Replacement of an Onsite Environmental Data Acquisition System with a Virtual One

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In order to keep pace with the growing demands of data reliability and IT support of software systems, today's environmental professional must work closely with their DAS supplier to evaluate different system architectures. Basic data collection functions, risk management considerations, fundamental software design, quality of the device communications and human resource factors are a few of the underlying challenges facing the corporate CEMS Team when considering a DAS virtualization project. Successful implementation and execution requires planning, patience and a cooperative effort from all involved parties.

This paper addresses the successful implementation of a compliant air emissions data acquisition system within the virtual framework of a corporate IT environment. Key areas addressed in this paper include:

- Use of Virtual Servers and the associated risks when applied to DAS systems
- Virtual Server Implementation Strategy
- Management of Human Resources
- Lessons learned and future considerations

<u>Introduction</u>

Air compliance is an ever-changing world and with that change come new responsibilities and opportunities. The environmental manager at a typical power generation facility is always making adjustments to keep pace with the challenges of demonstrating compliance on a consistent basis. In recent years, they have dealt with more stringent air compliance rules, increased demands on data reporting accuracy and software integration changes to support new electronic reporting requirements. Couple the compliance tasks with the growing concerns about data security that may change plant operations, and the everyday environmental manager has the expanded role of integrating Information Technology (IT) requirements into the overall compliance model.

A prototypical stack emissions data acquisition system (DAS) is defined as a system made up of proprietary 3rd party software residing on a personal computer or server communicating with continuous emission monitoring systems (CEMS) and the plant DCS to build a comprehensive air compliance model. Over the years, advances in networking, browser technology and remote accessibility have evolved, but for the most part the original DAS model running as a stand-alone software system remained. The stand-alone DAS survives because it adequately satisfies its intended purpose. Environmental departments are able to defend the traditional DAS standard because the model is well-proven and reliable. The plant is able to operate productively, in part, because the DAS model works so well.

Although the independent DAS model still survives in most places it is now being challenged by the more stringent IT standards handed down to the plants by corporate directives. The days of independent computing systems are rapidly closing. Integrating IT into the environmental software process is becoming a requirement for environmental engineers. As new standards evolve, the DAS industry as a whole must be more accountable to end user requirements. This includes, but is not limited to information technology directives. Software as a service (SaaS) is the new battle cry of IT reliability and virtualization of hardware is a growing reality that merits consideration.

Our Case Study Project called for removing all local DAS servers and moving them over to virtual servers located in another State. The technological issues associated with a major change in environmental software policy are difficult to overcome, therefore the ability to get the electric generating plants to accept a new system is more daunting. Electric utilities are historically resistant to change. In general, anything new is met with skepticism and doubt. Many plants are wary of having IT involved in anything that is related to the operation of the plant or dealing with regulatory compliance because it violates the status quo. Adding a new virtual system removes the ability to touch an actual server increasing the perceived risk. As a result, effective change management is critical to the success of a project of this type.

This paper will address the technical, strategies and the human resource issues associated with replacing an onsite environmental data acquisition system with a virtual one. The traditional independent software system had adequately served the company's environmental needs well for years, but it would no longer pass the IT test. At the end of the process, 79 reporting units spread across 13 plants in Florida were collecting data on 18 virtual servers located in Raleigh, NC. It is the intent of this paper to present the results of this total solution process, which brought together the efforts of a well-defined project management plan, the operational excellence of site personnel and the use of state of the art, application specific software tools, to achieve a complete DAS system virtualization project.

Project Drivers

Progress Energy has defined its environmental vision as:

Progress Energy will consistently achieve excellence in our environmental performance in delivering on our commitment to safely provide reliable and affordable power. We are a forward-looking company that is dedicated to continual improvement in environmental performance and stewardship for the benefit of the communities we serve.

The Progress Energy environmental mission is further defined in the Corporate Responsibility Report. This report lists 5 areas of focus.

- **Compliance** - Comply with local, state and federal environmental laws and regulations.
- **Performance Accountability** - Maintain an environmental management system, including the use of objectives and goals to measure, track, drive and continually improve performance.
- **Minimizing Impacts** - Effectively manage waste streams and promote prevention of pollution. Take appropriate measures to prevent environmental degradation and be prepared to act effectively in the event of an environmental emergency.
- **Stewardship and Transparency** - Proactively address environmental issues and find innovative solutions to protect and improve the environment. Communicate environmental performance to stakeholders and support effective community efforts in environmental education, protection and conservation.
- **Management and Employee Commitment** - Assure that employees and contractors are aware of their individual roles in implementing this policy.

Any project that affects the environment must be aware of these areas and work to ensure that all rules and regulations are followed.

With this critical Environmental objective in mind, the two major goals of the DAS virtualization project were:

- Standardization of hardware and software
- Integration of the IT department into the DAS support model

Standardization

Standardization was a very important part of this project. When the evaluation process for the selection of a DAS vendor was started there were three critical needs in regard to standardization. First, the DAS software must be consistent throughout the organization. Every plant must run the same version of the software. Individual configurations could be different but the interface and tools had to be the same.

Second, the hardware interface between the analyzers and the DAS computer had to be the same at all sites. Proprietary hardware was discouraged but not excluded. PLC's were recommended as they could be purchased off the shelf from local distributors.

Third, the DAS must be based on Microsoft's Windows© platform and must run on the same PC hardware.

Integration of IT

The IT department has always been on the outside of the DAS looking in. They accepted this but did not like it. Both the plants and environmental organization preferred this separation as the interaction with IT had been historically adversarial. As part of this project it was important that this relationship be changed. The CEMS Team had been supporting the hardware and operating system software for 15 years and it was time that this responsibility be removed from their duties. Progress Energy has an extensive IT department with resources and technology expertise that needed to be leveraged. Instead of being bogged down with the information technology issues, the CEMS Team needs to be focused on ensuring that the DAS is properly monitoring and reporting compliance with the existing rules and regulations.

After the decision to involve IT had been made a list of requirements was created. A summary list is provided below.

- Supply and maintain all the DAS server hardware and operating system software
- Supply and maintain all databases
- Supply and maintain all client workstations
- Install/update server and client DAS software
- Use standard IT processes and procedures

The first 4 requirements are tasks that all IT departments handle. The last item was more difficult to implement as IT historically had limited interaction with the DAS. If existing processes and procedures could be used then the integration of IT would be much easier to accomplish. Anything outside of the norm would require additional work, IT involvement, managerial approval, and documentation to accomplish.

Risk Assessment

Prior to making any decisions about changing the air compliance data acquisition and handling system model at a power generation facility the project management team had to assess the risks associated with a major change in the way data is collected, stored and reported. Environmental Management, Operations and Information Technology all have to be considered. In order to best manage the risks the technical requirements and performance standards of the new software must be well defined.

Environmental Management must maintain the overall objectives of compliance. Daily functions, alarming, data collection and indicators of compliance have to be available real time and reliably communicated to the plant personnel. Reliability of data availability is a critical consideration when changing from a traditional DAS to a virtual one.

Operations charter is to maintain production while operating within the specified limits of compliance. In the case of a major software change that impacts compliance, operations must be assured that there will be no significant interruption to production. Changing a DAS environment to make it more IT supportable will only work if production is maintained with a high degree of reliability.

IT sees risks in support issues and potential problems with software systems that fall outside the corporate domain and directives. Their goal is to bring standards and consistency to all software used throughout the corporation. To this end, IT felt the need to define their requirements before Progress considered a DAS change.

Project Overview

The risk assessment analysis resulted in a decision to replace the existing DAS at all of the Progress Energy generating facilities located in Florida. Table 1 provides a detailed list of the plants and types of units that were affected.

The Site Description column (Table I) offers insight to the monitoring profile for each site and provides the software supplier with an overview of the data validation, logging and reporting requirements associated with each source/unit type. In terms of software demands as they apply to Acid Rain compliance, the Site Description column coupled with the Monitoring Plan and the Air Permit tells the DAS vendor everything they need to build the compliance engine of the software. Site specific sources were further defined as being either CEMS-based monitoring or Appendix E predictive monitoring at the unit level.

CEMS-based units were grouped virtually to match current plant/unit level DAS systems and CEMS control hardware was standardized with PLCs. The Appendix E units were combined, placing the data from multiple peaking facilities into a common Appendix E virtual server. Reporting definitions for each source/fuel type, monitoring methodology and site-specific performance needs were all critical to the fundamental design and configuration of the DAS software.

Appendix E Units did not require any field hardware, integration or wiring changes. They transferred data to the existing local DAS servers via a direct Modbus communications interface to the Plant PI System. No data collection device or PLC hardware was needed. The new software had to support a direct interface to PI and operate on a virtual server, just like the CEMS-based units.

Table 1 – Florida Plant Profiles

Site Name	**Units (#)**	**CEMS Units (#)**	**Appendix E (#)**	**DAS Systems (#)**	**Site Description**
Anclote	2	2	0	1	(2) oil/gas Fired Boilers
Avon Park	2	0	2	1	(2) Appendix E CTs
Bayboro	8	0	8	1	(8) Appendix E CTs
Crystal River	4	4	0	2	(2) Scrubbed/(2) Un-scrubbed Coal Units
Debary	10	4	6	2	(4) CTs plus (6) Appendix E CTs
Higgins	4	0	4	1	(4) Appendix E CTs
Hines Energy Center	8	8	0	2	(8) Combined Cycle Turbines
Intercession City	20	8	12	2	(8) CTs plus (12) Appendix E CTs
Paul L. Bartow	8	4	4	2	(4) Combined Cycle Turbines plus (4) Appendix E CTs
Suwannee River	9	3	6	1	(3) oil/gas Fired Boilers w/common gas pipe & oil meters plus (6) Appendix E CTs
Tiger Bay Cogen	1	1	0	1	(1) Combined Cycle Turbine
Turner	2	0	2	1	(2) Appendix E CTs
Univ of Fla	1	1	0	1	(1) Combustion Turbine
	79	**35**	**44**	**18**	

Virtual System Architecture

Once the decision was made to move forward with a software change, the Project Management Team had to decide between a traditional DAS system architecture and a virtual one. Initially the architecture of the new DAS was going to be the same as the existing system as shown in Figure 1. In discussions with IT, the possibility of using virtual servers was brought up. According to the IT department the advantages of virtual servers included:

- Uses a standard IT server model

- Fully supported by IT 24/7
- Lower setup and ongoing maintenance costs

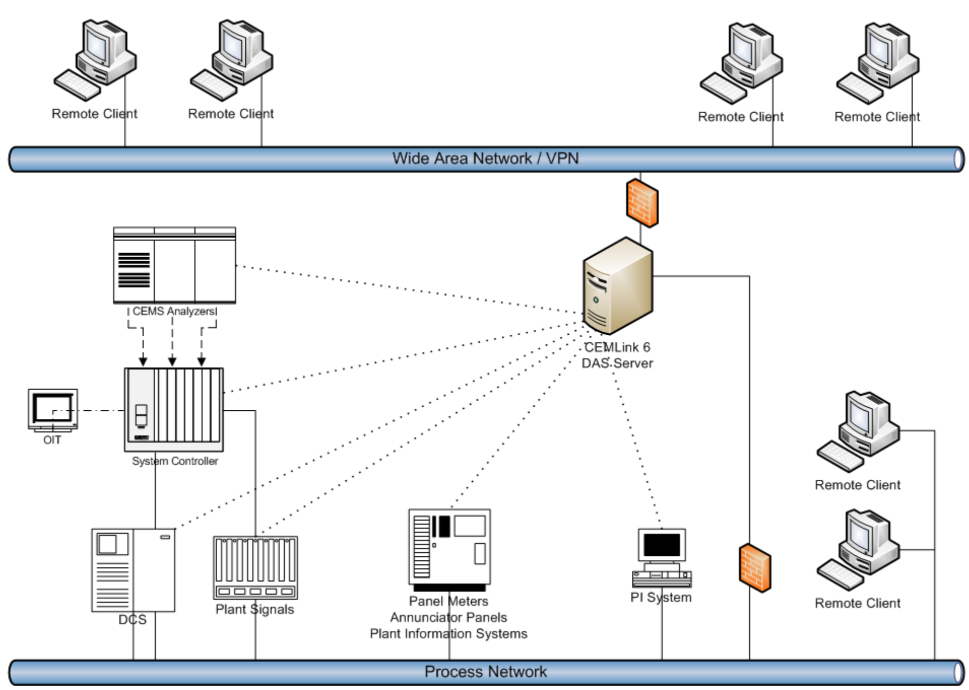
All of these advantages matched up well with the goals of the project but represented a major shift in the method for collecting and reporting the CEMS data. This appeared to be a good option but further investigation would be required. As part of this investigation a list of questions were posed to IT in order to better understand the new architecture. The questions and responses are found in Table 2.

Table 2 – Considerations for Use of Virtual Servers

Question	**IT Response**
How many virtual servers can be located on one machine?	Dependent upon the size of the Hosts and Guests. Currently there are 745 guests running on 45 hosts.
What safeguards are built in if the hardware running the virtual machines fails? How is the failure addressed?	VMWare in VMWare Clusters allows the guests to be automatically restarted on another host in the VMWare cluster.
What is the guaranteed up time for the virtual servers?	VMWare servers are housed at the data centers which provide higher availability due to the redundancy of these facilities and automatic failover capability of VMWare.
Since a virtual machine will be connected to a PLC located at a plant in Florida what is the guaranteed up time of the network?	Network uptime is > 99.99%
What is the response time for a server failure? A network failure?	Once an alert is received the technician are paged and diagnosis begins. The data center is manned 24x7 and an engineer is always on call.
What is the process for updating the virtual machines software?	To update a Host Virtual software the guests are moved off the live system and the host is updated. This can also be done when the Host hardware is updated.
What other risks of using virtual servers should we be aware of?	There is far less risk running servers as virtual versus physical which is demonstrated by the fact that over 75% of the data center servers are currently virtual servers.

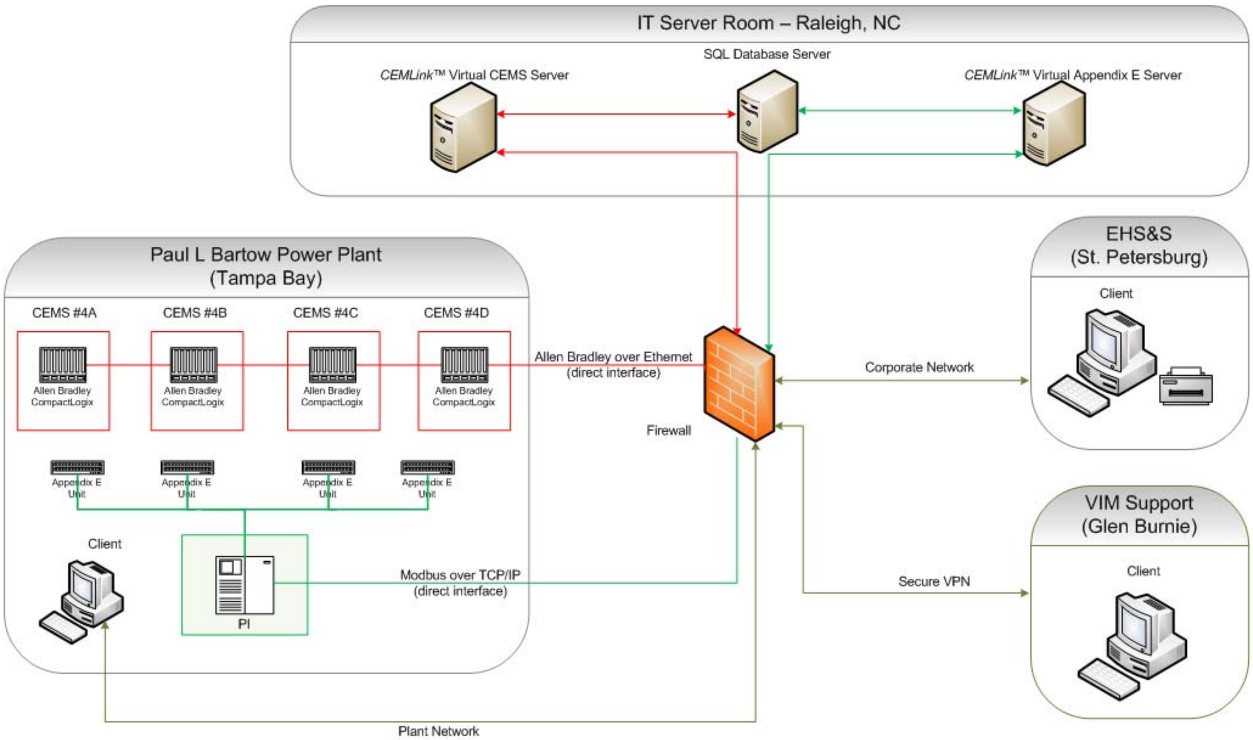
Question	**IT Response**
Can the SQL database be located on the virtual server or does it have to be on a cluster located elsewhere? What are the advantages and disadvantages of both?	VMWare supports SQL running on virtual servers but the best practice is to locate the database on one of the enterprise SQL Server clusters and the application on a virtual application server when possible.
What is the difference in O&M costs for virtual servers vs. servers located at the plant?	**Physical Server –** First year = $5,000, Ongoing = $2,750 **Virtual Server –** First year = $880, Ongoing = $140
What is the process for performing backups? Is a backup of the database sufficient?	From a backup perspective, we use TSM to capture files and folders. For servers with Databases, the DBAs use a tool that integrates with TSM that provides a clean backup of the DB's
What other advantages of virtual servers should we be aware of?	Higher availability, faster deployment, and quicker recovery. Support model is already in place for virtual environment and is not dependent on site personnel for hands on assistance.

Figure 1: Traditional DAS Installation



The proposed architecture for a virtual system is shown in Figure 2.

Figure 2: New DAS System IT Infrastructure



Before a decision could be made on the use of virtual servers the following technical risks with their use had to be considered.

- DAS server located in Raleigh data center cannot communicate with PLC's at all of the Florida facilities
- DAS client software cannot connect to virtual DAS server through plant firewall
- Increase in network traffic between virtual server and plant degrades performance at the plant

The first two items are very important. The PLC's are the front end data collectors that pass all of the emissions data to the server. If the server cannot communicate to the PLC then a virtual server cannot be used. Secondly, the DAS software client is used by plant operations and environmental staff to review the current status of the generating units, generate regulatory reports, and ensure compliance with the operating permits. Without this the plant cannot operate and the virtual server is not an option.

In order to determine if these risks could be overcome a pilot system consisting of a PLC, a virtual server and an SQL database was setup to mimic the final installation design. The Progress Energy IT department installed the DAS software on a virtual development server. To verify the proposed structure the database was located on the SQL server cluster as it would be in a live system. A PLC was placed in the CEMS shelter at the Florida facility and connected to the existing plant network. The DAS software was configured to communicate with the PLC at the plant and then started like a normal application. The DAS was readily able to communicate with the PLC and traffic could be sent both ways. Once the communications were verified the next step was to begin checking the impact on network traffic. The increase in traffic was negligible during the tests. No increase could be detected, no data was lost and the communication channels functioned as expected.

Based on these tests it was decided that the best option for the DAS replacement would be the use of virtual servers. After reviewing the information provided by the IT department and the risk mitigation performed as part of the pilot project, the evaluation team thought the use of virtual servers was warranted. The first system installed would use this architecture with a fallback option for installing a physical server at the site if needed.

Risk Management

With the decision on the system architecture made, attention could be turned to project implementation and managing the change associated with a new DAS. The operating plants participated in the new vendor evaluation process and were on board with the concept of a new DAS. When they realize what is involved and the work that has to be done their attitudes may change. It will be important to keep all the stakeholders informed about the status of the project and the communications line open in order to effectively manage the risk of a project of this size/scope. Everyone must believe that this change is worthwhile and that they have input into its success.

The risks associated with the human resource aspect of installing virtual servers are more difficult to quantify and address than the technical issues. The inherent distrust of the IT department by the generating plants makes it challenging to sell not only the complete takeover of the DAS computer hardware, but also the use of virtual servers. The risks that must be addressed are:

- Operations refuses to allow IT department to control DAS computer hardware
- Operations refuses to use virtual servers
- First installation of virtual server does not work and requires reevaluation of architecture

In order to adequately address all the issues associated with change-management, the Project Team established clear communication guidelines for each of the members of the critical path. Expectations, responsibilities and action plans for the CEMS Team, the IT Department, the Vendor and Plant Operations were followed throughout the project. Regularly scheduled update meetings were held on a daily and weekly basis to provide instant feedback on installations. Monthly meetings followed to address software usability, performance issues and process improvement. Fail-safes and back up plans were also established to convert back to a traditional model if the virtual one did not perform as expected. These project management steps proved to be critical to the overall success of the project and adequately addressed concerns at the plant level.

Summary of Results

Since all the plants involved in the Case Study were operational at the time of the upgrade, installation efficiency and operator acceptance were critical to the overall success of the project. The most visible success metric focused on unit downtime and loss of reportable data. The second most visible performance measure was gaining operator confidence in the new platform quickly and efficiently.

Several steps in each plant specific installation were capable of impacting unit downtime forming the primary metric for measuring results. System performance and reliability of daily operations formed the most visible metric. Great care was taken during all the preliminary steps to ensure and the Project Team's efforts were rewarded with a soft landing under some very challenging conditions. The project was successful, and all the major objectives were met. It was completed on time and finished up under budget. A summary of some of the key metrics and the associated results may be found in Table 3.

Table 3: Summary of Results – Performance Metrics

Metric	**Objective**	**Results Overview**
Software Architecture	Fundamental software principles of design must satisfy IT directives	The architecture, database configuration, integration process and system security were key areas of the new software that required the IT approval. The final solution met or exceeded all IT requirements.
Communications Verification	Verify that the CEMS PLCs can communicate real time data to the corporate virtual servers	A series of communication tests run over the Progress Energy WAN were conducted prior to installation of the first replacement DAS system to validate the use of virtual, remote servers. All tests were successful.

Table 3: Summary of Results – Performance Metrics (continued)

Metric	Objective	Results Overview
IT installation of DAS software	Verify that DAS vendor installation scripts could be implemented successfully by a Progress Energy DBA	The DAS vendor's database and software architects worked closely with Progress Energy IT to ensure that all software could be installed and run successfully. On site checks including calibration routines, report generation, and data editing were run following IT installation of software.
Pre-configuration Software check	Minimize field installation time and field training to support day to day DAS activities	The software provider implemented a comprehensive Project Engineering & Design phase at the start of each site-specific solution, documenting how the compliance engine, data validations and reporting would be configured.
Factory Witnessed Tests	Verify site-specific software functionality at the vendor's facility prior to field installation of any replacement system	Factory Tests were not required for every configured system. The Project Manager implemented FAT tests at key performance phases of the project. All factory testing was satisfactory prior to delivery.
I/O Integrity Verification	Minimize installation delays during system cutover from proprietary CEMS controllers to standard PLCs	I/O maps were built from site specific data prior to installing equipment. PLC panel fabrication ran in parallel with software engineering. All I/O panels were integrity tested prior to shipment.
PLC Integration & Field Wiring	Minimize installation delays due to field installation & wiring of PLCs	Field installation and wiring of new PLCs to replace the proprietary CEMS controllers was well executed through the use of pre-fabricated, plug-n-play PLC panels and slide out drawers.
Unit Downtime	<4-hours of unit downtime on any one change out	The average downtime for any on change out was 2-hours or less.
Network Performance	Demonstrate that there is no appreciable impact on network traffic by changing to virtual DAS servers	Network traffic increased by <1% after installation of the virtual DAS servers.

Table 3: Summary of Results – Performance Metrics (continued)

Metric	Objective	Results Overview
Installation Efficiency	The expectation was that each site installation would be as non-disruptive as possible without impacting plant personnel to any great degree	Each site installation started with a kick-off meeting conference call. A typical kick off meeting included, plant personnel, field installation/wiring team, field software Project Manager, DBA, software Product Manager, software database architect and a software developer. These meetings were used to set the tone of each install, mapping out the activity plan, and covering the sequence events needed to complete the cutover to the new software. All expectations were met with the help of these meetings.
Active Directory	Satisfy IT directive for security	Active Directory (AD) is a directory service created by Microsoft for Windows domain networks. Active Directory serves as a central location for network administration and security. It is responsible for authenticating and authorizing all users and computers within a network of Windows domain type, assigning and enforcing security policies for all computers in a network and installing or updating software on network computers. AD was successfully implemented.

Conclusions, Ongoing Activities and Lessons Learned

Phase I of the Case Study Project was completed on time in December 2011. As part of the contractual obligations the software provider was responsible for importing historical data into the new DAS system database. This data had to be integrated as if it was originally collected and processed by the new system. Data conversion is standard procedure when changing DAS systems from one vendor to another. All 79 reporting units submitted their XML Electronic Data Report (EDR) within the required 30-day window of the reporting quarter in which the conversion took place. Data submissions were all completed without the need for any extensions and all reports were accepted by Clean Air Markets Division (CAMD) Business Systems.

Reporting submissions were the acid test for the new system and ultimately demonstrated the successful implementation of the virtual DAS environment. Based on the success in Florida, Progress Energy has decided to keep moving forward with a similar plan for DAS conversions in the Carolinas. The plant profiles for the existing 7-plants are uniquely different than Florida with more full CEMS monitoring coal units and Appendix E Units using serial interfaces instead of Ethernet. Mercury (Hg) and Particulate Monitoring (PM) support will be required as well as some additional software features supporting i-series analyzer diagnostics, which is already part of the new software.

The project as a whole met all of the Phase I expectations and as we look forward to Phases II and III, we need to take a look at some of the lessons learned along the way. Some of the key lessons learned during Phase I include:

- Explore the virtual server option – not every organization will accept this but it should be investigated nonetheless. It offers better support options for a much lower cost than a standard physical server. Care must be taken to ensure that the hardware used in this application is up to the task of monitoring data continuously.
- IT needs to be more flexible in their requirements. Minor problems were found when trying to roll out new software releases, which were the responsibility of IT. Also, IT requirements inhibits the ability to provide software updates the way the EH&S wants them implemented and certain usability features, related to client performance, were lost because of IT restrictions. More up front time spent between IT and the provider might help alleviate some of these issues.
- Invest more testing time implementing other Appendix E communication strategies besides using PI as the process parameter data source. Direct Open Process Control (OPC) interface to the plant Distributed Control System (DCS).
- Ensure that IT understands the requirements – during this DAS replacement project it was evident early on that IT had no understanding of how the DAS worked. It is important to layout the entire system and its interactions to deliver the desired outcome.

In closing, time will tell if the virtual DAS system is the next true step-change in data acquisition for compliance, but clearly we have demonstrated a big step forward towards closing the gap between IT needs and EH&S requirements.