System Performance Best Practices

North Carolina State University – Raleigh, NC

Climate Zone	4A
Cooling Degree Days	1863
Heating Degree Days	3011
ISO	Southeast
Local Utility	Duke Energy

System Profile

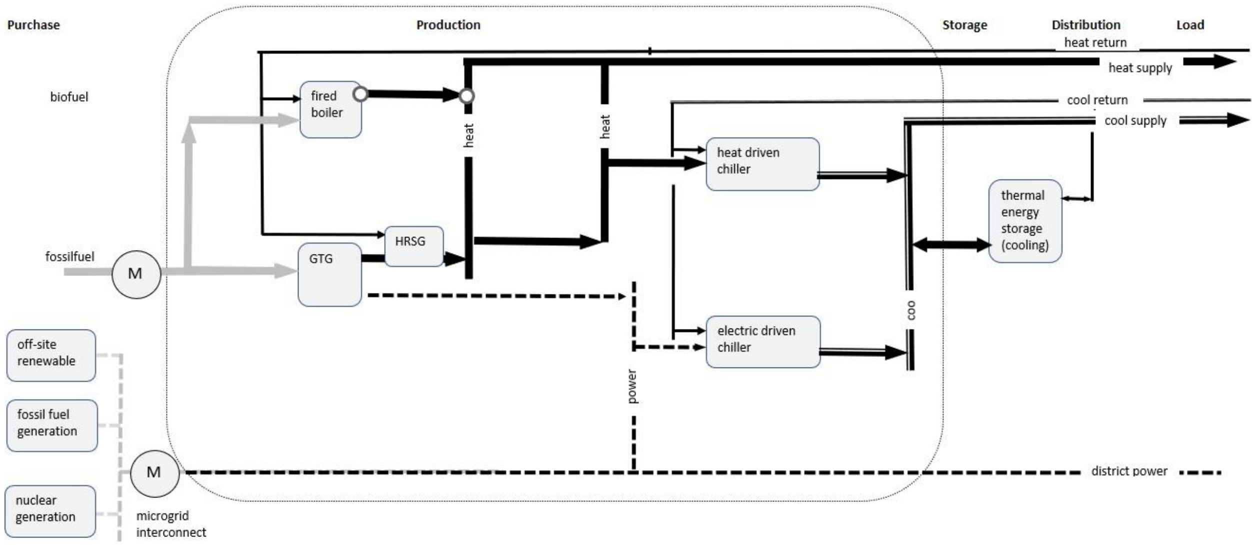
North Carolina State University is a large public research university in Raleigh North Carolina. Situated on 2000 acres (12.9 million sq ft) spread across 3 urban campuses, the university hosts over 36,000 students and roughly 9000 faculty and staff. Before 2000, the campus utilized a number of distributed chillers, situated in buildings, but the ad hoc loop did not provide the benefits of a centralized district cooling system. In 2000, the university made the decision to commit to district energy. In the scale-up, the university elected to collocate steam and chilled water production (and eventually CHP) under a single plant allowing them to deploy a single, multi-disciplinary management, operations, and maintenance staff. In 2012, the campus installed a CHP plant as part of the Cates Utility Plant, and later (2019) an additional unit to serve the expanded Centennial Campus. In addition to enhancing the reliability and resiliency of the Centennial grid, the expanded system supports university and state policies limiting energy consumption, including a state goal of reducing energy consumption per square foot in state-owned buildings by at least 40% over 2002-2003 levels, and the NC State 2010 Climate Action Plan goal of reaching climate neutrality by 2050.

The university currently uses a 17.5 MW gas-fired CHP system (125-150 psi) supported by three 5.5 MW gas turbines, one 1 MW steam turbine generator, two 25,000 lb/hr recovery boilers (each with a 25,000 lb/hr auxiliary burner), and one 30,000 lb/hr recovery boiler with a 30,000 lb/hr aux burner. The university also employs a 3.3-million-gallon TES tank, which serves 20+ buildings on the Centennial campus and provides 27,260 ton-hrs of cooling capacity.

System Capacity

CHP capacity	17.5 MW
District Heating (steam)	536,000 lbs/hr
District Cooling (chilled water)	31,600 tons
Chilled Tank Volume	3.35 million gallons

System Single Line Diagram



To view this graphic in a web browser, visit this site:
https://www.districtenergy.org/home/reports/ncstate

System Performance

1. **System Efficiency**
   - Boiler Efficiency: 71%
   - Condensate Return: 20%
   - CHP System Efficiency: 94%
   - Heat Generation Efficiency: 12,000 BTU/kWh
2. **System Reliability and Availability**
   - No Data
3. **TES Reducing Peak Demand**
   - 3.3 million Gallon CHW tank
   - CAPEX avoided by deferring a new chiller: $2,500,000
   - Efficiency improved by production of CHW at night: 5%
4. **Improved CHW system delta T**
   - Delta T: 9F

Technical Best Practices

Thermal Energy Storage (TES)

Capital expenditure avoidance was the primary driver for TES installation – when NC State built up the Centennial campus, the utilities team had to decide whether they wanted to invest in building up generation capacity or investing in storage as a near-term solution. Because the Centennial campus load falls at night, freeing up chiller capacity to fully charge the tank (even in the case of a chiller outage), the university determined TES installation to be a reasonable alternative to installing additional chillers to accommodate the new load.

In addition to savings on plant expansion, the university has been able to leverage TES for energy cost savings by fully shifting the campus's peak profile, avoiding costly peak demand charges by on the order of $250,000/yr.

A key hurdle in getting approval to build the TES tank was aesthetic: working with the campus architect to design a tank that integrated seamlessly into the surrounding landscape. The university asked a number of design firms to produce renderings of tanks that would fade into the campus landscape via both strategic placement (behind the existing plant, surrounded by trees) and exterior tank design. Ultimately, a tank design that matched the aesthetics of the surrounding buildings and was well hidden from most viewpoints, was approved by the campus architecture committee.

Reclaimed Water for Cooling Tower Make Up

NC state has identified another source of savings: reclaimed water. The university has contracted with the city of Raleigh to repurpose treated wastewater for make up in the cooling towers of their district energy system, incurring rate savings from the city and using less potable water overall. To implement this change, the university needed to invest in infrastructure upgrades that ensured total separation of the reclaimed water from the university's potable water distribution system and implement a strict practice of annual preventative maintenance. Even with the increased maintenance and chemical input costs, switching to reclaimed water has been cost-effective.

Management and Financial Best Practices

Performance Contracting

NC State has largely funded its CHP upgrades via performance contracting (as opposed to traditional fundraising, grant funding, or state appropriations). The ESCO Performance Contract model removed the required utilities expense from University's capital building budget request, enabling a large-scale plant improvement and expansion, while lowering University implementation risk by providing single source responsibility for procurement, construction, management, and energy efficiency.

The ESCO agreement requires NC State to run their CHP system 24/7. In considering future performance contracts, the university has weighed the value of up-front capital with the expense of long-term, potentially inefficient performance requirements. While the urgency and scale of the CHP upgrades necessitated a performance contract, NC State decided against the model in their 2019 TES installation: if the university opted to add the tank to the CHP contract, it would have taken 20-25 years to pay off. Instead, the university opted to use appropriated funds, resulting in more rapid simple pay back.