DUQUESNE UNIVERSITY

Overview of Cogeneration Facility

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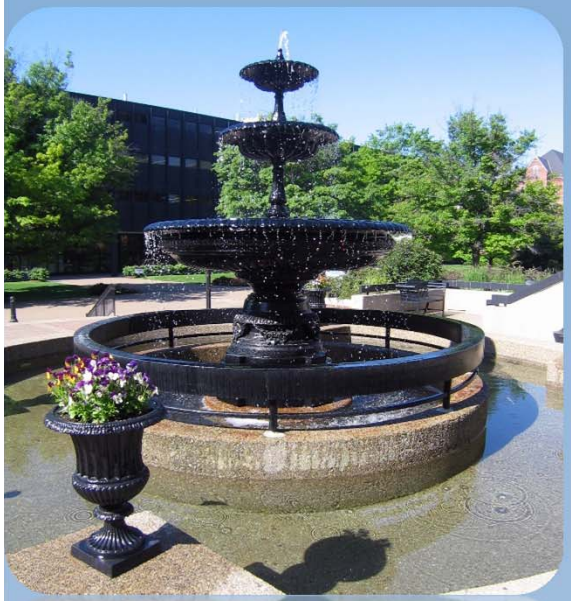
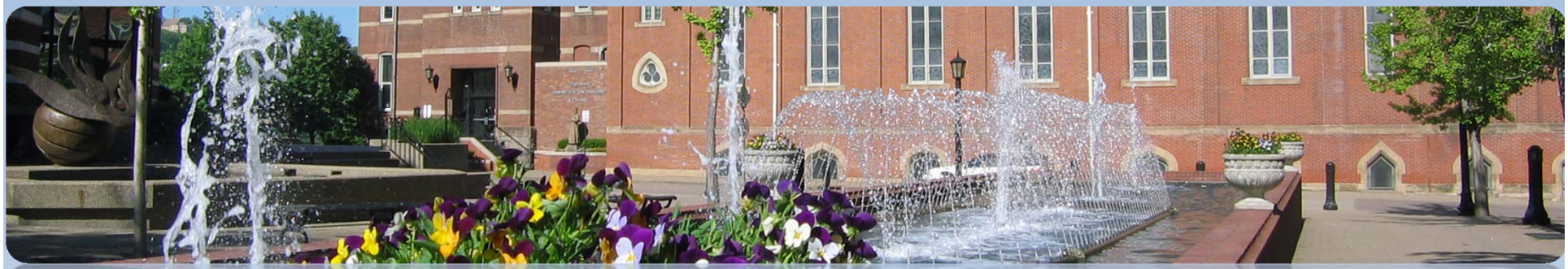
PUC Presentation



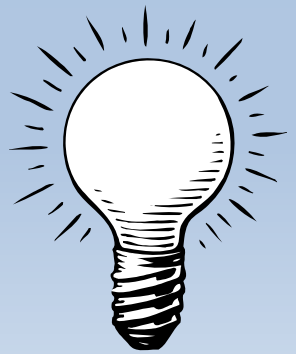
DUQUESNE UNIVERSITY

- Founded in 1878
- 50 acre campus
- Approx. 4 million total building square footage



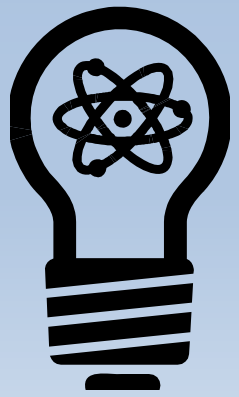
Energy Center History

- Duquesne signed an agreement with NORESCO, after facing several challenges:
  - Aging equipment
  - Environmental issues
  - Energy costs
- The partnership with NORESCO addressed these by developing the Energy Center and using the most advanced technology.



Energy Center History – Cont.

- Duquesne University and NORESCO entered into a 15 year contract Feb. 1996
- Start of construction was Feb. 1997
- Facility in Operation November 1st, 1997
- Project cost was approximately $9.6 million with NORESCO financing $4.5 million over the life of the contract
- Off balance sheet financing

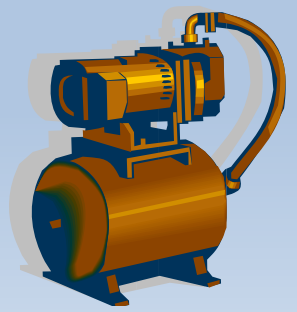


Relationship With Local Utilities

- At the time, Duquesne Light Co. had no independent customer energy generation. This concept was fairly new to them.
- Much effort went into the process from start to finish.
- The University had to adhere to interconnection regulations.
- Led to creation of Rider 16 which is back up power supply to non-utility generators.
- Relationship over time has improved and led to adjustment of Rider 16.

Energy Center Equipment

- 5MW Solar Tarus 60 natural gas fired turbine
- 25,000 lb./hr. waste heat boiler (125 psi)
- Natural gas compressor 15 to 235 psi
- Condensate receiver and boiler feed water system for new and existing boilers
- Utility electric interconnect breaker/relay system
- Existing electric system upgrade
- Electronic control package for co-gen and existing boilers



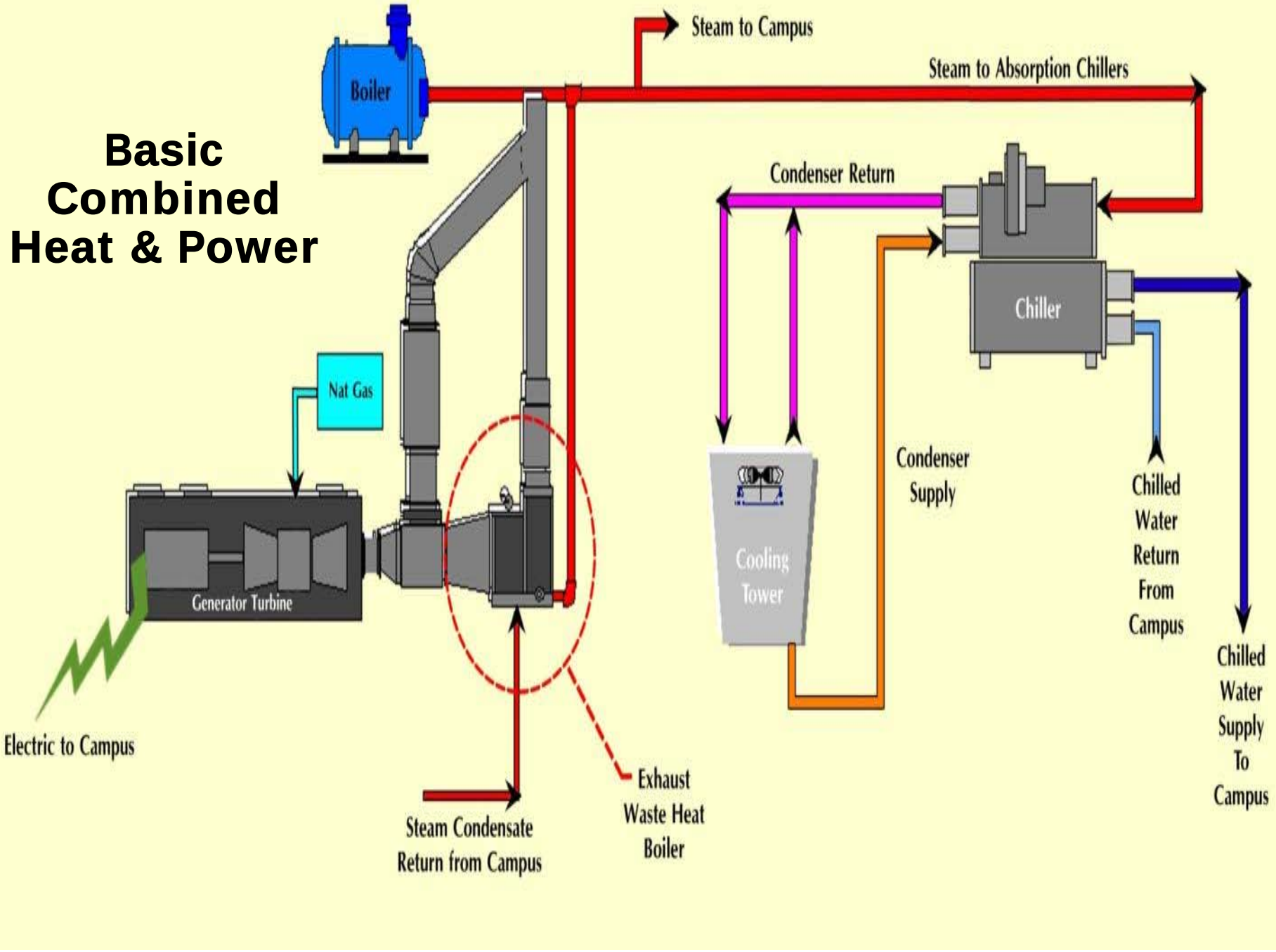
Energy Center Equipment – cont.

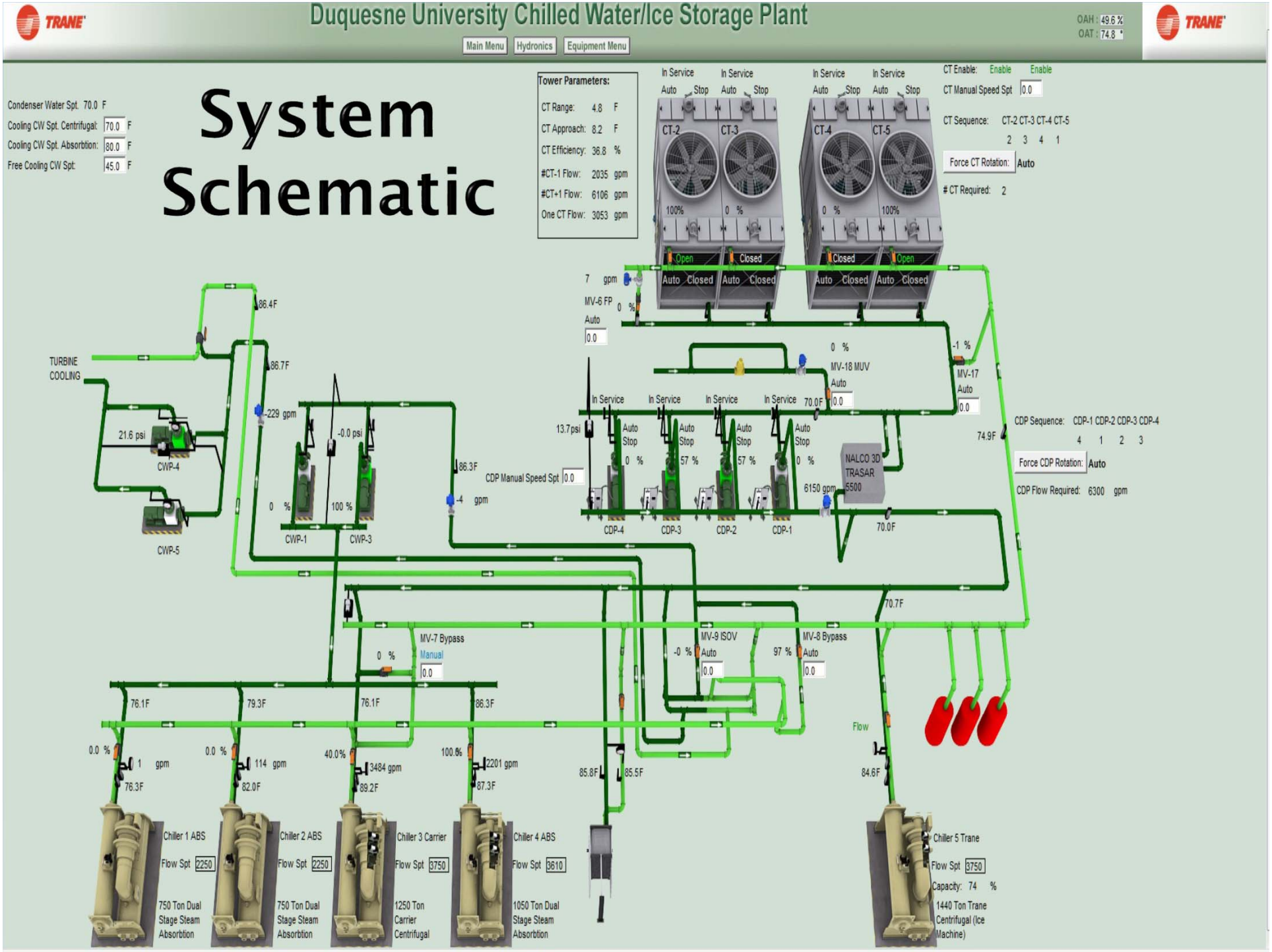
- Two (2) 750 ton 2 stage absorption chiller
- One (1) 1000 ton 2 stage absorption chiller
- Approx. 4,000 feet of 18 inch to 6 inch chilled water campus supply and return distribution piping and controls
- Two (2) 150 HP chilled water pumps
- Two (2) 250 HP condenser water pumps
- Four (4) cooling tower cells to handle 2,500 tons
- Internal plant chilled water and condenser water piping and controls
- Complete electric and control system

Design Scheme

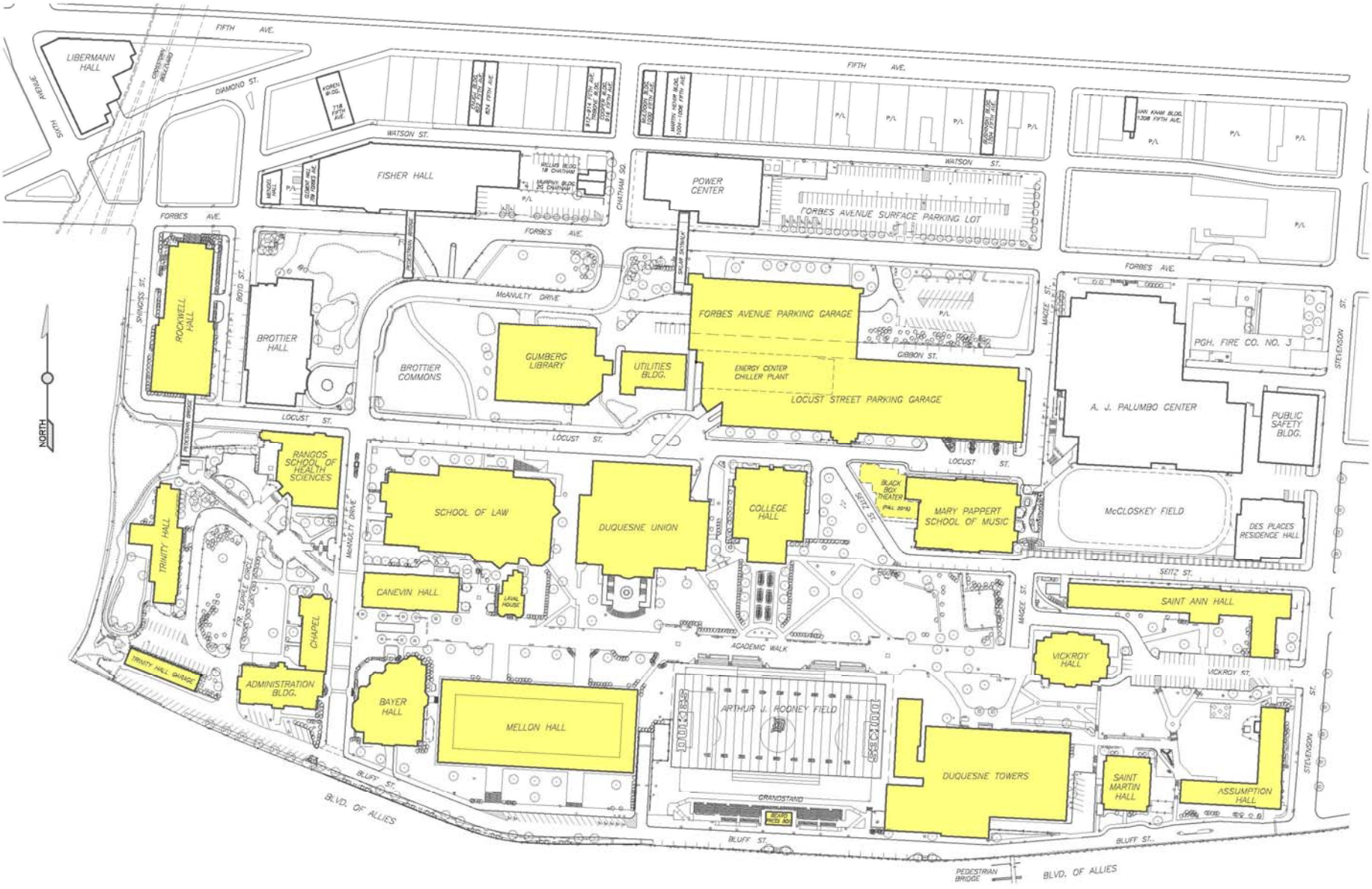
- Generator to run in parallel with Duquesne Light.
- Not intended to furnish all electric.
- Design to utilize all waste heat all the time.
- Waste heat to drive absorption chillers in summer and heat campus in winter.
- Can run isolated if load is reduced.
- Automatic load shedding.

Basic Combined Heat & Power

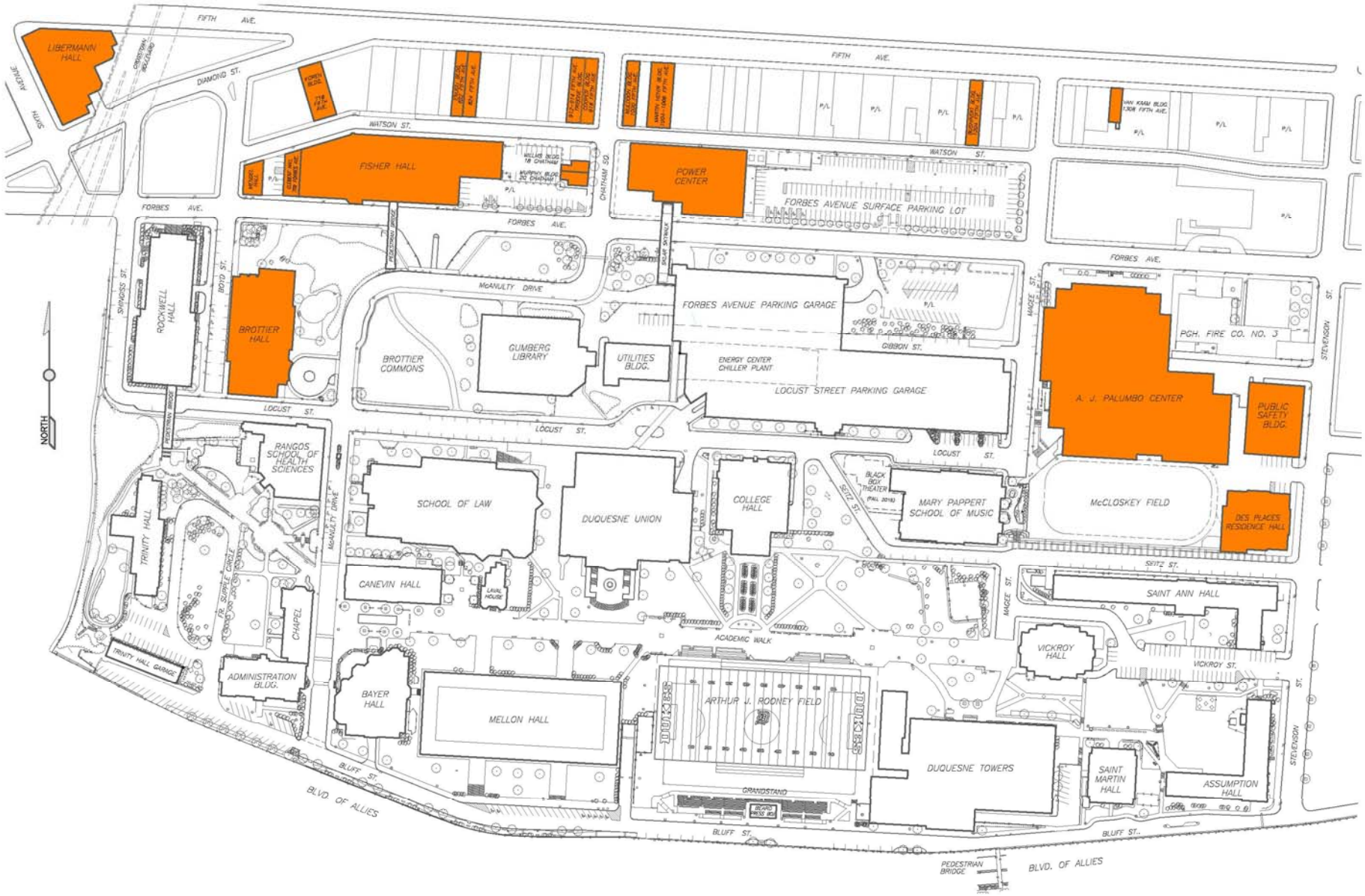



Duquesne University Chilled Water/Ice Storage Plant
Main Menu
Hydronics
Equipment Menu
OAH : 49.6 %
OAT : 74.8 °
System Schematic
Condenser Water Spt. 70.0 F
Cooling CW Spt. Centrifugal: 70.0 F
Cooling CW Spt. Absorbtion: 80.0 F
Free Cooling CW Spt: 45.0 F
Tower Parameters:
CT Range: 4.8 F
CT Approach: 8.2 F
CT Efficiency: 36.8 %
#CT-1 Flow: 2035 gpm
#CT+1 Flow: 6106 gpm
One CT Flow: 3053 gpm
CT Enable: Enable Enable
CT Manual Speed Spt 0.0
CT Sequence: CT-2 CT-3 CT-4 CT-5
2 3 4 1
Force CT Rotation: Auto
CT Required: 2
In Service Auto Stop
CT-2
CT-3
CT-4
CT-5
100%
0 %
Open
Closed
Auto Closed
7 gpm
MV-6 FP
0 %
Auto
0.0
0 %
MV-18 MUV
Auto
0.0
-1 %
MV-17
Auto
0.0
TURBINE COOLING
86.4F
86.7F
-229 gpm
21.6 psi
CWP-4
CWP-5
-0.0 psi
0 %
100 %
CWP-1
CWP-3
86.3F
-4 gpm
CDP Manual Speed Spt 0.0
13.7psi
In Service
Auto Stop
0 %
57 %
70.0F
6150 gpm
NALCO 3D TRASAR 5500
CDP-4
CDP-3
CDP-2
CDP-1
70.0F
74.9F
CDP Sequence: CDP-1 CDP-2 CDP-3 CDP-4
4 1 2 3
Force CDP Rotation: Auto
CDP Flow Required: 6300 gpm
70.7F
MV-7 Bypass
Manual
0.0
MV-9 ISOV
Auto
0.0
MV-8 Bypass
Auto
0.0
76.1F
79.3F
76.1F
86.3F
0.0 %
1 gpm
76.3F
0.0 %
114 gpm
82.0F
40.0%
3484 gpm
89.2F
100.0%
2201 gpm
87.3F
85.8F
85.5F
Flow
84.6F
Chiller 1 ABS
Flow Spt 2250
750 Ton Dual Stage Steam Absorbtion
Chiller 2 ABS
Flow Spt 2250
750 Ton Dual Stage Steam Absorbtion
Chiller 3 Carrier
Flow Spt 3750
1250 Ton Carrier Centrifugal
Chiller 4 ABS
Flow Spt 3610
1050 Ton Dual Stage Steam Absorbtion
Chiller 5 Trane
Flow Spt 3750
Capacity: 74 %
1440 Ton Trane Centrifugal (Ice Machine)

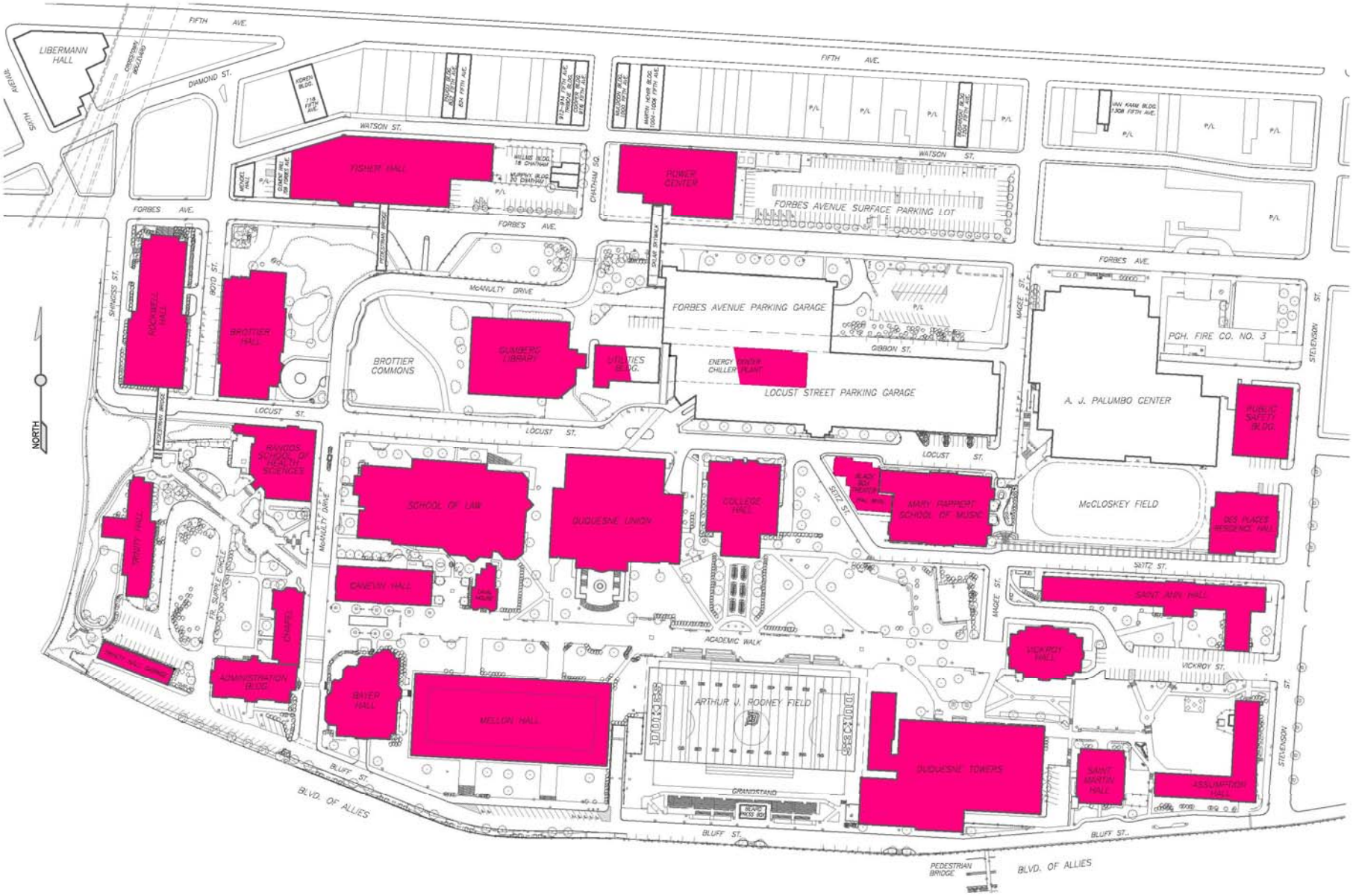
Electric Distribution System



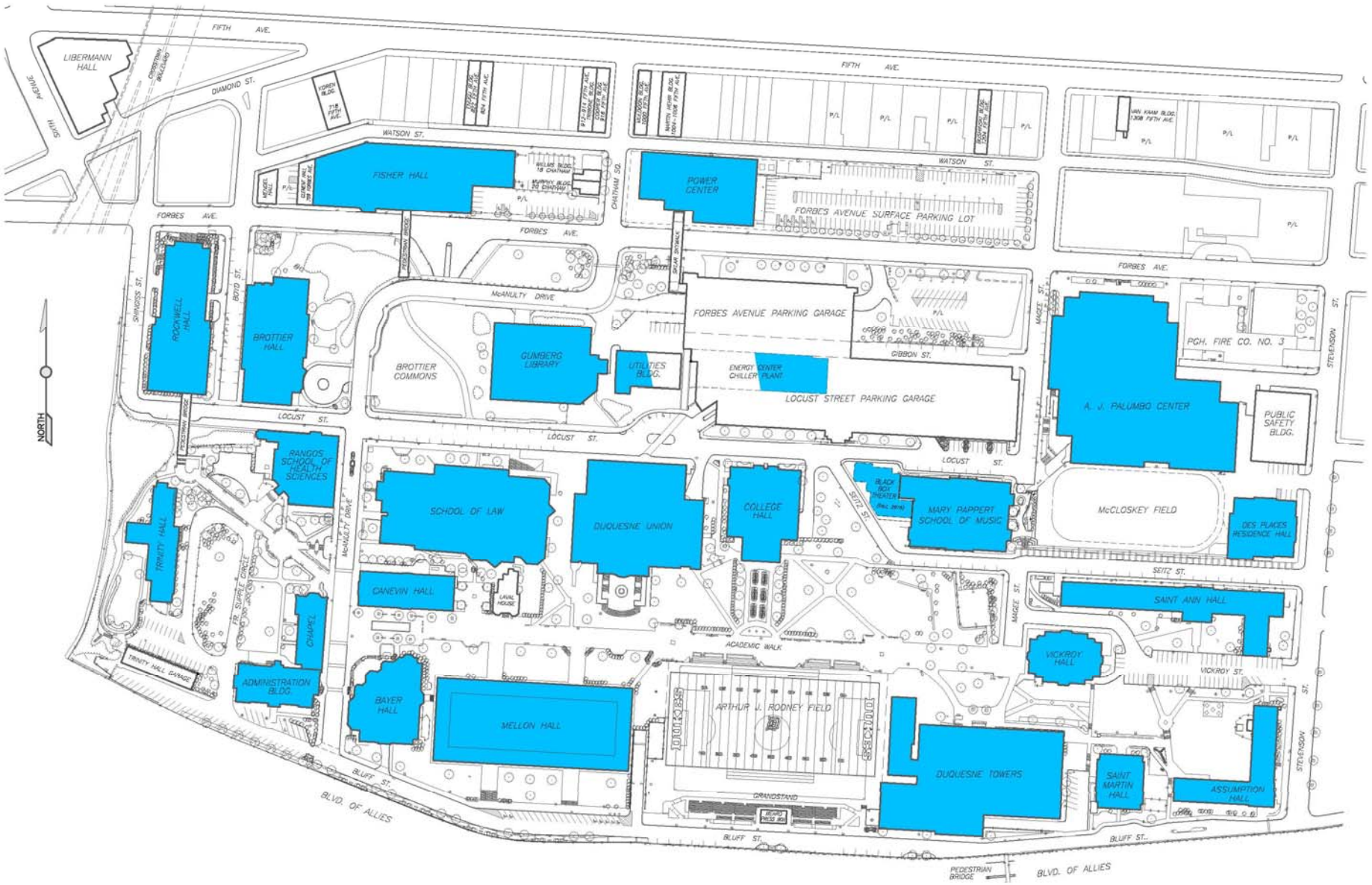
Duquesne Light



Steam Distribution System

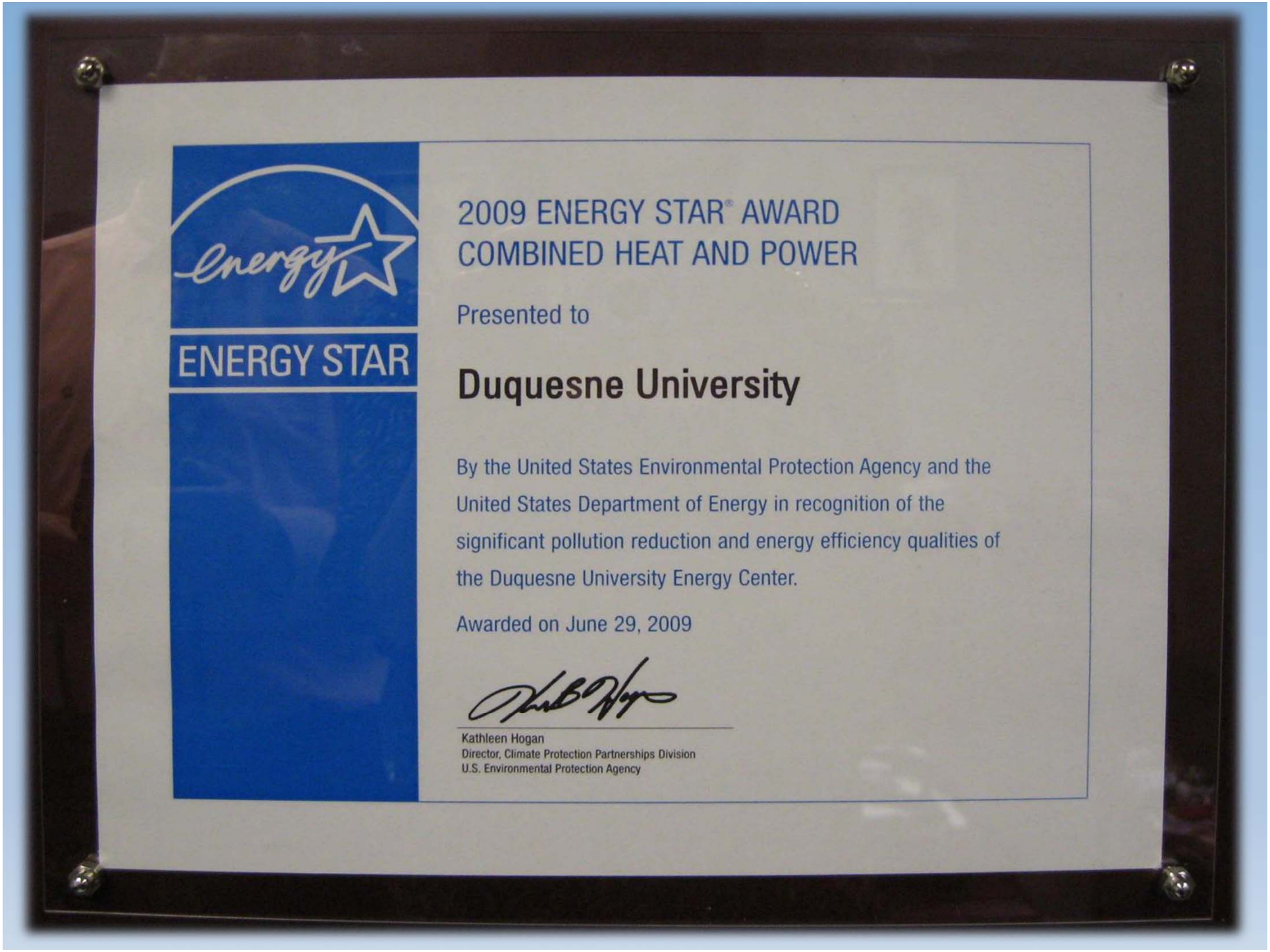


Campus Chilled Water System



Average Annual Performance

- Generator produced - 32,382,044 Kwh (86%)
- Imported from DLCO – 5,149,038 Kwh (14%)
- Turbine availability– 8,533 hours (97.5%)
- Waste heat boiler produced – 157,344 MLB (74%)
- Gas boilers produced – 56,617 MLB (26%)
- Gas turbine used – 406,766 MCF of natural gas
- Boilers used – 68,481 MCF of natural gas
- Energy center used – 14,430,034 Gal. of water


ENERGY STAR
2009 ENERGY STAR® AWARD
COMBINED HEAT AND POWER
Presented to
Duquesne University
By the United States Environmental Protection Agency and the United States Department of Energy in recognition of the significant pollution reduction and energy efficiency qualities of the Duquesne University Energy Center.
Awarded on June 29, 2009
Kathleen Hogan
Director, Climate Protection Partnerships Division
U.S. Environmental Protection Agency

How do Others Compare?

Comparison To Atlantic 10 Schools				
School	Year Completed	Total Carbon Footprint	Carbon Footprint/Student	Location
Duquesne University	2010	42,044.4	4.05	Pittsburgh, PA
Temple University	2009	233,138	8.33	Philadelphia, PA
Xavier University	2007	37,000	5.6	Cincinnati, OH
University of Massachusetts-Amherst	2007	142,237	5.4	Amherst, MA
George Washington University	2008	128,301	6.3	Washington D.C.

Source: Center for Environmental Research & Education - 2010

How we've grown

- Added additional 1,250 ton centrifugal chiller 2000
- Added 6,000 ton ice storage in 2007
- Added capacity and relocated cooling towers in 2014
- Added capacity is in accordance with the University's 10 year master plan on file with the City of Pittsburgh

Why we selected Ice Storage

- Added 6000 ton/hr. capacity without adding cooling towers
- Utilizes off peak electric rates
- No change in condenser loop piping
- More efficient utilization of existing equipment

28 Storage Tanks – 6000 ton hrs

Questions?