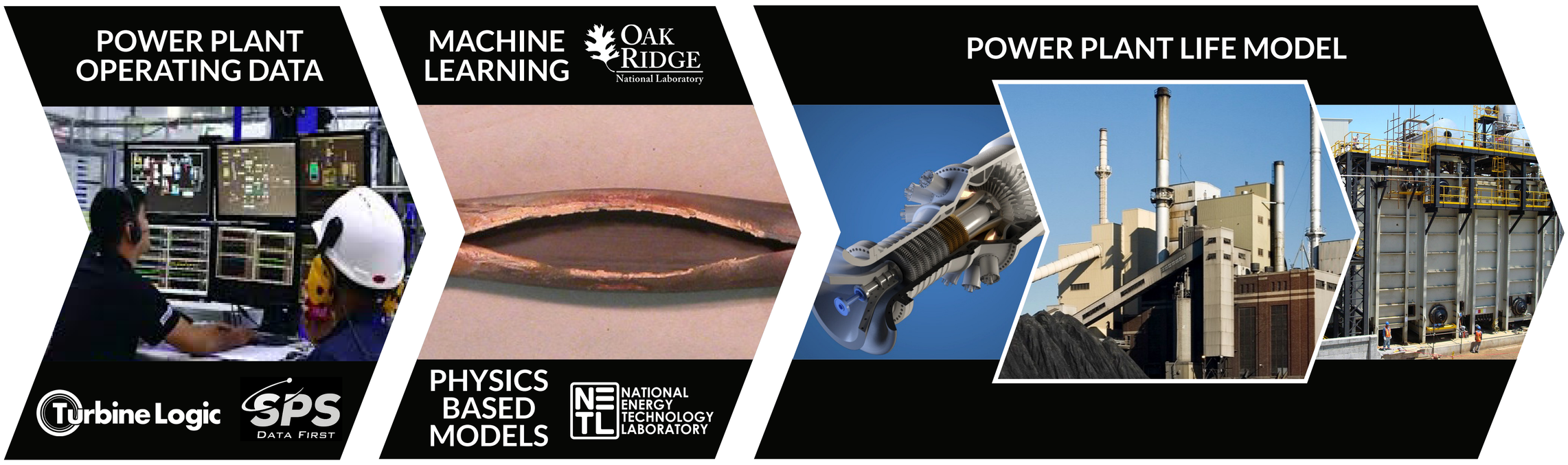
EFFECT OF CYCLE OPERATIONS ON HRSG AND COAL FIRED BOILER TUBES

Yong Liu[1,2], Youhai Wen[1], Tianle Cheng[1,2], George A. Richards[1], David E. Alman[1],
Steven W. Richardson[1], Jimmy D. Thornton[1], Salvatore A. DellaVilla[3], Robert F. Steele, Jr.[3], Chris Perullo[4]

1. National Energy Technology Laboratory, 2. Leidos Research Support Team, 3. Strategic Power Systems, Inc, 4. Turbine Logic



OVERVIEW

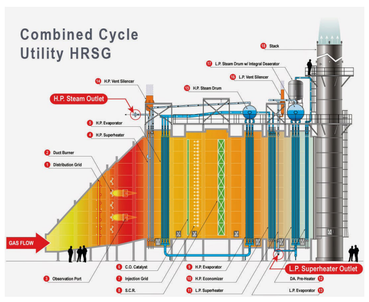
This HPC4MtIs Program aims to utilize the high performance computing (HPC) of DOE's National Laboratories to help industry develop new or improved materials that can withstand extreme conditions. The HPC4MtIs Program is part of a larger HPC4EnergyInnovation Initiative, a DOE-wide effort comprising the Office of Fossil Energy (FE), the Office of Energy Efficiency and Renewable Energy (EERE), the Office of Science, and the National Laboratories.

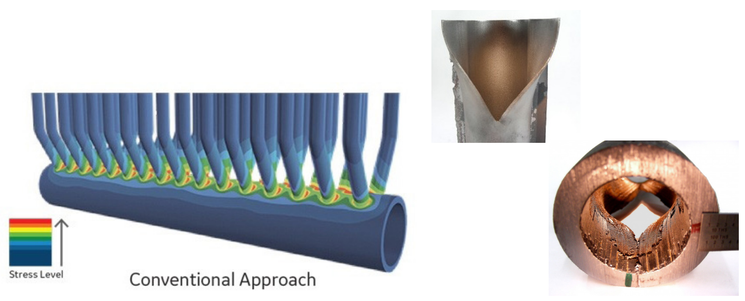
NETL and Strategic Power Systems, Inc. (SPS) will leverage their unique capabilities to optimize power plant operation to reduce failures due to cyclic operation of fossil energy-fired electric generation facilities. In combination with NETL's high-performance computing capabilities, the project will utilize near real-time process data characterizing the operating environment and dynamic conditions, from start-up to shut-down, to influence and develop predictive operations to improve performance, increase life, and reduce costs of cyclic operations. The goal of the research is to define the dynamic conditions that may lead to tube failures in heat recovery steam generators (HRSGs).

BACKGROUND

Changes to the US electricity industry are forcing a paradigm shift in how the nation's generating assets are operated. Natural Gas Combined Cycle (NGCC) or coal-fired power plants optimized as base-load resources are being increasingly relied on as load-following resources to support electricity generated from intermittent renewable capacity. Existing plants are being operated in ways that are suboptimal from the perspective of efficiency and capacity utilization.

In an effort to address these challenges by identifying and developing technologies that increase natural gas combined cycle or coal-fired power plant efficiency, improve unit reliability and availability, and enhance unit capability for flexible operations (e.g. "cycling"), a physics based model (CFD/FEA) is being developed to study the stress and fatigue of major components of plants such as the HRSG tubes under cyclic operating conditions.





APPROACH

This project will utilize field data, available in the ORAP® system from SPS, to assess the operation of NGCC and coal-fired plants in cyclic duty. The emphasis will be on HRSG and coal boiler operating conditions and failure experience related to tube failures. The project will be based on high fidelity data available in ORAP through the collection of near real-time process data - characterizing the operating environment and dynamic conditions, from start-up to shut-down, that affect the HRSG and coal boiler (i.e. the boiler tubes). This knowledge is important to influence/develop a predictive Operations & Maintenance (O&M) strategy to improve performance, increase life, and reduce cost.

NETL will utilize the commercial ANSYS finite element analysis (FEA) software to model the component performance at continuum level. NETL's Joule supercomputer can use ANSYS with an assortment of modules to simulate different scenarios to solve for combinational effects of fluid dynamics, thermal stress, heat transfer, and structural mechanics of components and materials. The model would include details of the material, weld joints, etc., for a prediction of the local stress as the component "cycles". Capturing detailed, local conditions in the material, during dynamic cycles, is expected to require substantial computational cycles. The large number of cycles, including a possible conjugate fluid flow and material stress analysis, is expected to require the resources of a large computing platform such as a national lab supercomputer.

BENEFITS AND FUTURE WORK

HRSGs are a fundamental component of fossil energy-fired electric generation facilities, regardless of fuel source (coal, oil, natural gas, combined cycles). Improving understanding of real-world HRSG operational patterns through analysis and modeling using ORAP® data has the potential to provide significant benefits across the electric power generation industry in terms of efficient HRSG operations, improvements in operational runtime and lifespan, and better maintenance planning for HRSG systems.

Growing intermittent renewable energy is forcing many fossil energy plants to transition from historical base-load generation to cycling operations. Understanding these operating environments and investigating the influence of cyclic start-stop cycles, time at temperature, and other cyclic operating conditions is important. This research will develop and validate analytic capabilities for natural gas combined cycle or coal-fired power generation reliability.

REFERENCES

https://www.ge.com/power/gas/hrsg

http://www.davidnfrench.com

2019 Crosscutting Annual Review Meeting | Pittsburgh, Pennsylvania | April 9-11, 2019

This work was performed in support of the US Department of Energy's Fossil Energy Crosscutting Technology Research Program. The Research was executed through the NETL Research and Innovation Center's Transformational Technologies for Existing Plants Field Work Proposal. Research performed by Leidos Research Support Team staff was conducted under the RSS contract 89243318CFE000003.

U.S. DEPARTMENT OF ENERGY | NATIONAL ENERGY TECHNOLOGY LABORATORY