SUCCESSFUL INTEGRATION OF MODERN INSTRUMENTATION AND CONTROLS FOR A RETROFIT PROJECT

Authored By:

Chris Beeler – Concord Engineering Group I&C Lead Engineer

Kevin Dahm – DTE Energy Supervisor Engineering

Robert Speranza – AECOM Chief I&C Engineer

Fran Harkins – AECOM Project Engineering Manager
1. Plant/Project Description

The Monroe Power Plant is located on the western shore of Lake Erie near Monroe, Michigan, and is comprised of four (4) generating units each rated at 800 MW gross. With a total maximum plant output of approximately 3,200 MW, the plant is one of the largest coal fired power plants in United States. The generating units each consist of Babcock & Wilcox supercritical boilers that were placed into service between 1971 and 1974.

In 2006, a program was initiated to install wet limestone forced oxidation flue gas desulfurization (FGD) absorbers and related systems on all four units, starting with Units 3 and 4 and common systems, followed by Units 1 and 2. As a result of these projects, the Monroe Power Plant became the first coal-fired power plant in Michigan to operate with scrubbers, and the first plant in the state to operate scrubbers in combination with Selective Catalytic Reduction systems (SCRs). The operational date for each FGD system is tabulated below.

<table>
<thead>
<tr>
<th>Unit</th>
<th>Operational Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit 1</td>
<td>December 2013</td>
</tr>
<tr>
<td>Unit 2</td>
<td>May 2014</td>
</tr>
<tr>
<td>Unit 3</td>
<td>October 2009</td>
</tr>
<tr>
<td>Unit 4</td>
<td>June 2009</td>
</tr>
</tbody>
</table>

The overall scope of the FGD retrofit projects included the addition of a significant number of new structures and equipment to the plant site. Bulk solids management was accomplished with the addition of material handling systems including conveyors and transfer towers, a gypsum storage building with shuttle fill conveyors, limestone barge unloading/delivery systems, and a limestone storage pile with rotary plow reclaimers. A water pretreatment system, comprised of multimedia pressure filters and associated chemical feed systems, was installed to supply make-up and service water to the FGD systems, and a physical/chemical wastewater treatment system was installed to treat FGD process effluent water before discharging it to the existing bottom ash pond. These materials handling/storage, water pretreatment, and wastewater treatment systems were designed to serve all four (4) units. Flue gas from the boilers was routed from the common discharge flue of the existing ID fans through two (2) new axial booster fans per unit. Two (2) 580-foot tall wet chimneys, each with two fiberglass reinforced plastic (FRP) liners, replaced the existing 800 foot tall single flue concrete chimneys serving each pair of units.

AECOM (Washington Midwest, LLC.) provided engineering, procurement, and construction (EPC) services for the project, including the balance of plant systems, absorber equipment buildings, a common reagent preparation building, common gypsum dewatering building, and a common wastewater treatment building. Absorber island equipment and outlet flue, reagent preparation equipment, gypsum dewatering equipment, and associated piping was furnished and erected by Babcock and Wilcox (B&W). Materials handling systems were designed, supplied, and erected by the Dearborn Midwest Conveyor Company (DMW). Water pretreatment systems were furnished by Anderson Water Systems, and wastewater treatment systems were
furnished by Siemens Water Technologies (SWT). Each pair of units utilizes a dual flue chimney designed, supplied, and erected by Hamon Custodis.

2. Control Systems

Controls and control systems have evolved from complete pneumatic systems and controllers that were used in many early industrial and power plant designs to hard wired control systems and analog controls in the late 1960’s and 1970’s and then to digital controls in the 1980’s. Digital controls in many power plants have evolved from Programmable Logic Controllers to Distributed Control Systems and also combinations of these.

In the early days of process controls, 1950’s and before, control system implementation consisted of analog devices wired together. Modifications to the control systems required stopping the process and rewiring devices with significant schedule and cost impacts. Adding or modifying control loops required changing and adding controllers, buttons, switches and other devices into the operator control boards. For pneumatic control systems, modification or additions to the control system often meant running new tubing and adding new devices, which also was time consuming and costly.

Pneumatic Process Controls

Figure 1: Pneumatic Process Control Board
Hard Wired Control Board

Figure 2: Hardwired Process Control Board

Control Board with mimic of process

Figure 3: Hardwired Process Control Board with Mimic Panel
In the 1960’s a British chemical company, the Imperial Chemical Industries, replaced a complete analog control system in an ammonia plant with an Argus Computer. A computer was now being used to perform the actual control instead of just being used for supervisory tasks, and was known as Direct Digital Control or DDC. The advantages were lower cost, improved operator interfaces, and better flexibility. With DDC, the amount of time required to make modifications to the process controls was reduced and reprogramming incorrect processes was simplified.

As computers were further developed they became less expensive, faster, and more reliable. Faster meant that computers could be used to control faster processes and more reliable meant that more critical processes could be implemented safely. The number of computers used for process controls grew from 5,000 in 1970 to 50,000 in 1975.

The next big step forward in process controls was when distributed control systems were introduced with the first successful implementation of a distributed DDC system in the 1980’s. With the introduction of distributed control came the necessity to communicate between devices and the controllers. One of the early major issues with this communication was that the systems were closed and there were no standard communications protocol to connect them. For a number of years many process control suppliers worked on providing their own proprietary digital communications systems standards. This resulted in a number of competing protocols. Many of them did not work well together at all. Finally, even though controllers were now digitalized, controllers still communicated using analog signals.

Concurrent to the above, as the industry continued to try to improve the functionality, management and organization of industrial processes in the 1960’s, Programmable Logic Controllers (PLC’s) came on the scene. At the time of PLC development, control systems were largely handled by using hard wired relay controls. Control rooms were filled with control boards with many relays, terminal blocks and a mass of wires. These systems presented many problems such as difficulty in expanding the process easily; large amounts of time to perform system modifications and problems with troubleshooting because of the specialized skill set required to do so. In 1968, a group of engineers from the Hydraulic Division of General Motors presented a paper at The Westinghouse Conference outlining the problems being experienced at their plant. Also presented was a design criterion for a “standard machine controller.” Specifications were developed and provided to four control system suppliers: Allen-Bradley, Digital Equipment Corporation, Century Detroit and Bedford Associates. The winning proposal came from Bedford Associates with a system they termed “Modicon.” In 1971, Allen Bradley started development of a system based on customer needs. This new concept was known as the Bulletin 1774 PLC and the new device was termed the Programmable Logic Controller. The PLC terminology became the industry standard.
In the 1970’s, the number of providers in the PLC business grew to seven. Companies found it very difficult to convince the end users that a cast iron box of computer hardware and software could do the same thing as 50 feet of cabinets, relays, and wiring.

Distributed Control Systems came about due to the increased availability of microcomputers in the world of process control. Various companies such as Honeywell, Bailey, Taylor, Foxboro, and Fisher Controls developed their own stand-alone control systems. As Distributed Control Systems developed further, it was believed that if openness could be achieved and greater amounts of data could be shared, even greater things could be achieved. UNIX was developed as the predominant operating system and TCP/IP was the predominant networking technology. As a result, suppliers also began to adopt Ethernet-based networks with their proprietary protocol layers. In the 1980’s an effort was made to develop digital communication standards for field devices. One of the biggest transitions undertaken was to move from the UNIX operating system to the Windows environment. Windows dominates the operating systems today.

Serial interfaces were first developed in 1962 with the development of RS-232 standard for serial communications. This standard formally defines the signals connecting between Data Terminal Equipment such as a computer and Data Circuit Terminating Equipment such as a modem. As needs arose for faster transmission speeds and longer communication distances, other serial standards were developed. These include RS-422 and RS-485 which can be run over longer distances.

The Modbus communication standard became the first widely accepted fieldbus standard in the 1970’s. A PLC manufacturer, Modicon, published the Modbus communication interface for a multidrop network. The original Modbus interface ran on RS-232, and subsequently evolved into RS-485.

By the mid 1990’s two supplier consortiums merged to form the Fieldbus Foundation. These consortiums were the InterOperable Systems Project and the WorldFIP North America. The fieldbus foundation worked to develop an international fieldbus standard by developing programs, conducting field tests and establishing a program for testing and registration of the fieldbus devices. Manufacturers, end users and others became members of the Fieldbus Foundation and at this point started developing open, non-proprietary specifications known as Foundation Fieldbus. This fieldbus technology was designed to replace the incompatible networks and systems noted above and provide open, fully integrated architecture for information integration and distributed real time control.
The 1990’s produced an era in process control that came to be known as the “Fieldbus Wars” because rival organizations competed to define what would become the IEC Fieldbus standard for digital communication with field instrumentation instead of 4-20 ma analog communication. In 1999, the IEC SC65C Industrial Network standards committee drafted a fieldbus standard and formed the initial IEC 61158 standards with eight different protocol sets called “Types”. These types are:

Type 1 – Foundation Fieldbus H1
Type 2 – ControlNet
Type 3 – Profibus
Type 4 – P-Net
Type 5 – Foundation Fieldbus HSE (High Speed Ethernet)
Type 6 – SwiftNet (developed for Boeing and no longer active)
Type 7 – World FIP
Type 8 – Interbus

Each one of these digital bus technologies had different advantages over the others. For example, ControlNet includes built in support for fully redundant cables. Profibus has two variations, Profibus PA and Profibus DP. Profibus PA (Process Automation) is used to monitor measuring equipment via a process control system in process automation applications while Profibus DP (Decentralized Peripherals) is used to operate sensors and actuators via a centralized controller.

Other digital bus technologies exist also. DeviceNet is a network system originally developed by Allen-Bradley (Rockwell Automation) and typical applications include information exchange and large I/O control networks.

Another protocol that deserves some discussion is Ethernet. Ethernet was developed in 1973 by Robert Metcalf, a PhD working for Xerox. Ethernet is a protocol that describes how networked devices can format data transmission to other network devices on the same network segment and how to put that data out on the network connection. Ethernet is the most widely installed local area network technology in use today.

Towards the end of the 1990’s, the technology began to develop momentum and the market consolidated around Ethernet I/P, Foundation Fieldbus, and Profibus PA for process automation applications.
Foundation Fieldbus is a digital two-way multi-drop communication link that connects intelligent measurement and control devices, automation devices, and display systems. These devices include transmitters, valves and work stations. Foundation Fieldbus enables the loop control to be distributed away from the process controller and into the field instrumentation. Smart Field Devices can convert the sensor data and also have function blocks and control algorithms. Foundation Fieldbus provides for standardized and customized function blocks, and distribution and execution of functions in multi-vendor devices in a seamless manner. It includes the ability to use and configure any vendor devices that comply with the Fieldbus Standard.

Fieldbus type wiring of local devices

Figure 4: Fieldbus Process Control Valve
3. **Engineering**  
A project decision was made prior to commencing the engineering and design for the original (Units 3&4) FGD units to use “Smart” instrumentation and field devices to the greatest extent possible. This decision to pursue these technologies was cost and schedule; reduction of the amount of copper cabling
in the field reduced the amount of labor and construction schedule required to get the overall system installed. The benefit to the end user was that a much more broad set of data that monitored the instrumentation networks as well as additional operating parameters for engineering, maintenance and operations personnel at what was perceived to be a fraction of the costs.

For the Units 1 and 2 FGD project, personnel from Engineering, the Distributed Control System (DCS) vendor, construction, startup and commissioning, the owner, and plant operations and maintenance reviewed the design and developed key opportunities to improve the implementation of the instrumentation and control systems based on findings from Units 3&4. The following items were addressed during the engineering phase of the project.

a. Foundation Fieldbus for instrumentation

i. Smart devices are programmed with both software and firmware. Software is a set of variables that are able to be manipulated by a third party to produce the desired output or effect. Firmware is software that is “locked” down by the manufacturer. Manufacturers will change firmware and download it to a device to fix commonly known problems in the programming after manufacture, but in general, firmware is designed to encompass the entire lifecycle of a device. DCS vendors will typically “integrate” instrumentation and controls devices into their system library and create “soft” devices that detail how the software is coordinated with the DCS monitoring and control. As the firmware is changed (a device revision) by the instrumentation manufacturer, a DCS OEM will typically take the new device revision and update their system to “integrate” the new device. Some developed during the course of the projects from ongoing use of the digital bus technologies include the following:

- The use of firmware and its implementation on project instrumentation and the DCS is a process that needs to be managed from the initial issue of the I&C specifications. If firmware is not correctly implemented in the control system, the data points are not accurately monitored, thus causing either control system errors, or at the worst case, not providing the required process control parameter. During the design of the project, the DCS vendor and engineering “froze” the device revisions based on DCS integrated
devices. The use of known devices was the primary goal of this portion of the project, as all parties were familiar with the device and the DCS OEM had already taken all necessary steps to implement a fully functional device in its’ system.

- Device revisions that were new to the DCS OEM were sent to DCS OEM’s facilities to integrate into the system. The project bore the cost of acquiring a typical instrument that had the new firmware revision loaded. The instrument was then sent to the DCS OEM’s offshore facilities to fully develop all of the software ties required to achieve full operation of all the features provided in the device. This process needed to be managed, as the DCS OEM only integrated devices on a quarterly cycle. However, to ensure the devices were included in the quarterly cycle, the instrument revision that was planned to be used for the project was required to be available to the DCS OEM approximately 6 months before operation of the device at the site was to commence.

- Third party provided instrumentation that was not clearly defined by the provider needed to be integrated via other means. Devices in this category were narrowed down to just a handful through management from the initial specification phase. These devices were reviewed and either replaced, if there was only one instance of the device and it had no differentiated functionality, or integrated in the field to allow for operation of the devices only. Full integration occurred as part of the DCS OEM’s normal process and allowed access to advanced functionality for these devices. The key element to the end user was the knowledge of the devices that were not integrated at the time that the units were in operation.

ii. One of the project goals was to duplicate the design as much as possible from the as-built Units 3&4 design. This process was started almost immediately after the Units 3&4 went into operation. The project team dedicated personnel and resources to verify the redlines and as-builts that were sent in from the construction and commissioning teams. In addition, the client was consulted to determine how they perceived the as-builts, and their level of satisfaction with the currently operating units. There were some
instances where deviations to the Units 3&4 design were deployed to correct the design after thorough operation of the system. Some of these deviations are described below.

The operations staff indicated issues with one valve accessory for on-off pneumatically actuated control valves. The system overall had fairly high and regular vibration in the process piping, which caused the actuating devices to malfunction quite often. These actuators were the only devices that experienced this issue, so the project made the decision with the plant to replace them, as the plant was doing for the operating units on a maintenance project. Working with the plant staff, an equivalent replacement was established and specified for Units 1&2. In addition the decision was made to use flex tubing at instrument air trees to better compensate for differential movement between process piping and the plant steel. The clients design standards forbid the use of flex tubing as part of the original installation, but a deviation to the standard was granted during the project due to the potential impacts on the instrumentation.

Additionally, there were some instances where instrumentation did not “line up” operationally with how the plant wanted to operate. Although there were efforts to address this requirement in the early stages of the Units 3&4 project, there is no better experience than actually being on the board. The overall operation of the plant, as well as the control room configuration and manpower staffing, had changed quite dramatically once the first two units were constructed. The operations and maintenance staff recognized opportunities to optimize the plant control system by changing the segmentation of equipment in operating units so that they could better utilize the process and guard against any tertiary failures that could contribute to unit trips. While the design did not consider anything beyond a single point failure, these changes and the resultant improvement in redundancy helped the O&M staff better plan for outage work in the control systems network. Additional engineering design time and material quantity was utilized to revise some Fieldbus networks in the Gypsum and Reagent buildings. The already-installed instruments were re-routed to new controllers installed for the Units 1&2 project. Control of these devices was copied in kind to the new controller that was provided and the
system was operationally independent from the Units 3&4 systems entirely.

b. Modbus over Ethernet for 4160 Volt Switchgear

An advantage of using a digital network to communicate with the 4160 Volt switchgear was the depth of information available from the smart relay. Additional benefits included the ability of the relay to communicate to the control system via two independent networks. In the Units 3&4 design, redundant cabling was routed to network switches that were located at the breaker. At that point, a single cable was connected between the switch and the breaker relay. The primary network was designed to operate on a high speed Modbus TCP/IP network, while the redundant network is designed to operate on the RS485 network. The control system was designed to use the high speed network, unless it is unavailable, and then transition to the opposite network. By changing the network as stated (and shown below), the project achieved true redundancy all the way through to the relay. This allowed for greater operations and maintenance flexibility.

Figure 7 – Original Units 3&4 4160 Volt Communications Network Design
c. As the design evolved and differences between the configuration of the Units 3&4 project and Units 1&2 were recognized, a concerted effort was made to be able to factory test all items that interfaced with the DCS. To facilitate this testing, the project worked in concert with the DCS OEM and all of the electrical equipment OEM's to build an integrated factory test that included the smart devices that were procured from the Electrical OEM's and the DCS. The project developed the plan to provide a DCS “suitcase simulator”, which consisted of a single DCS controller and the interface modules required to communicate with the electrical equipment. This allowed all parties to ensure that all the internal wiring that the electrical equipment factory installed was correct. Also, all software links, software addresses, and engineering ranges were reviewed and checked. These items were pre-programmed in both the DCS and the equipment prior to the test. As issues arose, the factory representative, who in general was the software expert, was available immediately and issues were worked to completion in the suppliers’ shops. Consequently the field startup and commissioning period for each piece of equipment was much easier, since the bulk of software issues were addressed prior to equipment shipment and with a more expert staff communicating directly face to face to resolve any issues. The advantage to the project was a greatly reduced field
service charge from both the electrical equipment vendors and the DCS OEM. Much less oversight was required in the field and a more controlled startup and commissioning period was executed.

d. Remote IO Panels for Control and Modbus for parameter monitoring for 480 Volt Load Centers

i. The initial Units 3&4 design for 480 volt switchgear was reconfigured multiple times due to a number of factors. The vendor initially specified a PLC to automate the gear with a data link through to the control system. In general the client and the project specifically prohibited the use of PLCs for a number of reasons: to save money on stocked spare parts; to not require operations and maintenance staff to train on dissimilar equipment; and to streamline the control system. Once it was determined that the PLC was actually part of the switchgear, a number of “fixes” were implemented. The switchgear was communicating to the smart relays on a proprietary bus network and a Modbus converter was added to allow for native Modbus communications to the control system. Multiple conference calls were initiated to enable the DCS to command the breakers through these new links. Although this addressed the communications, it did not allow for the breakers to actuate from the control system within a timely manner. At some points, depending on network traffic, the breakers would not actuate for almost 30 seconds, which was not acceptable for critical applications. Additional equipment, in the form of addressable relays, was added to speed up the commands from the DCS to the switchgear. The addressable relays took precedence on the Modbus network, and typically caused the actuation time of the breakers to be under 3 seconds. For critical component power feeds the commands and feedback were hardwired to the local DCS cabinet and directly actuated from the native IO modules.

When engineering and design commenced on the Units 1/2 project, the switchgear vendor advised that the addressable relays were no longer supported, as they were at the end of their product lifecycle. Again their proposed solution involved the use of PLCs. The project team discussed the potential alternatives and the need to provide componentry and functionality similar to the Units 3&4 equipment. The decision was made to use native IO from the DCS
vendor as remote IO located in the switchgear. This solution served to address multiple issues:

- All indications and controls were native in the DCS. This eliminated all lag times for breaker actuation and indication at the process graphic.
- Additional monitoring parameters (breaker amps, volts, etc.) were again transmitted via a Modbus data link. The data link was perfectly capable of monitoring this information in a timely fashion without the burden of performing control functions.

ii. There was an appreciable cable savings, as the remote IO panel was located in a cubicle that was utilized previously for the addressable relays. By providing the remote IO panel, the project was able to use a multi-strand fiber optic cable for signals instead of multiple copper conductor runs. The electrical equipment OEMs terminated all wiring internal to their switchgear at the factory in a controlled environment that had a more rigorous oversight program. The project team was able to again use a “suitcase simulator” solution and operate the breakers from the graphics. All software settings were checked and verified in the factory. This provided a more streamlined process during commissioning and gave the Owner greater confidence that the solution implemented would work in the plant setting.

e. DeviceNet for Motor Control Centers

As a result of the project decision on Units 3&4 to utilize DeviceNet communications on the Motor Control Centers (MCC) the same Bus technology was utilized on Units 1/2. At that time, the DCS equipment did not natively communicate via DeviceNet. This resulted in a number of converters being installed in the DCS cabinets and daisy chained together to line up the controls of the various motors with the process controllers for the respective process systems. For Units 1&2, the DCS OEM developed a new module to directly communicate with DeviceNet, eliminating the third party devices. As part of this development, the DCS vendor was able to incorporate most of the features of the third party device and provide a device that was functionally equivalent. Most
importantly, a majority of the design from Units 3&4 was able to be duplicated without any major perturbations. As with the other electrical equipment, the MCCs were factory tested with the “suitcase simulator.” No major issues with the new design were detected during this checkout.

4. **Construction and Commissioning**  
   a. **Fieldbus Cordset/Segment Packaging**

   i. The project realized that there was an opportunity to improve the management of the cable cordsets that were used for the Foundation Fieldbus network. Engineering and design decided early in the Units 3&4 project to employ a concept the vendor termed as a “rolling warehouse”. This consisted of a caged cart that was to be inventory controlled by the project and utilized by the onsite craft/construction crews as needed to fill any short term gaps in the specified Bill of Materials. This concept proved to be flawed in that it allowed for shortcuts by construction. The control of the warehouse was not as expected, and the craft picked up material as they saw fit, with little or no checks on actual need or reference to materials already delivered as part of the base order. The material vendor was responsible to restock this mobile warehouse as needed then to reclaim material that was left at the end of the project. In some instances, the material was damaged while in other instances the material was part of the original specified quantities and was not necessarily a stock item. The returned material was often restocked by the vendor for a fraction of the original price. Once the labor to track and reconcile the material orders was factored in, the net result was considered as an overall negative cost impact to the project.

As a result of the extensive as-built and redline effort from the Units 3&4 project, it quickly became apparent that the installed components were not in line with what was specified and therefore required the project to re-evaluate the approach to material control on-site. The engineering and design team decided to package the bulk cable and junction boxes on pallets and designate them for use in very specific areas by network. The construction management team and material management teams were consulted and each party agreed with this strategy and approach.
While engineering had to be much more precise with lengths, quantities, and overall network development, the end result was much less time spent by all parties (including the material vendor) to complete the project and there were very few instances of additional material required. The craft were more refined with their installation practices and more organized in their approach to the cable installation, resulting in fewer instances of as-built drawings required.

ii. Due to the consistency with the prior project of the equipment being provided, the design was in large part much more complete as it was turned over to construction. In many instances, the design was turned over to construction well in advance of the “early” start dates on the schedule, allowing for construction to review the design, interpret it, and plan their work early. It was staged and installed, typically from the Fieldbus junction box (brick) out to the instrument and then from the brick to the DCS cabinet. In addition, the project prewired the DCS cabinets with connectors that allowed for the quick connect fitting use to be maximized. As opposed to terminating each segment in the cabinet at the construction site, the quick connect fittings were installed on the DCS cabinets, internally for cabinets in conditioned environments and externally for cabinets that required NEMA 4 ratings. This reduced the amount of work hours required in the field to modify cabinetry for conduit penetrations and terminating individual conductors.

b. FAT at vendors’ facilities

i. Electrical systems

As discussed previously, the DCS “suitcase simulator” used for factory acceptance testing greatly improved the overall quality of the instrumentation and controls system for the project. The DCS OEM was able to gain a better understanding of how to implement logic for the smart devices functionality ahead of DCS programming and commissioning. For example, in many instances contact states were better defined and developed within the breaker compartments, thus allowing the DCS programming to hit the site in an almost fully functional state. The electrical equipment OEM’s better understood what was expected at
construction and commissioning, providing an additional advantage that is not typically realized during the engineering effort or FAT. The OEM’s were able to provide a better qualified resource to address specific needs that they could anticipate based on the results of the DCS “suitcase simulator” testing.

ii. Instrumentation

While the largest systems that required inspection in the factory were the Electrical components, the instrumentation was just as critical to the success of the project. The project team was able to verify the process instrumentation settings and programming via a Fieldbus configuration handheld device. Using this device, the instrumentation was powered on and the firmware settings were confirmed. Additionally, the control valves were functionally tested for proper operation using the handheld device. This reduced the instances of improper firmware dramatically, surfaced potential issues earlier in the process, and provided a greater level of certainty as the instrumentation was installed and functionally tested from the DCS graphics.

c. Commissioning

As noted above, the combined engineering and construction advantages allowed for system turnover for commissioning at the scheduled early start dates. The commissioning team, which was supplemented with Plant Operators who would eventually operate the systems, was therefore able to have more time to run through various plant scenarios as part of the integrated functional testing. Each IO point was loop checked from the field device through to the control system graphic. There were great efficiencies realized in completing the loop checks for Units 1&2 compared to Units 3&4 because of the extensive engineering effort to ensure that all items conformed to the system specifications. The commissioning effort was typically staffed as a normal 8 hour work day, 5 days a week. Engineering support was on-site regularly and as needed to address any and all potential conflicts or non-conformances. The overall staff was dramatically reduced (from approximately 20 to 10 personnel) from the manpower required on the original Units 3&4
project. As noted previously, the DCS OEM, the electrical equipment OEM's and the technology providers were able to get the proper resources to the construction site as they were needed.

The result of all of these measures was the ability to complete integrated functional testing in the outage window ahead of schedule. The project team spent the final 3 to 4 weeks of each tie-in outage as training sessions to transition ownership of the facilities to the plant operators. The overall customer satisfaction was greatly increased and the number of warranty items defined was reduced from approximately 150 items on Units 3&4 to less than 20 items on Units 1/2.

5. Operations and Maintenance

a. Project Plant Database

   i. Client developed an Structured Query Language (SQL) database for the entire plant

      As part of the ongoing improvement process the DTE Energy engineering staff recognized the need to consolidate the massive amounts of information they were receiving from all of their subcontractors into a central database, and they contracted with a third party to create the Project Plant Database (PPDB). The PPDB is a tool that the DTE Energy now employs to manage all reference drawings, cable numbers, calibration data and numerous other parameters in a single location. It allows the DTE Energy to track project progress as well and determine if any remedial actions are required in real time. The application was developed to be greatly customizable to allow DTE Energy to manage projects going forward and to provide flexibility to change as the projects or plants change.

   ii. All parameters were recorded and/or turned over to the client to enter into their SQL database

      In essence, prior to creating the PPDB, DTE Energy suffered from information overload. While the design engineers were able to help point the DTE Energy to design documents that they needed to review, DTE Energy was faced with a bow
wave of drawings and data at turnover that became a huge task to manage. The decision was made to create the PPDB to manage information in real time. The tool is able to take excel files in and output to excel files as well. DTE Energy has pre-defined the format of the excel files such that they can be managed into the import tool of the database. In addition, DTE Energy is able to provide historical information for the equipment that is managed through this database. This can be useful when evolving from a device that is at its lifecycle end to a new device in the market. Further, calibration data sheets, control system functionality and equipment manuals can be referenced and recorded in the database to provide a complete picture of the device.

iii. Start up and turnover was months ahead of schedule

As the project was approaching completion, DTE Energy was able to ensure that the PPDB was operating as anticipated. Since the PPDB was rolled out on the DTE Energy’s side as part of the project, DTE Energy was able to implement all of the data turned over as it was being received, rather than months later. DTE Energy in turn were then able to perform the key operations and maintenance functions prior to startup to ensure that they could track progress and equipment details. The subcontractors were unaffected by the PPDB as they were just instructed to turn over their databases in native format. DTE Energy then manipulated the structures of the database and imported the data. Prior to turnover DTE Energy was able to use the calibration data sheets generated by the PPDB and tracking capability to monitor project progress from the instrument level up. This gave them functional experience with the PPDB and assured them that they could use it going forward on new build projects and implement in existing plants to track data.

b. Control Room Layout and Configuration

i. Initial Units 3&4 FGD Room Design

As the Units 3&4 project closed out and the 1/2 project ramped up, the operations staff decided that instead of
operating in line with the units (the power block has two separate control rooms: one for Units 1/2; and one for Units 3&4), they wanted a consolidated FGD control room. This allowed operations flexibility to control multiple units with a smaller number of staff and for the FGD operations to be integrated as a single process that was dispatched and communicated with the independent power block control rooms. However, the Units 3&4 design left no area in the FGD control room for additional consoles required to operate the new 1/2 FGD.

ii. Revised Control Room Configuration

The Units 3&4 FGD control console was arranged in an “L” shape and tucked in the back corner of the Units 3&4 Plant Control Room. When the need to modify this room was realized, Operations management was consulted. They decided that the new control room would re-purpose the existing tagging center and were adamant that the console be designed as a “C” shaped console. DTE Energy engineering worked with operations and for a $300 investment built a mock up in a conference room so that operations staff could get a feel for the design. Both the engineering option (2 independent consoles) and the Operations design (“C” shaped single console) were mocked up using plywood, graphic screen shots from the control system, and sheets to simulate the walls. Engineering built the mockup to full scale, including full scale prints of the screens and keyboards/pointing devices. As the operators sat in both configurations, it became increasingly obvious that two operators on staff could not work in the “C” console. The independent consoles were much more ergonomically acceptable.

In the end, due to engineering’s ability to accurately mock up the design, the plant was designed with more efficient use of the limited space for the control room.

6. Final Project Results
The project improved the following items as an end result:

- Foundation Fieldbus network implementation
- Control Networks for electrical equipment
- Overall construction effectiveness and efficiency
- Startup and Commissioning schedule was greatly reduced

As the project evolved, great care was taken to continuously improve the quality and end user experience with the new technology and equipment provided. As a result of this, the end user was better prepared to take the system over and operate it in an orderly manner. Field changes, warranty claims, re-design were all minimized. End user satisfaction was greatly increased from the previous project.

REFERENCES:

- Distributed Control Systems from Wikipedia