FACT SHEET

STANFORD ENERGY SYSTEM INNOVATIONS (SESI) PROJECT

SUSTAINABILITY OPPORTUNITY

In October 2009 Stanford released a comprehensive and long-range Energy and Climate Action plan aimed at raising the bar in energy efficiency and the use of innovative, clean, and renewable energy supplies on campus. The plan includes high-efficiency standards for new buildings; continued efficiency improvements for existing buildings; and the cutting-edge energy supply system known as the Stanford Energy System Innovations (SESI) project, which the Board of Trustees gave concept approval of in December 2011. SESI represents a transformation of university energy supply from 100% fossil-fuel-based combined heat and power (CHP) plant to grid-sourced electricity and a more efficient electric heat recovery system. In 2011, Stanford's greenhouse gas (GHG) emissions peaked at 230,000 metric tons. This new system, along with Stanford's solar procurement, reduces campus emissions approximately 68% below peak levels, and saves 18% of campus potable water.

THE SESI PROJECT

Since 1987, Stanford relied on a natural gas-fired CHP plant for virtually all its energy demand. Although efficient, its fossil-fuel-based source caused the CHP plant to produce 90% of Stanford's GHG emissions and consume 25% of the campus' potable water supply. As a result, Stanford's GHG reduction strategy focused primarily on transforming the university's energy supply through a new Central Energy Facility (CEF).

The new CEF includes three large water tanks for thermal energy storage and a high voltage substation that receives electricity from the grid. A key feature of the CEF is an innovative heat recovery system that takes advantage of Stanford's overlap in heating and cooling needs. In addition to the CEF, the SESI project converted the heat supply of all buildings from steam to hot water.

The efficiencies gained from the new CEF and hot water conversion, along with Stanford's commitment to procure much of its electricity from solar, reduces the university's overall GHG emissions by 68% from peak levels. Further details on the SESI project are outlined in Stanford's Energy and Climate Plan, available at http://sustainable.stanford.edu/sites/default/files/Stanford_Energy_%26_Climate_Plan_2nd_Edition.pdf.

Aerial view of the new Central Energy Facility

IMPLEMENTATION

Stanford completed conversion of over 20 miles of steam pipelines to hot water pipelines across the entire campus in October 2014 and upgraded 155 buildings to hot water piping in March 2015. The work was carefully sequenced in multiple phases to minimize disruption to campus life. As each phase of piping and building conversion was completed, that section of campus moved off steam to hot water via a regional heat exchanger that converted steam from the existing cogeneration plant to hot water at a district level. A full transition

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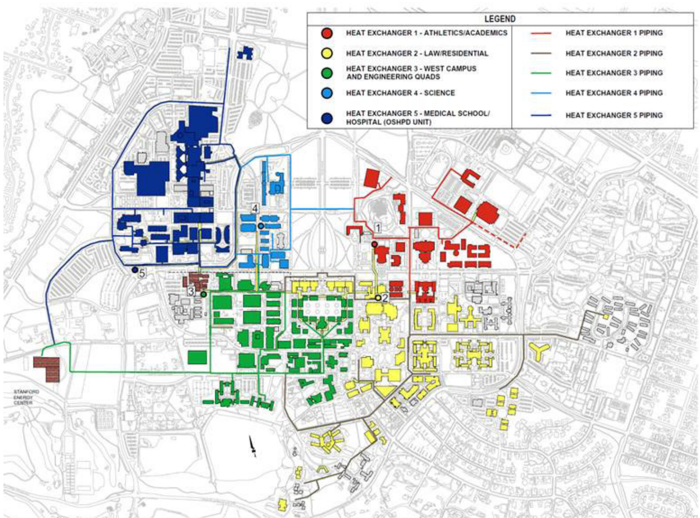
from the CHP plant to the new CEF took place in April 2015, when the regional heat exchange stations were removed, and the CHP plant was decommissioned and removed to make way for new academic buildings within the campus core.

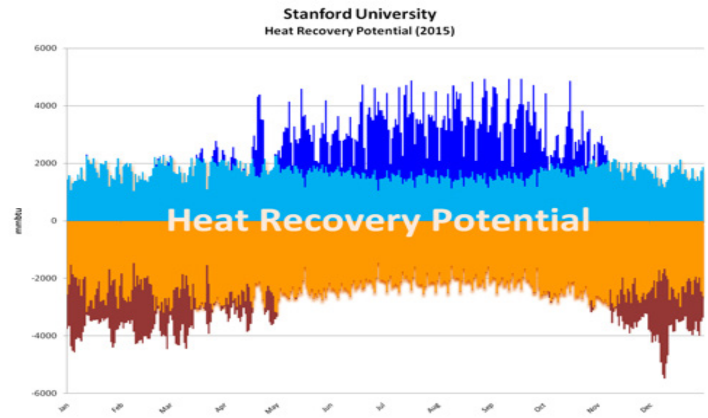
Overall Conversion Plan



INNOVATION: HEAT RECOVERY

Stanford's many varied pursuits, from cutting-edge research to olympic-level athletic facilities, result in the campus having a 70% real-time overlap of heating and cooling demands. This presents the opportunity for heat recovery—using waste heat collected by the chilled water system to meet the university's concurrent heating need. The new heat recovery system collects waste heat from buildings via a chilled water loop and captures it at the CEF for reuse, eliminating the use of cooling towers to discharge the heat. Instead, heat recovery chillers move waste heat collected from the chilled water loop to a new hot water loop that distributes heat to the buildings. The heat recovery system meets 88% of the heating load on campus with waste heat and reduces total campus potable water consumption by 18%.

Although the heat recovery system had a modestly higher capital cost than a conventional boiler and chiller plant design, it had a lower up-front cost than a new CHP plant, has the lowest lifecycle cost of all options, and will pay Stanford back many times over in coming years. At the same time, it positions Stanford as a national leader in energy efficiency and carbon reduction.

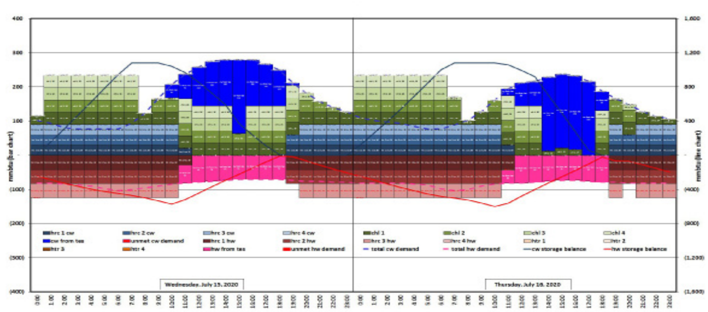


The simultaneous overlap of annual heating and cooling demand on campus

INNOVATION: MODEL PREDICTIVE CONTROL

The facility's highly complex, yet repetative, operations warrant a computerized model that can automate much of the day-to-day functionality.

The Central Energy Plant Optimization Model (CEPOM) is a patented technology developed by Stanford that creates a forward-looking hourly plan for optimal operation of the CEF. The energy modeling and dispatch system uses over 1220 variables including building occupancy, ambient conditions, time of year, projected energy prices, weather forecast, current system conditions, etc. to develop 15-minute dispatches that show the optimal way to run the plant.



Sample optimal CEF dispatch plan generated through CEPOM

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SUSTAINABLE STANFORD