ASHRAE Iowa Chapter

History Project 2015-16

IOWA STATE UNIVERSITY POWER PLANT

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INTRODUCTION

The Iowa State University Power & Central Mechanical Plant has existed in some form since 1884. The power plant was utilized as a central heating plant as early as 1891, when they began using coal-fired boilers and steam engines for cogeneration. 2016 marks the 125th year of power and heating cogeneration. See **Appendix A** for a diagram of the cogeneration. Here is a steam engine from 1914:

Image 1- http://www.fpm.iastate.edu/utilities/history.asp

They began using central chilled water in the 1960's for campus cooling. The focus of this history report will be on the heating and cooling systems. In addition to these, the plant contains power generation, water treatment, compressed air, and accompanying distribution systems.

Power was first needed on campus in 1880 when Thomas Edison provided electric lamps for demonstration in the Physics Lab. The first plant was and Edison Isolated Electric Plant built in 1884, which powered the electric lights in the Old Main building. These replaced a gas lighting system. The current plant located on Beach Ave was built in 1906. The site was selected due to:

1. Railway sidings were available on site
2. It was at a lower elevation than central campus, which allowed for gravity condensate return lines
3. It was removed from the major college buildings, thus removing the dust, smoke, and noise from campus.

Power plant management was required to live in houses next to the plant- a practice that continued into the 1960's. Here is the plant with the houses in 1930:

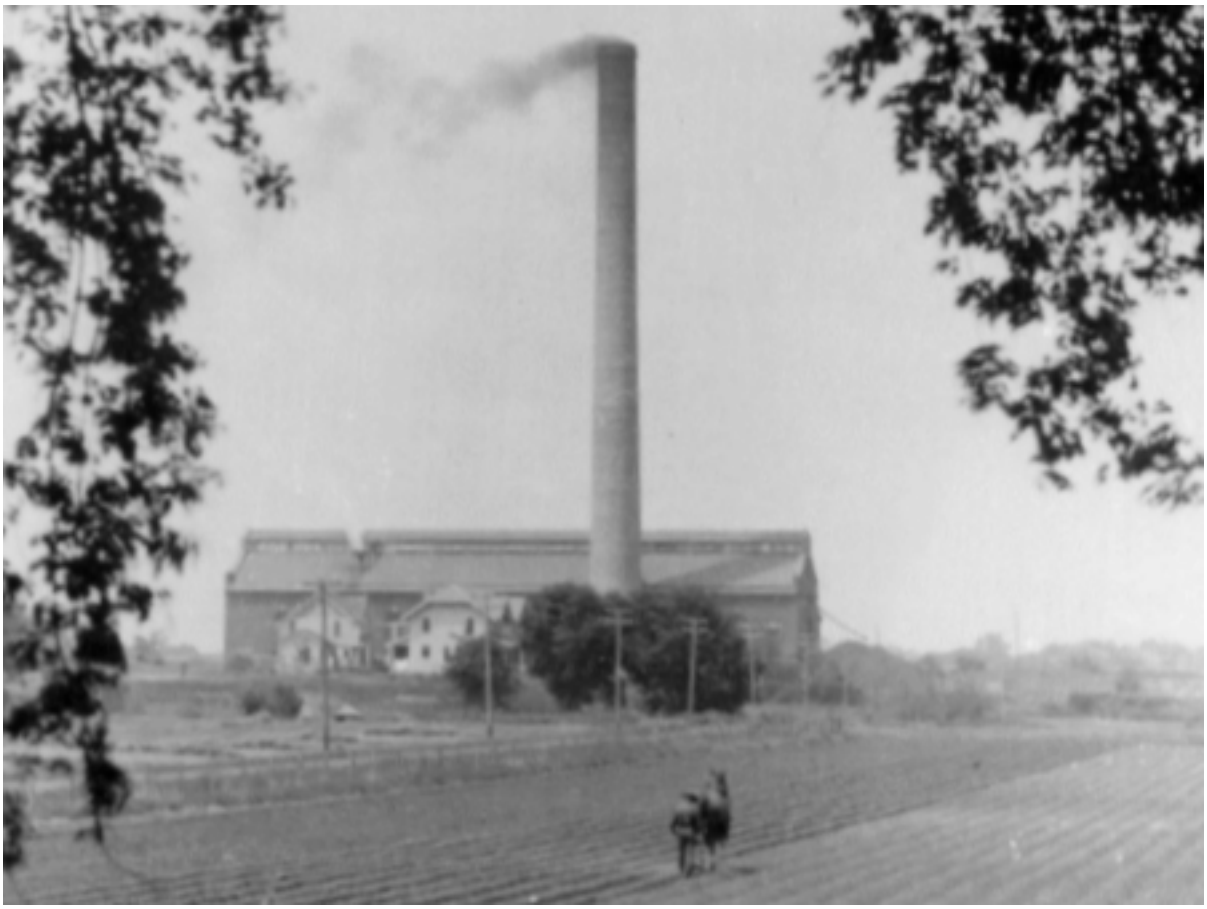

Image 1- http://www.fpm.iastate.edu/utilities/history.asp

HEATING

In 1891, the plant used a Corliss steam engine to generate electricity, and used the exhaust steam to heat Engineering Hall- now called Marston Hall. This was their first use of coal-fired cogeneration, which they still use to this day. The only difference is they use "extraction" turbine generators, rather than a steam engine. The boiler-generated steam at 400 psi is used to power a steam engine or turbine to generate electricity. The steam leaves the turbines at 90 psi and is distributed for campus building heating. The first circular-top, brick steam distribution tunnel was constructed in 1903. It is 460 feet long and ran between the old plant location and Engineering Hall. It is still in use today. In 1912 a new "main" steam tunnel was dug from the current plant location. It is 2,060 feet of poured concrete. It originally contained 10" low pressure 6psi steam lines, 6" condensate return lines, and high voltage electrical lines. In 1911 compressed air lines were installed and in 1913 90 psi steam lines were added.

In 1912, the central heating plant boiler room housed two Aultman-Taylor boilers with Roney underfed stokers. These were relocated from the previous College Power Station. To meet demand and consolidate equipment, four additional 160 psi Babcock & Wilcox boilers were added by 1914. The Aultman-Taylor boilers were demolished in 1921 and replaced with 2 more Babcock & Wilcox 160 psi

boilers. A new Murray 250 psi boiler was installed in 1938. The stoker never worked properly and it was converted to gas/oil firing in the 1950's. It was demolished in the late 1960's. The boilers were continuously updated for the next several years- with pauses for the great depression and World War II. The 2 oldest boilers currently in the plant were installed in 1959 & 1967. They were only very recently shut down and decommissioned.

In 1988, (2) Pyropower circulating, fluidized-bed boilers were installed. These were two of the first fluidized bed boilers installed in the United States. These 100-plus foot tall boilers burn the coal in a turbulent air atmosphere in a combustion chamber being fed air and limestone. It causes complete combustion of the coal and the limestone reacts with the sulfur to form calcium sulfate. The product is then removed as a dry ash. Here is a cross-section diagram of these boilers:

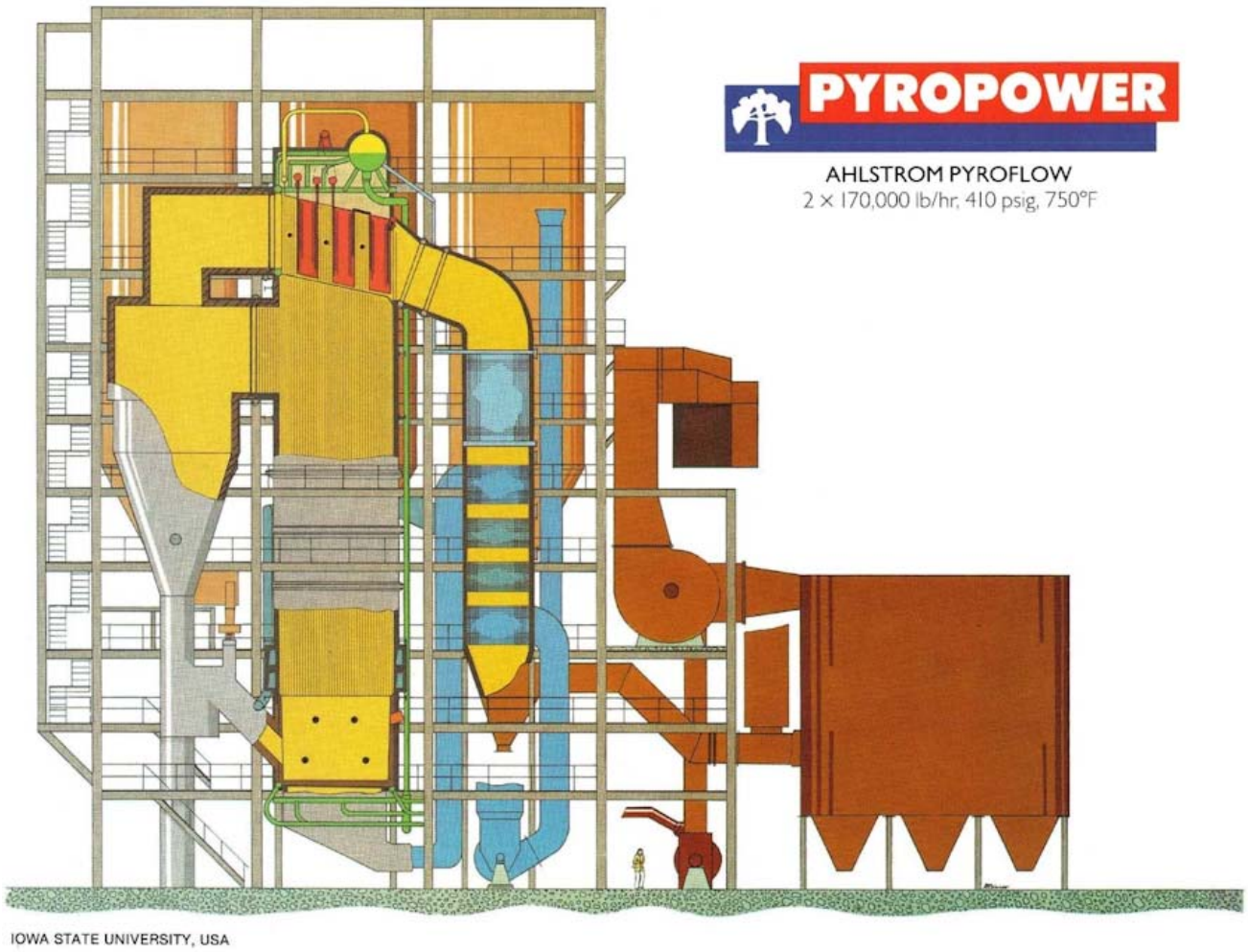

Image 2- http://www.fpm.iastate.edu/utilities/images/boiler.png

Here are the control panels for the fluidized-bed boilers:

Image 3- Photo from 2/17/16

In 2012, a $42 million project was approved to convert 2 of the old coal boilers to natural gas and to install 3 new Cleaver Brooks natural gas-fired boilers. The new boilers are rated at 150,000 lbs/hr and 400 psig stem @750 degrees F. They have also run backup on fuel oil. This project helped to meet the new EPA emissions regulations published in January of 2013. The new boilers were started a few months before the compliance deadline of January 31st, 2016.

Image 4- Photo from 2/17/16

COOLING

The Iowa State campus first started adding air-conditioning in the 1960's on a building-by-building basis. During the planning stages of the Iowa State Center and Maple-Willow-Larch dormitory complex, the university decided to provide cooling from a central plant. The first 5,000 ton chiller was installed in 1968. It is an industrial, field-erected, steam driven unit. Over 5 miles of large chilled water lines were added throughout the campus. The lines are direct-buried, ductile iron pipes up to 30" diameter. Additional steam-driven chillers were added in the 70's & 80's. Here is one of the 5,000 ton, steam-driven chillers with the condenser tube bundle opened up for cleaning:

The plant currently houses 4 chillers in the main plant. 3 of the 4 chillers are steam turbine-driven and one is powered by an electric motor. There is another 4,000 ton, steam-driven chiller at the separate North Chilled Water Plant. 2 of the chillers use 400 psi steam, and the other 2 use 90 psi steam. The North Chilled Water Plant was installed in 2004 and is interconnected to the 4 main plant chillers. In total, they have 17,000 tons of cooling capacity in the main plant, + 4,000 tons in the North plant. The chilled water system supplies 40 degree F water, and returns 55 degree F water.

CURRENT-DAY USAGE

Here are some of the figures of what the plant inputs and outputs for the fiscal year 2015:

1. Coal burned at power plant = 100,283 tons
2. Nat Gas Burned at Power Plant = 640,036,000 cubic feet
3. 46MW of electric capacity
4. Peak electrical demand = 28MW
5. 7% of the campus electricity comes from 4 wind turbines at the Story County Wind Energy Center near Zearing, IA.

***See Appendix B for more info on the inputs & outputs for 2015**

THANK YOU:
Thank you to Jeff Witt, P.E., Director of Utilities Services for Iowa State University for great assistance on this history project. Also, a big thanks to Scott Jasper, P.E., Mechanical Engineer w/Design Services at ISU for his contributions. It would not have been possible without their generous time and efforts.

Appendix A

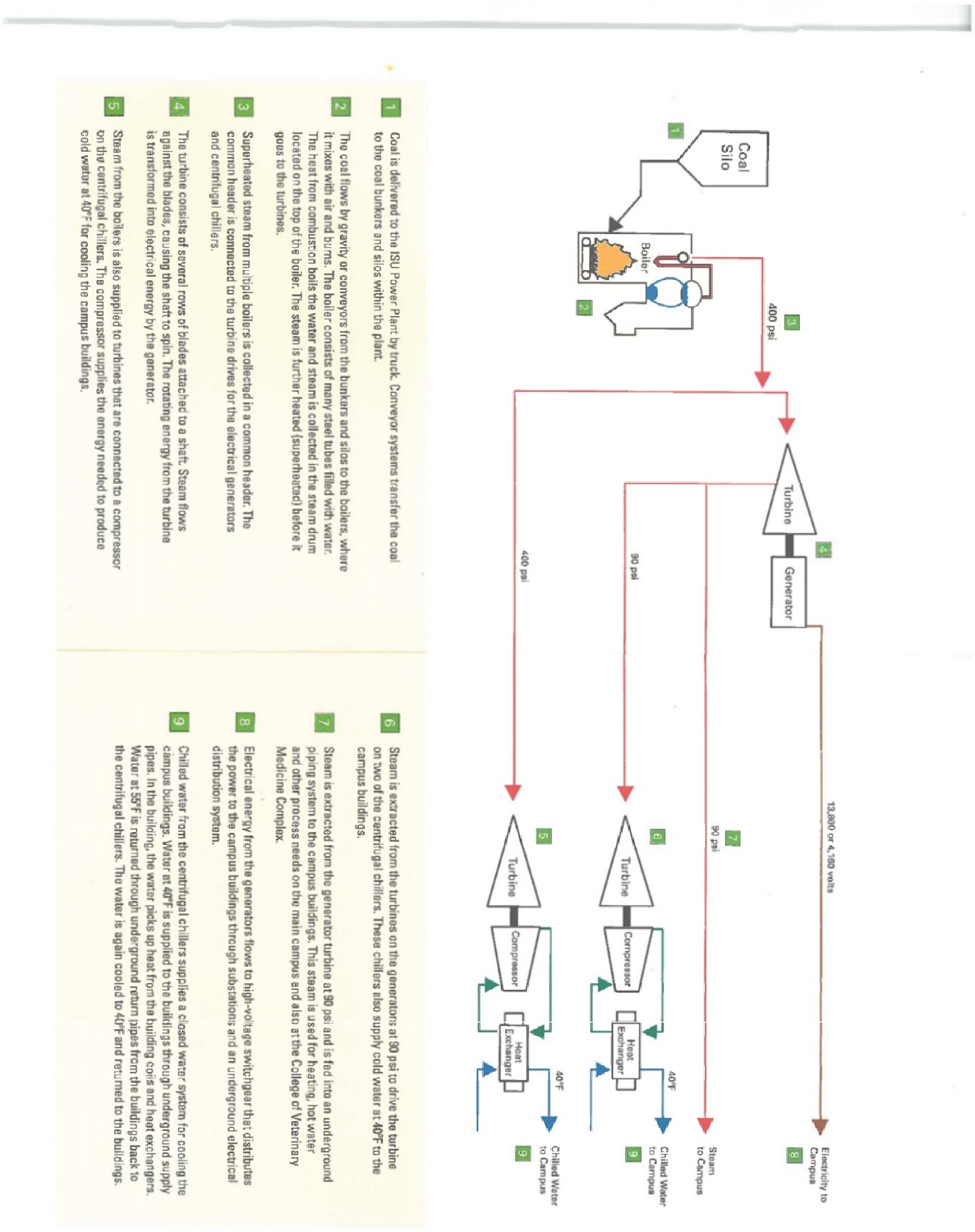

Image 5- Iowa State University FP&M

Appendix B

Iowa State University
Utility Enterprise
Fiscal Year 2015 Factsheet

Overall Budget	$40,272,665
Enterprise Replacement Value	$458,139,000
Number of Employees	75
Coal Burned at Power Plant (tons)	100,283
Natural Gas Burned at Power Plant (cubic feet)	640,036,000
Limestone Used at Power Plant (tons)	17,536
Ash Generated at Power Plant (tons)	26,280
Steam Generated (pounds)	2,128,520,000
Peak Steam Production (lbs per hour)	351,000
Steam to Main Campus (pounds)	890,457,000
Peak Steam to Campus (lbs per hour)	282,000
Chilled Water Production – Main Campus (ton-hours)	35,853,000
Peak Chilled Water Production (tons)	14,919
Electricity Consumed on Main Campus (kilowatt-hours)	176,240,000
Electricity Generated (kilowatt-hours)	115,003,000
Grid Electricty Purchased (kilowatt-hours)	48,877,000
Wind Electricty Purchased (kilowatt-hours)	12,283,000
Campus Wind Turbine Production (kilowatt-hours)	77,000
Peak Electrical Demand (kilowatts)	28,300
Natural Gas Used on Campus (cubic feet)	27,002,200
Potable Water Consumed (gallons)	304,036,000
Sewage Produced (gallons)	340,547,000

Image 6- Iowa State University FP&M