NeuCo
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Let's Keep the Conversation Going

When I was first approached about the idea of NeuCo creating an optimization weblog, I was skeptical to say the least. I hardly knew what a blog was let alone why we should have one. Yet several months later here we are live in the blogosphere at **www.TheOptimizationBlog.com**, the first online forum devoted to power plant optimization.

My skepticism dissolved once I thought back to the Users Summit NeuCo held this past May, and how three days was not nearly enough time to share ideas, give feedback and brainstorm about upcoming challenges. When the event concluded, we promised customers that we would continue some of those important discussions that were started. I'm now convinced that **The Optimization Blog** will be a forum for us to do just that. Unlike a one-way communications forum, a blog is a place for having conversations.

We hope that **The Optimization Blog** will give our customers and others in the industry an outlet for sharing ideas, which in turn will help us to better understand their needs and feed our product development efforts. It's also a resource for you to access the ideas and best thinking of people at NeuCo and others in the industry. And finally, we hope that it will provide value and enjoyment for readers through relevant content.

So after you read this edition of ***OPTions***, if you want to express your opinion or hear the opinions of others, I welcome you to join the conversation at **www.TheOptimizationBlog.com**.

Curt Lefebvre, *President & CEO*

REDUCING CO_2 — DEGREE BY DEGREE

Addressing CO_2 Emissions with Optimization

Soon, every power generator in the US will face CO_2 emissions legislation. Optimization allows plants to lower CO_2 and simultaneously manage other, often competing, plant objectives.

Welcoming the inevitable

Although the US Congress hasn't yet furnished a plan for restricting greenhouse gas emissions, the power generation industry is betting billions of dollars that it will. In fact, many in the power industry welcome federal legislation: They're concerned about states acting on their own, creating a hodgepodge of laws that could be stricter than any future federal regulations. To date, over 20 major corporations — including several in the power generation industry — have joined USCAP (United States Climate Action Partnership), a coalition pressing for "immediate action to enact mandatory national legislation" for reducing greenhouse gas emissions.

Coal-fired power generators are looking for ways to keep older plants running and reexamining plans for new plants. Among their most promising options are relatively low-cost optimization technologies, which can reduce CO_2 emissions as a function of improved boiler efficiency and heat rate. Compared with hardware-based alternatives and physical retrofits, optimization preserves existing assets, requires significantly lower capital investment and maintenance costs, minimizes installation lead time, and delivers a flexible solution platform. When combined with hardware-based approaches, optimization can make even greater contributions towards lowering CO_2.

A 2.5% heat rate improvement at a 350 MW plant burning 1.7 million tons of coal each year will avoid approximately 108,000 tons of CO_2.

A solution that's ready, now

Lowered CO_2 is already being realized at plants using optimization, particularly ones that combine solutions for soot, combustion, maintenance and performance. Collectively, these solutions can improve heat rate by roughly 2.5%, which results in less coal consumption. On average, each ton of coal burned generates roughly 2.75 tons of CO_2. So a 2.5% heat rate improvement at a 350 MW plant burning 1.7 million tons of coal each year will avoid approximately 108,000 tons of CO_2.

Managing tradeoffs

While CO_2 is the "emission du jour," power plants will need to address this greenhouse gas while balancing other, often competing, objectives under tight constraints. Optimizers are able to learn an individual plant's complex process relationships, and dynamically determine optimal set points for achieving multiple goals under strict constraints. With optimization, plants can lower CO_2 while continuing to achieve other important plant goals.

For more discussion about CO_2 and how power plants are addressing pending regulations, visit www.TheOptimizationBlog.com and read Peter Spinney's blog post: *Coal-Gen 2007: Reflections On All That Has Changed In A Year*. ■

INSIDE

Customer Spotlight

NRG Big Cajun II

The Big Cajun II power plant has a track record of embracing innovations and technologies that improve plant performance. In 1999, Big Cajun II decided on a relatively new technology — combustion optimization software — and purchased NeuCo's CombustionOpt®. Since then, the plant has evolved and grown, and so has their application of optimization technology.

Recognizing an opportunity for improvement

Owned and operated by NRG Energy, Big Cajun II is a coal-fueled power plant located outside of Baton Rouge, Louisiana. In the late 90's the plant sought ways to improve heat rate and their ability to profitably sell power on the wholesale electricity market.

"We had already addressed the major hardware issues, so optimization was the next step," said Winston Hunt, senior control specialist at Big Cajun II.

Big Cajun II installed CombustionOpt on two 575 MW Riley Turbo boilers and soon realized significant results. Overall, CombustionOpt increased plant efficiency while simultaneously significantly dropping NOx emissions. The plant subsequently installed CombustionOpt on a third unit, a 600 MW B&W opposed-fired unit retrofit with overfire air and low-NOx burners and saw similar improvements in performance and emissions.

Continuing improvement

Based on their success with CombustionOpt, Big Cajun II decided to add PerformanceOpt®, which is currently being installed on Unit 1. "We wanted to further improve our heat rate, reliability and operational consistency," Hunt explained.

PerformanceOpt continuously monitors unit operations, alerts users to gaps between actual and achievable unit efficiency and capacity, and calculates the impact of those gaps so that users can prioritize actions. It also enhances CombustionOpt's performance by providing it with real-time knowledge about thermal efficiency and coal quality.

Big Cajun II is also upgrading to the latest version of CombustionOpt on its three units. "We want to take advantage of the enhanced functions," Hunt said. The new version will also give Big Cajun II operators greater visibility into the optimizer's actions — a critical attribute for Cajun's operators who use the software on a daily basis. ■

Join the Conversation at The Optimization Blog

Our new blog is place for NeuCo, customers and others who care about asset optimization to connect. Just launched, this feature of NeuCo's website is a place where optimization experts will be blogging about everything from optimization applications, emissions regulations, and NeuCo's own product development to trends in the power generation industry. It's also a place where customers can share their thoughts and insights on power industry issues, and talk to NeuCo about their own optimization experience.

Having an ongoing conversation with customers is key for providing solutions that address your most important power plant needs. So join the conversation at www.theoptimizationblog.com, or click the blog link at www.neuco.net.

New Members Spotlight

NeuCo welcomes the following new customers to its ProcessLink user group:

- Allegheny Energy Harrison Station
- Alliant Energy Edgewater Generating Station
- Ameren Duck Creek
- Exelon Eddystone Generating Station
- We Energies Pleasant Prairie Generating Station

A Primer on Optimization

Direct optimization, model predictive control, neural networks... it can get a little confusing. To help you figure it out, here's a quick primer on some of the optimization and modeling approaches used in the ProcessLink® platform.

What is Optimization?

Optimization is about taking actions that extract the best possible results from a process. ProcessLink supports *direct* and *model-based* optimization.

Direct Optimization

With direct optimization, the optimizer improves a process by taking an action and comparing the result to the process' previous state. For example, if an optimizer is trying to improve NO_X emissions by manipulating secondary air dampers, it would apply a damper bias. If the action improved NO_X, the optimizer would take another action in the same direction. This trial and error approach is repeated, as the optimizer continually searches for improved operating performance.

Model-based Optimization

With model-based optimization, the optimizer searches a model of a process to determine what actions will provide the best results. This allows a more complete search to be carried out before an action is taken. The primary model-based approaches used in ProcessLink fall into two categories:

Numeric Optimization

A mathematical engine called a *solver* uses an algorithm to search possible action combinations for the one that leads to the best result. For example, CombustionOpt® uses numeric optimization to determine the optimal fuel and air mixing ratios in the boiler to improve NO_X and boiler efficiency within constraints such as CO limits and fan amps. By leveraging neural network models that capture the relationships between all variables impacting the process, the solver finds and implements the combination of air and fuel biasing which will keep the firing concentration at its optimal performance.

A variation of numeric optimization used for certain highly-dynamic situations is model predictive control (MPC). Within a specific time horizon, MPC predicts all *future* outputs of a process based on changes made to the process' inputs *now*. After determining the action associated with the best future performance, the action is taken and the process is repeated. MPC is a valuable tool for reheat and superheat temperature control because of its ability to predict the future impacts on steam temperatures from all measured disturbances, and to map available actions.

Rule-based Optimization

The optimization search is driven by an *inference engine*, which provides a way to rank a set of possible actions that are described in the form of situation-action rules. One type of inference engine is *Propose-Apply*, in which possible actions are proposed and then compared with one another until the optimal action is found. SootOpt® uses this form of optimization, in addition to numeric optimization, to search a set of proposed soot cleaning actions for the best one to take next.

The Foundation: Modeling

Models are representations of processes that can be used for optimization. ProcessLink uses three types of modeling:

First Principles

First principles models use proven equations based on the laws of physics and chemistry to represent processes. This type of modeling is only possible when there is a complete understanding of the physical laws governing the process in question. PerformanceOpt's® thermodynamic model of the boiler and steam cycle is an example of first principles modeling.

Neural Networks

Neural network models start with data and "learn" relationships between a process' inputs and outputs, in much the same way that the brain does. A neural network model is able to map complex action-response relationships by observing the process in action. This type of model is flexible and able to adapt its own structure based on its experience. CombustionOpt uses neural networks to model the highly-complex, non-linear combustion process, and MaintenanceOpt® uses neural networks to model things such as turbine bearing vibrations in order to find behavioral anomalies.

Heuristics

Heuristic models represent knowledge in the form of situation-action rules. Instead of attempting to fully represent a process, heuristic models use knowledge to opportunistically represent situations in which experts know what to do. For instance, SootOpt uses heuristic models to describe what sootblowing actions will achieve a desired response, and MaintenanceOpt draws from hundreds of heuristics to direct the user through a diagnostic decision tree and get to corrective action.

ProcessLink Brings It Together

No single modeling or optimization approach is "best" for all situations, and many situations require a hybrid approach. ProcessLink, the technology platform that supports and integrates all NeuCo solutions, can combine modeling and optimization methods to address the broad spectrum of optimization challenges. This integrated platform approach enables ProcessLink to apply the best method or combination of methods for the application at hand, and allows plants to optimize holistically across processes and systems. ■

Employee Spotlight

Camilla Podowski, *Sales Program Manager*

Describe your role at NeuCo and how you've grown within the company. I started working as a project manager two weeks after we got the award for the first DOE CPPI project. I spent the first couple of months getting an organizational structure around the project. Since then, I've ventured into all different fields including Product Management, Sales, and Contracts.

How does your background affect your perspective and approach to work? I think my first job out of grad school as a nuclear engineer really got to me. I'm obsessed with having processes in place — I'm attracted to "chaos" scenarios, probably because I get satisfaction out of "tidying things up" (and yes, sometimes this will take me into places like the copy room in our Boston office with a large black, plastic bag).

What do you find most challenging about the power industry? That it is fairly regulated and thus sometimes slow to adapt to new ideas.

What excites you about working for NeuCo? The people — everyone's intelligent, fun, and committed! NeuCo has an open-minded culture that embraces different nationalities and work-hours, and gives people chances to try new things like working remotely or a new role within the organization.

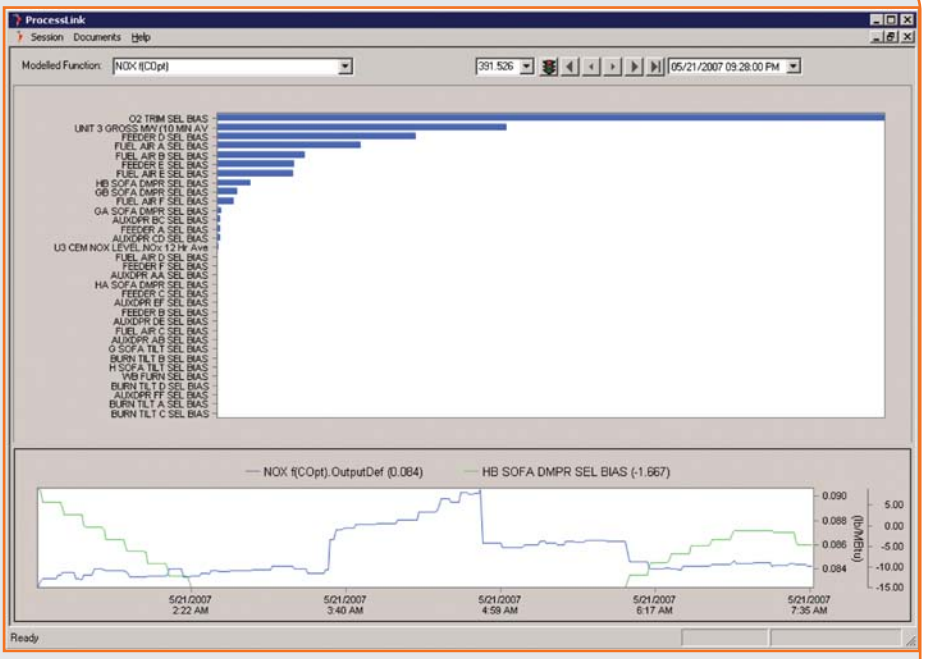
Living in California, what are the ups and downs of working from a remote location? The down is that I'm not in the office and can't interact face-to-face with people. The up is that it's always sunny in California and my commute is about 10 steps!

What's your favorite activity when you come to Boston? Sleep! Having two kids under seven and spending a few nights in a hotel is like a vacation. And of course — hanging out with NeuCo employees — both during and after work! ■

Tech Tips

Model Causality Analysis

One form of model analysis available in ProcessLink is Model Causality, a powerful tool for querying models to learn cause and effect in a complex multivariable environment. Model Causality Analysis can be used to determine which model inputs had the greatest (or least) impact on the model's prediction of a particular event. For example, if a positive or negative NOx event occurs, you can query the model to find out which levers used by the Optimizer had the greatest influence on that event.



ProcessLink's Model Causality Analysis View

Causality is estimated by running a sequence of scenarios where, one by one, each of the inputs to the model is held constant. The ability of the model to predict the value of interest is evaluated for each of these scenarios. The causality analysis ranks, and presents in order, the contribution of each model input to the model's prediction of an event. This can be a valuable tool for gaining deeper operational insight.

User Tip: To run a causality analysis, go to the Model Trend View under the models tab. To invoke a Model Causality View:

1. Left-click and drag the cursor to select the desired period of time or event. Ensure you select a period in which the model prediction tracks the actual value of the process variable.

2. Right click on the chart area to bring up the context menu. Where a model is present this menu will show a causality option.

3. Two charts are then displayed: a Causality Bar Chart and a Model and MV Trend Chart. The Model and MV Trend Chart displays the model prediction along with any model input that is selected by clicking on the bars of the Causality Bar Chart (shown above). ■