Clemson Data Center Case Study

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Outline

• About Energy Services
• About Clemson’s Data Center
  – 20 yr. old facility
  – Mainframe computer
  – Old generator and DX units
• Mandate to upgrade IT capabilities
• Different cooling techniques employed
• Specifics of the current cooling systems
• Benefits of this partnership
Energy Services

• We provide knowledge and project management skills to customers who want to improve their electrical and mechanical systems but do not have the internal resources.

• Our initial meetings begin with understanding the customer’s needs.

• Our solutions draw from both regulated and non-regulated offers.

• The Clemson story is multifaceted, spanning nine years and multiple phases; however, today we will focus on the cooling requirements.
Data Center

Regulated Duke Energy

Onsite Generator Services (a regulated offer with a filed tariff)

Clemson University Data Center

• Clemson is ranked 21st among public universities by U.S. News & World Report for 2016

• Our data center supports:
  – Clemson academia and administration
  – SC DHHS Medicaid contract
  – DR/Colocation for SC state agencies and several research partners
  – Top 5 public academic compute cluster in the US
    • More than 1500 users across almost all campus departments
    • Numerous research grants (>90M since 2007)
## Timeline

<table>
<thead>
<tr>
<th>Year</th>
<th>Major Projects</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007</td>
<td>20 year old facility with end of life infrastructure and a mandate to build high performance computing. Installed 2 UPSs, 250 Ton Chiller and 5 CRAH units.</td>
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<tr>
<td>2010</td>
<td>Major expansion of HPC required much larger infrastructure. Installed 2 Generators, 2 UPSs, 2 Chillers, 6 CRAH units and a new 2.5 MVA service to the facility.</td>
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<tr>
<td>2013</td>
<td>HPC outstripped cooling capacity. Installed a tertiary chilled water loop for rear door heat exchangers.</td>
</tr>
</tbody>
</table>
IBM Mainframe
Tape Silos for the Mainframe
The Cluster – 512 nodes
Each rack contained 36 computers
HPC Drives Expansion

Computing Capacity - TFLOPS
The Mechanical Systems

- Computer Room Air Conditioners (CRAC)
- Chillers
- Chilled Water Pumps
- Computer Room Air Handlers (CRAH)
- Rear Door Heat Exchangers
Condensing Units
2007 Chiller
Chiller #2

- **Unit**: ~57.0°F
- **Chill Water Entering Temp**: ~46.6°F

**Time Remaining Until Rotation**
- 5 days 23 hours 45 mins 31.603 sec

**Last Rotation Date & Time**
- 2015-08-25T15:07:04.429-04:00

- **Outdoor Air Temp at Chiller**: 87.5°F

- **Chiller Mode**: Run
- **Active SetPoint**: 44.0°F
- **Compressor #1 Amps**: 208 A
- **Compressor #2 Amps**: 202 A
- **Actual Capacity**: 103.3%
- **Capacity Limit**: 107.0%
- **Voltage A to B**: 481 V
- **Evaporator Water Flow**: True

- **Active Alarms**: False
- **Chiller Alarm Status**: False

**Compressor #1 Information**
- Evaporator Refrigerant Pressure: 40.5 psi
- Condenser Refrigerant Pressure: 258.6 psi
- Evaporator Refrigerant Temp: 45.3°F
- Condenser Refrigerant Temp: 148.5°F
- Condenser Air Flow Percent: 100.0%
- High Side Oil Pressure: 243.5 psi
- Oil Temperature: 160.0°F

**Compressor #2 Information**
- Evaporator Refrigerant Pressure: 42.7 psi
- Condenser Refrigerant Pressure: 262.9 psi
- Evaporator Refrigerant Temp: 47.8°F
- Condenser Refrigerant Temp: 150.0°F
- Condenser Air Flow Percent: 100.0%
- High Side Oil Pressure: 243.2 psi
- Oil Temperature: 158.3°F

- **Control Panel Chiller HOA Switch**: Hand | OFF | Auto
2007 CRAH
System Differential Pressure

SetPoint
12.0 psi
DP - 1 - 12.8 psi
DP - 2 - 11.2 psi
Average DP - 12.0 psi
Average Loop Supply Temp - 43.2 °F

Secondary Loop System

Supply 43.2 °F

Pump - 4
Bypass Mode - AFC
Drive Mode - Auto
Speed Signal - 61.6 %
Speed Feedback - 61.4 %
Speed Frequency - 36.0 Hz

Pump - 1
To Chiller #1
52.5 °F
Capacity - 64.3 %

Pump - 2
46.4 °F
To Chiller #2
57.0 °F
Capacity - 103.3 %

Pump - 3
62.4 °F
To Chiller #3
63.1 °F
Capacity - 0.0 %

Pump - 5
Bypass Mode - AFC
Drive Mode - Auto
Speed Signal - 0.0 %
Speed Feedback - 0.2 %
Speed Frequency - 0.1 Hz

Pump - 6
Bypass Mode - AFC
Drive Mode - Auto
Speed Signal - 61.6 %
Speed Feedback - 61.2 %
Speed Frequency - 36.7 Hz

Return 69.5 °F
2010 Chiller
Secondary Loop Pumps
Motor Control Center
Secondary Chilled Water Loop
CRAH Monitoring
Technology Drove Changes

- 500 Tons Chilled Water Capacity
- Hot Aisle / Cold Aisle Containment
- GPU arrive on the scene
  - Unable to maintain temperature to HPC
  - Installed closed loop rear door heat exchange system (4 doors)
  - Expansion drove a redesign
First Cooling Loop
Tertiary Water Loop
**Rack Loop Pressure Control**

**Main HOA**
- AFC | OFF | BYP

**Drive HOA**
- HAND | OFF | AUTO

**Pump - 7**
- 62.1 %
- 63.8 %
- 38.3 Hz

**Main HOA**
- AFC | OFF | BYP

**Drive HOA**
- HAND | OFF | AUTO

**Pump - 8**
- 0.0 %
- 0.1 %
- 0.1 Hz

**System Differential Pressure**

<table>
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<tr>
<th>SetPoint</th>
<th>Actual</th>
</tr>
</thead>
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<tr>
<td>12.0 psi</td>
<td>DP - 1: 12.1 psi</td>
</tr>
<tr>
<td></td>
<td>DP - 2: 12.3 psi</td>
</tr>
<tr>
<td></td>
<td>Average DP: 12.2 psi</td>
</tr>
</tbody>
</table>

**Time Remaining Until Rotation**
5 days 23 hours 54 mins 20.822 secs

**Last Rotation Date & Time**
2015-08-25T15:52:18Z-04:00
Rear Door Heat Exchangers
Air Out of Servers 95 to 105 F

Air Out of Heat Exchangers 70 F

Air In to Server Cabinets 68 F
Heat Exchanger Connections
Heat Exchanger Piping
Monitoring System

- Clemson University
  - Projects in the NOC
  - First responders to alerts

- Duke Energy
  - Monitors alerts
  - Dispatches to perform maintenance/repair
  - Reviews trends
Monitoring Panel
The Electrical System

• There is so much more to this story.
• The capacity of the utility delivery was increased.
• Backup generators and UPS equipment were installed.
• Come to the Critical Facilities Summit, October 3-5\(^{th}\), 2016, Charlotte Convention Center; i.e., [www.criticalfacilitiessummit.com](http://www.criticalfacilitiessummit.com)
Customer Reception, Sponsored by Energy Services
Oct 4th, 6:30 – 8:30 PM
Summary

• Needs led to discussions about what could be done, which led to a plan and a partnership.
• Each party challenges the other to continually improve.
• Clemson is much better positioned to be a viable hosting and disaster recovery site for many other clients.
• Nov. 2015: #118 cluster worldwide (722 TFLOPS) and top 5 among US public academic institutions.
Questions