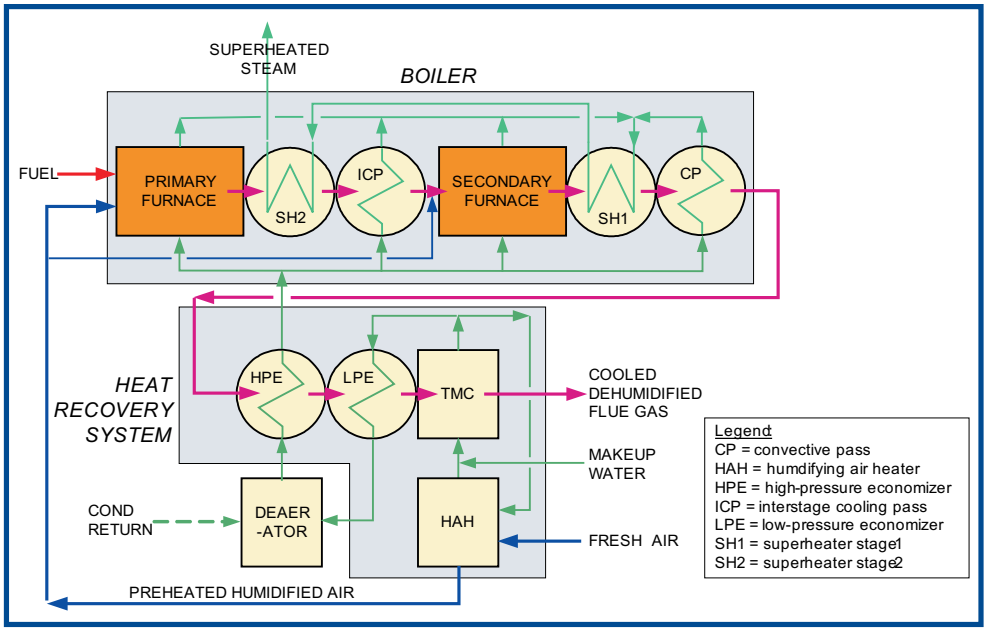
2nd Generation Super Boiler Technology for Watertube Boilers

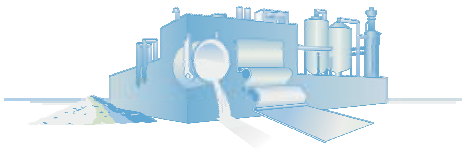
Second Generation Set to Surpass Capabilities of the First

With most conventional industrial boilers reaching the end of their life cycles after over 20 years of operation, replacement technologies aim to significantly improve upon identified shortcomings of large size, relative inefficiency (75%), and high emissions (63 ppmv NO_X, 400 ppm CO). Currently entering its demonstration phase, the first generation firetube boiler boasts a unique staged intercooled combustion system and latent heat recovery system that brings 94% HHV efficiency, NO_X emissions below 5 ppmv, and over 40% reduction in boiler footprint and weight. With the development of several new concepts, the second generation will improve upon the capabilities of the first for application to large high-pressure watertube boilers.

To satisfy the more demanding steam service of watertube boilers, concepts such as a Flash Evaporation Cooler (FEC) and staged Transport Membrane Condenser (TMC) have been developed to maintain high efficiency and compact design. High-pressure superheated steam capability (greater than 1500 psig/ 1500°F) may be achieved through staged superheating and/or a direct-fired superheater (DFSH) concept. Ultimately, the technology's ultra-clean combustion could eliminate 103,000 tons of NO_X, 830,000 tons of CO, and 28 million tons of CO_2 annually from the atmosphere. In total, the U.S. industry could save over $4 billion per year through the Super Boiler's increased energy efficiency and reduced equipment costs.



Simplified Schematic of 2nd-Generation Super Boiler, Version 1



Benefits for Our Industry and Our Nation

Advanced industrial watertube boilers will have the capability of reaching 94% fuel-to-steam efficiency and emissions below 2 ppmv NO_X, 2 ppmv CO, and 1 ppmv VOC on natural gas fuel. The boiler design will allow for >1500°F, >1500 psig superheated steam, burn multiple fuels, and will be 50% smaller/lighter than currently available watertube boilers of similar capacity. Once commercialized, this technology has the potential to save over 500 trillion Btu per year in energy.

Applications in Our Nation's Industry

The vast majority of boilers 50 million Btu/hr and larger, as well as most boilers requiring high-pressure and high-temperature steam, are watertube boilers.

Project Description

The goal of this project is to develop a high-pressure watertube boiler system that incorporates and improves upon the capabilities of the firetube Super Boiler system.

Barriers

Major barriers to be overcome include:

- Achieving a fuel-to-steam efficiency greater than 94%;
- Reducing combustion emissions to: NO_X emissions below 2 ppmv, CO emissions below 2 ppmv, and VOC emissions below 1 ppmv;
- Incorporating the capability to operate on multiple fuels;
- Producing high pressure and high temperature steam greater than 1500°F and 1500 psig; and
- Reducing the watertube boiler system weight and footprint by 50% of currently available boilers.

Pathways

The technical approach involves evaluating design concepts that include two-stage intercooled combustion for natural circulation, forced circulation, and/or once-through watertube boilers. Specifically, the new DFSH concept will be tested as an option for >1500°F steam temperature, including evaluation of projected industrial utilization of high-temperature steam. Heat recovery from flue gases will be based on improving the previously developed TMC and Humidifying Air Heater (HAH). The effectiveness of the novel FEC will be evaluated as an alternative to the HAH for producing cooled recycle water to the TMC. Solid-state power generation modules will be an option for electricity generation, and methods for increasing heat transfer in radiative and convective sections of the boiler will be evaluated to reduce weight and footprint. Additionally, emissions reduction will result from optimization of the combustion system for deeper staging and tuning the boiler wall heat extraction profile to further reduce peak flame temperatures.

The assessment of all of these design elements will lead to the recommendation of a single overall design for demonstration.

Progress and Milestones

- Develop and evaluate boiler design concepts for the watertube boiler system to establish a design basis for two-stage intercooled combustion
- Evaluate approaches to improving heat recovery, heat transfer, and superheating and incorporate them into the watertube boiler design
- Select a single watertube boiler design and scale-up for demonstration
- Select a host site and complete the engineering, fabrication, and installment of the watertube boiler for demonstration
- Complete field testing and final evaluation of the watertube Super Boiler system

Commercialization

The project has various partners that will participate in the development and commercialization of the watertube Super Boiler system. GTI will lead the project team consisting of two major boiler manufacturers, Aqua-Chem and Alstom Power. Pacific Northwest National Laboratory will develop the compact heat exchanger technology, Oak Ridge National Laboratory will assist in the superheater development, and Georgia Tech will contribute its expertise in basic combustion science and flame stability. GTI will license the technology for commercial development and dissemination.

Project Partners

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Alstom Power
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Oak Ridge National Laboratory
Oak Ridge, TN

Georgia Institute of Technology
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Pacific Northwest National Laboratory
Richland, WA

A Strong Energy Portfolio for a Strong America

Energy efficiency and clean, renewable energy will mean a stronger economy, a cleaner environment, and greater energy independence for America. Working with a wide array of state, community, industry, and university partners, the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy invests in a diverse portfolio of energy technologies.

U.S. Department of Energy
Energy Efficiency and Renewable Energy
Bringing you a prosperous future where energy is clean, abundant, reliable, and affordable

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