Implementation Results for Integrated Optimization at Dynegy's Baldwin Energy Complex

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This paper discusses the current implementation results for integrated optimization at Dynegy's Baldwin Energy Complex. This project is part of the first round of the Clean Coal Power Initiative, a ten-year, $2 billion initiative to demonstrate advanced coal-based power generation technologies in the field.

NeuCo's CCPI Round 1 project entails a cost-shared partnership between NeuCo and the Department of Energy, while Baldwin contributes the host site, human resources and engineering support to ensure the project is successful.

Over the course of this 4-year CCPI project, NeuCo will install and refine multiple real-time, closed-loop process optimizers that will address combustion, sootblowing and SCR operations, overall unit thermal performance and plant-wide economic optimization at all three Baldwin units – two 600-MWe cyclone-fired units (1&2) and one 600-MWe tangentially fired unit. When completed, this installation will represent the first time multiple optimization software modules of this breadth have been integrated into a computerized process network in coal-fired power plants.

A benefits analysis released by the DOE's National Energy Technology Laboratory (NETL) asserts that by installing such technologies, power companies could significantly reduce NOx emissions by 13,420 tons per year (tpy) through cyclone optimization and 64,990 (tpy) through sootblowing optimization. Experts believe that generators could save (annually) over $139 million from improvements in combustion and post-combustion system operations, unit performance and plant profit optimization.

Products being Implemented

At Baldwin, NeuCo is/will be installing and refining four real-time, closed-loop physical process optimizers:

- CombustionOpt – The market leading combustion optimization system that manages the tradeoffs between NOx, CO, boiler efficiency, LOI and Opacity through closed-loop optimization of the fuel/air and temperature distributions in the furnace.
- SootOpt – A closed-loop sootblowing optimization system that directs sootblowing hardware to achieve the appropriate balance between too few and too many soot blowing practices in each furnace zone, within the context of global heat rate and emissions objectives.
- SCR-Opt – A closed-loop system that manages ammonia injection to coincide with actual furnace NOx production, thereby maximizing the SCR's NOx removal effectiveness, optimizing reagent use and managing secondary reactions.
- PerformanceOpt – An advanced performance management system that identifies and diagnoses efficiency and capacity problems that can be addressed by the operator, and takes or recommends actions to alleviate these problems.

In addition, NeuCo will layer on top of these products a higher level business process optimizer that 1) \that identifies and diagnoses maintenance-related efficiency, capacity, and reliability problems and prioritizes maintenance activities according to their relative costs and reliability risks.; and 2) assesses the real-time costs of plant operations and coordinates actions toward plant profitability.

Challenges

Baldwin is an ideal candidate for integrated optimization because in recent years Baldwin had added substantial new equipment to its boilers such as low NOx burners, overfire air and SCRs. These improvements have introduced Baldwin to new degrees of complexity in the relationships between sootblowing, SCR operation, combustion and unit heat rate.

Baldwin's cyclone boilers increase the operational challenges for two reasons: 1) most traditional combustion modifications cannot be deployed because of their unique design; and 2) these units are burning 100% Powder River Basin coal, as opposed to the higher heating value, high sulfur Illinois coal they were designed for. Developing a commercial combustion optimization solution for cyclones will allow these typically large and NOx-intensive generating assets to capture some of the same benefits that optimization technology has already made available for pulverized coal boilers. A further challenge is relating the operations of the cyclone units and the T-fired unit toward the common goal of plant-wide profit optimization.

NeuCo's optimization systems must also leverage the control and IT investments already made by Baldwin, such as its DCS platforms, local area network, plant data historian, sootblowing systems, and sensor technologies. The project will demonstrate the applicability of integrating the online optimization system with power plant operations to increase the thermal efficiency, fuel efficiency and reliability of the plant.

Status and Results to Date

Combustion and SCR Optimization

The first step in the project was to optimize the combustion process and streamline the SCR operations within Baldwin's two cyclone units. The neural control models initially focused on minimizing either CEMS or SCR inlet NOx before and during ozone season. While substantial NOx reductions (15-20%) were achieved, NeuCo and Baldwin found that controlling for NOx alone allowed for too much variability in the sensitive cyclone stoichiometries. At this point, models and objectives for each of the cyclone stoichiometries (as functions of gross air and cyclone specific biases), were added to CombustionOpt. The optimizer was then configured to maintain specific stoichiometries. Other tuning changes also made the system most sensitive to these objectives and less sensitive to NOx, particularly during high-MW-value operations, thereby stabilizing unit operations, including slag-related outages and NOx emissions.

While the stoichiometric approach toward optimization showed significant results, we believed that stoichiometry was a flawed estimator of temperature due to fluctuations in

oxygen efficiency at a given stoichiometry. Therefore, NeuCo began to look at data gathered from the low cost flame scanners on each cyclone and to explore spectroscopy as a tool for cyclone management, since we believed valuable inferences drawn from flame quality could produce a robust proxy for temperature. NeuCo has been able to use this flame scanner data to develop models that are of sufficient fidelity for use by CombustionOpt. The next step on Unit 2 may be to broaden the use of flame quality models for cyclone optimization to replace or complement the working stoichiometry models. Because the flame scanner models represent temperature and other key factors in cyclone stability and NOx creation, these models are expected to provide further operational enhancements.

NeuCo also worked with UniSearch, Inc. to install its LasIR TDL slip analyzer with 4 single traverse light paths on each unit, two per SCR section, just downstream of the SCR, above the air pre-heater. NeuCo was able to successfully model ammonia (NH3) slip as a function of CombustionOpt fuel and air bias variables, thereby mapping actual boiler process biased controls to the slip analyzer at the SCR outlet. The NH3 slip models will be deployed during the 2005 ozone season to enhance SCR NOx removal efficiency and reduce NH3 slip. The ability to accurately measure, model, and optimize an on-line signal indicating NH3 slip has substantial implications for SCR performance.

Sootblowing Optimization

NeuCo has also been working closely with Diamond Power's ASI Division (formerly Applied Synergistics) to integrate with their state of the art Furnace Cleanliness Model (FCE) with furnace heat flux measurements and Soot Cleaning Expert (SCE) systems on Baldwin's Unit 3, which is a 600MW T-fired B&W unit. Closed loop configuration has been completed and initial experimental operation of the unified approach is scheduled to begin in the next few weeks. Furnace and convective-pass heat transfer characteristics exert a major influence not only on steam side dynamics, but also feed back through fuel and air master controls to affect firing. Optimization of this complex system, based on local knowledge of surface cleanliness and global intelligence of operating context, is expected to result in improved heat rate and emissions. This system will also be a part of the fully integrated process optimization suite, which includes CombustionOpt and PerformanceOpt, on this unit.

Conclusions

NeuCo's CCPI project at Dynegy's Baldwin Energy Complex has been underway for just over one year, and there has already been substantial progress and results, including significant NOx reductions and improved slag control at the two cyclone boilers. In addition to the Combustion, SCR and Sootblowing optimization advancements reported in this paper, the phase 1 implementation of PerformanceOpt is also underway.

As plant complexity increases through retrofits, re-powering applications, new technologies and plant modifications, the integrated process optimization approach being demonstrated at Baldwin can be a enabling technology to both support a plant operator's

control objectives and link them seamlessly in real time to corporate objectives of increased availability, reliability, efficiency and lower emissions.

In the future, NeuCo, Baldwin and DOE will provide further updates on extending process level optimization up the value chain to the level at which three units within the plant are responding in a single optimization environment to the plant's real goal: profitability.