CHAPTER II - IT PRODUCTS AND SERVICES

Brief History of Plant Control Systems

In the early part of this century, power plants were equipped with handwheels on valves at the boiler and steam turbine. There was no control room. Later, motors were added to these critical flow devices and the handwheels could then be remotely operated from a central control room. Pneumatic controls came next, based on the application of air pressure to force a valve shut or turn it open. In those days, each unit might have its own control room. But there was still the need for operators to be stationed at the valves and instruments constantly just to effect the operation of the unit.

Control algorithms began to get more sophisticated and by the 1950s, an elaborate central control room, with strip chart recorders, dials, and meters was standard. As critical loops became integrated, and more dials and meters were located in the control room, fewer and fewer operators were needed at manual stations along the boiler and turbine. An elaborate array of relays, transmitters, and hardwired programs were developed for discrete control of critical plant loops.

Until the late 1960s, steam turbine/generators were controlled by mechanical/hydraulic governors. As early as 1968, an electrohydraulic speed control device was available. Meters, gages, and lights displayed equipment status to the operator, while pen/ink and paper strip charts recorded performance. Remotely operated air cylinders and motors provided the muscle to respond to changing plant situations. Automation was generally restricted to combustion control, regulating fuel and air flow to meet the steam demands of the turbine/generator. Operators performed manually functions like purging the furnace, lighting the burners, adjusting dampers, opening and closing fuel valves, starting and stopping pumps and turning burners on and off. Safety systems to prevent furnace explosions and fires were an early requirement of controls.

In the 1960s, the programmable logic controller (PLC) was introduced and it gradually replaced relays and hardwired programs. But process control became more and more complex and standard pneumatic controls became too imprecise for executing commands on the control devices. Large amounts of plant data were transferred and stored on utility mainframe computers.

In the late 1970s the, DCS came into being; it used computers to spread functionality over multiple processes and control loops. Today, the DCS technology, based on proprietary configurations, still is the standard in large power plants, but advances in PC-based control and continuing advances in PLC technology have combined to threaten the DCS reign in power stations. The need to integrate plant-level control and functions and activities with the rest of the corporation, using PC-based software, is driving the plant towards a PC-based operating environment, perhaps with only a few mission critical systems existing on more robustly designed networks platforms.

The old control panels are a thing of the past for power stations installed today. All interfaces with the operators are conducted through a computer screen or CRT. Perhaps a few of the most critical measurements are hardwired into a panel, mostly for comfort, not for need. Smart valves are supplied which include microchips on valve controllers to perform diagnostics, data collection, and manage communications. Today, valves can be calibrated and configured from a remote PC.

A 250-MW gas turbine/combined cycle unit can essentially be started up with the push of a button and monitored remotely from any location on the planet. The operator is akin to an airplane pilot. More often than not, he is being trained to keep his hands off of the controls and let the automation system do its job. The operator's, or pilot's, job is to monitor the control system, and be ready to respond in the event of upset conditions.

Categories of IT Products and Services

Although the thrust of this report is integration of IT modules into a comprehensive suite, it is instructive to review several individual IT market sectors that, in the last few years, have become important for power generation.

Process Optimization

Most of the process optimization packages applied at power stations make use of neural network technology in some form, though one distinguishes its use of Bayesian analysis and internal heuristics, instead of neural networks. Although the math and statistical techniques embodied by them are complex, all of the packages seek to analyze huge amounts of data, now available from computer-based control systems, then discover patterns in those data that suggest an optimum combination of unit set points for a given set of fixed conditions. These set points are then either provided to the plant operator as a set of advisories, or the software can operate closed-loop and automatically signal a control device to change.

Three years ago, there were at least half a dozen serious suppliers of process optimization software for power plants—Pavilion Technologies, Pegasus Technologies, Ultramax, Lehigh University, Neuco, EPRI/Gnocis, and Praxis. Now, all but Ultramax and Lehigh have teamed up with bigger brothers. Pavilion is working with ABB, Pegasus is linked up with KFx, Neuco is in partnership with DB Riley Inc., and Praxis is aligned with General Electric Co. Aspen Technologies reportedly is working closely with Westinghouse Process Control. A relatively new entrant to the business is a company called KnowledgeScape.

Each one of these suppliers has major programs with leading utilities that have experienced significant progress over the last several years. Pavilion is working closely with Duke Power and Virginia Power, Pegasus with Ameren UE and Jacksonville Electric Authority, Ultramax with Illinois Power/Illinova and Tennessee Valley Authority, Lehigh with Potomac Electric Power Corp., EPRI/Gnocis with Southern Co., and Neuco with Arizona Public Service and Cajun Electric. Ultramax reports that it has now optimized over 70 units with its technology. Lehigh recently reported that it has optimized 17 units and a site license with one utility for 21 units is pending. Gnocis has been applied to several units within the Southern Co. Based on informal reports from the other suppliers, these software packages have probably been applied to at least 150-200 coal-fired units, which could represent 50 or more power stations.

Important to note is that, while many stations have "optimized" their operations with these packages, fewer have reportedly integrated them into their day-to-day operations. For example, the "holy grail" of process optimization software packages is running the plant in closed loop, that is, the software recommends and then automatically adjusts key process setpoints without operator intervention. Very few plants that are applying these software packages have achieved this sophisticated level of performance.

Most of the process optimization work has been in reducing NO_x emissions while limiting the impact on carbon in flyash, unit heat rate, and other emissions (CO, for example). However, the basic analytical and calculational techniques at the heart of process optimization are also being applied to other areas of the plant—predictive emissions monitoring, general performance monitoring, and predictive maintenance. Expanding the role of process optimization promises to be a key area of future growth in the power industry. Gains in these areas are impressive—NO_x emissions reductions are usually substantial—ranging anywhere from 5-55 percent depending on load, fuel, and many other factors—and heat rates have been concurrently improved by 0.5-

2.0 percent. Such improvements represent a significant savings in fuel, compared to the modest investment for the process optimization package.

According to suppliers, these packages can be installed from plant to plant for an investment in the range of $100,000 to $500,000. These figures usually include at least a site license for the software, basic training of personnel, and expertise to install the software, get it up and running, and train or calibrate the software (provide it a database from which it then "learns").

A key issue with this software is maintaining it over the life cycle period. For example, an older station with a 74-MW unit and a 235-MW unit with a DCS retrofitted in 1993-1994 had applied optimization software in the last few years. Although the plant reported success with the software, it needs to be "retrained" with new baseline data because of hardware changes to the plant and because it was originally set up for baseload operation. Time and manpower limitations currently hinder the plant from getting the most from the program. This example doesn't suggest the failure of the optimization package, but indicates that resources are necessary to maintain its capability.

In general, process optimization adds a layer of responsibility to the plant staff. Plant operations are dynamic and steadily changing parameters—furnace cleanliness, fuel characteristics, quality of sensor readings, etc.—affect the models that are built by the software to recommend set points that optimize the process. Getting good quality data from calibrated, tuned, and well-maintained sensors is as imperative as having control devices that can make use of updated information.

Today, the recognition is prevalent among process optimization suppliers that the software/neural network expertise must be combined with the hardware and combustion-related expertise. Most of the leaders in this business sector expect (1) that every significantly sized power plant in the country will use some version of process optimization, and (2) the process optimization software will ultimately be embedded into a comprehensive power plant IT "brain." The alliances indicated above already suggest that this is happening.

Open Systems and Fieldbus

One of the most important current trends in the supplier side is the move to "open" systems. Granted, the definition of open is in the eyes of the beholder. However, the upshot is that actual control room equipment and interfaces are dominated in name by the traditional process automation suppliers, but more and more software and hardware is being purchased from PC-based suppliers and Microsoft Corp. resellers and alliance partners.

The other part of the open systems revolution, only now emerging in the power plant business, is Fieldbus Foundation, Profibus, ControlNet, and other in-plant communication bus standards. This is analogous to the 4-20 mA signal that is the backbone of all process control communications with a plant. These all fall under the generic term, fieldbus.

Fieldbus is important because it could allow the traditional automation suppliers, who are losing their value-added to PC- and software-based suppliers, to recapture and add value at the control device. Fieldbus allows many signals to be carried from a control device, sensor, or transmitter—information about the health and condition of the device. Many diagnostic functions can be carried out at the device itself instead of having to bring the signals to the control room and then send them back to the device.

According to one top industry executive (Yeager, Westinghouse), fieldbus will lead the industry to the next phase of process automation: migration of control functions to field devices. Indeed, the literature of all the major automation suppliers has many references to fieldbus. However, it is important to realize that awareness of fieldbus is just emerging within electricity generation, though it has been adopted more widely among process industries. Some suppliers expect that over 70 percent of field devices sold after the year 2000 will be so-called "smart" devices that are fieldbus compatible.

An example of the benefits may be seen in calibration. Surveys show that the majority of control devices and sensors are out of calibration regularly. Smart devices will be able to self-calibrate and/or inform plant personnel directly that calibration is needed.

Gordon McFarland of Honeywell echoes Yeager's predictions: "New providers of electric services will be built around information—process, laboratory, maintenance, dispatch, model-based control, cost, other components. All this information will be deployed on an open, high-performing, hardware-independent platform using commercially-available Microsoft-based network/system software. However, industrial strength networks will be used to ensure an open but secure information network."

Indeed, at least a few of the automation suppliers have "ceded" the supply of the business system and plant network, and are now focused on the local network, the open control system, and the fieldbus. One supplier calls this a two-partner strategy.

Fieldbus, and the IT revolution in general, have motivated suppliers of valves, sensors, and control elements to upgrade their offerings and to begin to focus their business on services, not hardware supply. For example, a supplier of temperature sensors can add value by taking responsibility for maintenance and service on a contractual basis. Because the relevant data about the condition and performance of the sensor can be transmitted not just to the plant personnel or anywhere the information is needed, specialists can monitor sensors anywhere in the world, then deploy repair specialists as needed.

An important question also is how long so-called standard fieldbuses will be around. At least one report suggests that Ethernet-based networks, used in office environments for years, are robust enough to handle field control systems and communications. And Ethernet may ultimately become the lower-cost approach. One critical advantage: TCP/IP, the Internet protocol, is commonly implemented over Ethernet, making it easy for device vendors and others to incorporate web-server technology into network-connected devices.

But while the benefits of fieldbus are known to vendor and user alike, the technology's market penetration has been slow in the process and manufacturing industries, and virtually non-existent in power plants. Primary reason: lack of an international fieldbus standard. Individual vendors have invested heavily developing a specific network, and, understandably enough, would like the international standard to match it. For awhile, numerous vendors fought to define that standard in committee meetings, marketing campaigns, and the trade press. Then, alliances began to form, and the number of competing standards dropped to a handful.

Now, the battlefield has narrowed to essentially three combatants: ControlNet International, promoted by Rockwell Automation; Profibus International, popular with European suppliers, particularly Siemens AG; and Fieldbus Foundation, advocated by US distributed control system (DCS) vendors.

In October 1998, the two largest alliances—Profibus and Fieldbus Foundation—nearly declared war, when an important vote on IEC standard 61158 was defeated. The vote achieved a two-thirds majority; however, it was defeated by a committee rule saying a proposed standard is defeated if more than one-fourth of all countries oppose it. Eleven countries cast negative votes.

Profibus led the opposition, asserting that IEC 61158 was "technically deficient and unproven." The Fieldbus Foundation, which supported the standard, publicly decried its "German opponents," announced it was considering legal action against them, and moved to disallow six of the negative votes.

Fortunately for users, the rhetoric toned down, and in July 1999, a memorandum of understanding was signed between the various parties. Consensus of the signatories—all three major fieldbus organizations, along with suppliers Fisher-Rosemount, Rockwell Automation, and Siemens AG—was to integrate relevant sections of the three specifications into the existing IEC documents before the end of October 1999.

More good news is that suppliers are not waiting for the latest committee vote, and are working to simplify the application of fieldbus technology. For example, Rockwell Automation, which supplies ControlNet devices, has joined the Fieldbus Foundation and says it will offer training on fieldbus configuration. In November 1998, Rockwell introduced a linking device between ControlNet and the Foundation Fieldbus H1 network, which makes it possible to access Foundation-compliant devices and transfer the data throughout a manufacturing or process plant via ControlNet's high-speed, deterministic safe network.

Other controls suppliers have started to support both of the superpower standards—Profibus and Foundation Fieldbus—suggesting that if the industry can't agree on a single international fieldbus standard, at least it can agree on two. ABB Automation, for instance, says that it supports its customers in Europe with Profibus devices, and its customers in North America with Foundation-registered components.

PC-based Technology

The question of whether the PC is suitable for "process control," a question that is still actively debated at power industry IT meetings, has essentially been replaced in other process industries by how quickly will it be fully integrated into the mainstream control systems. This is an important area wherein the power industry seriously lags its brethren in other process sectors.

One of the ways that plant control systems have become "open" is by using the Windows-based NT operating system (OS) instead of UNIX or even a vendor-proprietary OS. NT is a Microsoft product which means that it easily interfaces with most other Microsoft desktop applications.

NT is reportedly very stable compared to Windows 95. While there has been almost ceaseless debate about the suitability of NT for industrial applications, the OS appears to have won out and IT suppliers like Fisher-Rosemount are using it for process control at chemical and process/power stations. Most of the industry's traditional DCS suppliers now offer systems based on Windows NT, including Honeywell, Westinghouse Process Control, and ABB Automation.

But Windows NT is only one "standard" that has become popular in the industrial control world. OLE and OLE for process control (OPC), ActiveX, and Visual Basic for Applications (VBA) are powerful programming standards that control and supervisory software are built around today. These already permeate the process and manufacturing industries and many experts anticipate that they are going to penetrate the power industry swiftly. OSI Software Inc. is a good example here. It pioneered the application of real-time data collection software, which many power stations now use. Importantly, the company promotes the fact that it received the "Designed for Microsoft Windows NT and Windows 95" logos, and that its technology tools are Microsoft standards, ActiveX technology, VBA, and an SAP certified R/3 link (R/3 refers to SAP's latest enterprise-wide resource management system software).

The larger trend here is the development of a "workspace" customized for the specific facility that at least to the user appears independent of all software applications. For example, Intellution Inc. boasts a workspace that allows you to create a document in Microsoft Word, call up any related project file in an OLE-compliant application, edit that file, and return to the original Word file, all with the single mouse click and within the same screen.

Intellution and many others bring the power of object-oriented software to bear on the workspace. Just like a PC is constructed of chips and boards to create a working unit, object-oriented software modules "plug and play" seamlessly with each other. Pieces of "off the shelf" computer code modules are linked together in an object-oriented system, in contrast to proprietary systems where custom code is written for each application.

In fact, object-oriented technologies (OOT) have essentially blurred the lines between the traditional distributed control system (DCS), programmable logic controller (PLC), and PC-based systems. Again, Microsoft is at the bottom of OOT, with its distributed component object model, but object linking and embedding (OLE), OPC, ActiveX, Java, and Dynamic HTML (the language of web page construction and transmission) are also part of OOT. In many ways, what these technologies do is allow intelligence to reside closer to the device level, freeing up processing power and time and speed for high-level functions at the PC.

Sensors, Control Valves, Pumps, Dampers, and Control Elements

On the other hand, while information delivery and transfer advances, and diagnostics capabilities grow, little emphasis is still being placed in the power industry on improving the basic sensor and final control device technology. A control valve, from a mechanical and performance point of view, is still a control valve. Most temperature sensors are thermocouples backed by technology from the last century. Dampers still have age-old problems with leakage and sealing that no amount of IT is going to solve. You may be informed that the damper is leaking without having to take a trip to the device, or see the effects in performance, but it is still likely to have the same probability of leakage as before. Communications technology is several times more reliable and precise than a sensor or control element.

Plus, fundamental pieces of information are still missing. Coal facilities still lack good data about their basic raw material—most plants still plug in a sample taken daily from the coal pile or unit train. Gas-fired power plants also collect little information about fuel flow and quality. Even monitors as basic as O_2 measurement often give operators trouble and are still considered unreliable, even though they've been used for decades. Few gas-turbine based plants are equipped with differential pressure sensors across inlet-air filters and selective catalytic reduction systems, which are needed to calculate even a modestly accurate heat rate.

Basic initial and final control device technology has barely budged. What virtually all control element suppliers have done is add microelectronics packages onto their hardware to provide diagnostic capabilities, trending, maintenance indicators, calibration, and so on. However, improving how the actual device does its job—opening and closing, sealing, resisting corrosion and erosion, etc.—has changed little. Better initial and final control devices are often confused with better signal processing, more sophisticated analysis of the data already available, or traditional measurement techniques combined into a single "instrument." So-called smart electronics, for which advances have truly been remarkable, only affect the signal after it is produced.

Some control valves require more than a 10 percent change in the input signal before they will respond, preventing a control loop from performing effectively with today's precise control systems. In fact, several DCS retrofits at power stations have been tripped up because of antiquated control devices that do not respond properly. Almost without exception, valves, dampers, and actuators are analog devices with continuous position settings over the span from fully open to fully closed. This is true regardless of the actuating medium—air, oil, or electric power. Seemingly minor changes in the process or harmless degradation of mechanical elements in control devices can distort the intelligence being transmitted by today's smart electronics.

The market for sensors worldwide was estimated in one report to be $9-billion in the process industries alone, with power generation accounting for 22 percent of this figure. Flow, temperature, and pressure are predominant parameters for sensors in power stations.

Enterprise-wide Programs

An important goal of most major IT suppliers was to become the information "window" on the plant. This is analogous to being the turnkey contractor for engineering, procurement, and construction of a new power station. Many suppliers liked to show an information "wheel" with their firm in the middle, interfacing with sub-suppliers to obtain vital information. However, with the plant controls being integrated into a corporate-wide information system, this goal became a moot point.

Now it appears that some form of enterprise resource planning software is the main engine driving the business. This software typically takes three forms: (1) enterprise resource planning (ERP) packages that "do everything, monolithic giants that cost hundreds of millions of dollars for large corporations to implement; (2) enterprise asset management (EAM), a mid-range solution that cost tens of millions of dollars; and (3) computer-based maintenance management systems (CMMS) that can be implemented for under $1-million. ERP and EAM usually include some form of maintenance management system or work management system. Examples of ERP firms are SAP, PeopleSoft, J.D. Edwards, and Oracle. Examples of EAM firms are Indus International (which recently merged with TSW International), PSDI Maximo, Walker Interactive, Mincom, and Engica/Logica, with the first two dominating the power industry at present. Several of them have an Oracle database system at their heart.

Another major category of IT is the distributed control system (DCS)/automation supplier. All of the DCS/automation firms have been busy stripping their offerings of proprietary architecture, enabling them to be integrated into the larger IT framework. The overall objective is to integrate process control and business IT systems throughout the plant. In the last few years, Westinghouse rolled out Ovation, ABB Bailey Controls its Symphony suite of DCS tools, Yokogawa Corp. of America its Enterprise Technology Solutions, Fisher-Rosemount its PlantWeb, and Honeywell its TotalPlant package.

What these developments mean is that what started out as modest functions have been expanded to include more functions. CMMS has evolved into EAM and the DCS into plant information management systems (PIMS) because the plant systems need to communicate with the business systems of the owners.

Automation Research Corp. (ARC) estimates that the ERM/CMMS market will top $1-billion in 1999, and will become close to a $2-billion market by the end of 2002.

Plant Design Software

Another important general category is plant design software. These packages can range from what are considered effective packages for preliminary design for initial budgeting estimates (Enter Software, Thermoflow, and Sepril) to full-blown packages used to perform the detailed design of power stations and manage the workflow/communications that surround it (Intergraph, Bentley/Jacobus, CAD Centre, Primavera, and Aspen). Once again, some of these firms began with modest costing/scheduling software functions and expanded; others began with sophisticated two- and three-dimensional modeling and graphics capabilities.

According to a report by Daratech Inc, Intergraph is by far the largest of the plant design and visualization firms, with over 50 percent of the market. CadCentre Ltd. enjoys 16 percent, while Bentley, EA Systems, Dassault Systems and others each have between 2.0 and 4 percent of the market. Shares of market in the power industry may be different from these figures. In the 2-d market, Autodesk (33 percent), Bentley (24 percent), and Intergraph (23 percent) rank in the top three. Over 70 percent of the systems are used on the Windows NT platform. Interestingly, the power industry ranks second in terms of market percentage in 1998 for plant design software. Oil/gas is first (27.3 percent), chemicals third (16.6 percent), petrochemical is fourth (13.5 percent).

In many ways, another IT function, document management, is being subsumed by plant design just like CMMS was swallowed up by EAM and ERP. Document management includes the conversion of existing hard-copy drawings of plant systems into electronic files as well as the creation of new documents originally in electronic form that are managed throughout the plant's life cycle.

Key to the plant design suite—marketed under labels such as plant continuum, life-cycle services, and data asset approach—is a single database, properly integrated and supported by appropriate applications, and provided with interfaces to real-time information. Once again, the objective is familiar: to tear down the barriers and delineations between conceptual and detailed design, engineering and procurement, construction and O&M, and so on. To do this, these packages now make full use of the Internet and Web communications protocols. Design teams across the globe now have access to current design information at all times, which is updated when anyone makes a change.

At nuclear plants, such capabilities are vital because regulators are ever vigilant. Using computer-based design information as a continuous strategic asset helps support regulatory requirements less expensively than before. Duke Power Co., for one, now sees the entire business of running a nuclear plant as an "information management task."

To build new plants, the industry has adapted powerful software programs that allow firms to evaluate different power plant cycles and equipment options in a fraction of the time it might have taken ten years ago. What was once known as preliminary design can be conducted in a matter of hours—with the proper software and training in how to use it, of course—resulting in a cost estimate within +/- 15 percent.

Detailed design is also done on huge software platforms that allow project participants from around the world to build the plant in cyberspace. Today, these systems are being directly linked to supplier computer networks so that designers, primary and secondary equipment and subsystem suppliers, owners, and others can all work in concert to speed up design, engineering, and construction. Key to these systems is a single relational database, properly integrated and supported by appropriate applications and provided with interfaces to real-time information.

According to Intergraph Corp., Huntsville, AL, entire 700-MW nuclear power projects can be designed today using computer-based design tools, in at least one case with multi-million dollar cost reductions in construction, drawing production, and material control. Today, it takes little more than one engineer and one designer to handle all the piping design for a 100-MW cogeneration facility, using new 3-D CAD design, graphics, and communications tools, according to other advanced design system suppliers.

Document Management

An area closely related to plant design software is document management. DM systems store text, video, audio, and graphic images, run on client/server platforms linked to Intranets, and allow authorized users to view, change, and route current versions of the documents in the system.

Because it is intimately tied to the design and engineering process, it is probably best categorized as a subset of plant design software.

In the power generation arena, it has its greatest impact with nuclear plants. They can cost more than $1-million to implement, according to one source, but they have features that go well beyond relational databases, ERP programs, and collaborative work systems like Lotus Notes and e-mail. This market was estimated at over $300-million in 1998; the share in power generation is not known but is probably a small fraction of this figure.

Predictive Maintenance

This, another broad IT category, has some essential specific tools for an IT-enabled power station. Like so many other areas, predictive devices—which can continuously link devices like advanced vibration monitors, or hand-held devices which are used to take intermittent readings—are combined with software packages to arrive at knowledge-based asset management.

The basic PdM suite at a power plant today includes vibration analysis, shaft alignment measurement, tribology for lubrication systems, and thermography to detect patterns in heat loss and gain. Tribology and oil analysis includes spectroscopic methods, ferrographic methods, and particle counting techniques. Oil analysis may be conducted in-house, samples may be sent to an outside lab, or portable devices may be used to gain a quick read on contaminants in the oil.

In addition to these common techniques, a variety of specific ones are used from plant to plant. Acoustic emissions monitors tell boiler operators when they have a tube leak; wear particle analyzers indicate when a steam turbine is suffering from solid-particle erosion in the high-pressure turbine module. Boiler life estimation routines can suggest when tube wall thinning has progressed to the point that a failure may be imminent. Ultrasonic analysis shows where leaks may be occurring in steam traps and compressed air systems, where bearings on rotating equipment may be deteriorating, and can help gage where piping has thinned severely because of erosion or wear. Finally, borescopes are applied to inspect gas and steam turbine blades and rotors without having to tear the machine apart.

PdM, however, predicts a situation. It is up to the staff and those that rule on investments to do something about it. The direct output of a PdM device is data, which must be translated into a conclusion and then an action or task. Again, the common rule applies—the expenses and investments in PdM, like many IT functions, are largely in the training, expertise, and commitment necessary to make them successful. However, that expertise does not necessarily have to reside at the plant. Borescopes and thermography devices can be operated by plant staff, for example, but the captured images can be sent elsewhere for analysis and recommendations.

In addition, PdM isn't cheap, especially in terms of manpower committed. Therefore, the most successful programs take the time to determine which pieces of equipment should be inspected, or subjected to the PdM device, and at what frequency.

The payout from a successful PdM program can be very high. The largest power station in the country, the Palo Verde nuclear station, reports that its PdM program, which is comprehensive and has extensive management backing, returns at least six dollars for every dollar invested in it.

Telecommunications

Telecommunications firms are major players in IT that shouldn't be neglected. Representatives from AT&T, for example, have reported on wireless, postage-fee-based communications services that can be applied to ease the tasks of remotely organized teams of specialists responsible for power plant assets.

Although the large telecommunications firms clearly have the networks and the technology for mobile, and wireless, and the computer firms make the laptops and portable computing environments, a host of smaller firms is actually putting the devices together to make a business. Handhelds and wireless devices are common on the transmission and distribution side of the business, but are only now emerging in the power plants. One reason is that wireless communications signals can interfere with other in-plant networks; also, radio-modem transmission can be garbled or blocked by trees, mountains, lightning, and other forms of interference.

In a typical wireless setup, workers use mobile, handheld, or laptop computers wirelessly linked to internal systems, with which they can automatically receive directions to a job site, review the job's history, identify equipment and materials needed, create and transmit work orders and bill of materials, check inventory for parts and arrange for on-site delivery, access manuals and repair diagrams, and conduct and input inspection readings. The technologies enabling all this are: (1) a new line of ruggedized hand held terminals, (2) Windows-based graphical user interfaces, and (3) wide-area networks, built with satellites, analog cellular equipment, or packet-switched network architecture. Many so-called workforce automation

(WFA) schemes may also be based on geographical information systems (GIS) or global positioning systems (GPS).

Again, the theme of open integration emerges. According to one mobile technology specialist at a utility, it is the ability to integrate with existing systems. An Achilles heel with these devices is battery life. Just like many users of portable computers have suffered through batteries that don't last as long as predicted, or that don't hold their charge as long as they are supposed, so do these devices.

Many of the WFA programs at power stations are implemented through CMMS or EAM programs.

Environmental Compliance

Because of intensive monitoring and reporting requirements to authorities, environmental compliance is a specialized subset of plant-level IT. Continuous emissions monitors for criteria pollutants—primarily NO_x, SO_2, and others—are now standard for new plants and large coal-fired plants governed by the Clean Air Act have had to retrofit such monitors. Often, these monitoring systems are integrated into a software and reporting system that essentially automates the recording and reporting of the data and the calculations based on the data.

In recent gas-turbine-based combined cycle IPP projects, the plant CEM system is linked to the authorities at the state level and to others who need to have real-time access to this data. Although power stations still harbor great suspicions about the reliability of CEM systems, much of it well-placed, some IT experts anticipate that CEM system data can become critical pieces of information for automated feedback loops in the power plant control system.

An important subset of the neural network applications also resides in environmental compliance. So-called predictive emissions monitoring (PEM), the use of high-powered, sophisticated neural networks, allows a plant to avoid actual in-stack/duct monitors. By using other data readily available at the plant, such as coal characteristics, and a process model of the boiler, the real-time emissions can be predicted. Regulators are only now becoming comfortable with such procedures but they have the capability to relieve power station personnel of much aggravation and maintenance with the CEMs. This is also a clear example in which an IT "system" is able to replace a mechanical system (i.e. CEM monitors).

PEM systems are especially attractive for gas-turbine-based power systems, gas-fired boilers, or other cycles in which the fuel is relatively homogeneous. In at least some cases, a

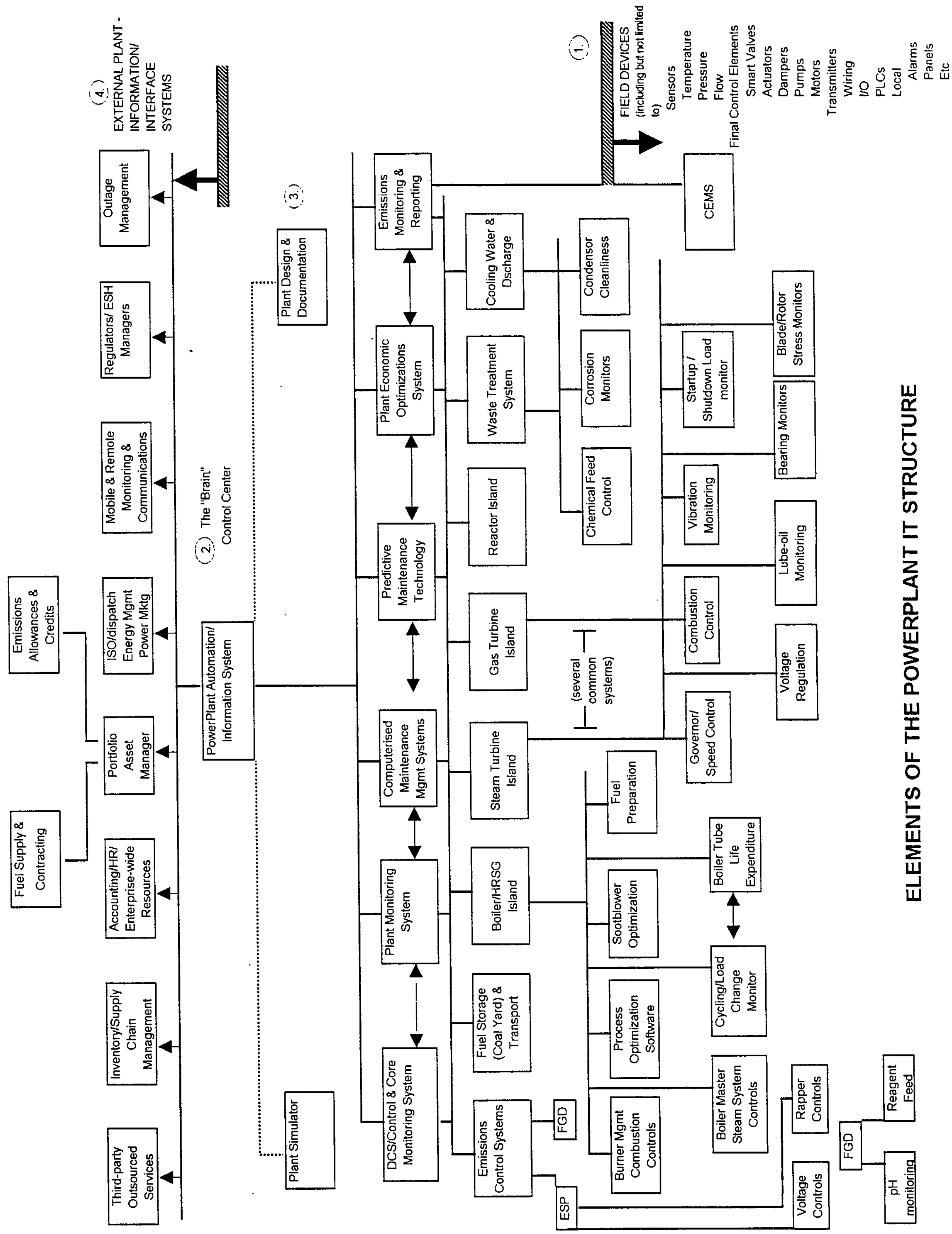
PEMs system can operate on a standard PC. Importantly, a PEMs system can provide valuable diagnostics, unit efficiency, and turbine health information to the facility. Whenever CO or NO_x emissions increase, it indicates problems in the gas turbine combustion process, especially in today's advanced machines with extremely sensitive low-NO_x firing systems. Because a CEMs system for a gas-turbine power plant can cost around $200,000, with annual maintenance costs as high as $40,000, substituting PEMs is economically attractive for monitoring and reporting NO_x and CO emissions.

Segmentation of the Industry

This report has been segmented first by combustor type and then by new vs. retrofit. A third division has been by product.

Figure II-I shows the IT product divisions for fossil-fired plants. The broad categories are plant automation systems, field devices, plant design, and the external interface information technology. The coal-fired plant has many more Input/Outputs (I/Os) than the gas-fired turbine. The forecasts in the following chapters are segmented into these four categories.

FIGURE II-1.



ELEMENTS OF THE POWERPLANT IT STRUCTURE
(4.) EXTERNAL PLANT - INFORMATION/ INTERFACE SYSTEMS
Outage Management
Regulators/ ESH Managers
Mobile & Remote Monitoring & Communications
ISO/dispatch Energy Mgmt Power Mktg
Emissions Allowances & Credits
Portfolio Asset Manager
Fuel Supply & Contracting
Accounting/HR/ Enterprise-wide Resources
Inventory/Supply Chain Management
Third-party Outsourced Services
(2.) The "Brain" Control Center
PowerPlant Automation/ Information System
(3.)
Plant Design & Documentation
Plant Simulator
Emissions Monitoring & Reporting
Plant Economic Optimizations System
Predictive Maintenance Technology
Computerised Maintenance Mgmt Systems
Plant Monitoring System
DCS/Control & Core Monitoring System
Cooling Water & Dscharge
Waste Treatment System
Reactor Island
Gas Turbine Island
Steam Turbine Island
Boiler/HRSG Island
Fuel Storage (Coal Yard) & Transport
Emissions Control Systems
FGD
ESP
Condensor Cleanliness
Corrosion Monitors
Chemical Feed Control
(several common systems)
Fuel Preparation
Boiler Tube Life Expenditure
Sootblower Optimization
Cycling/Load Change Monitor
Process Optimization Software
Burner Mgmt Combustion Controls
Boiler Master Steam System Controls
CEMS
Startup / Shutdown Load monitor
Vibration Monitoring
Combustion Control
Governor/ Speed Control
Blade/Rotor Stress Monitors
Bearing Monitors
Lube-oil Monitoring
Voltage Regulation
Rapper Controls
Voltage Controls
FGD
Reagent Feed
pH monitoring
(1.) FIELD DEVICES (including but not limited to)
Sensors
Temperature
Pressure
Flow
Final Control Elements
Smart Valves
Actuators
Dampers
Pumps
Motors
Transmitters
Wiring
I/O
PLCs
Local
Alarms
Panels
Etc