Operational Issues of A Fluctuating Campus Steam Production and Distribution System at The University of Arizona

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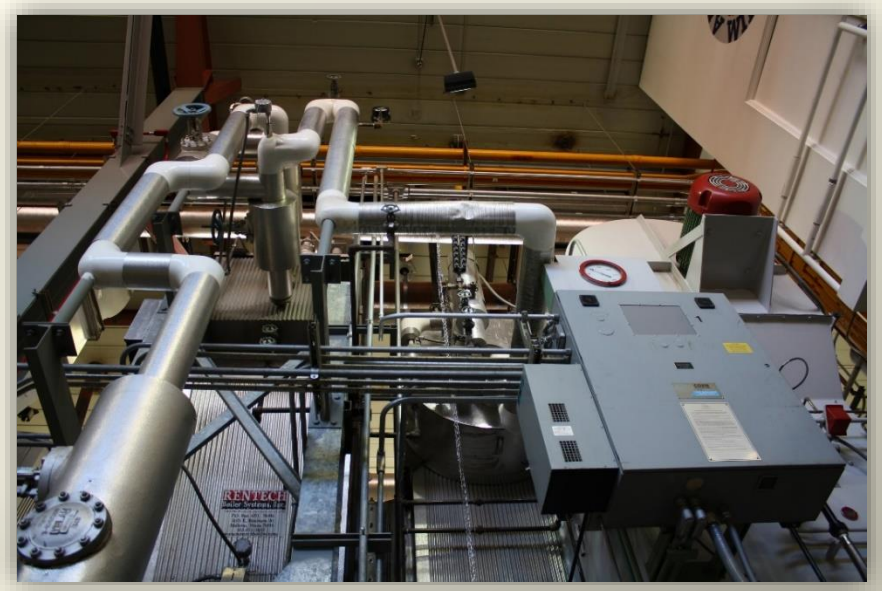
2018 Rocky Mountain APPA-Educational Session #1, Track 4

Presentation Objectives

- Identify steam production and distribution hurdles for a campus wide system.
- Identify strategies for overcoming recognized issues.
- Identify results of implemented issues.
- Share relevant solution experience



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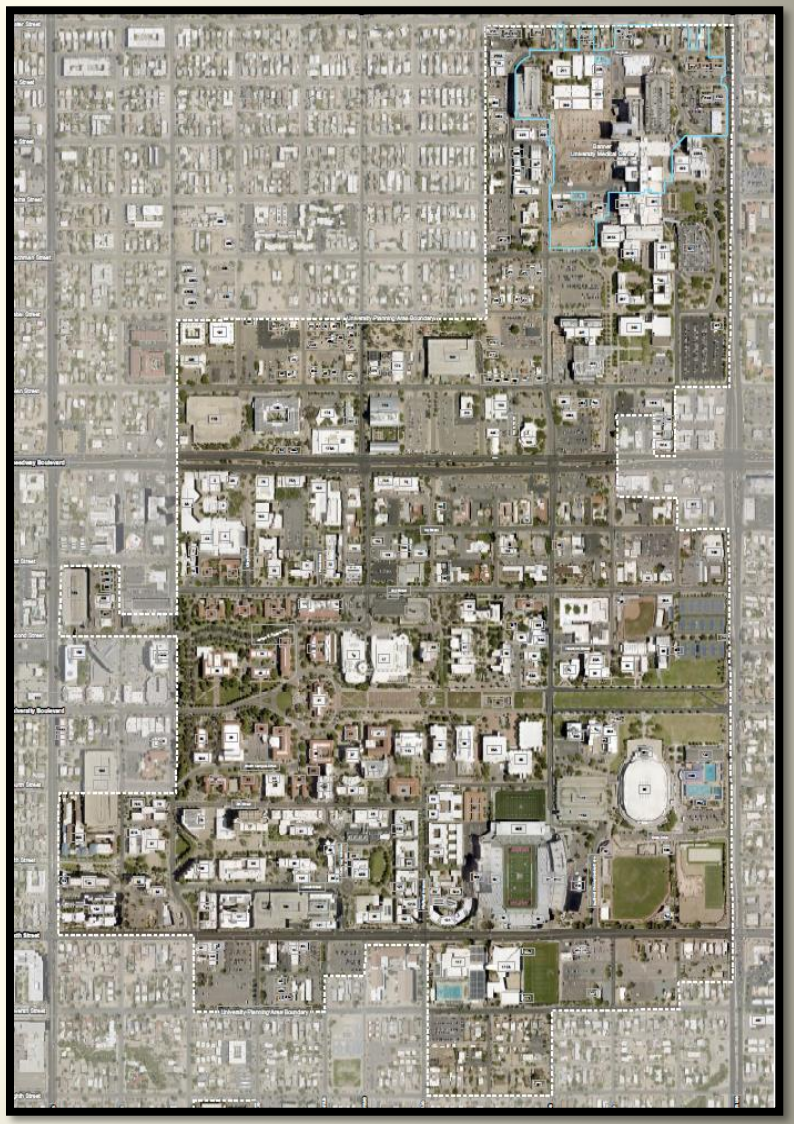
General Campus Statistics

- Chartered 1885
- Located in Tucson Arizona
- Student Enrollment-34,000
- 130 Buildings
- 13.5M Square Feet of Conditioned Space
- Variety of Campus Building/Space Uses
  - Classrooms
  - Offices
  - Dormitories/Student Housing
  - Research Laboratories
  - Large Auditoriums
  - Level I Trauma Hospital
  - NCAA Division I Sports Complexes



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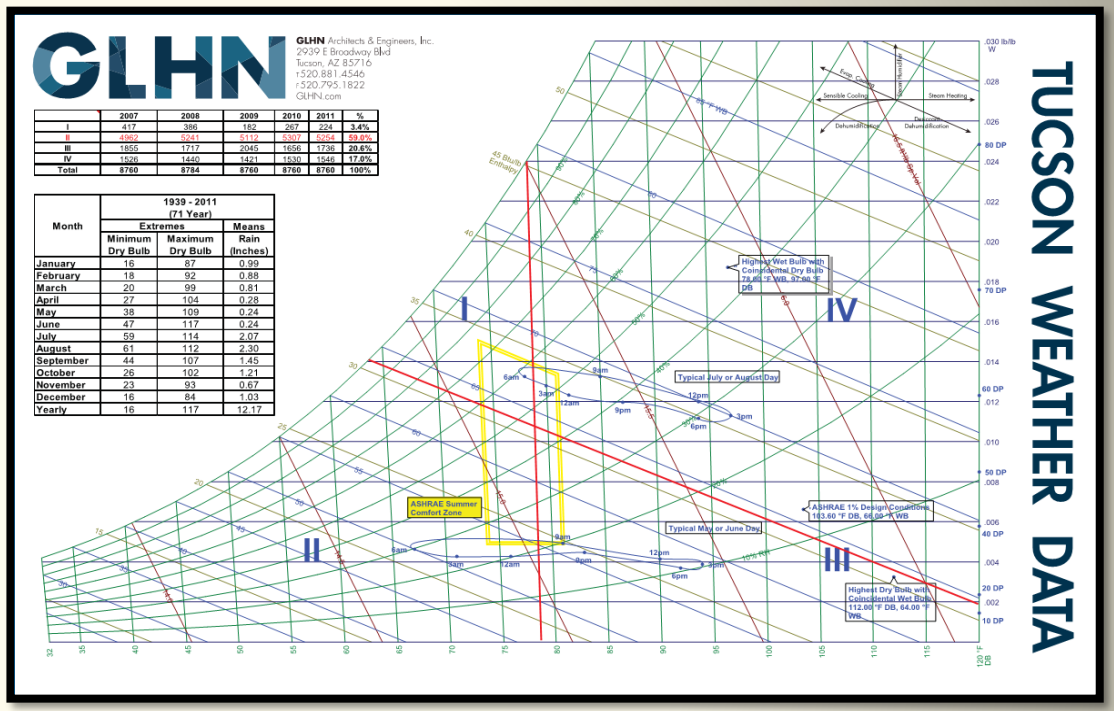
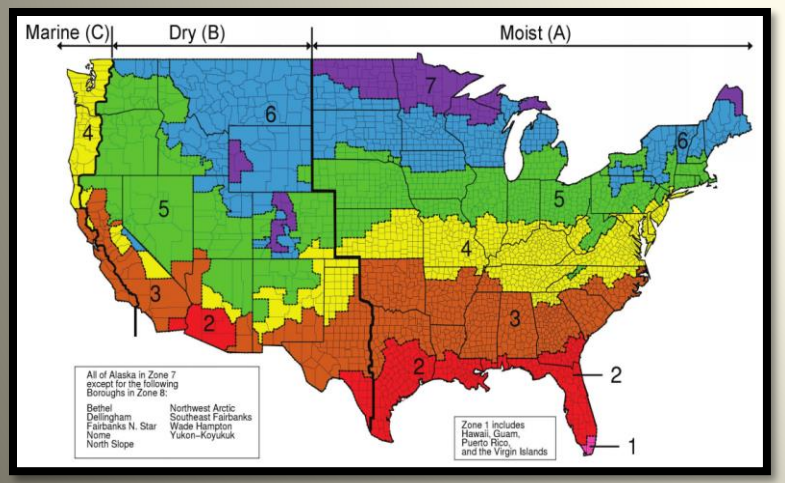
Tucson Design Conditions

- 2,500' Elevation
- Summer 1%:
  - 104F DB, 66F WB
  - 3,310 CDD (65F)
- Winter 1%
  - 32F
  - 1,400 HDD (65F)
- Climate Zone 2B



	2007	2008	2009	2010	2011	%
I	417	386	182	267	224	3.4%
II	4962	5241	5112	5307	5254	59.8%
III	1855	1717	2045	1656	1736	20.6%
IV	1526	1440	1421	1530	1546	17.0%
Total	8760	8784	8760	8760	8760	100%

Month	1939 - 2011 (71 Year) Extremes		Means
	Minimum Dry Bulb	Maximum Dry Bulb	Rain (Inches)
January	16	87	0.99
February	18	92	0.88
March	20	99	0.81
April	27	104	0.28
May	38	109	0.24
June	47	117	0.24
July	59	114	2.07
August	61	112	2.30
September	44	107	1.45
October	26	102	1.21
November	23	93	0.67
December	16	84	1.03
Yearly	16	117	12.17



Month	Average Yearly Hours In Range (Dry Bulb) 2007 - 2011											
	<10's	10's	20's	30's	40's	50's	60's	70's	80's	90's	100's	110's
January	0	0	10	93	229	232	145	35	0	0	0	0
February	0	1	5	59	190	200	139	66	12	0	0	0
March	0	0	0	8	101	207	207	150	68	3	0	0
April	0	0	0	1	40	138	203	184	135	19	0	0
May	0	0	0	0	4	45	175	203	190	120	8	0
June	0	0	0	0	0	0	50	156	200	206	106	1
July	0	0	0	0	0	0	1	163	289	212	78	0
August	0	0	0	0	0	0	0	180	286	206	71	0
September	0	0	0	0	0	0	44	249	232	176	19	0
October	0	0	0	3	12	103	201	213	162	50	0	0
November	0	0	2	8	104	219	204	126	55	4	0	0
December	0	0	6	100	244	239	113	39	2	0	0	0
Yearly	0	1	22	273	924	1,382	1,483	1,764	1,631	997	283	2

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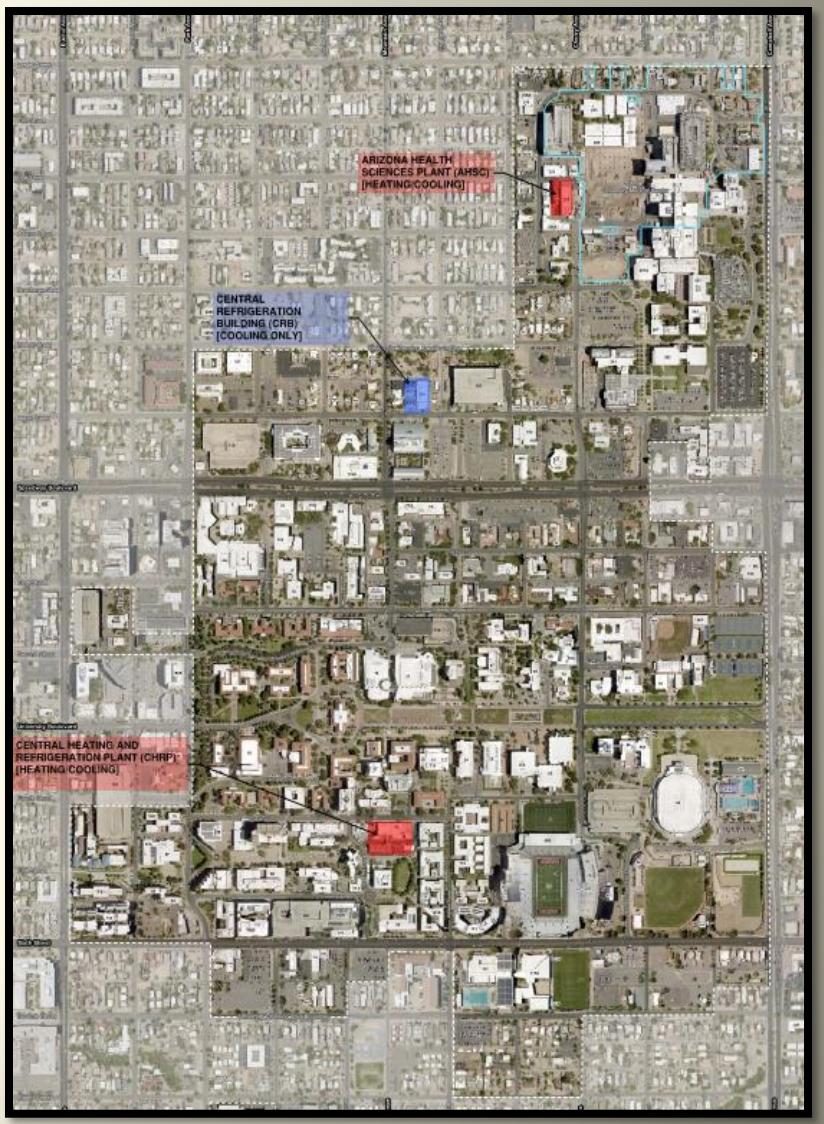
Campus **Cooling** Statistics

- (3) Central Cooling Plants
- (22) Water Cooled Centrifugal Chillers With a Combined Capacity of 33,700 tons
- 30,750 Ton-Hrs of Thermal Ice Storage
- 9,200 HP of CHW/CW Pumping Capacity



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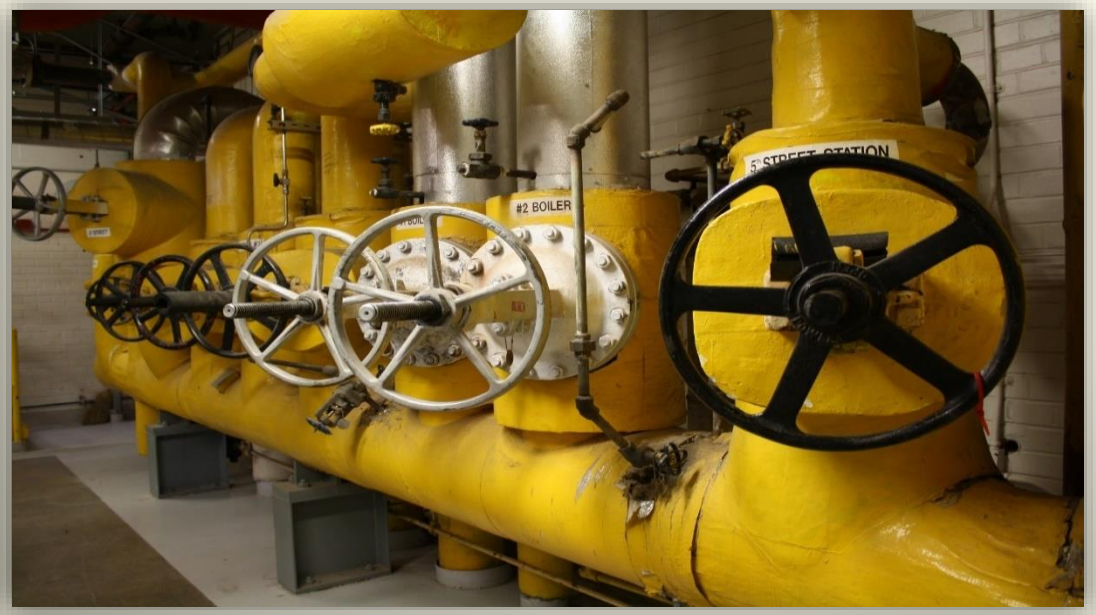
Campus **Heating** Statistics

- Interconnected Campus District Energy System
- 6.5 Miles of Underground Utility Tunnels
- (2) Central Heating Plants
- (2) Cogeneration Turbines (Total of 12MW Power Production)
- Steam Generation Capacity of 320,000 lb/hr of 100 psig Sat. Steam
- (12) Boilers Ranging in Capacity from 50,000 lb/hr to 9,300 lb/hr



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CHRP Heating Statistics

(7) Boilers

- Installed Capacity-161 KPH
- CHRP Firm Capacity-111 KPH
- Peak 2017 CHRP Load- 111 KPH
- System Efficiency-77%

CHRP Boilers

HRSG -33.1 KPH

Boiler 1 -50 KPH

Boiler 2 -50 KPH

Boiler 3 -54 KPH

Boiler 4 -9.3 KPH

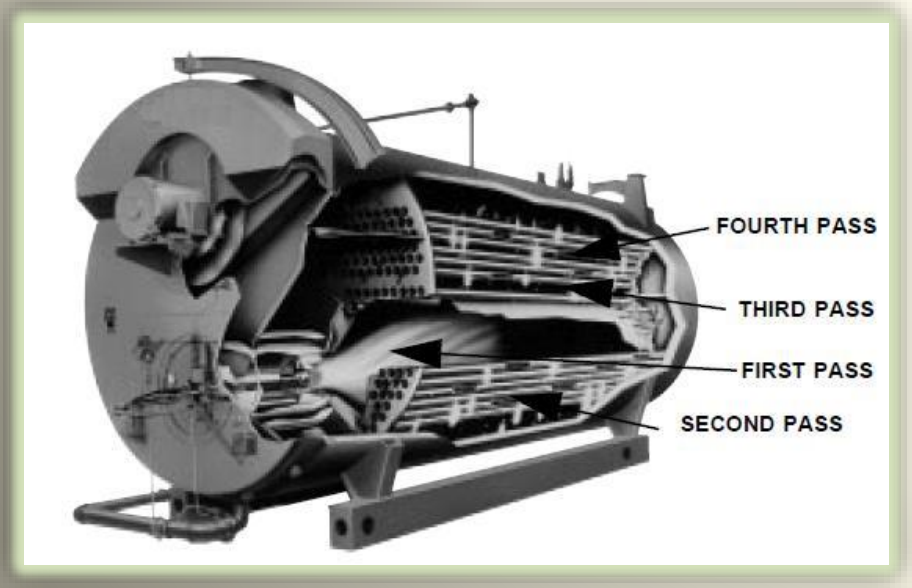
Boiler 5 -9.3 KPH

Boiler 6 -9.3 KPH

Boiler Basics-Tube Configuration

Fire Tube

- Water Circulates Around the Tubes
- Lower Capital Cost
- Higher Water Volume
- Easier to Maintain Water Level



Water Tube

- Water Circulates Within the Tubes
- Ability for Larger Capacity and Pressures
- Faster Startup

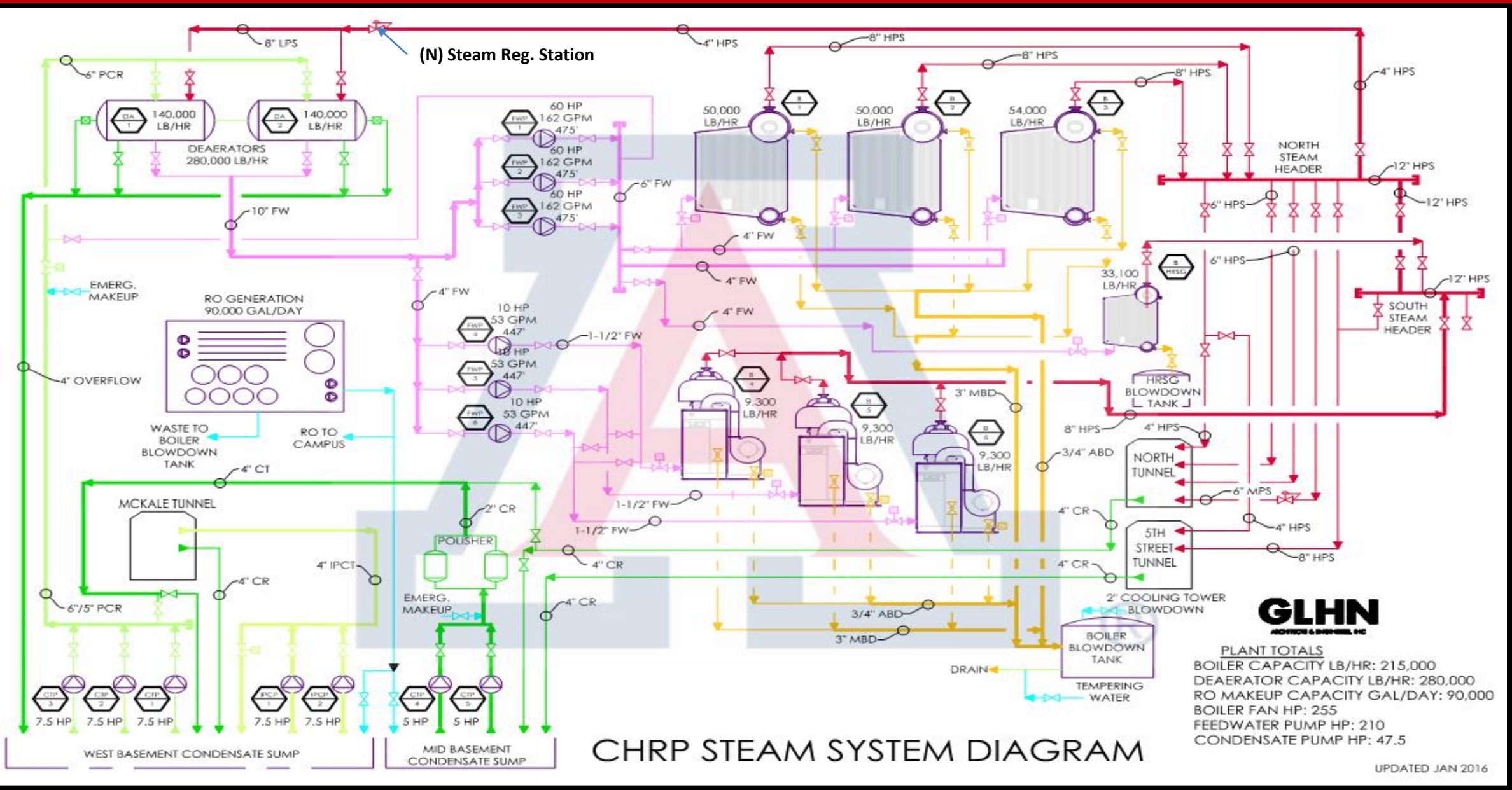
University of Arizona-CHRP

CHRP Boiler Comparison

- Boilers 1 & 2 (50KPH)
  - "D" Type, Water Tube
  - Variable Modulation
  - Combustion Eff. - 83%
  - Turndown to 30% Capacity

- Boilers 4, 5, & 6 (9.3KPH)
  - On Demand, Water Tube
  - Two Step Modulation
  - Combustion Eff. – 87%
  - Turndown to 30%

University of Arizona-CHRP Heating



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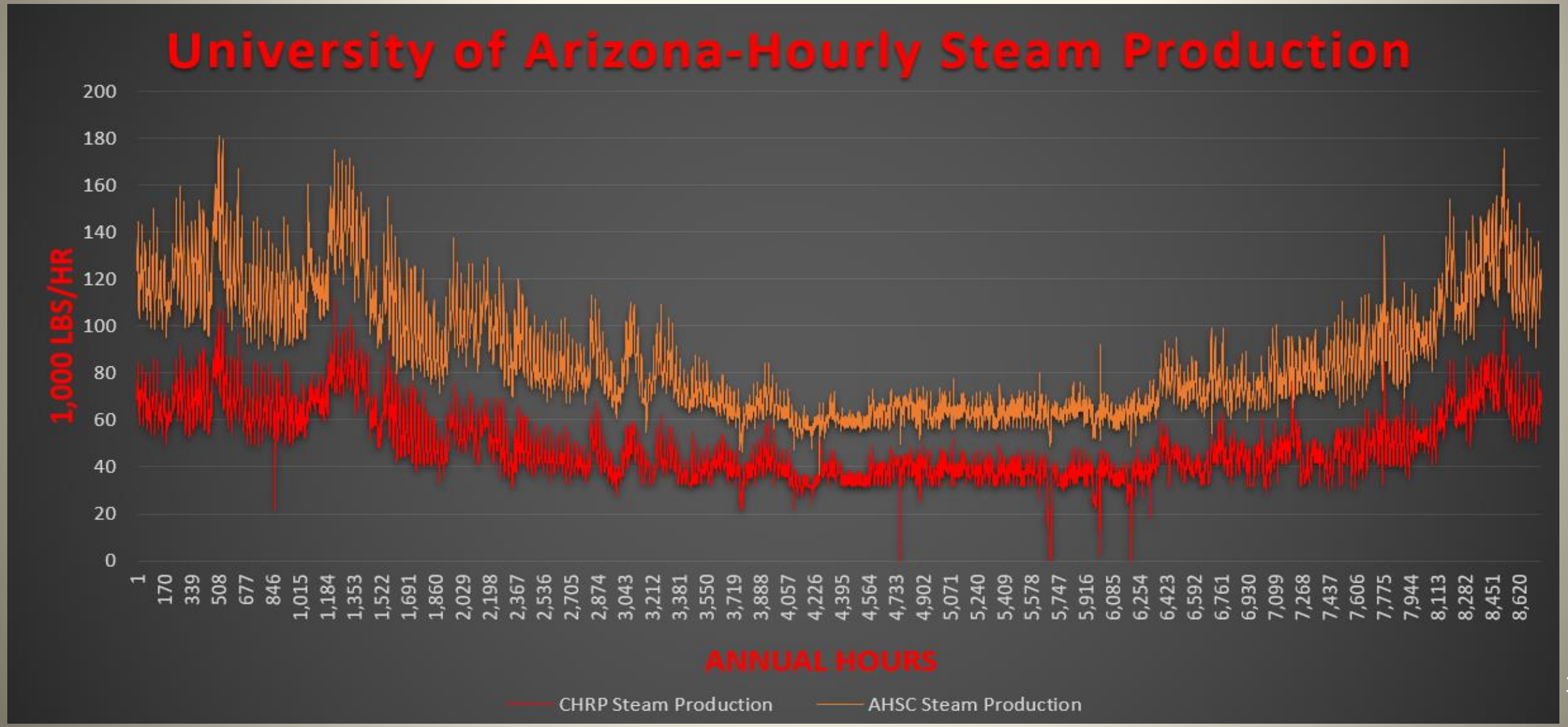
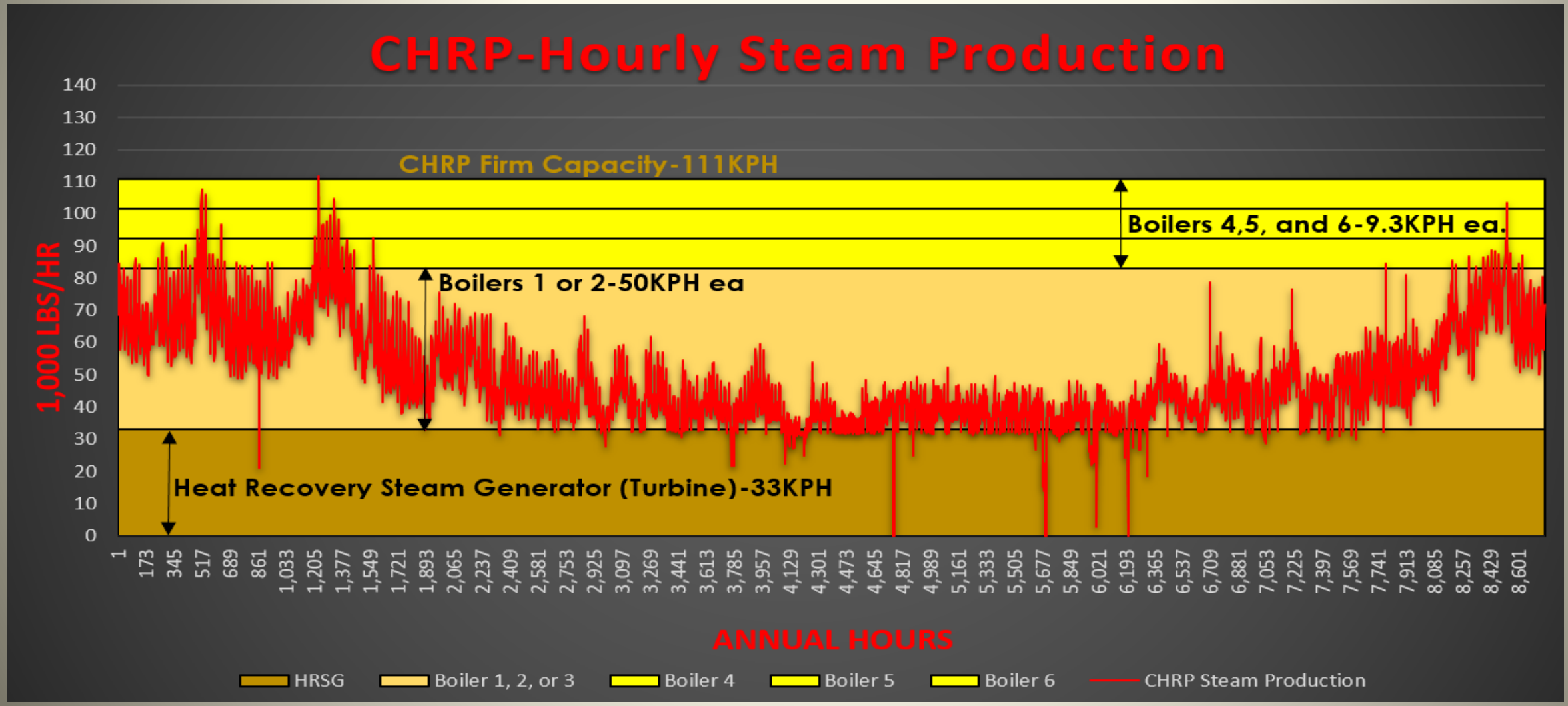
Campus Steam Load Profile



CHRP Steam Load Profile



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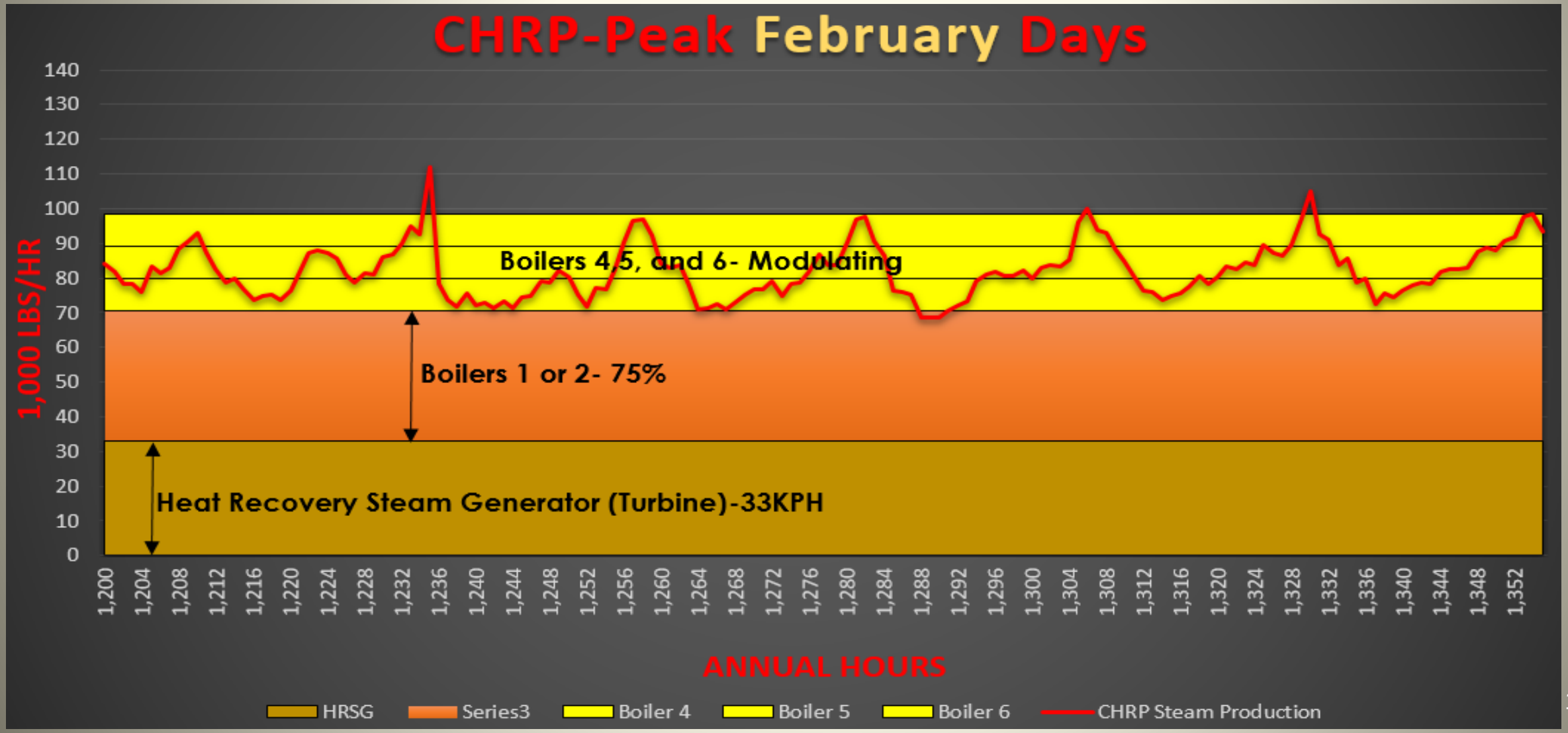
CHRP Steam Load Profile-Peak



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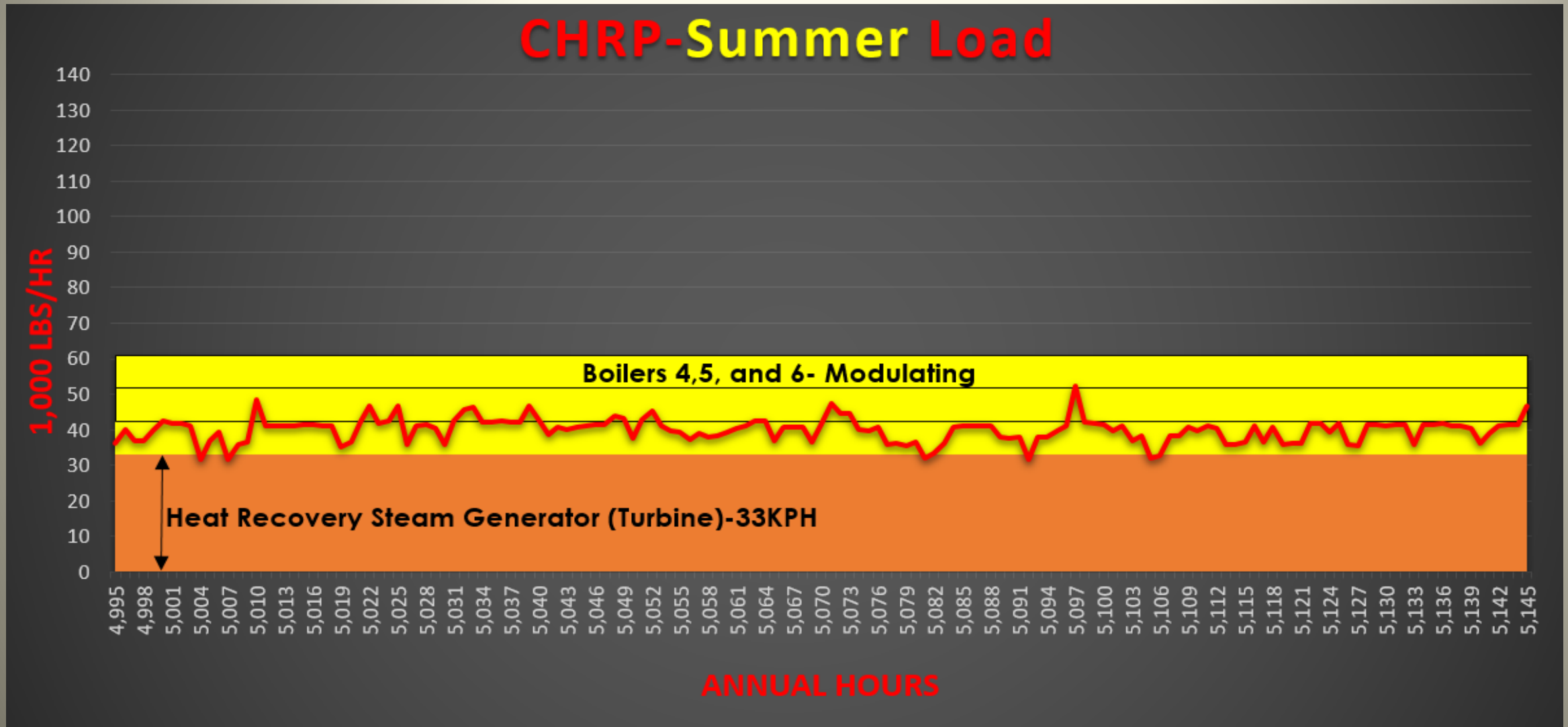
CHRP Steam Load Profile-Summer



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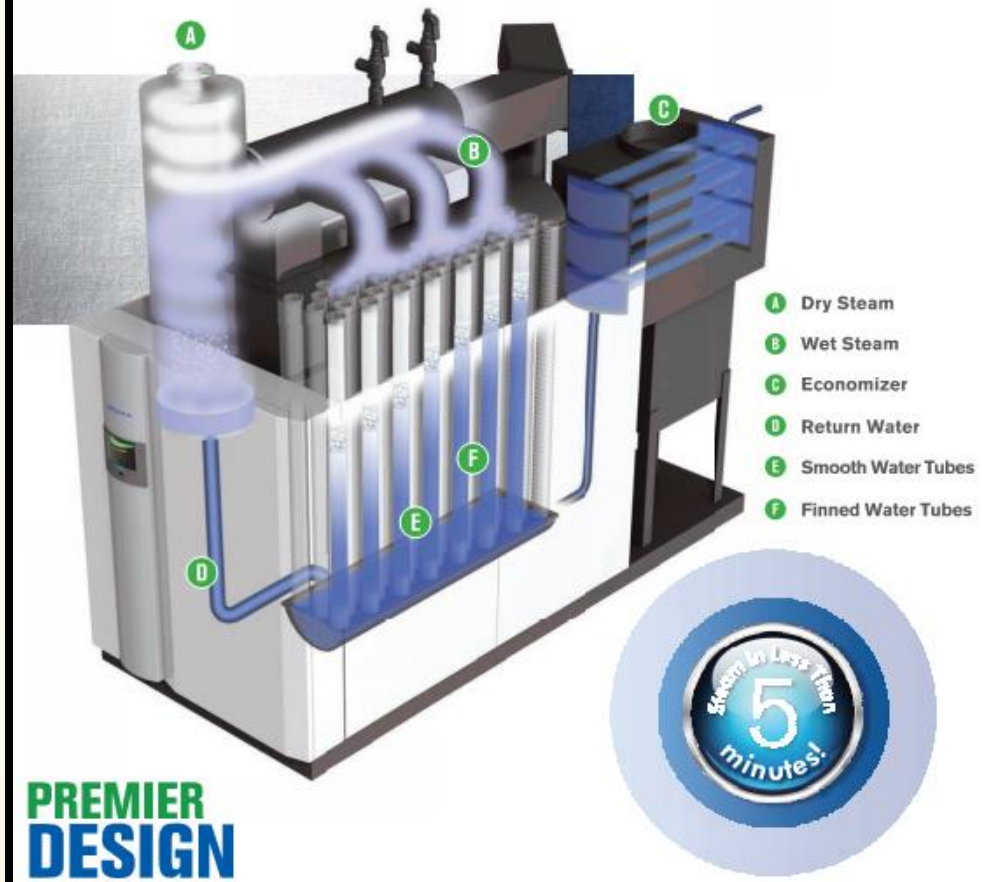
Although conventional wisdom state that a pressure vessel with the largest surface area will be the most efficient, this does not hold true for MIURA's unique boiler design. MIURA's proprietary burner is specifically designed for each pressure vessel resulting in optimal performance. Natural gas and propane burn very cleanly and as a result we can forgo conventional wisdom shying away from flame impingement. By spreading the flame **directly onto the water tubes**, this greatly reduces the flame temperature resulting in **higher efficiency** and **lower NOx** (without the need for gas re-circulation). In addition, each pressure vessel includes fin tubes that increases the surface area and turbulent flow to the maximum heat transfer. Most importantly, each tube has been designed to provide optimum protection against thermal shock.

The **low water content** in the LX boiler design also contributes to a much safer boiler design. Because the interior is multiple tubes sandwiched together instead of one large vessel, failure is substantially less catastrophic. With well over 140,000 boilers in service, there has never been a fatality associated with a MIURA boiler failure.

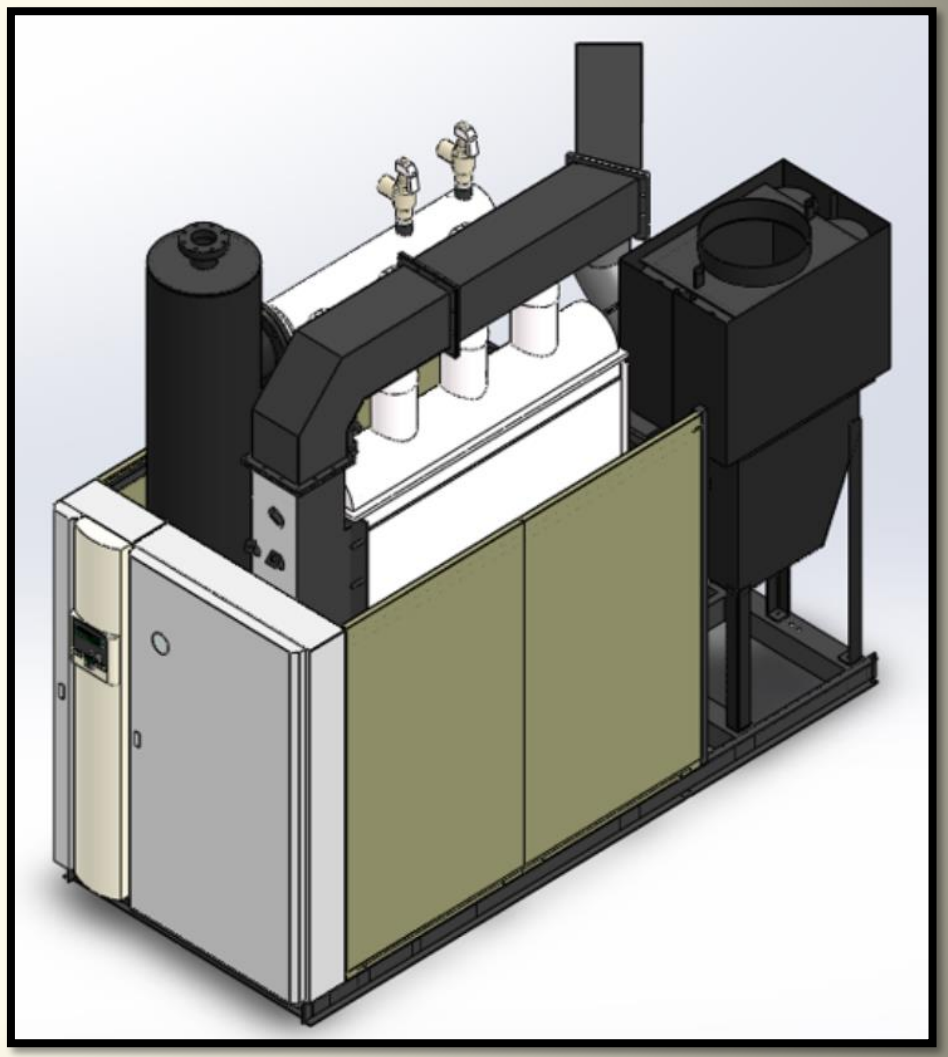


PREMIER DESIGN

Because of their low water content and exclusive "floating header" design, MIURA LX Boilers produce steam in less than 5 minutes. This quick cycle not only helps you get to work faster, but also use substantially less gas. The small footprint occupies 50% less floor space than typical firetubes, with no need for tube space. Double your capacity in the same space, or reduce space requirements by half for new construction. And best of all, MIURA's premier design results in fuel-to-steam efficiencies of up to 87%.

Pros of a Low Volume Design

- Easier to Follow Load
- Cold Standby-reduces energy losses associated with typical startup-purge, and warm-up cycle
- Modularity of Design-
  - Ease of change out
  - N+1 Redundancy is easier to achieve
- Emissions Improvements (Nox, CO2)



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Cons of a Low Volume, Modular Design

- Water quality is paramount!
- Lifespan expectations

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Operational Differences

- Higher Eff. @ Higher Fire (>30%)
- Demand Based Capacity Availability
- Reaction Time Comparison
- Maintenance
- Automation
- Reliability
- Time of Day Operation
- Safety In Regard to Water Volume

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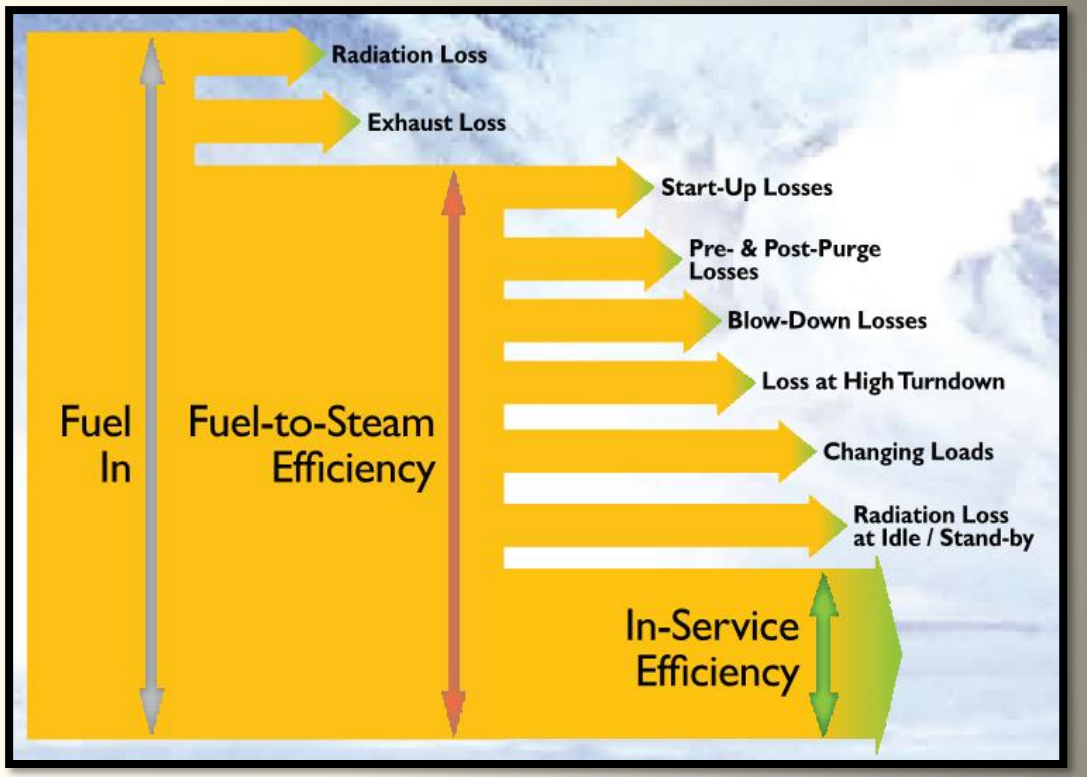
Operational Cost Comparison- Boilers 1-3 vs Boilers 4-6

- Reduction in Boiler Radiation Losses
  - ❑ 0.69% vs 0.45%
- Increase in Combustion Efficiency
  - ❑ 83% vs 87%
- Reduction in Standby Losses
  - ❑ 345 lb/hr → 3,022,545 lb/yr



Assumption-NG Cost $6/MMbtu

CHRP Large Boiler Operation Only-$1,057K per year in NG Costs
Combination Operation-$993K per year in NG Costs

Annual Savings of $64,600

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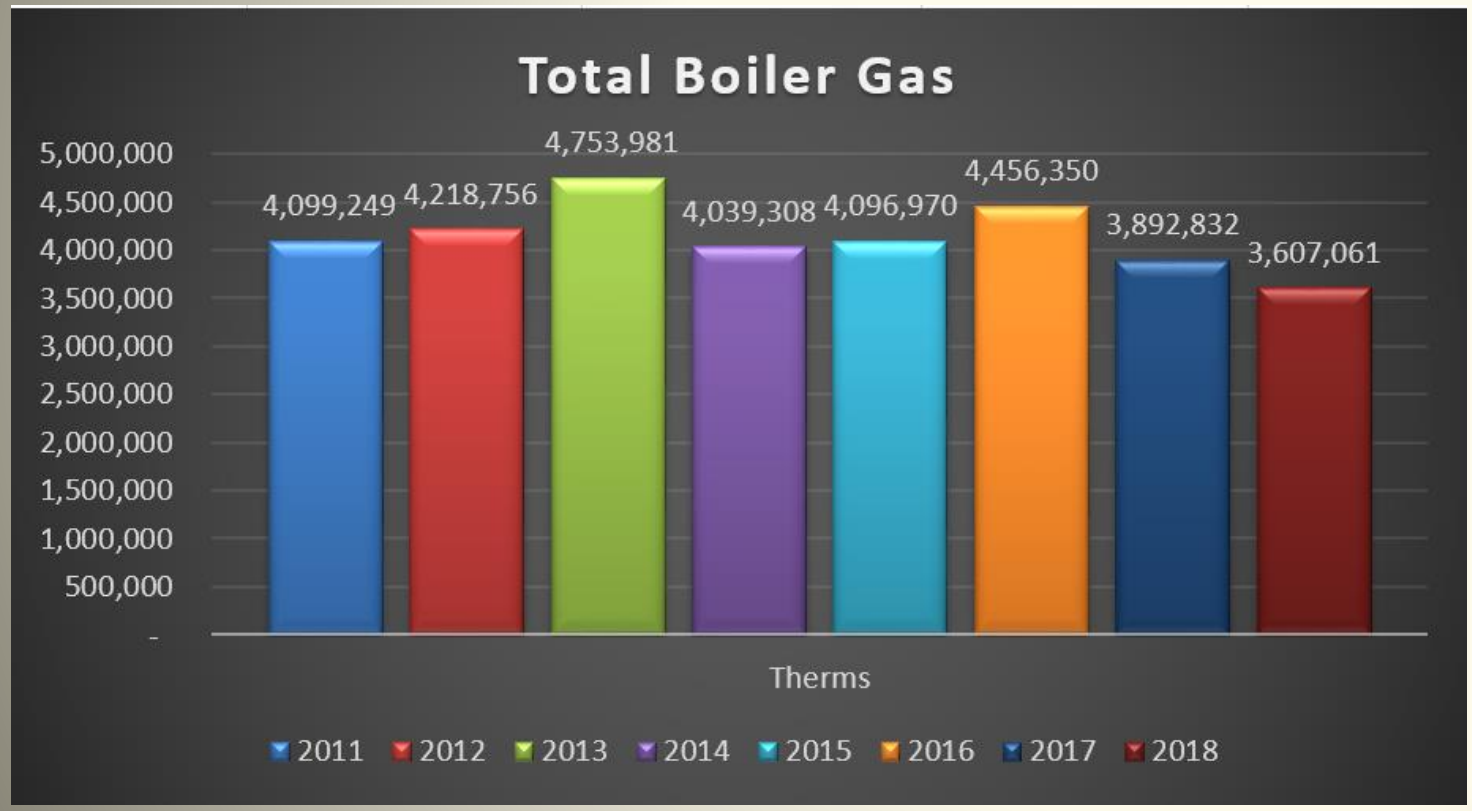
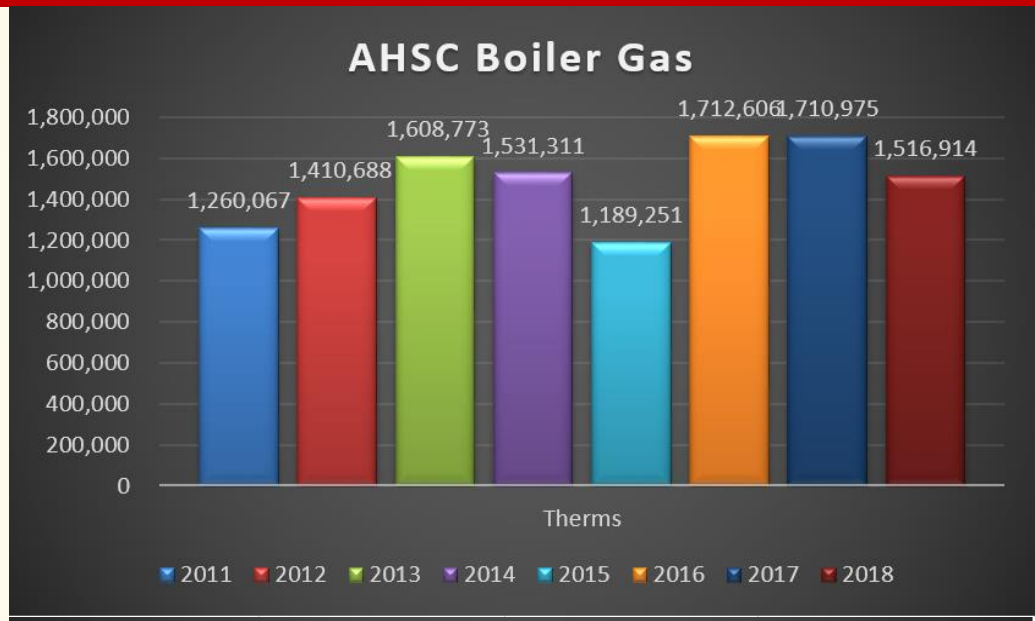
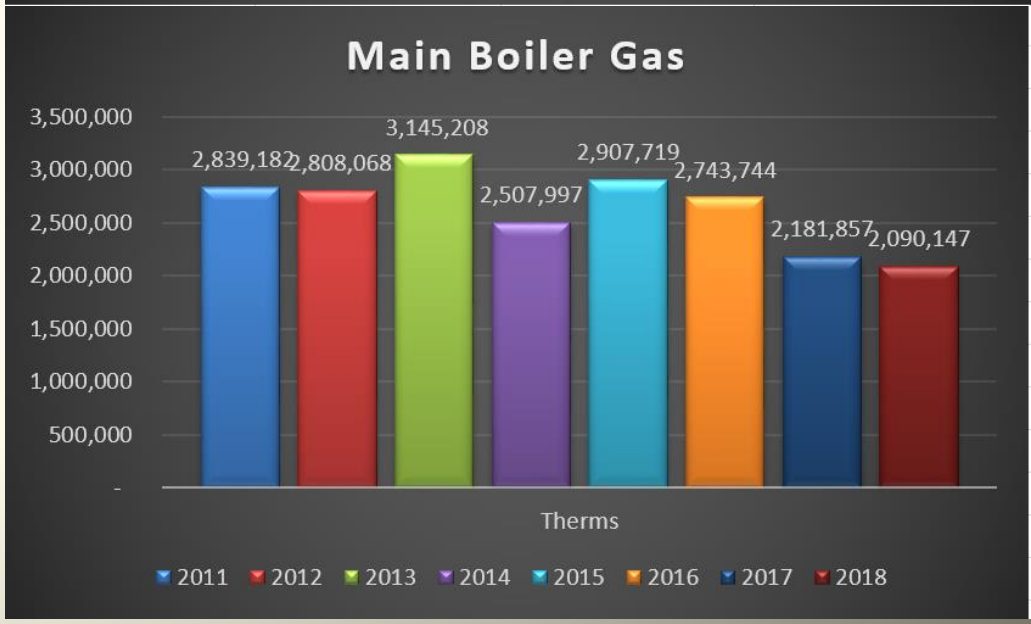
UA Natural Gas Trends-2011-2018







Questions?

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