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VIA FAX AND OVERNIGHT MAIL

November 20, 2007

Ms. Elizabeth O'Donnell
Executive Director
Kentucky Public Service Commission
211 Sower Boulevard
Frankfort, KY 40602

RE: Consideration of the Requirements of the Federal Energy Policy Act of 2005 Regarding Fuel Sources and Fossil Fuel Generation Efficiency, Admistrative Case No. 2007-00300

Dear Ms. O'Donnell:

Enclosed are the responses of Duke Energy Kentucky, Inc. to the First Set of Staff Data Requests in the above-referenced cases.

If you have any questions, please contact me at 513-419-1843.

Sincerely,

John J. Finnigan, Jr.
Associate General Counsel

JJF/bjl

Enclosures

cc: All parties of record (w/encl.).

KyPSC-DR-01-001

REQUEST:

Provide the following for each unit

a. What was the heat rate (Btu/kWh) at the time of initial operation (both name plate and actual experience)?

b. What is the heat rate today?

c. Identify the actions that the company has taken that have impacted heat rate and identify whether the actions have had a positive (by lowering the heat rate) or negative impact (by increasing the heat rate).

RESPONSE:

There is no one "name plate" heat rate value for a unit, the "actual experienced" heat rate is a continuum. Units are designed to operate the most efficiently at or near their full load condition. It is not unusual for a unit to see at least a 10 to 15% increase in heat rate from a full load state to a minimum load state. There is heat required to get a unit started up that is not accounted for in the design heat rate curves. The more a unit is started up and shut down the higher the amount of heat required that does not generate any MW thus raises the net heat rate.

a. Initial year readings are based on Duke Energy historical records. Miami Fort 6 operated at an average of 108 net MW (NMW) out of 163 NMW possible during its first year, 1960. At that NMW level its design heat rate would have been 9,293 Btu/kWh. It actually performed at 9,414 Btu/kWh. East Bend operated at an average of 441 NMW out of 600 NMW during its first year, 1981. At that NMW level its design heat rate would have been 10,004 Btu/kWh. It actually performed at 10,233 Btu/kWh. Woodsdale station, units 1 through 6, operated at an average of 251 NMW out of 564 NMW during its first year, 1993. At that NMW level its design heat rate would have been 15,375 Btu/kWh. It actually performed at 18,406 Btu/kWh.
b. Per FERC Form 1 Reporting: Miami Fort 6 2006 annual heat rate was 10,409 Btu/kWh at an average of 131 NMW out of 163 NMW. The East Bend 2006 annual heat rate was 10,283 Btu/kWh at an average of 587 NMW out of 600 NMW. Woodsdale station's 2006 annual heat rate was 32,404 Btu/kWh at an average of 16 NMW out of 564 NMW.

c. There have been various equipment changes that have negatively impacted heat rate. Miami Fort 6 has added 2 sets of precipitators, removed and not replaced one stage of Intermediate Pressure (IP) turbine blading, and replaced condenser tubing with lower heat transfer capability but higher availability tubing. East Bend has added and SCR for NOx reduction (more fan power required from increased pressure drop of SCR), upgraded the FGD, increased coal SO2 level which requires more auxiliary power for the FGD, , installed more low NOx burners (usually reduce boiler performance). Woodsdale is being dispatched by MISO mostly at extremely low loads, about 5 MW per unit, most likely for system spinning reserve requirements. The ability of the Woodsdale units to operate from 5MW up to 94MW is very useful for MISO, as these units can be used to cover the morning and evening rapid load changes that occur quicker and than coal units.

   Routine maintenance items are done to improve the heat rate of the system. Turbine overhauls have significant positive heat rate impacts. These types of overhauls usually occur beyond every 10 years. Over time these benefits will degrade. Other more routine maintenance work that is done much more frequently also can improve the efficiency of the generating system. Condenser cleaning, pulverizer overhauls or tuning, and pump overhauls are such examples. These types of maintenance items are done on an as needed basis however occur more frequently than turbine overhauls. Specific improvements to East Bend include a re-tubed inner loop of the condenser, improved cooling tower performance, and lessened winding losses by going to a water cooled generator stator.

PERSON RESPONSIBLE: Steve Sandfoss

KyPSC-DR-01-002

REQUEST:

What is the average system-wide heat rate?

RESPONSE:

The 2006 annual net heat rate for the Duke Kentucky units (East Bend, Miami Fort 6, and Woodsdale 1-6) was 10,449 Btu/kWh utilizing the FERC Form 1 data.

PERSON RESPONSIBLE: Steve Sandfoss

KyPSC Staff First Set Data Requests
Duke Energy Kentucky Case No. 2007-00300
Date Received: November 15, 2007
Response Due Date: December 5, 2007

KyPSC-DR-01-003

REQUEST:

What technologies are available for increasing the efficiency by lowering the heat rate of installed fossil fuel generation? What are the costs and benefits associated with these technologies?

RESPONSE:

The net heat rate of fossil fueled generating units is the energy conversion (coal to electricity) result of several systems and the power and energy necessary to operate those systems that make up the entire "generating unit." For a typical modern coal-fired unit these systems include, but are generally not limited to, depending on the individual unit design and age, the following: fuel (coal) unloading and handling, fuel preparation (coal pulverizing), combustion air handling (forced draft, induced draft fans and combustion air heaters (steam and waste flue gas)), boiler water treatment and handling (demineralizing and feed water heating, boiler feed water pumping), the boiler itself and all of its water/steam pathways and combustion pathways (ducts, etc.) and heat transfer surfaces (super-heaters, re-heater, economizer, etc.) the steam turbine-generator itself and its related systems (blading in various stages, seals between stages, lube oil, etc.), steam condenser to cool and condense the turbine exhaust steam back to boiler feed water, cooling towers and related systems to cool the condenser, ammonia transfer and injection to selective catalytic reduction (SCR) system for NOx control, electrostatic precipitator (ESP) field energizing power and rapper power to clean the plates for fly-ash capture, for flue gas de-sulfurization (FGD) to control sulfur emissions - limestone or lime unloading, lime and limestone preparation to make FGD slurry, FGD slurry pumping, FGD oxidation air compressing and injection, FGD waste dewatering, and handling. All of these systems generally require auxiliary power and energy to operate, or otherwise have an impact on the efficiency of the entire energy conversion system, that lowers the net output and efficiency of the generating unit's ability to produce electricity.

The net heat rate is also impacted by how the unit is operated. That is, a unit's most efficient operating point, where all the equipment mentioned above operates at its best efficiency, is at or near full load. If for system reasons, the unit must operate "off" this point or follow load going up-and-down on a minute-by-minute basis, overall net efficiency is adversely impacted. In addition, in the case of East Bend Unit 2, which has two joint owners, each owner may operate their share differently thereby impacting the net heat rate for the unit. Finally, it is important to note that some apparent net heat rate "improvements" or "degradations" over time may be the result of changes in accounting practices and procedures, or other administrative impacts, rather than actual physical changes or improvements. That is, the process and procedures by which purchased fuel, fuel "used," and/or fuel remaining in inventory is accounted for, measured, and/or weighed. Things like improvements to "scales," or changes in electric metering, metering points, or methodologies for determining auxiliary power usage, could be examples of changes of this type.

With that background, there are generally two "types" of heat rate improvement projects that may be performed. The first type, generally involves extensive routine maintenance to the existing equipment that makes up the "unit," as discussed above, to bring it back to original performance. This can typically involve both capital and operation and maintenance (O&M) expenses. This type can be considered a "non-sustainable" heat rate improvement, as the equipment will wear and degrade once again in operation after the investment has been made. The second type, generally involves fundamental improvements in, or modifications to the original design basis of the process. This typically always involves major capital expenses. This type can be considered a "sustainable" heat rate improvement, as it typically represents a baseline shift in the performance of the unit.

The first type, the non-sustainable heat rate improvement projects, are usually performed during regularly scheduled maintenance outages. However, it is typically neither feasible nor economic to attempt to bring equipment all the way back to original performance. For example, patching holes in ductwork reduces air in-leakage and improves the efficiency of the boiler. However, it is not feasible to eliminate all ductwork leakage. The entire duct would need to be replaced with like-kind new material. This would only accomplish a very small incremental improvement over selective patching, but would obviously cost much more (diminishing returns).

Similarly, for steam turbines, for example, leading stage turbine blade rows are often replaced as maintenance items during turbine overhauls. This is because they operate under the most extreme conditions within the turbine, and typically take the brunt of solid particle damage. Replacing all of the blades on the turbine every time would result in the maximum performance improvement, but replacing just the select few blade rows accounts for most of the benefit. Therefore, once again, significant additional cost would yield little realized additional benefit (which would again deteriorate significantly within just a few years of operation).

Hence, heat rate generally tends to "see-saw" between major maintenance activities, deteriorating gradually during operation, and then making step change improvements after major maintenance is performed. However, original design performance is not re-attained given the reasonable limits of equipment maintenance. As a comparative example, the fuel economy of a car tends to degrade with time as it is driven. Spark plugs foul, fuel injectors foul, fuel filters plug, air filters plug, tire tread and inflation change, etc. Hence, most people invest in their cars with periodic maintenance to correct these deficiencies. However, it is not common to replace piston rings, valves and valve seats, torque converters, or even tires, on any given maintenance cycle. Such major investments could be made, and would result in improved fuel economy, but would invoke excess cost for little realized benefit. Thus, such types of maintenance are typically not performed.

The second type, those that produce a sustainable baseline shift in efficiency, the fundamental design of the process must be improved. This requires process and multidisciplinary engineering design activities, and usually results in issuances of new documentation such as drawings, performance curves, and operating/maintenance manuals. Often, major changes to the structure or facilities must be made to accommodate the new technology being applied.

Opportunities for achieving fundamental process improvements are limited. Some examples include upgrade of the complete steam turbine to modern design "dense pack" technology, applying advanced controls to electrical components (such as replacing all constant speed motors with variable frequency drives), or conversion of an entire steam-cycle process from operating at sub-critical conditions to operating at supercritical conditions (basically a replacement of the boiler pressure parts and steam turbine/high energy piping systems). These types of projects can achieve 3% to 6% improvements in heat rate (not percentage points of efficiency, but percent improvement in original heat rate) that may be sustained. Once again, however, after the initial retrofit, the efficiency will degrade during operation. It will again "see-saw" across a lower baseline value than the previous pre improvement design.

Obviously, these types of retrofit projects are capital and labor intensive. They can range from ten million dollars for a new steam turbine, to hundreds of millions of dollars for a boiler conversion, and can take unit outage time from months to years to implement. In addition, these types of major projects tend to trigger a New Source Review (NSR) analysis. It is possible that, in order to execute these types of projects, additional cost would be incurred to comply with the latest pollution control requirements to make the unit comply with New Source Performance Standards (NSPS). This could, and usually does on older smaller units, outweigh the economic benefits of improving the heat rate or efficiency of the unit.

Continuing with the car example, these types of major projects could be compared to completely replacing the car's existing engine with a new hybrid drive train. This could require changes to the vehicle's frame, interior, and exterior in order to accommodate the new components (batteries, motors, transaxle, etc.) that the original design of the car did not consider. This would result in significant and ongoing fuel economy improvement, but would also be very expensive and result in excessive down-time for the car during the conversion.

PERSON RESPONSIBLE: John G. Bloemer

KyPSC-DR-01-004

REQUEST:

What is a reasonable goal for heat rate improvement (lessening the heat rate) over a 10-year planning horizon for individual generating units and the company's fleet of fossil fuel generation?

RESPONSE:

Unfortunately, due predominantly to the recently issued Clear Air Interstate Rule (CAIR) and Clear Air Mercury Rule (CAMR) which require reductions in the emissions of SO2, NOx, and Mercury, heat rate is likely to degrade (increase) in the next few years, as opposed to improve (decrease). This is because additional environmental controls are being installed on many units in the nation. These controls consume additional auxiliary power, and that reduces the amount of power that the unit can send to the grid (or conversely, increases the amount of fuel that must be burned to maintain the same net power output). This increases the net heat rate of the unit. In addition, most units would have received normal maintenance during the extended outages usually required to "tie-in" these new environmental controls. As a result, they are already at the "valley" of the heat rate "see-saw," and should expect to see degradation in the near term, not additional improvement.

Specifically, in the case of Duke Energy Kentucky's East Bend Unit 2, the unit must begin annual operation of the existing selective catalytic reduction equipment (SCR) for NOx control beginning in 2009. This will annualize the heat rate impact that the unit is already experiencing during the ozone season operation of that equipment. In addition, the flue gas desulphurization equipment (FGD) on the unit was recently upgraded to increase the removal efficiency of SO2. This also requires additional auxiliary power that will increase heat rate relative to history in perpetuity.

Also, in the case of Duke Energy Kentucky's Miami Fort Unit 6, the unit has recently received a low NOx burner upgrade. Typically, low NOx operation of the boiler results in increased unburned carbon in ash which increases heat rate. Also, while no other CAIR/CAMR compliance projects are currently planned for Unit 6, it is very likely that the unit will be forced to different fuel supplies in the future in order to comply with CAIR/CAMR. These fuels will likely require enhancements to the particulate controls (ESP) on the unit, resulting again in increased auxiliary power usage and higher heat rates.

Additional impacts of the CAIR/CAMR implementation over the next several years will be the impacts to the price of SO2 and NOx emission allowances, and for the first time bring in the price of mercury allowances. All of these are incorporated into the dispatch price of the unit, and these changes may result in a change in operation compared to historical levels. As a result, the net heat rate may be impacted by any change in unit operation (see response to KYPSC-DR-001-003 on how unit operation may impact heat rate).

As discussed in the response to KYPSC-DR-001-003, some improved technology could be applied to change the fundamental energy conversion process which may, prevent degradation of, maintain, or slightly improve, current or future expected net heat rate, but NSR concerns remain.

Finally, with the risk of some type of CO2 reduction legislation and/or rules looming, East Bend Unit 2 is a candidate unit (larger unit currently with SCR and FGD equipment) to test developing technologies for CO2 capture and sequestration. The site is already hosting a US Department of Energy Phase II CO2 Sequestration Study involving the drilling of a test CO2 injection well. If, in the future, the unit is host to a CO2 capture technology demonstration, it could result in a significant increase in heat rate (up to 30% increase or more depending on the technology and level of implementation (CO2 capture percentage)). The current state of technology for CO2 capture systems is very energy intensive, and short of a major breakthrough in CO2 capture technology, any mandated control of CO2 emissions in the future will have a very dramatic impact on all existing and future fossil fueled generating units with large increases on net heat rate and a significant decreases in generating unit efficiency and net capability.

PERSON RESPONSIBLE: John G. Bloemer

KyPSC-DR-01-005

REQUEST:

Although the Integrated Resource Planning and Certificate of Public Convenience and Necessity processes allow for consideration of generation efficiency initially, is there any Commission mandated process that provides for continued consideration of generation efficiency?

RESPONSE:

The Commission can review records of the efficiency of a company's generating units at any time by requesting records pursuant to KRS 278.230. The Commission can investigate the efficiency of a company's generating units at any time pursuant to KRS 278.250. The Commission can request regular reports of the efficiency of a company's generating units at any time by requesting such reports pursuant to KRS 278.255. The Commission can conduct an investigation into the efficiency of a company's generating units at any time pursuant to KRS 278.260. The Commission can also review the efficiency of a company's generating units in connection with general rate cases, IRP cases and FAC cases.

PERSON RESPONSIBLE: N/A

KyPSC-DR-01-006

REQUEST:

How does the company consider generation efficiency on an ongoing basis after the initial operation of a generating unit? Are annual or periodic studies performed? Explain in detail.

RESPONSE:

As indicated in the response to KYPSC-DR-01-003, the Company performs periodic routine maintenance activities that are directed at recovering the majority of heat rate that is lost through equipment degradation during normal operation. This degradation is monitored at least monthly through a measurement of the unit heat rate (unit monthly net generation (metered) and fuel heat input (fuels accounting and measurement)). However, this determination of heat rate, like all other measurements, is subject to uncertainty. In the case of heat rate, for which typical values for existing coal fired units are 9,500 to 11,000 BTU/kWh, the measurement has an error band that is generally at least +/-100 BTU/kWh (or about 1%). The shorter the term of measurement (day, month, year), the higher the uncertainly is going to be. It should be noted that this monthly determination of heat rate is NOT the result of a formal unit heat rate test, like that might be performed during new unit acceptance testing to verify that a new unit meets performance and efficiency guarantees from the original equipment vendors. A heat rate test of this type is very labor intensive and expensive to perform, and as a result is not a routine practice.

As discussed in the response to KYPSC-DR-01-003, the efficiency of a unit also varies with the way it is operated. To expand on the discussion in KYPSC-DR-01-003, as capacity factor (how much the unit operates overall, the number of start-ups, etc.) and output factor (when in operation, the average load state of the unit) increase, heat rate tends to decrease as the unit is operating at more efficient load points. In addition, ambient conditions play a significant role in unit efficiency. As ambient temperature drops, boiler efficiency naturally decreases as there is more waste heat in the exhaust flue gas. Conversely, as ambient temperature increases, steam surface condenser performance degrades as the cooling water temperature increases. These effects are neither controllable nor recoverable. Therefore, due to measurement uncertainly, short-term variations in unit operations, and even ambient conditions, monthly heat rate trends do not necessarily demonstrate long-term degradation or improvement effects. Annualized heat rates are better suited for this purpose. Even then, operational impacts experienced on the unit from year-to-year can outweigh degradation or improvement and mask true equipment performance issues. For example, heat rate can decrease year-to-year if the unit is operating at more efficient load points, even as the equipment is degrading.

Conversely, heat rate can also increase year-to-year if the unit is operating at less efficient load points, even if the equipment performance is remaining constant.

As indicated above, even though it is measured and tracked, the total unit heat rate measurement is not necessarily indicative of how efficiency is being lost or gained. Only component-specific performance testing can determine this. Example tests include turbine section efficiency, boiler efficiency, air heater air in-leakage, steam surface condenser cleanliness and air in-leakage, pump performance, fan performance, cooling tower performance, etc. These types of tests are typically performed at least annually, while some, such as turbine section efficiency, may be monitored almost continuously via advanced tools available today such as plant operation information data collection systems and on-line performance monitoring software. Again, all of these measurements are subject to uncertainty. Periodically performed tests are typically more accurate than continuous tests, as they are usually performed more in-line with published industry test procedures and codes. Continuous tests, while useful for monitoring for step-changes in performance, are subject to additional uncertainties such as plant instrumentation calibration (versus using certified test instrumentation).

Once component-specific testing has been performed, the amount of total unit performance degradation that is actually recoverable must then be determined. For example, auxiliary power consumption may be measured and compared to original design to determine if an excess of power is being consumed internally. However, given the recent environmental retrofits (SCR, FGDs, etc.) auxiliary power consumption is much higher than original design, but this cannot be corrected or mitigated in any way, as these newly added components require power to operate. The associated net heat rate degradation is therefore unrecoverable. The same is true for a boiler efficiency test performed during the winter that shows low efficiency. The impact on the efficiency due to the ambient temperature is not recoverable.

Only long-term trends of multiple tests, corrected for unrecoverable losses, may indicate performance changes overall. These long-term trends, more than absolute values, in component performance are then factored into planning future routine maintenance activities.

PERSON RESPONSIBLE: John G. Bloemer