The focus of this research is on the transient thermodynamic properties and dynamic behavior of a Heat Recovery Steam Generator (HRSG). An HRSG is a crossflow heat exchanger designed for extraction of energy from the exhaust gas of a traditional power plant through boiling. Superheated steam is sent through a turbine to generate additional power, raising the efficiency of a power plant. The addition of renewable energies and the evolution of smarter grids have brought forth a necessity to gain a comprehensive understanding of transient behavior within an HRSG in order to efficiently manage the power output of traditional plants. Model-based techniques that can simulate a wide range of operating conditions can be valuable and insightful. For this reason, a multi-physics model of an HRSG has been developed in Siemens T3000 plant monitoring software. The layout and conditions of a reference HRSG have been provided by Siemens Energy Inc. along with validation data for comparison and correlation. The HRSG selected is a three pressure stage HRSG. Simultaneous simulation of these three pressure systems and their thermodynamic interactions has been achieved. An HRSG is built of three major subsystems, namely economizers, boilers, and superheaters. A lumped control volume approach has been implemented to efficiently model the energy and mass balances within each subsystem. Considering the goal of real time simulation, special attention was paid to balance computational burden with numerical accuracy.

A major focus of this research has been modeling the complexities of phase change within a boiler. A switching mechanism has been developed to numerically model the dynamic heating and evaporation of boiler liquid. To increase robustness of the model to numerical fluctuations and perturbations, bidirectional flow comprising of boiling and condensation was modeled. This numerically robust model shows good agreement with validation data provided by Siemens.