

STANFORD ENERGY SYSTEM INNOVATIONS (SESI) PROJECT: STEAM TO HOT WATER CONVERSION

REUSE CONSIDERATIONS



INTRODUCTION

Stanford Energy System Innovations (SESI) is the cutting-edge energy supply system designed to meet the university's future energy needs while reducing GHG emissions and water consumption. It transitioned Stanford's energy supply from a natural-gas-fired combined heat and power plant to grid-sourced electricity and a more efficient electric heat recovery system. The use of innovative heat recovery technology required Stanford to upgrade its aging steam system to a hot water distribution system to supply heat for buildings. Stanford installed over 20 miles of hot water piping and converted 155 buildings to receive hot water instead of steam in less than three years, from fall 2012 to spring 2015.

THE NEED FOR HOT WATER: STANFORD'S HEAT RECOVERY SYSTEM

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. Stanford's heat recovery system collects waste heat from buildings via a chilled-water loop and captures it at the Central Energy Facility (CEF) for reuse, largely 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 93% of the heating load on campus with waste heat and reduces total campus water consumption by 18%.

STEAM TO HOT WATER IMPLEMENTATION

Stanford's Department of Project Management completed conversion of over 20 miles of steam pipelines to hot-water pipelines across the entire campus in October 2014, and all buildings were upgraded 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 and transitioned to hot water via a regional heat exchanger that converted steam from the existing cogeneration plant to hot water at the district level. A full transition 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.

The university kept small sections of the existing steam system in operation to service Stanford's biomedical research needs, which require processed steam for sterilization and research. In conjunction with the new CEF, Stanford built a small Process Steam Plant consisting of three unmanned fluid steam boilers that produce the small amount of steam needed to accommodate the process steam services.



Construction crews install piping along Serra Mall

CONSIDERATIONS FOR STEAM PIPE REUSE

The campus investigated potential reuse of the steam distribution system in order to save time and money during planning and implementation. However, it was found to be safer, faster, and more affordable to overlay a new hot water piping system on campus for the following reasons:

STEAM TO HOT WATER CONVERSION REUSE CONSIDERATIONS

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- **Size of the Pipes:** Less than half of the steam supply lines were large enough to reuse for hot water. Hot water delivers less Btu of energy than steam; as such, a majority of the existing steam lines are not large enough in a typical steam system for reuse in a low temperature (less than 212 °F) hot water (LTHW) system. Similarly, none of the condensate return lines were large enough to reuse for LTHW.
- **Variation in Depth:** Steam lines are usually the deepest buried utility due to the high temperature of the lines, which can melt other utility pipelines and cables. Reusing the steam lines would require deep digging to replace the corresponding condensate return lines—which would be paired with the reused steam supply lines—as they would be too small for LTHW.
- **Replacement Issues:** Steam and condensate lines at Stanford are mostly direct burial and are surrounded by powered insulation material. In exposing and replacing the condensate part of the steam supply and condensate return system, the insulation around the re-used steam line would need to be removed and replaced. This replacement substantially adds to the capital and labor cost—labor being the most expensive component of implementation.
- **Logistics:** The logistics of trying to convert individual buildings and districts of the campus by reusing steam lines would have been disruptive to campus life. It would require long building heating outages as the steam lines would have to be de-energized to carry out the required work. Stanford actually completed the first regional LTHW conversion in the Athletics area of campus using conventional

methods of uncovering and replacing existing steam lines with a 'conventional' North American LTHW piping system. The process was time-consuming and expensive, and was ultimately deemed inappropriate for the remainder of implementation.

After careful planning and investigation, the SESI program team confirmed that steam pipes could not be reused for hot water distribution. Given this conclusion, Stanford researched alternatives and discovered that LTHW systems used in Northern Europe would provide a suitable alternative. This system is:

- **Safer:** The pipes do not present a significant melting or safety threat (as steam would, so they are buried at a shallower depth).
- **More efficient:** The system uses direct-bury valves and does not require vaults.
- **Quicker to implement:** The pipes are pre-insulated; have a robust built-in leak detection system; require no chemicals to protect the inside of the pipes (instead they utilize high pH and oxygen starvation); and are very fast and inexpensive to install, compared to the conventional methods used during the first section of conversion in Athletics. By keeping the existing steam system in place and installing the new LTHW in parallel, it has been easier for technicians to subsequently convert buildings. Both steam and hot water are available before making the transfer, allowing for a much shorter cutoff time—from a few days to a week, maximum.



A new regional heat exchanger



Building conversion from steam to hot water

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