
- Multi-Stage Centrifugal Compressor
- Alternative drives, multiple drivelines in same unit (steam, gas, electric)
- Ideal for district cooling
- Brine cooling, air-cooled condensing, radiator cooling
- 40 to 50-year life



Single Stage Absorption Chillers



- Manufactured in North America since 1958
- Over 4,000 Units Installed Worldwide

Application Considerations

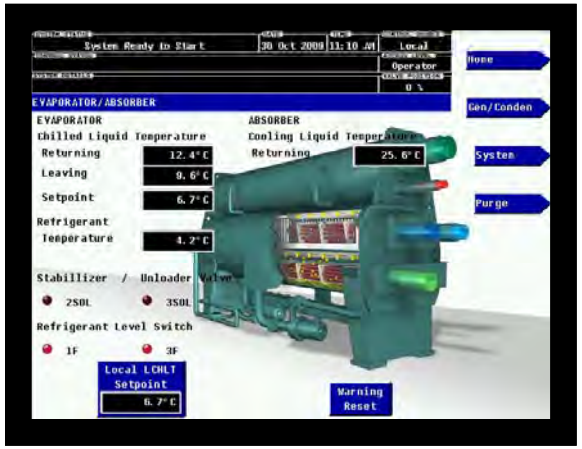
COP = 0.70

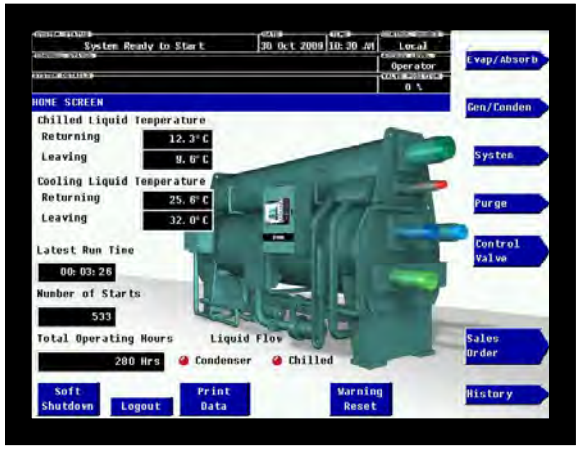
Typically driven by low pressure steam (15 psig) or hot water (180°F -266°F)

Minimum Leaving Chilled Water Temperature 40°F (4°C)

Minimum Entering Condenser Water Temperature 45°F (7°C)

Typical Condenser Water flow rate: 3.6 GPM/Ton





Class I Div II Group C & D: Refinery & Petrochemicals

Two Stage Absorption Chillers

Steam

Direct Fired (gas/oil)

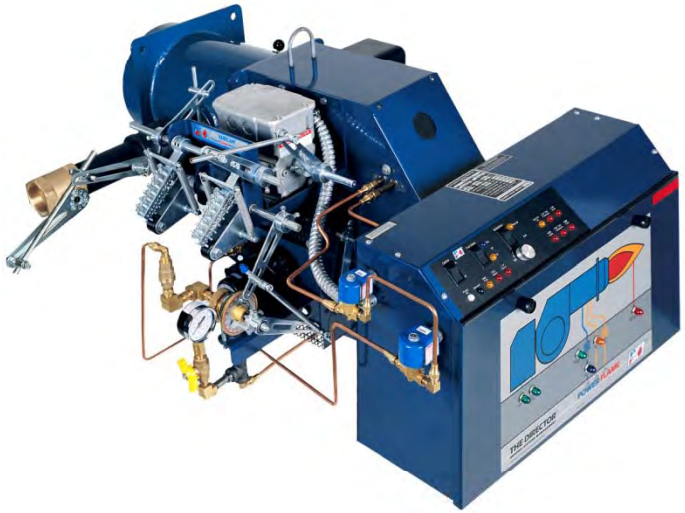
- Made by YORK since 1991
- Licensed from Hitachi Japan
- Over 1,200 Units Installed Worldwide

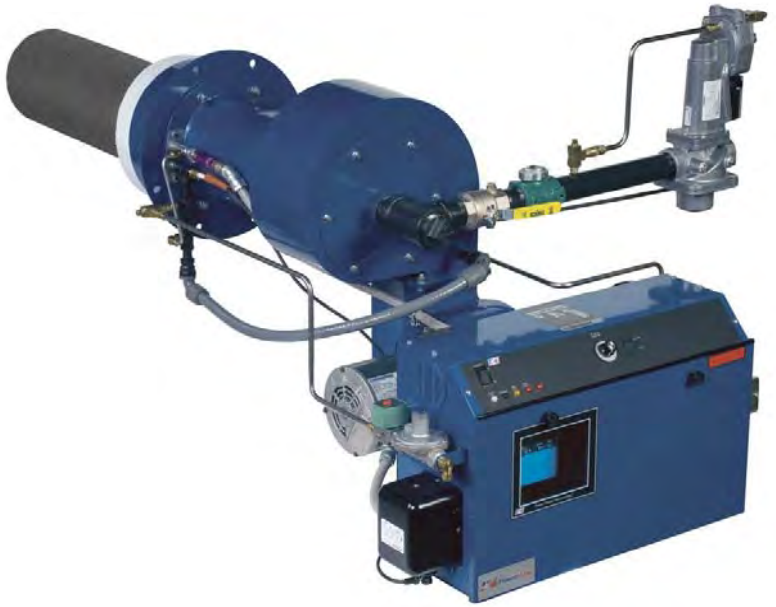
Johnson Controls

Application Considerations

- COP = 1.00 – 1.20
- High pressure steam (45 - 125 psig) or direct firing of natural gas/oil
- Minimum Leaving Chilled Water Temp. 40°F
- Minimum Entering Condenser Water Temperature 68°F
- Typical Condenser Water flow rate: 4.0 GPM/Ton
- Chiller-Heater or Simultaneous chilled and hot (heating) water up to 180°F

LOW NOx 9 PPM Natural Gas Burner





Sustainable Benefits

Water as the refrigerant

Quiet and vibration free

Great turndown (10% to 100%)

Clean burning natural gas

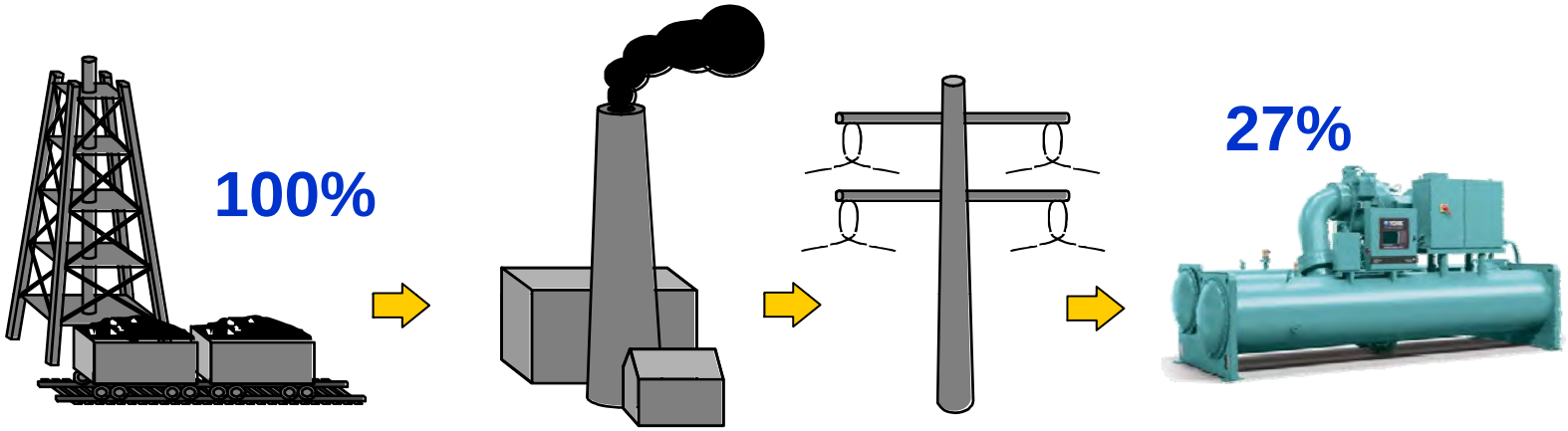
Harnesses waste steam or hot water

Reduced electric energy and infrastructure charges

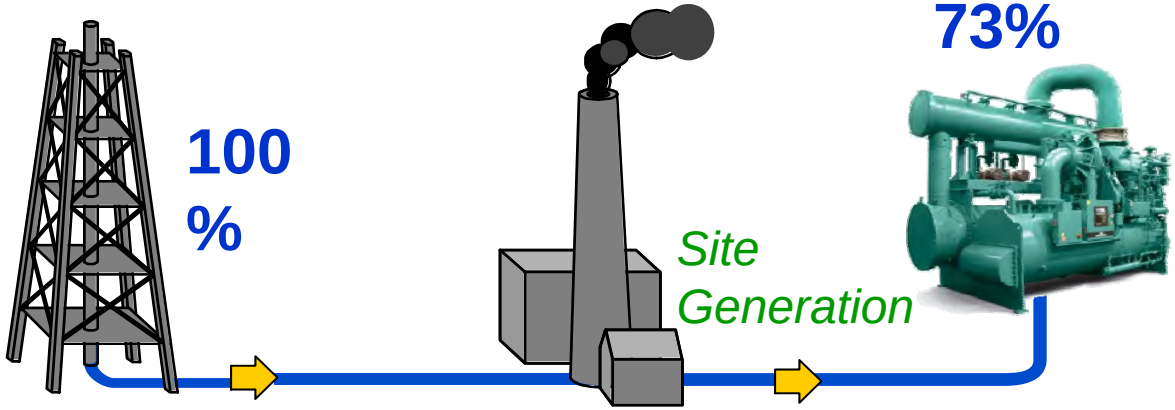
Reduced emissions

Traditional vs. Combined Heat and Power (CHP)

Traditional Power Generation



CHP



Johnson Controls

CHP – Thermally activated cooling technologies

CHP technologies

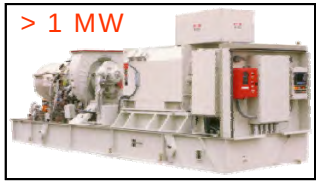
Thermally-Activated Cooling Technologies

800ºF

600ºF

360ºF

180ºF



Gas-turbine

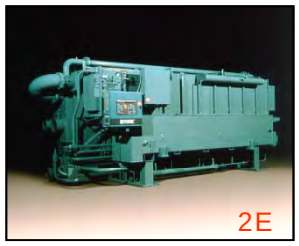
Solid Oxide Fuel Cell

Microturbine

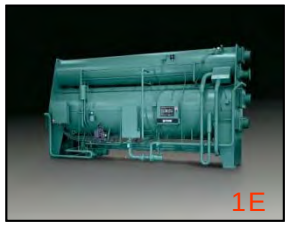
Internal Combustion Engine Exhaust

Internal Combustion Engine Jacket + Exhaust

Steam Turbine Centrifugal Chiller



Double-Effect Absorption Chiller



Single-Effect Absorption Chiller

Combined Heat and Power Wisdom

- **Buildings over 100,000 sq.ft**
- **High load factor (maximize both power and thermal load factor)**
- **‘Thermal First’ approach to maximize the load factor**
- **Cooling Thermal/Electric Ratio**

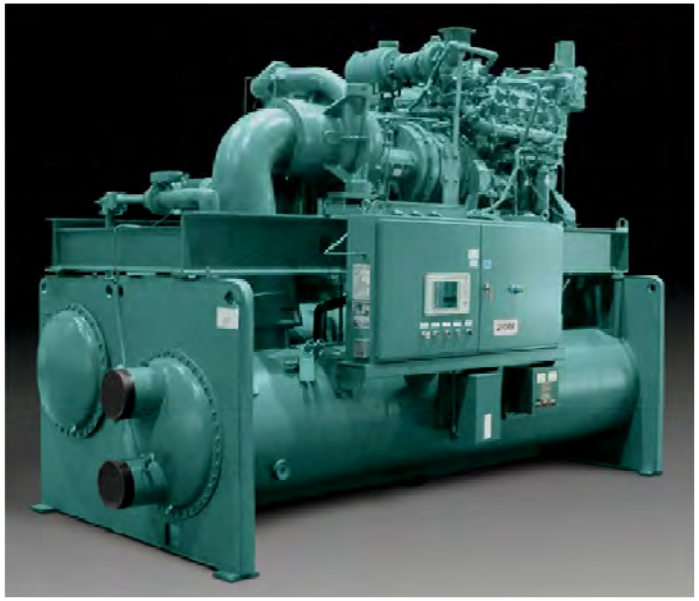
THERMAL REVENUE REPRESENTS THE PROFIT

Thermal-Electric Ratio

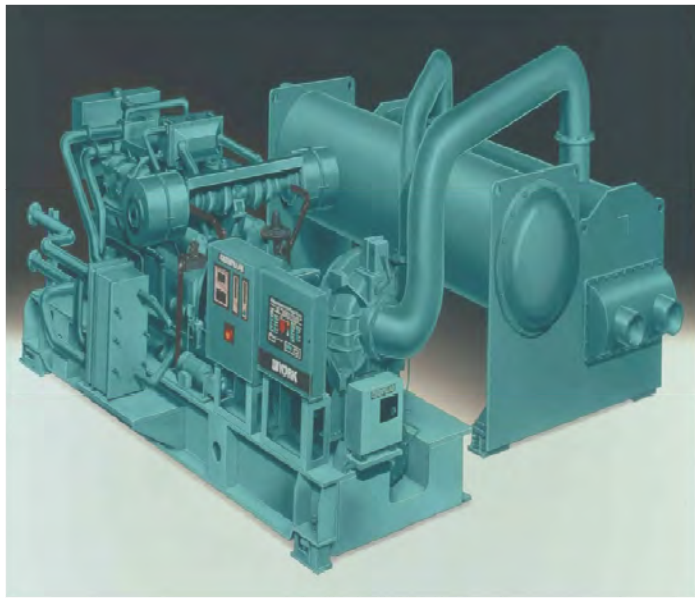
Prime Mover	Electrical Power Output	T/E Ratio (Tons/KW)	Cooling Technology
Combustion Gas Turbine 	> 5 MW	0.6 – 0.7	Steam Turbine   Centrifugal Two Stage Absorption
Micro-Turbine 	< 1 MW	0.4 – 0.5	Single Stage Absorption 
Internal Combustion Engine 	0.2 -3 MW	0.2 – 0.4	Single Stage Absorption 
Fuel Cell 	0.25 – 1 MW	0.1 – 0.2	Single, Two Stage Absorption  

Gas Engine Driven Chillers

MOST EFFICIENT CHILLER



500 – 800 tons



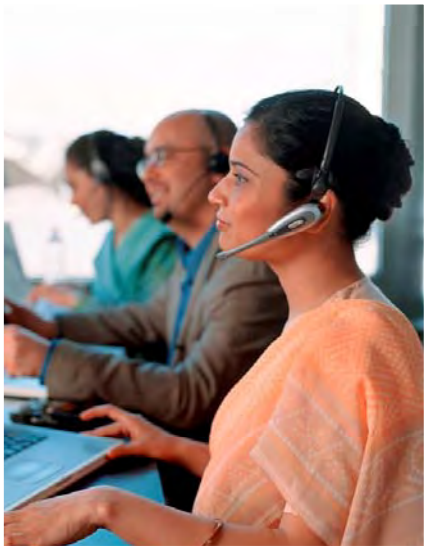
1200 - 1800 tons

Site vs. Source COP

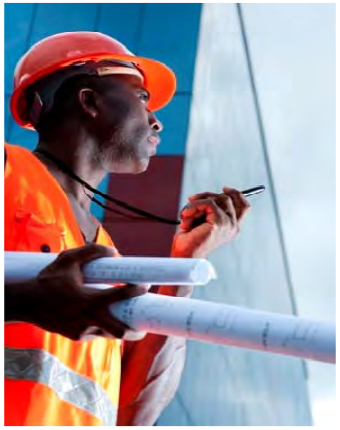
THERMAL CHILLERS	COP SITE	COP SOURCE
Absorption Chillers		
Single stage	0.70	0.64
Two stage direct fired	1.00	0.91
Two stage steam fired	1.20	1.09
Steam Turbine Driven Centrifugal Chiller	1.20	1.09
Gas Engine Driven Centrifugal Chiller	2.10	1.93

	COP SITE	COP SOURCE
Electric motor driven centrifugal	6.10	1.53

We create buildings and environments that help people achieve




Because when buildings work better … people work better

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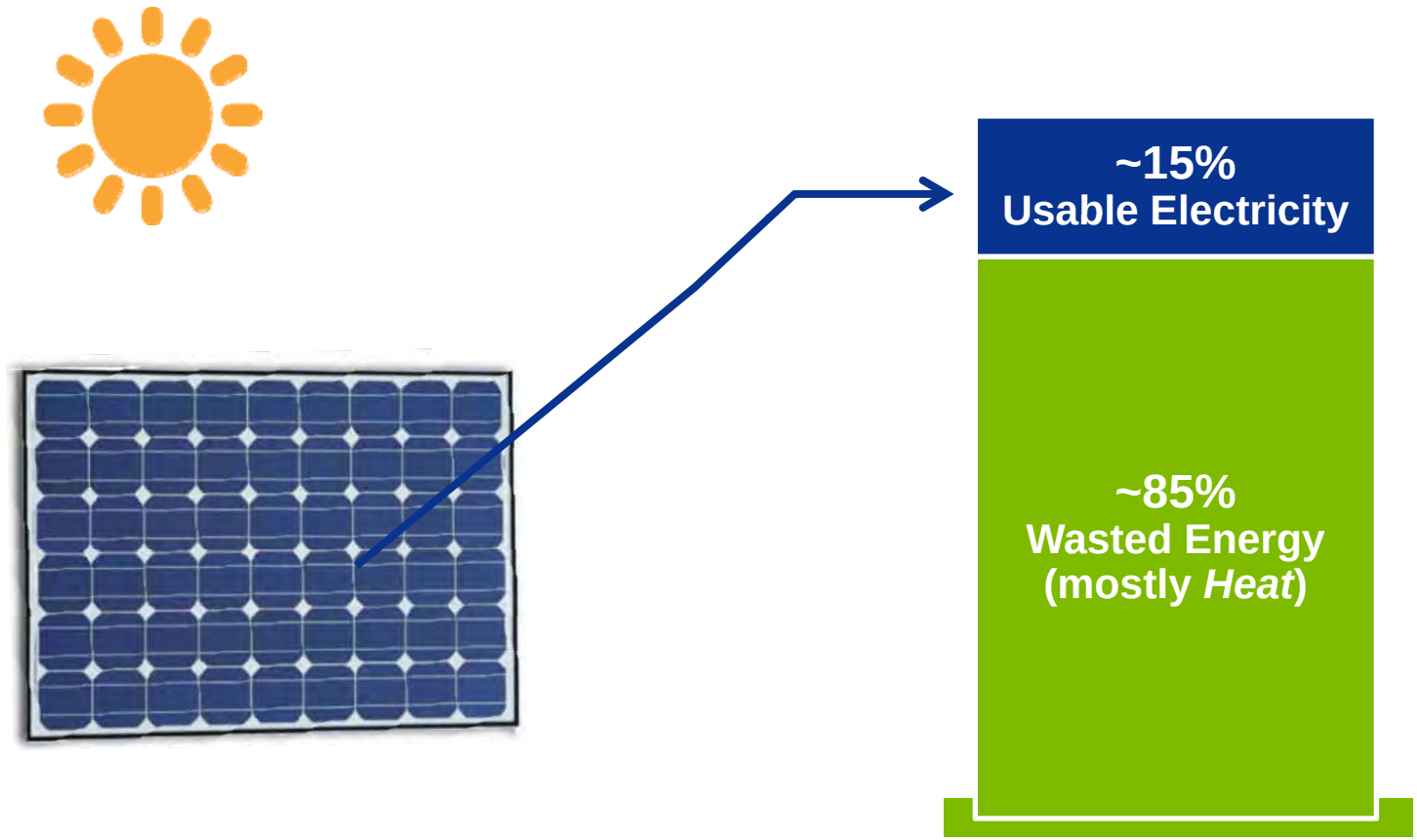
THANK YOU

Solar Cogeneration

PV Utilizes a Fraction of the Solar Potential

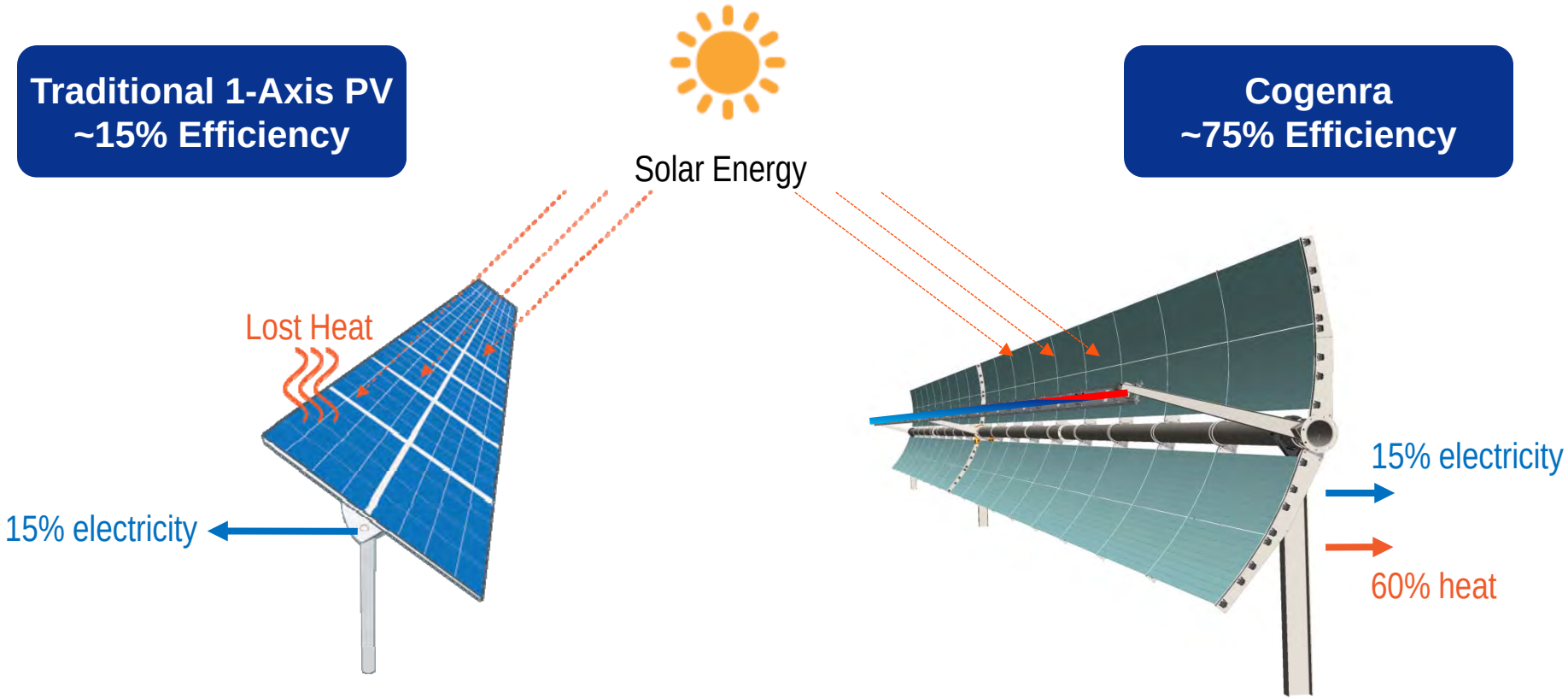


Solar Cogeneration

Captures 5X Energy Vs. PV

Traditional 1-Axis PV
~15% Efficiency

Cogenra
~75% Efficiency



Lowest Cost PV + "Free" Solar Heat

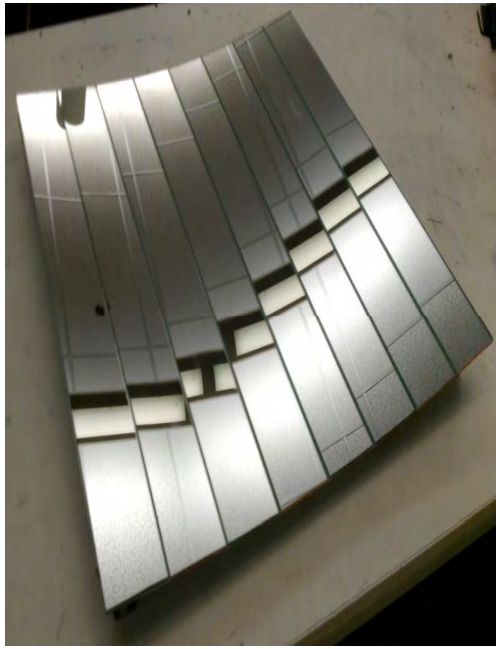
Low Cost Planar Optics

Standard PV Module

cSi PV Module
$100 / m^2

vs.

Planar Concentrator



Steel-Glass Reflector
< $20 / m^2

80% Area Cost Reduction ➔ Lowest Cost PV

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Core Technology: High-Efficiency PV-Thermal

Modular Concentrator

- Low-cost single-axis tracking
- Planar optics*
- Snap-in-place assembly*

High-efficiency with Integrated Heat-Recovery

- High efficiency (15% PV + 60% heat)
- Proprietary thermal-electrical stack*
- Direct-laminated extruded channel*

Low Cost: Efficient PV, Valuable Heat

** Patent-pending:* 12/712,122 , *12/788,048 , 12/622,416 , 12/744,436 , 12/781,706,* 61/347,585, 13/291,531

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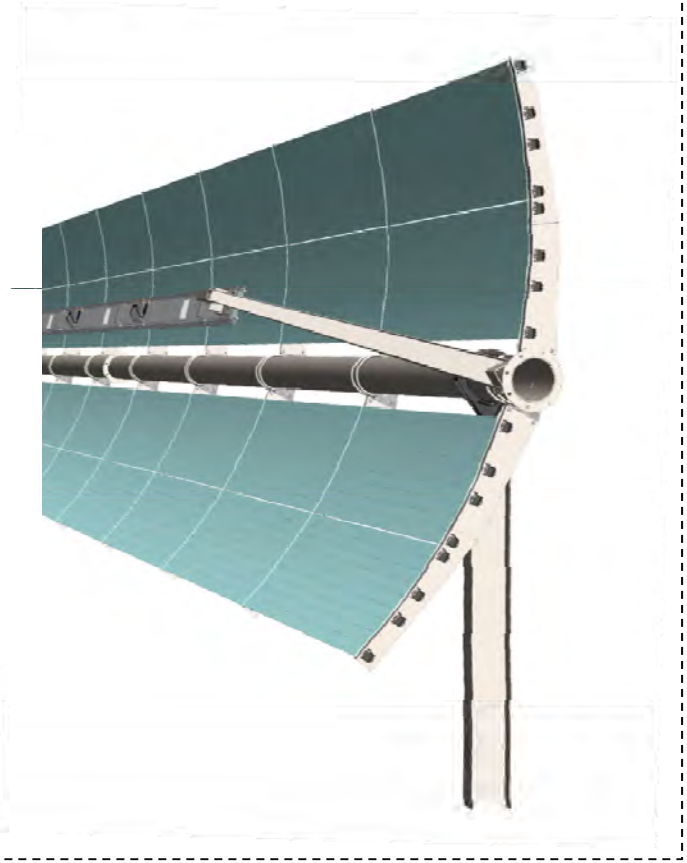
Actively Cooled Concentrating Solar

PLATFORM

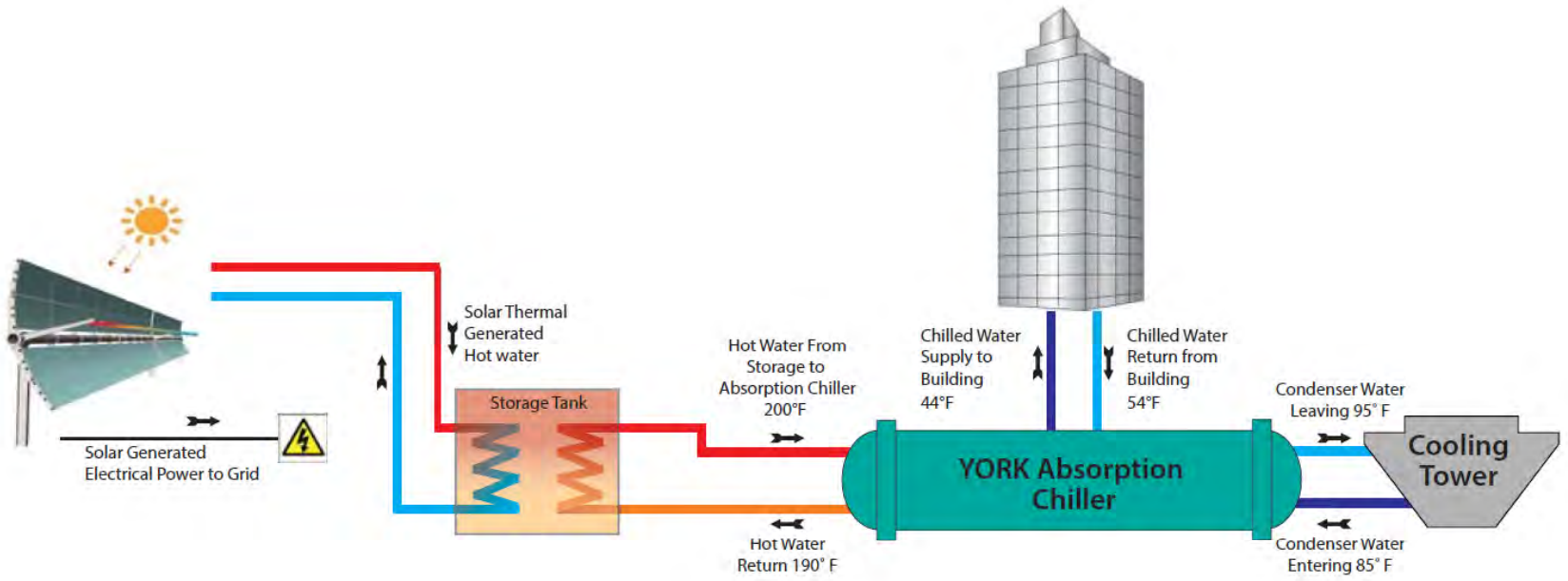


APPLICATIONS

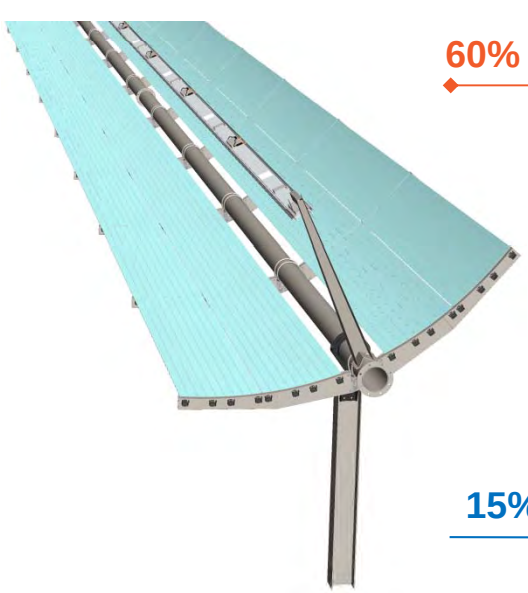
- PV
- \+ Heating
- \+ Cooling
- \+ Storage

Lowest Cost Solar Electricity & Free Thermal Power

Solar Combined Heat Power Cooling Solution



Solar Cooling



60% Solar Heat

Thermal Chiller
COP = 0.7

420 W/m²

+

Chilled Water

15% Solar PV

Mechanical Chiller
COP = 5

750 W/m²

* Cooling power per sqm of solar array

PV +"Free" Heat ➔ 50% More Cooling

Why Solar Tri-generation?

@1000 W/m² Solar					
	PV	Solar Hot Water	Solar Cogeneration		
	Electricity	415F Steam	Electricity	212F Hot water	
Efficiency	15%	60%	15%	60%	
Energy Captured	*150 W*/m²	*600 W*/m²	*150 W*/m²	*600 W*/m²	
Integration		*2E Abs Chiller*		*1E Abs Chiller*	
COP*	5X	1.3X	5X	0.7X	**Total**
Cooling	**750 W/m²**	**780 W/m²**	**750 W/m²** +	**420 W/m²** =	**1170 W/m²**

50% More Cooling Output than Solar PV or Thermal

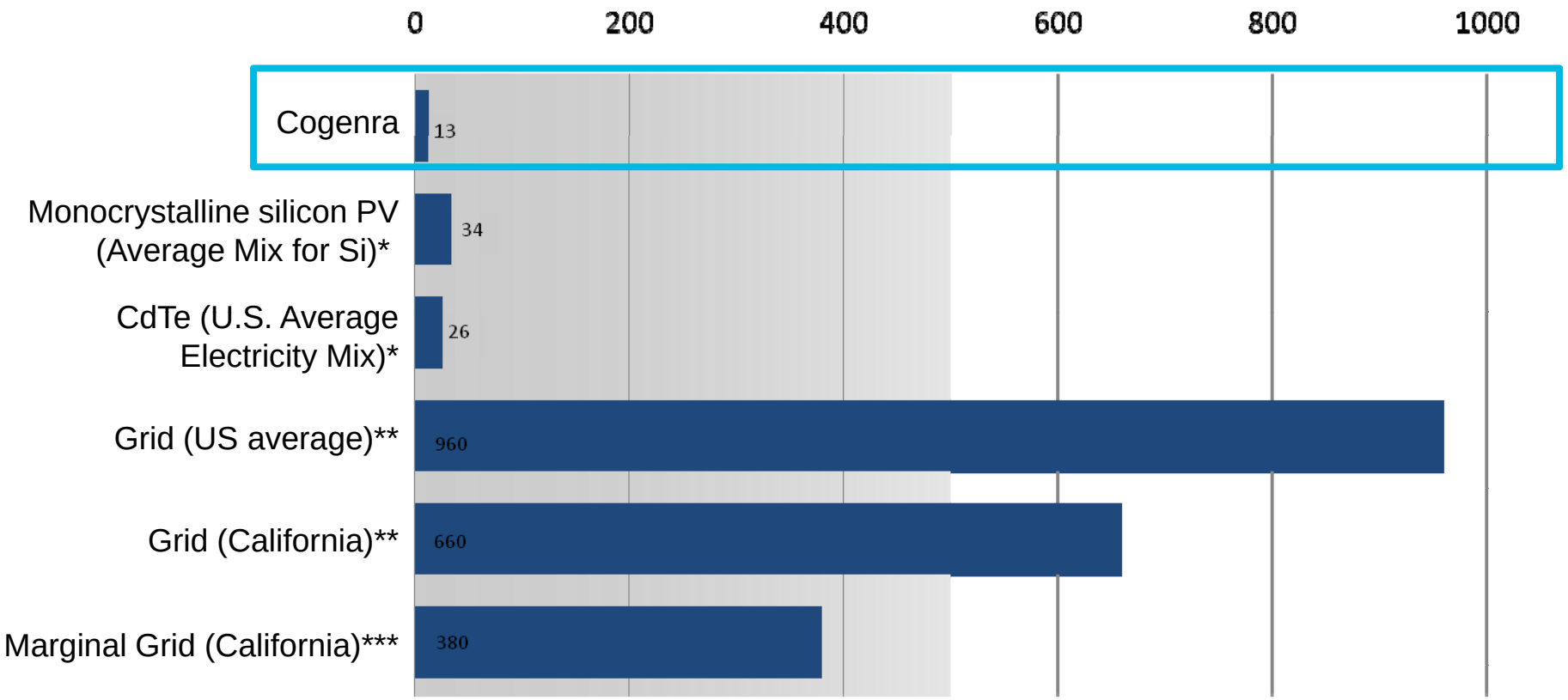
Solar Cogen Cooling Project Metrics

Cooling Delivered		100 tons	500 tons	1000 tons
Solar Electrical Capacity[1]	Electric Nameplate Power (KW)	200	950	2000
Area Cooled[2]	ft^2	28,000	140,000	280,000
Space Required[3]	ft^2	30,000	150,000	300,000
Greenhouse Gas Emissions Reduction[4]	Kg CO_2	242,000	1,127,000	2,250,000

1 Based in Phoenix, AZ.
2 Based on average ASHRAE cooling load at 280 sf/ton
3 Includes array row spacing
4 Based on average typical grid emissions factor

Lifecycle GHG Emissions

g CO_2 per kWh_e Delivered



* Fthenakis, et al., "Emissions from Photovoltaic Lifecycles", Environmental Science and Technology, 2008, 42, 2168, 2172.

** Indirect emission reduction factors from U.S. Department of Energy, EIA. Voluntary Reporting of Greenhouse Gases Program. See: http://www.eia.doe.gov/oiaf/1605/pdf/Appendix%20F_r071023.pdf, including emissions avoided from generation at the margin (from fossil-fuel sources) and indirect transmission and distribution losses.

*** Marginal electricity factor from California Environmental Protection Agency Air Resources Board, Detailed California-Modified GREET Pathway for California Average and Marginal Electricity. Version 2.1, February 27, 2009

Target Sectors

Government	Technology	Healthcare	Food & Beverage	Campus
Airport	Manufacturing	Pharmaceutical	Food processing	University
Wastewater Treatment	Distribution	Hospital	Dairy	Corporate complex
Correctional	Data center	Laboratory	Refrigeration	
District cooling	Research & development			
Public complex				

Additional Qualifications

- Large conditioned space (>30,000 sq. ft.)
- Space available for solar collectors (>25,000 sq. ft.)
- Land or continuous flat roof

Food & Beverage	Education	Hospitality	Housing	Military	Industrial	High Tech	Health Care	Water
Clover Stornetta Farms	Cal State San Marcos	InterContinental Hotels & Resorts	Family Housing (2)	United States Army (2)	Southern California Gas Company	Juniper Networks	Tucson Medical Center	avista technologies
Gatorade	The University of Arizona (2)	Equinox	Dutton	Department of the Navy (2)	Marcegaglia	facebook (2)		Reclamation (2)
Sula Vineyards	UATechPark (2)	Relais Duca di Dolle	La Posada at Park Centre, Inc. (2)	Marine Corps Warfighting Lab	General Hydroponics	Bay-Area High Tech		
Maui Brewing Co.		Zusterna						

2 = Repeat orders

Cogenra Solar Projects

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Army Base El Paso, TX

- Single stage hot water chiller in a Container

- Solar Thermal Collectors provide hot water (the driving heat source)

The Only Practical Solar Storage Solution

Electricity ← **Cogen** → **Heat**

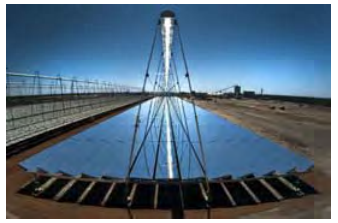
PV + Battery

- PV only, heat wasted
- Low capex, Chemical batteries,
- Modular scale
- **18% Efficiency**
- **Questionable storage (cycles)**

Cogenra

- PV + Hot water (~120C)
- Low capex; Water storage
- Utility scale & customer site
- **24% Efficiency**
- **Robust storage**

CSP



Super-heated steam (>400C)
High capex; Molten Salt storage
Utility scale, high distribution costs
18% Efficiency
Challenging Storage

Cost & Modularity of PV + Storage of CSP

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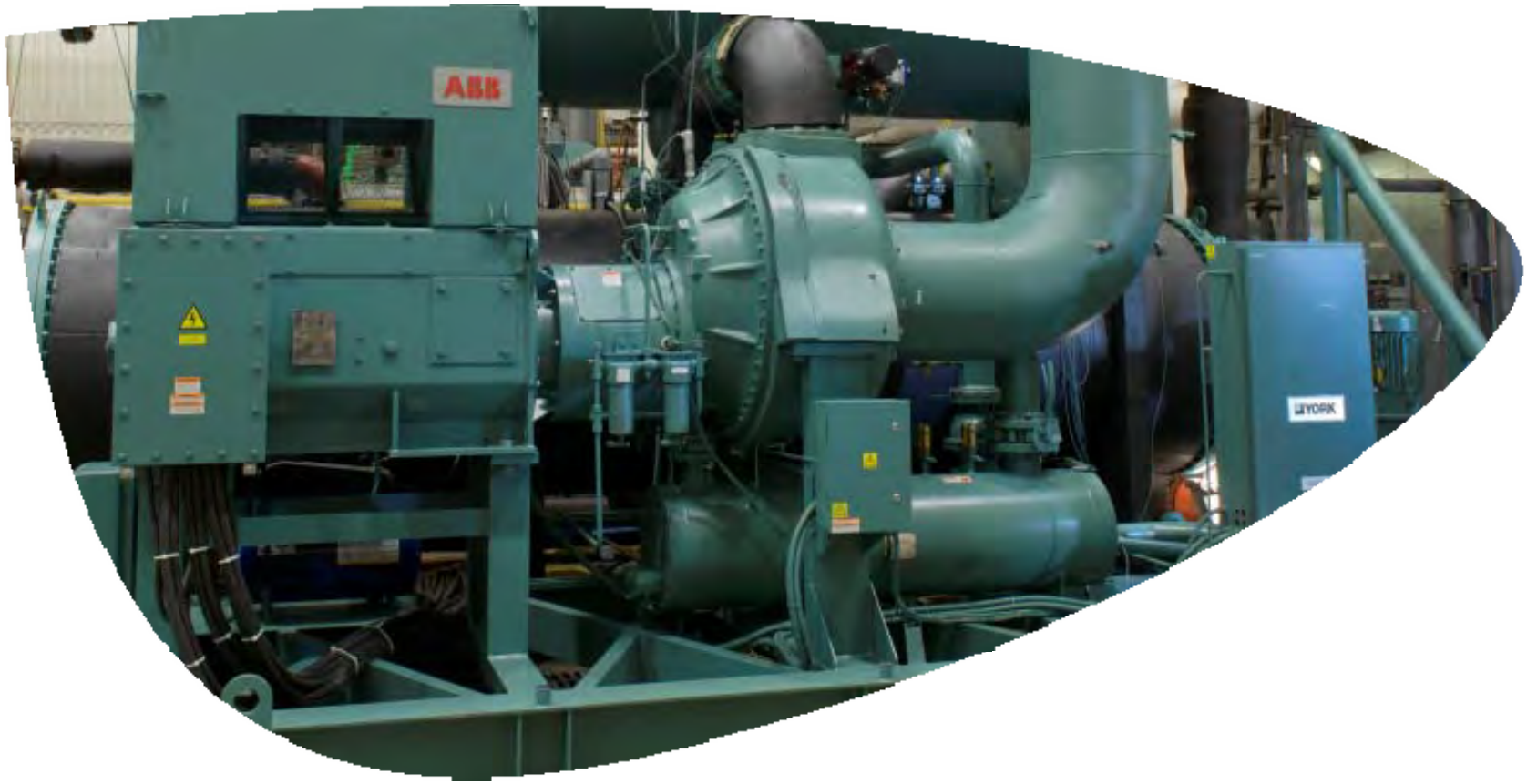
WASTE HEAT TO POWER SOLUTION



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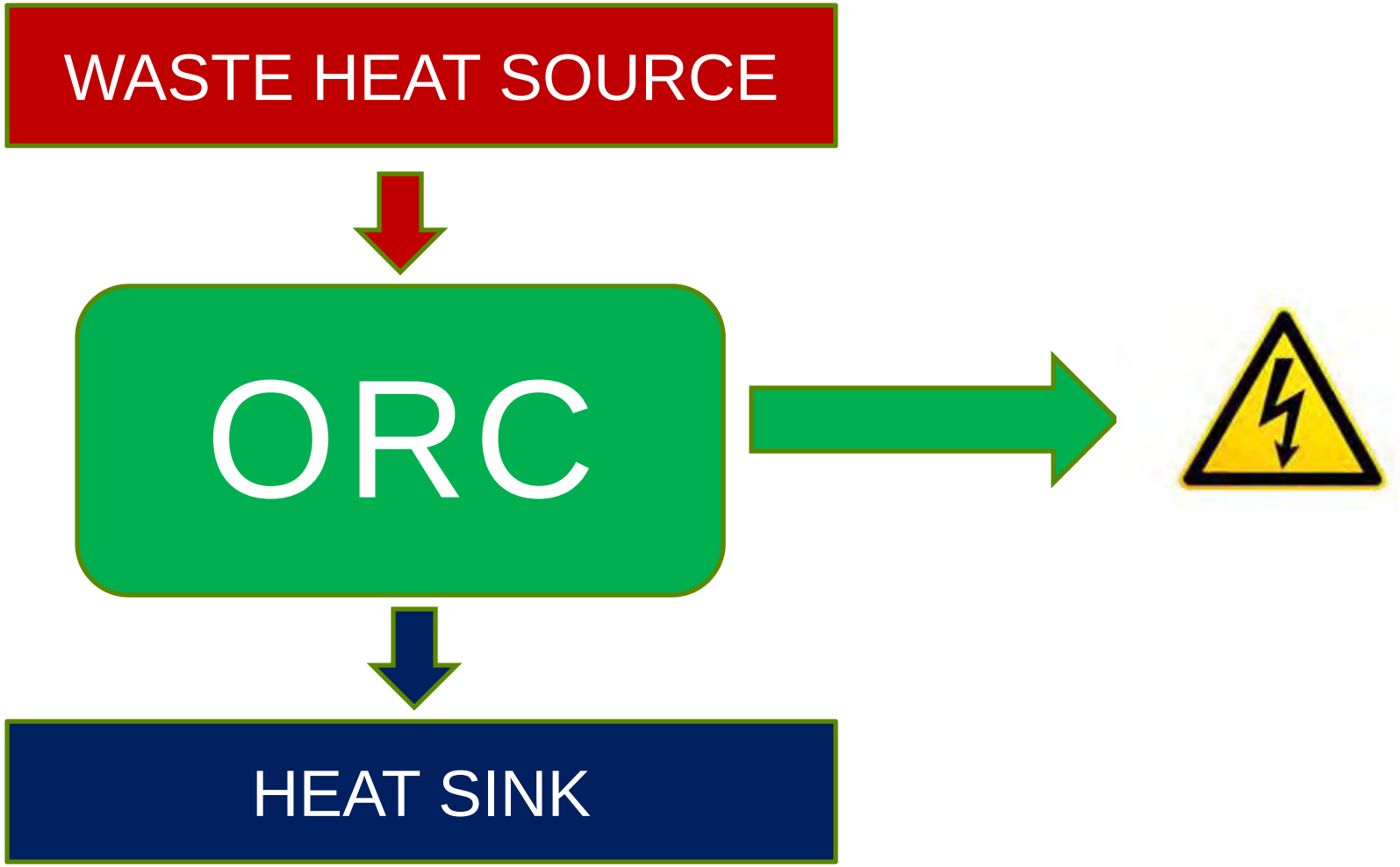
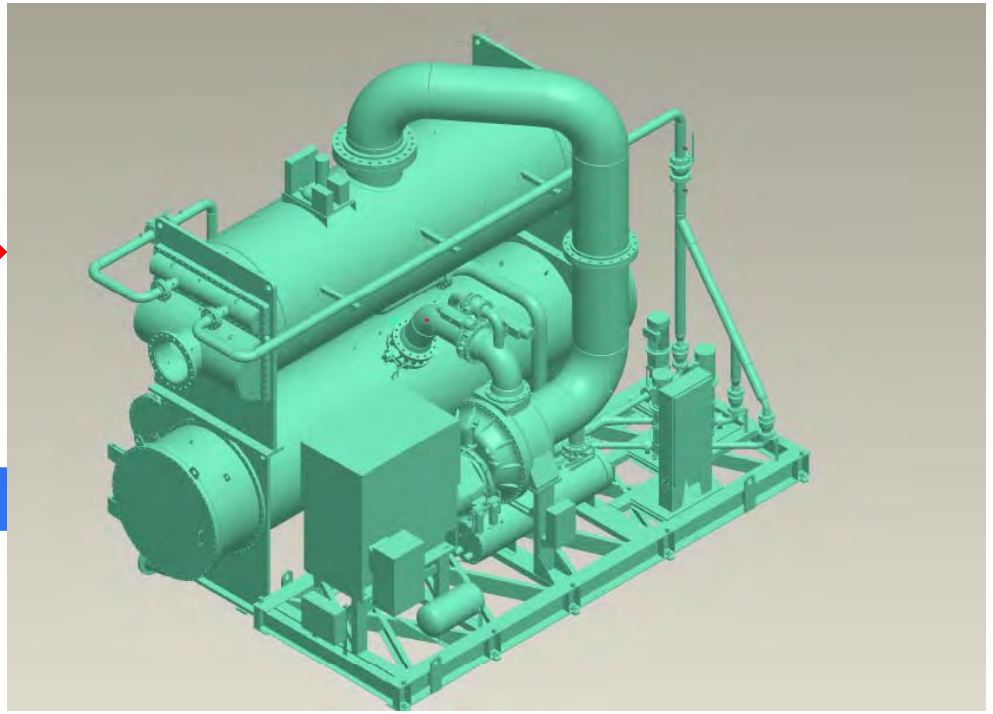
What is an Organic Rankine Cycle?



What is an Organic Rankine Cycle?

HOT WATER (194 F – 285 F)

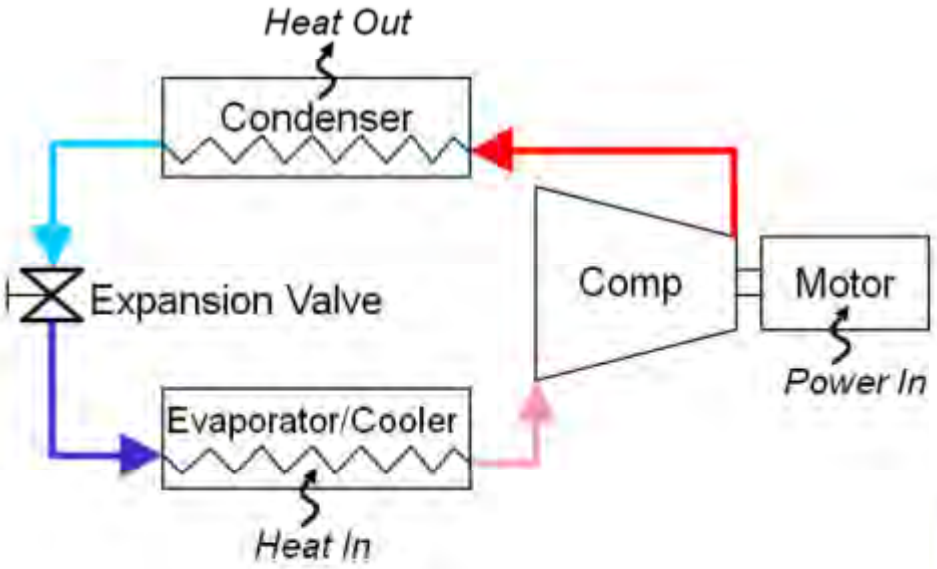


Electricity (500 KW – 3.5 MW)

FUEL FREE POWER FROM WASTE HEAT
with NO GHG EMISSIONS

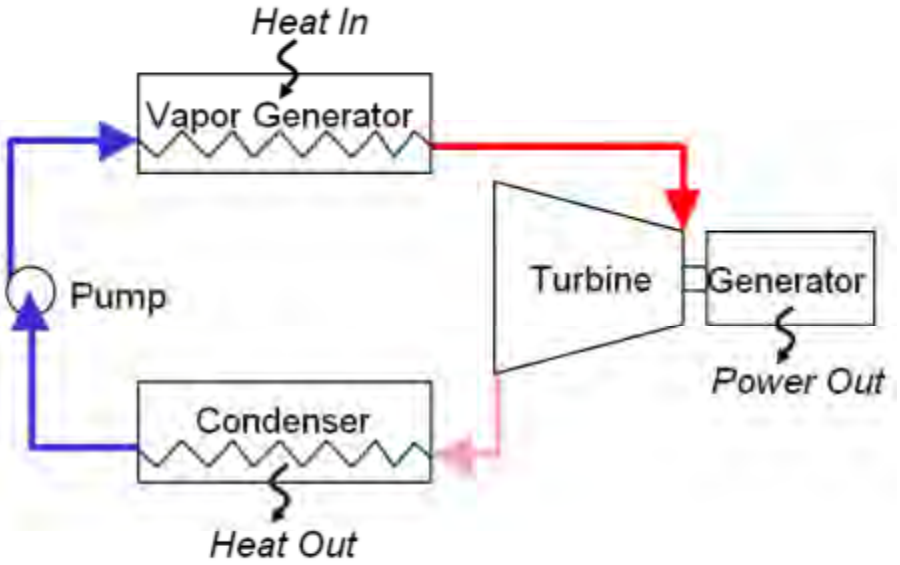
Chiller derived Organic Rankine Cycle

Vapor Compression Cycle (VCC)



4-stage thermodynamic cycle

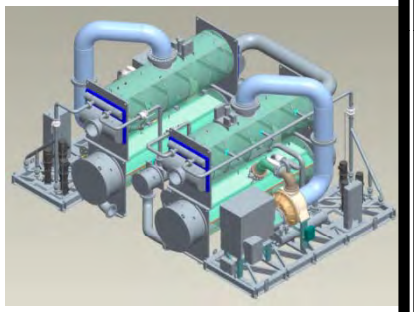
Organic Rankine Cycle (ORC)

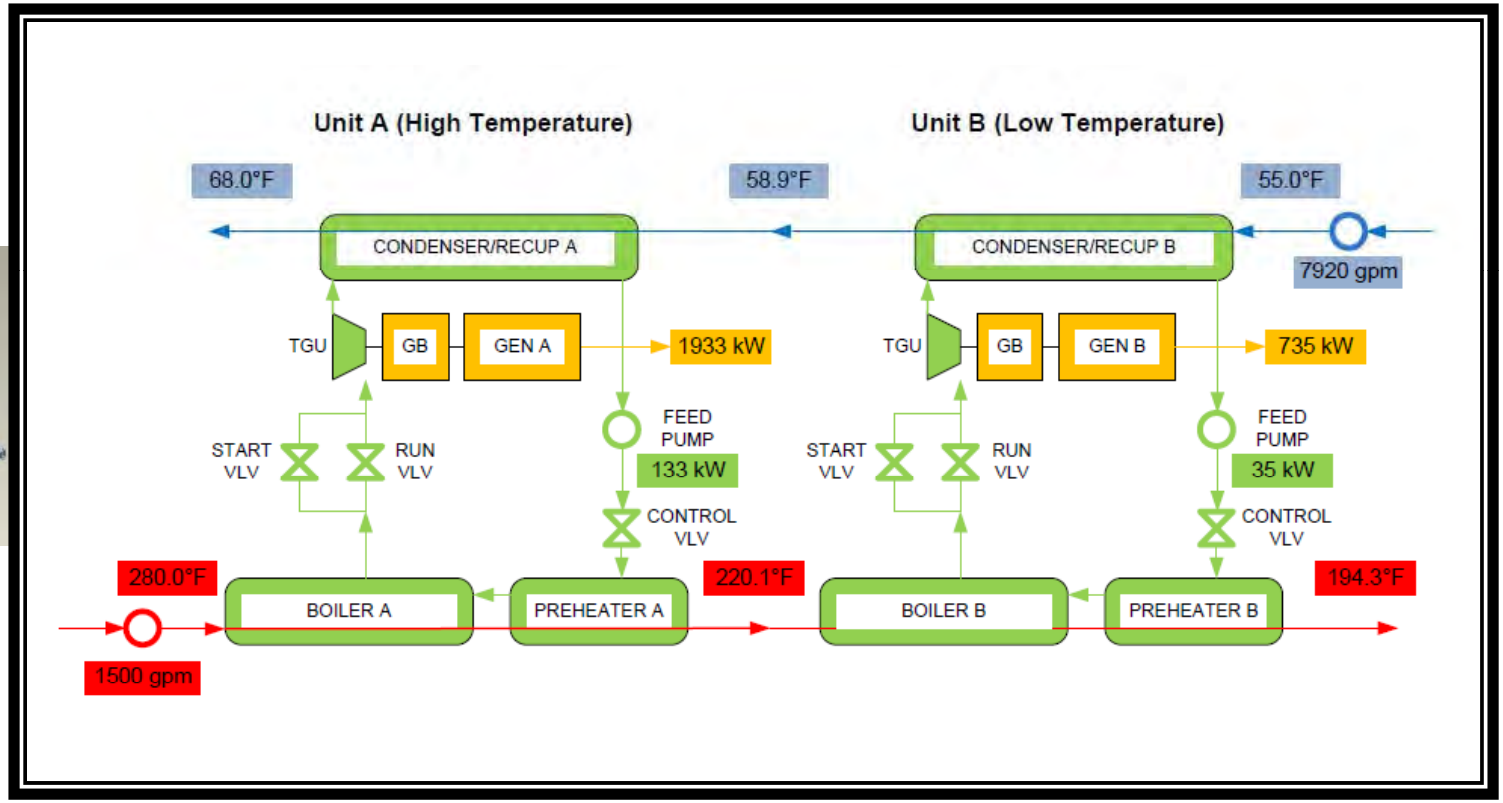


Completely Integrated in San Antonio, TX

Great Customer Benefits

Unique Series-Counterflow





UNIT A + UNIT B = 1 PAIR

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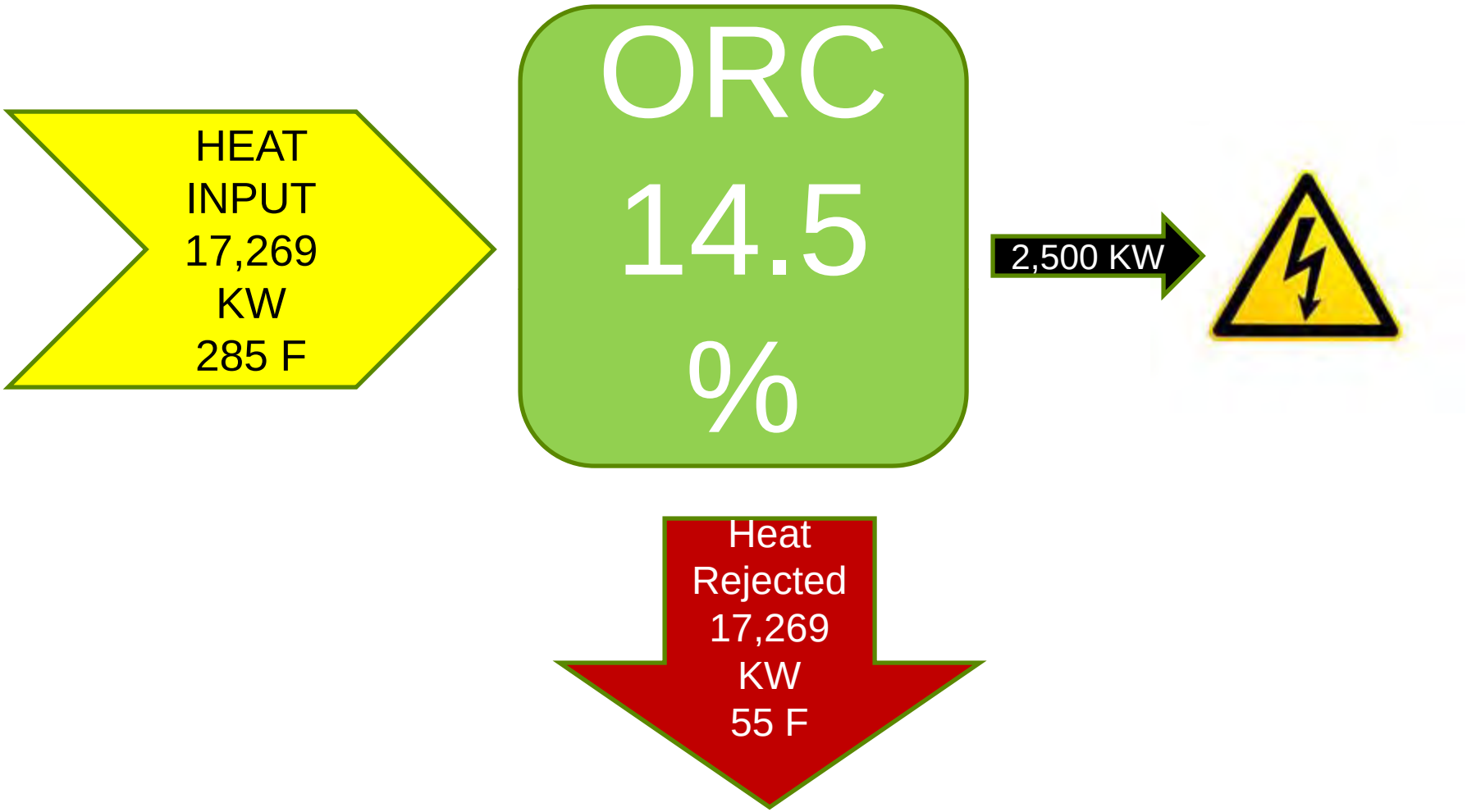
ORC Applications

- Availability of waste heat (195 – 285 F) **AND** heat sink
- **High cost of electricity from the grid** (> $ 0.10/kWh)
- **Year-round** demand for electrical power
- Electrical power output **500 KW – 3.5 MW**
- Applications:
  - ORC as a bottoming cycle in CHP - Gas Engines, Turbines
  - In combination with conventional Steam Rankine Cycle
  - Industrial Waste Heat Recovery
    - Cement, Steel, Chemical, Refineries, Metals, Minerals, Glass, Pulp & Paper, Food
  - Compressor Stations – TX, OK, LA, PA,…
  - Geothermal – CA, NV,…
  - Biomass
  - Incinerators
  - Solar

ORC Efficiency Example



Recap - ORC

- Clean Compelling solution for electrical power generation
- Proven technology, high reliability

Building Efficiency

Helping people achieve great things

Johnson Controls

THANK YOU