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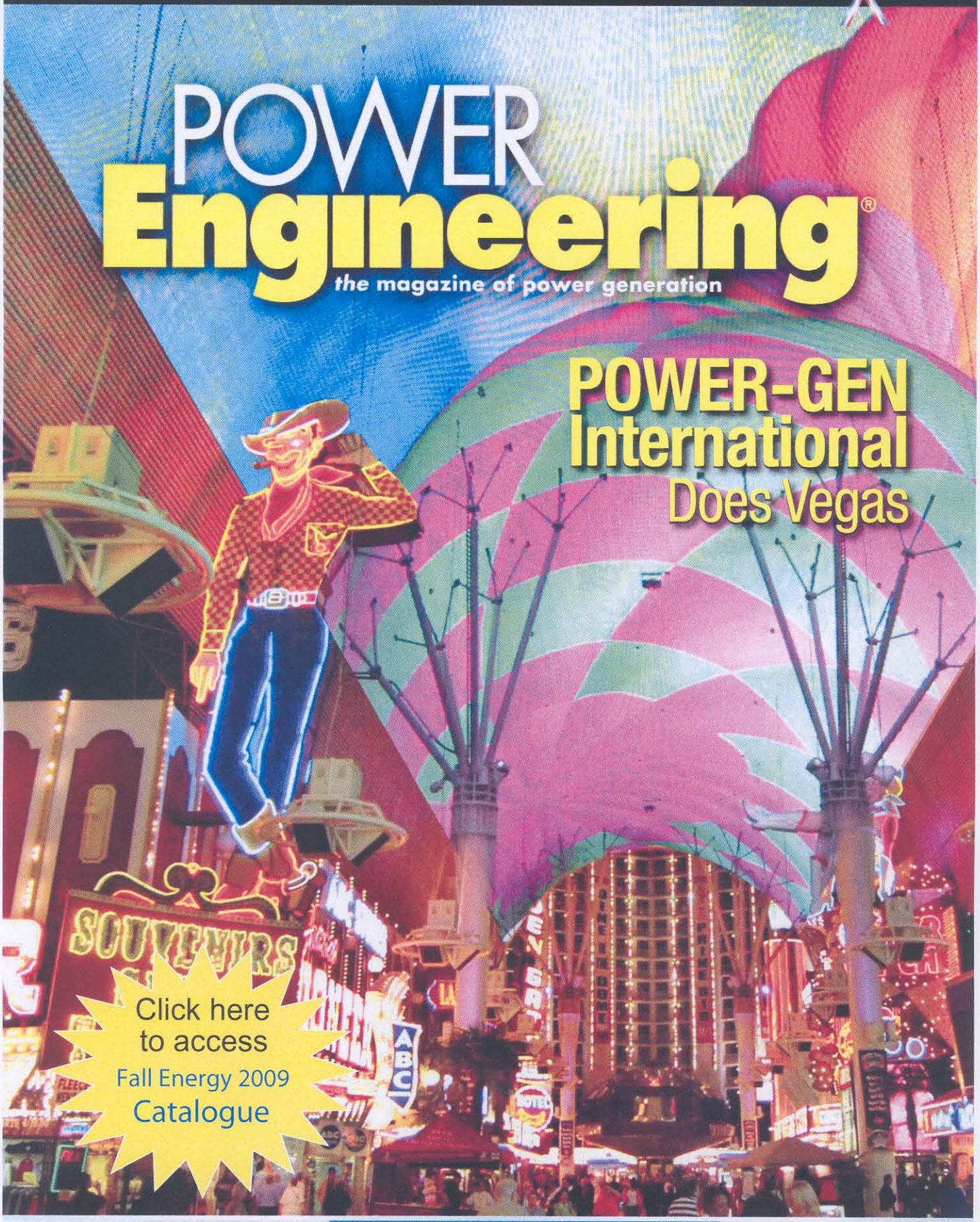

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An Opportunity to Improve Coal-fired Generation Efficiency

Given public sentiment about reducing greenhouse gas emissions, the existing fleet is in the crosshairs as offering the best opportunity for reductions.

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Historically, "best in class" performance in the generation sector has equated to high plant availability; benchmarking or other comparison methods have been successfully used within the industry to identify gaps and improve sector performance overall. With the advent of deregulation in the industry and the growth of independent power production, availability is often viewed within a commercial context rather than an absolute performance context: how to assure the plant is available when it is likely to be dispatched (to make money). This has led to the creation of new metrics (a.k.a. commercial availability metrics) to be used when assessing true best-in-class performance.

Measuring best-in-class performance is likely to grow more complex if energy efficiency moves to the forefront and CO_2 footprint become a more visible measure of performance. Applying efficiency metrics is not without its challenges. In fact, application of efficiency metrics has many parallels to that of commercial availability—lack of adequate data, different measures and different economic "value" among markets and participants, to name a few. Hence, does the opportunity to improve existing power plant efficiency warrant industry focus? And, if so, how does one best orchestrate a large-scale industry drive to address the opportunity?

Is There an Opportunity?

To evaluate the opportunity, the National Energy Technology Laboratory (NETL) embarked on an effort to study and assess the magnitude of the potential for U.S. generating units. NETL estimates that a reduction in U.S. greenhouse gas emissions on the order of 150 million metric tons (MMmt) of CO_2 per year could be realized by driving fleet performance levels to that of the highest performers. (In 2007, 10 percent of the coal-fired generating capacity in the U.S. operated at an average efficiency of 37.9 percent, significantly higher than the industry average, 32.5 percent. Efficiency is defined

U.S. COAL-FIRED POWER PLANTS RANKED BY EFFICIENCY

Decile	No of units	Net nameplate capacity (GW)	Capacity factor	2007 total generation (BkWh)	2007 generation-weighted efficiency (HHV)
1	181	30	67%	177	26.5%
2	108	30	70%	180	30.0%
3	90	30	73%	189	31.0%
4	73	30	73%	189	31.7%
5	84	30	75%	194	32.4%
6	75	30	69%	181	33.2%
7	79	29	71%	182	34.0%
8	70	30	70%	186	34.9%
9	57	29	72%	184	35.9%
10	46	30	74%	192	37.9%
Overall	863	297	71%	1,856	32.5%

by usable energy (busbar energy generated) divided by energy in (as received heat content in coal).

Further, if a proportionate level of improvement could be achieved worldwide, an additional 850 MMmt CO_2 per year of reductions could be realized. This would equate to an opportunity of roughly 1 billion metric tons CO_2 per year. This figure is supported by work of the World Energy Council Performance of Generation Plant (PGP) committee, which has focused on the broad issue of benchmarking plant performance and costs, and more recently, on the CO_2 issue. Based on their work, "taking into consideration the performance improvements already achieved at power plants around the world, it is estimated that if the average level of performance for power plants worldwide were to achieve the same level, savings of approximately US$80 billion per year could be made. In addition, GHG emissions worldwide could be reduced by one billion tonnes (10^9t) CO_2 per year."

In Figure 1 on page 122, all the coal power plants in the U.S. were ranked from most efficient to least efficient (based on 2007 performance) and then divided into 10 groups (deciles) of equivalent capacity. The analysis shows a wide range in efficiency: the top decile efficiency, 37.9 percent, is five percentage points higher than the overall average. The wide range is a function of plant design and condition, operations and maintenance practices, fuel quality and site conditions. Hence, substantially different opportunities for efficiency improvement exist across the fleet.

Can This Opportunity be Captured?

The current situation—with significant and rising public sentiment around reducing greenhouse gas emissions—will likely lead to future adoption of a policy that focuses on the near-terms results. This places the existing fleet in the crosshairs as the best opportunity for significant reductions. At this point, the question turns toward, "Do we have the tools to do it and do we have the policy/regulatory framework to support rather than derail the process?"

Over the past two decades, industry has shown the ability to improve asset availability in spite of an aging fleet. If we view efficiency improvement through the same lens, one could surmise that adequate levers to improve efficiency either in the form of operational tools or via plant modifications must exist and be coupled with adequate incentives. In July 2009, NETL hosted a workshop with industry professionals to discuss the coal power

efficiency opportunity. The participants recommended a number of practical steps that could improve power plant efficiency, including the following:

- Hire and train operations engineers at each generating unit. (Such positions used to be standard at power plants but have become rare.)
- Apply tools for measuring efficiency, identifying issues and quantifying heat rate or capacity deviations and differential emissions.
- Conduct audits at generating units to identify heat exchanger fouling, leaks and other issues; shut down for maintenance more frequently.
- Upgrade instrumentation and control programs and reduce air firing.
- Install variable speed drives for motors for mid-load duty cycles.
- Install coal drying and feed water heating systems that use waste heat.

It was noted at the workshop that the majority of ideas offered for improving power plant efficiency would not trigger New Source Review (NSR) and could be deployed within conventional operations and maintenance programs. Other, more dramatic efficiency improvement options including turbine upgrades would need to be addressed with NSR requirements. A copy of the workshop report can be downloaded at http://www.netl.doe.gov/energy-analyses/index.html.

What are the Obstacles?

Industry experts frequently cite the risks associated with triggering NSR as the No. 1 issue that inhibits aggressive action for efficiency improvement. The risk that such improvements might also increase plant output or reliability—triggering NSR requirements—has stymied projects that would or could improve efficiency. For substantive investment in capital improvements targeted at plant efficiency, issues with NSR must be addressed.

Temporarily parking the NSR issue to the side, what keeps the industry from adapting an aggressive efficiency improvement posture? Over the past few decades, coal power plant efficiency has been compromised by a number of factors outside of NSR including: 1) fuel cost pass-through, 2) uncertainties in plant life and/or role within the generation fleet and 3) the attractive margins for coal-fired generating units that could be realized without optimizing heat rate. Many coal-fired generating units operate in a system where fuel costs are passed through to the rate base. Such structures are designed to protect utility companies from swings in fuel costs. They have the consequence, however, that the generating unit owners have limited financial incentive to reduce fuel use. With plant roles being more uncertain given age and political liabilities, any shutdowns for proactive maintenance or equipment upgrade must be worth the lost earnings due to downtime and be consistent with the generator's strategy. The magnitude of operating revenues from a coal-fired generating unit relative to the cost for fuel has made it easier to reduce focus on efficiency.

A fourth impediment to high efficiency at coal-fired power plants, ironically, lies with fuel-switching strategies used to comply with sulfur dioxide emissions limits. Many plants with boilers designed for bituminous coal are instead burning low-sulfur sub-bituminous coal. Efficiency from sub-bituminous coals will be intrinsically lower due to higher moisture content; however, further efficiency impacts may also result from a unit not being designed or fully modified to mitigate the coal's impact on efficiency.

It is interesting to note that obstacles cited are not technological or even that costly given returns on investment possible in terms of fuel/environmental costs. Rather, the obstacles that are largely regulatory in nature—NSR and fuel pass-through—greatly diminish the incentive for improving plant efficiency. Experts cite the need to tie energy policy to regulatory reform if these obstacles are to be properly addressed.

How to Measure Results?

Our last hurdle lies in means to establish performance targets and to measure performance against such targets. Means for establishing valid performance targets at the individual generating unit should consider unit design and condition, fuel, environmental equipment present, load shape and capacity factors. Such data are not generally available within current reporting structures.

At the workshop, NETL staff presented a multi-variable regression analysis that compared the characteristics of the top 10 percent efficiency coal-fired generating units to the overall population. The idea is that the most efficient generating units may have characteristics amenable to high efficiency

that cannot be emulated at all units. For example, the most efficient plants may, on average, burn higher fuel content coal. The analysis indicated 35.5 percent as an average efficiency target for the U.S. fleet if all the power plants achieve operation and maintenance practices consistent with the top 10 percent cohort. The 35.5 percent efficiency target assumes that all generating units that are refurbished to improve efficiency are refitted with SO_2 and NO_x controls. Industry participants suggested that more detailed design data about each plant was needed to conduct a proper analysis; some plants are not designed for as high efficiency as others. NETL is gathering data needed to conduct a more robust analysis and hopes to publish a report on the coal power efficiency opportunity by the end of the calendar year.

Some of the work required to measure performance and performance improvement might be realized via need for both formalized requirements for greenhouse gas reporting and the opportunity to measure and transact against CO_2 offsets generated within the fleet should a CO_2 market and cap-and-trade program be implemented.

Improving the efficiency of coal-fired power plants is an idea for greenhouse gas mitigation that merits more attention and discussion than it has received. The opportunity is substantial, tangible and do-able in the near-term. Incentives (and the removal of dis-incentives) are all that is needed for "efficiency" to become the next industry standard for "best in class." pe

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