Intelligent Production Fields

Innovative Use of Siemens Automation in Oil & Gas Production

Application Brief

Intelligent Production Fields

Application Description

Process Description

Onshore Oil and Gas production fields consist of well sites, where well stream fluids are extracted, and gathering systems, which transport the extracted fluids to a central processing facility. Here they can be processed prior to collected transportation. The integrated control and monitoring of hydrocarbon production is significant because the production field consists of multiple well sites distributed over a wide geographic area.

Due to the functional and geographical disparate nature of well sites, they have traditionally only been considered as stand alone entities with local control only required for each site. This results in a minimal amount of information located in isolated pockets.

However, in today's competitive market, it is essential to maximize the use of technology to improve field management and operational effectiveness. One of the primary reasons this has not been done has been the lack of high bandwidth cost effective communications.

Control Challenge

Typically, well sites have a relatively small amount of instrumentation, usually less than 60 data points. These consist of a mixture of analogue and digital inputs for monitoring with a few analogue and digital outputs to control choke and block valves, which sometime include a subsurface shutoff valve (SSSV).

This has traditionally been accomplished by the use of (RTU's) or small (PLC's) or a mixture of both. Depending on the hydrocarbon content of the well stream and location, Fire & Gas detection and mitigation may be included within the control scheme.

This data is then transmitted to a central location by the use of low bandwidth radio or a modem operating over a dedicated line. This results in the RTU only being polled for data infrequently, meaning that the data displayed at the operator station may be several or even tens of minutes old.

Industry Trends

Today new challenges and technologies have arisen which require owners and operators to re-evaluate how they manage their assets. These changes have lead to new

possibilities and trends within the industry, providing both economic and environmental reasons for operators to take advantage of them.

Communication Systems

Advances in telecommunication and data handling now enable increasingly larger amounts of data to be captured, stored and analyzed. The options of communication are now much wider and more flexible. These include fiber optic, cell phone (GSM), satellite and now, with the advent of 3G mobile services, effective wireless broadband.

Along with the development of corporate intranet structures, any data that is obtained is immediately available worldwide. This gives the local operations group the facility to get corporate experts to oversee problems, and give best advice on any developing or unforeseen challenges.

Data Availability

The increase in communications technology has been directly attributable to the increased performance of electronic components. This has provided more powerful microprocessors and increased diagnostic information on components. Operators can now focus on the economic value of their operations more than they have been able to do before.

The aforementioned improvements in data communications mean that it is now possible to access data from remote sites in real time. This means that operations management can now make better informed decisions regarding field operations, knowing that they made their choice with the most viable and latest information available at that moment.

It also means that the line between DCS and PLC/SCADA is becoming increasingly thinner. DCS system networks are now able to be spread over geographic areas that were previously the domain of Wide Area Networks (WAN) without any adverse effect on the DCS's operation.

Security

Due to the increasing threat of sabotage, surveillance is now on the agenda of operators to ensure secure and uninterrupted operations. Traditionally, security consisted of a fence with some barbed wire and maybe a discrete alarm point if the site was entered.

Because of recent economic and political instability in areas such as the Middle East and Nigeria's Niger Delta, to name but two, the incidence of sabotage, whether politically or economically motivated, has focused the minds of operators on securing their assets.

This has lead to a renewed interest on security, which has also benefited from the communications developments. It is now possible to use some of the communications bandwidth to send time lapse CCTV images to the main control centre.

The use of more advanced intrusion detection systems has also enabled more meaningful alarms to be raised. These are especially valuable when the site may be

located near a population center or is adjacent to a thoroughfare with a high volume of transient traffic.

Whereas previously the security facet of operations was intended to prevent people or animals coming into harm, it is now additionally focused at preventing sabotage of the process facilities and allaying environmental impacts. Sabotage can take several forms; most notably, a terrorist attack leading to the destruction of the site, or more benign forms such as theft of equipment or consumables.

Field Management

Reservoir management is one area where technology, such as 3D and now 4D seismic, has greatly improved the understanding of reservoir formation. What is required to develop it in order to maximize the return from the field has also been enhanced. Improvements in data technology have assisted greatly in this regard.

The improvements in down hole instrumentation reliability, coupled with data transmission improvements and better geological understanding, mean that the field management role has now been made significantly easier. It is now possible to operate the field in the most optimal manner to ensure not only maximum production rates, but also to maximize the field life. This is a win-win situation for the owners and operators of the field.

It is also possible to deploy enhanced oil recovery (EOR) technology to provide improved recovery and to afford the greatest benefit for maintaining reservoir conditions,

Asset Management

Asset Management is now about so much more than instrument devices. It also includes such factors as asset utilization, not just whether a device has a fault. These new features have given operators the ability to gain information not only of the process but also the complete view of the process equipment and its performance. The operator can now develop more refined control strategies, which are better able to enhance production optimization from the field.

The data from the equipment is not exclusively related to the process conditions, but also the serviceability of the equipment such as pumps, motors, instrumentation and control devices. This information is critical so as to allow operators better planning of maintenance activities, which means production interruptions can be minimized and costs can be reduced.

Environmental and Safety

Environmental laws have become far more stringent over the past decade or so. After several well publicized environmental incidents, operators have become adverse to this kind of bad publicity. It therefore makes sense to minimize if not avoid any incidents that may lead to an environmental incident.

In concert with security there is an increasing tendency within the industry to apply functional safety concepts as described by standards like IEC 61511 to all safety related

controls. These functional safety concepts, at their basic level, provide the methodology to define the risks associated with a process and the systems used to mitigate it.

Users concerned about economic and the environmental risks may use Functional Safety concepts to quantify and address those issues. An example is the increasingly used EIL (Environmental Integrity Level). Organizations that apply Functional Safety to their large processes like Gas Plants and Refining show a natural tendency to be consistent in their approach to safety.

This drives functional safety concepts across the organizations and down to even small systems. If these concepts are used, the ability to define the risk reduction levels of the control system and the use of certified safety systems will be required.

Electrification

The use of electrical equipment as prime movers, and trace heating for production areas is gaining strength. The ability to use electricity, with an ever increasing electrical infrastructure, is available in areas where it was previously cost prohibitive.

The compactness, low maintenance and high efficiencies associated with electric motors means an increase in the use of electrical apparatus. The added efficiency of variable frequency drives is further accelerating this trend.

In gas fields, it is now possible to replace traditional gas engines with small gas turbine generators in the field. When combined with electric motors and drives, they are highly efficient.

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Siemens Solution

Siemens offers a full portfolio of products for all levels of production automation. Furthermore, when the emerging trends begin to converge and the operator wants a more integrated, more efficient operation, then Siemens can offer a unique set of solutions that can greatly enhance the producing operation and make it more competitive.

Fields that require more dynamic control and optimization, security and integration of electrical components are appropriate for Siemens expertise. Siemens can put together a complete solution tailored to the specifics of the individual field. *One Company, One Solution*.

Intelligence in production fields is a matter of increasing the transparency of what is happening at remote well sites, optimizing controls and bringing that increased data set into a centralized facility. Here, a streamlined operations team can make informed decisions and take immediate action.

Major Components

There are four major components of the Intelligent Production Field:

- Communications
- Automation and Control
- Security
- Electrification

Communications

The communication networks are at the heart of modernizing a field. The integration of the many well sites that make up a field has traditionally been limited by the lack of and expense of the communication structure. New technologies offer a range of options for transmitting data resulting in lower costs and higher bandwidths.

Satellite, cell, fiber optics and radios are all options for communications. Siemens can help determine the options available and supply many of the components in the networks. Regardless of the communications technology in use, Siemens can use it to upgrade the data and intelligence of your operation.

Automation and Control

The Siemens PCS7 Telecontrols system is a unique blend of the functions of the PLC, SCADA and DCS. Using PCS 7 as the backbone of your automation and control scheme offers unprecedented flexibility and large potential benefits. The system offers the ability for:

- Real-time process control and optimization
- Diagnostics and status of the control system, major assets, and field operations

- Shared operator control and remote monitoring
- Multi-network SCADA functionality
- Integration of Safety and Electrical functions
- Integrated data management
- Integrated engineering

Security

Layered with the same communication network, Siemens offers integrated security systems that can include:

- Facility access
  Know who and when are at each location.

- Intelligent Video
  Combine multiple cameras and remote sensors into a single, intelligent screen

- Fiber Optic Sensing
  Sense third party interference in real time over large geographies

Electrical Apparatus

Siemens is a leader in electrical apparatus, motors and drives. As the trend moves toward electrification, the integration of electrical equipment with the controls and monitoring system grows increasingly important. Siemens can supply seamless integration. Whether you are needing electrical distribution or control of motor-drive on the well, *Siemens has the solution*.

Customized to Your Field

The correct solution is one tailored to your field. It is important to define the needs of the operation and determine the economics for applying the technology. If tertiary recovery methods are employed, control aspects rather than just monitoring become more important. If the reservoir is fragile, close coordination of the production may require additional control steps.

Some things are constraint limited. Intelligent Video, for example, requires high bandwidths that may be limited by the communications network, and Fiber Optic Sensing requires available fiber in close proximity to pipes.

Architectures

Overall Architecture

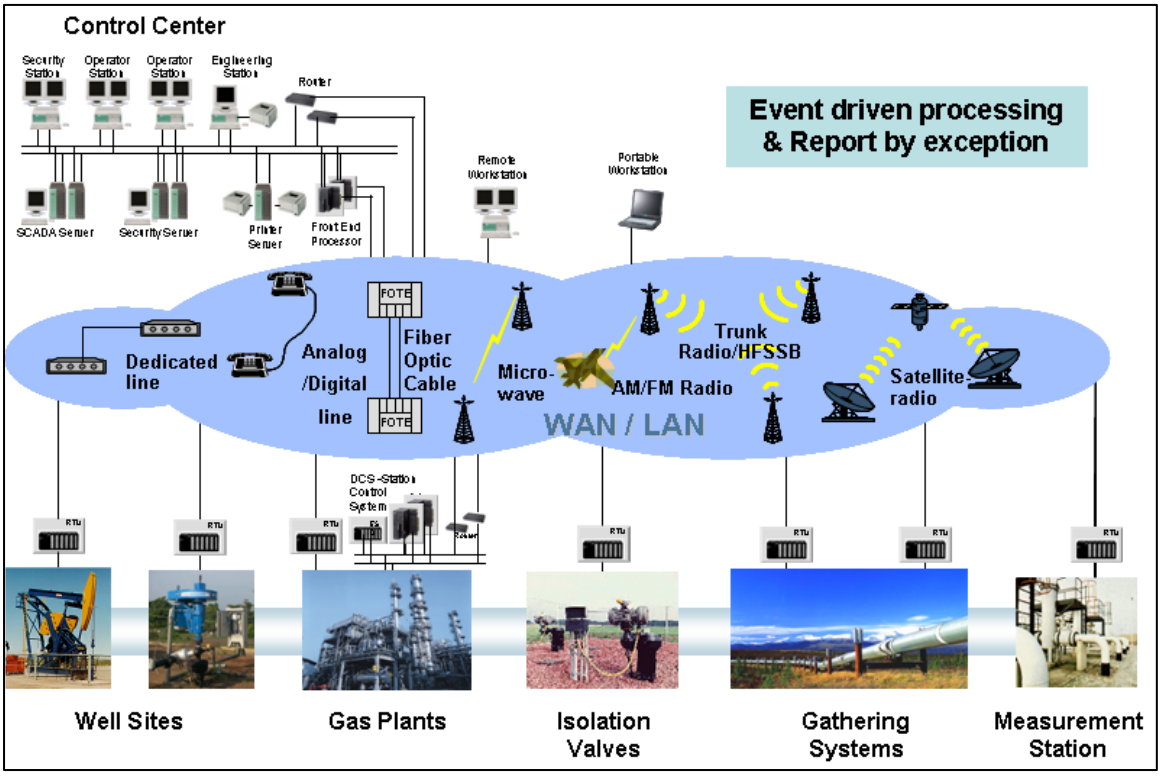
The goals in field automation are:

- Create a safe and secure operation
- Gather more data on the equipment and operations

- Turn data into useful information that drives production, efficiency, and reliability
- Minimize trips to remote locations
- Maximize the effectiveness of trips to remote locations

Therefore, looking at a production field as a whole, including well sites, gathering systems and processing facilities, is the only way to make those goals achievable.

The key is to create the ability to generate useful data at the individual sites, and then gather that data to a central location where it can be analyzed, evaluated and used. The Siemens Solution is to design small systems at each site that will collect and time stamp the data, and then utilize the PCS 7 Telecontrols system to communicate the information back to a central location. At that point, a traditional DCS structure delivers process control, advanced control, alarming, asset management, analysis, archiving, and reporting.



Production Field Overall Architecture

Site Architectures

The overall architecture begins with the right system at each site. Because each field is different and sites vary, a specific design will be required to match the requirements. However, some typical site automation architectures would be:

Well Site

At the well site, a relatively small number of Input and Outputs (I/O) are tied to a control system and data from there is relayed to the main PCS 7 Telecontrols system.

Processors

Siemens offers two options for RTU processors depending on the site requirements:

Small RTU

- Typically up to 100 I/Os
- S7-300 with SINAUT TIM, IEC Library or Modbus CP
- Failsafe option
- Flexible, affordable

Large RTU

- Typically up to 500 I/Os
- S7-400 with SINAUT TIM, IEC Library or Modbus CP
- Failsafe option
- Redundancy Option

Architecture Options

There are options that can reduce the I/O count, footprint and provide enhanced diagnostics:

ProfiBus PA Fieldbus

ProfiBus PA is a fieldbus that allows the attachment of multiple transmitters and sensors on a common network. Because up to 25 instruments can be added to a single wire pair, and no I/O modules are required, savings can be made in wiring costs, footprint and RTU costs. Instruments over ProfiBus provide remote diagnostics and the ability to set parameters and reconfigure from a remote location.

Siemens has a ring bus structure for ProfiBus PA that adds additional reliability. Options for ProfiBus PA include intrinsic safety for hazardous areas and TÜV approved safety protocol for meeting safety system standards.

Smart Motor Control Centers (MCC)

Siemens offers Smart MCCs based on Siemens Simocode. Simocode provides motor protection but communicates digitally by ProfiBus DP to send a variety of motor information. This includes voltage and current levels, number of starts, overload

warnings and bearing temperatures. These provide valuable asset data on the motor and the attached pump or compressor.

Drives

When a Variable Frequency Drive (VFD) is used, they can communicate directly by using ProfiBus DP. Again, this allows asset data on the motor/drive system and eliminates the need for drive feedback inputs. Configuration of the drives can then be handled remotely as well, reducing commissioning and maintenance time.

Emergency Shutdown Systems

Emergency Shutdown Systems (ESD) can be incorporated into the main RTU or designed as a stand-alone system. Siemens provides certified systems to SIL 3.

Fire & Gas

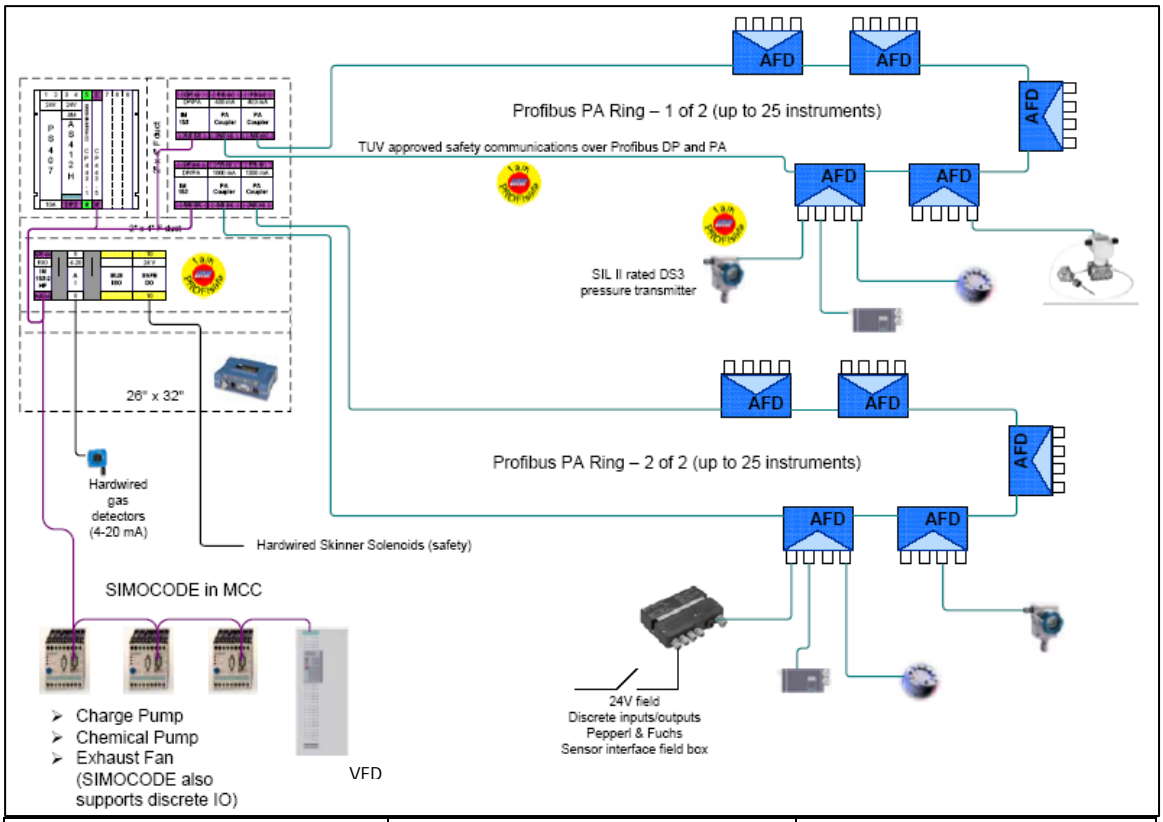
Fire and Gas sensors are often required for safety. Siemens' systems can integrate these sensors into the main RTU, eliminating the need for additional, diverse systems, and providing a common data communication link. Options for Functional Safety designs are available.

Video

Cameras can be incorporated into the well site design allowing remote monitoring. These inputs can be incorporated into the RTU design or can be part of an intelligent video system.

Wireless Access Point

If the SCADA connection supports a link to the Internet or to corporate information systems, a secure wireless access point can be included to provide a secure connection. This can connect to a worker's laptop or portable device back into the main information system to check status, update records and gather assignments.



Analog Inputs	Discrete Inputs	Discrete Outputs
Wet Gas Flow (per well)	Pump Suction Low	* Charge Pump Run
Sale Gas Flow (per pad)	Tank High Alarm Level	** VFD Start
Injection Pressure	Tank Low Alarm Level	* Chemical Pump Run
Casing Pressure	* Booster Pump Feedback	* Exhaust Fan Run
Radar Tank Level (multiple)	** VFD Feedback	Surface Shutdown Valve (SIL)
Separator Pressure (per well)	High Pressure Discharge	
Reboiler Temperature (per well)	Pump High Vibration	**Analog Output**
Separator Temp (per well)	Oil Cooler Level Float	Separator Pressure Control Valve (per well)
Heat Trace Temp (2 per well)	** VFD Fault	
Gas Monitor Floor LEL	Tank 4 HiHi Level	
Gas Monitor Ceiling LEL	Tank 9 LowLow Level	
Gas Monitor Electrical Area LEL	Tank 12 HiHi Level	
Gas Monitor in MTR LEL	Gas Valve Open Position Switch	
Gas Monitor Offload LEL	Gas Valve Closed Position Switch	
Gas Monitor Offload LEL	Offload High LEL	* Not needed with SIMOCODE
	Injection building High LEL	** Not needed with Drives ES

Typical Well Site Architecture

Gathering System

As part of the gathering system, additional facilities may be required. These might be separation units, sulfur recovery, pump or compressor stations or storage tanks. Because of the relatively small I/O counts and the need to get the information back to a remote facility, the core architecture of the gathering system is similar to that at a well site. However, some additional features may be required.

Building Security

Larger units or pump/compressor stations may have structures that require access control. Siemens can integrate building security access into the overall system.

Intrusion Alert Systems

For pipelines or perimeter control, Siemens can offer Fiber Sensing Systems or intelligent video.

Leak Detection

Most gathering systems are difficult for hydraulic modeling for leak detection but can be vulnerable to leakage, either accidental or deliberate. Siemens' mass balance leak detection utilizing ultrasonic technology is often an affordable, accurate and easy to install alternative.

Operator Interface

In facilities where operators are present either full or part time, the ability to look into the process is critical. At any point in the PCS 7 Telecontrols architecture, full access to the system can be provided, allowing control and viewing of the local facility in addition to other, remote portions of the system.

Gas Plant

If a gas plant is part of the field design, the architecture requirements change radically. Gas Plants require a large amount of I/O and more sophisticated control. The Siemens PCS 7 Telecontrols is, at its core, a DCS system.

This allows full process control functions and safety systems for control of the gas plant. Since cryogenic separation is extremely energy intensive, the ease of connecting the electrical components into the system is particularly advantageous.

If a gas plant is part of the overall field, it makes an ideal location for a centralized operations center. All the distributed sites can be brought back to a common control center.

System Components

Well Site Automation

Control System

Traditional control systems have been rather arbitrarily divided into two divisions:

- **PLCs and SCADA**
  Programmable Logic Controllers (PLC) were developed for machine control on the factory floor. PLCs are very good at high speed, discrete logic, and have evolved to be more full function.

  Supervisory Control And Data Acquisition (SCADA) systems are the monitoring packages designed for collection of data across a wide area. They are typically designed for use with a variety of end devices, and handle issues like buffering data and loss of network.

- **DCS**
  Distributed Control Systems (DCS) were designed for large process systems such as refineries, and include both control and monitoring in a tightly integrated package. As they were designed for the process industry, there are built-in libraries for handling typical process loops, flow, pressure, temperature, etc.

  Since large process plants put a high value on keeping a process running, systems are designed to have complete, seamless redundancy available when needed. Because of the communication infrastructure available at a large process facility, the systems typically assume a real-time network with no buffering of data.

A combination of machine and process control coupled with a wide geographic area, the Oil Patch presents itself as a unique place. Traditionally, production field automation has been done with PLCs and SCADA systems, mainly because of limitations in DCS.

DCS systems have not scaled down to the size needed at a well site nor have they dealt well with spread communication networks. However, through a combination of emerging trends and new innovations at Siemens, that traditional thinking is changing.

When the communication and electrical infrastructures are in place in large fields, the increasing number of data points, and the need to integrate control functions across the reservoir cause operators to reevaluate their approach to production automation. Siemens offers a unique combination of PLC/SCADA control and DCS to meet those requirements.

Siemens DCS technology, PCS 7, is based on its industry leading PLC line with added enhancements specific to the process industries. This technology provides the unique ability to scale the system and provide both PLC and DCS functionality.

Siemens' introduction of PCS 7 Telecontrols gives this unique DCS system the functions of traditional SCADA systems. It offers a range of network options and signal buffering for those less reliable communication paths common in the oil field.

Motors and Drives

The electrification trend is pushing the use of electric motors with variable frequency drives to gain increased efficiencies and lower emissions from traditional gas or diesel engines. Today's micro-turbine technology, for example, can supply low amounts of power at remote sites. Siemens offers a range of motors and drives to enhance your efficiency and reliability.

Process Instruments

Siemens has a full range of process instruments to measure pressure, temperature, flow and level. A radar level transmitter, for example, is ideal for oil storage tanks. Wireless options, remote setup and diagnostics can save installation and operating costs.

Infrastructure

Communication Networks

Siemens can help with a wide variety of communication options. From planning the overall site network, to integrating controls on the existing infrastructure, Siemens can offer expertise and options to enhance your operation. Ethernet integration is a particular specialty where Siemens offers a range of switches, connectors and access points designed for the industrial environment.

A wireless access point at the well site, for example, can allow a secure connection to a worker's laptop or portable device back into the main information system in order to check status, update records and gather assignments.

Electrical Infrastructure

Siemens can also assist with the electrical side of field modernization. From local distribution networks to full scale power plants, Siemens has the ability to offer solutions that meet the local requirements. Of course, the protection, monitoring, and data collection on those networks feed seamlessly into the automation systems.

Security

Some of the main risks for the oil and gas facilities are: construction activities near assets, third party activities, tampering, weather-related damage, malicious intent, sabotage, etc. Any of these actions can produce serious damage for people, the environment, processes, installations and continued production. Siemens supplies a wide range of security solutions including technologies in facilities access control, intelligent video and fiber optic sensing.

Access Control and Intrusion Detection

Siemens offers systems to secure access to facilities including central monitoring control rooms and individual well sites. The products and systems are flexible, scalable and easy to use. Siemens' range of access control and intrusion detection products and systems provide freedom of movement in a secure environment.

Intelligent Video

Siemens' Siveilance^{tm} SiteIQ^{tm} Solution goes beyond traditional video by displaying all surveillance input on a single screen. It is based upon Intrusion, Access and Video applications, installed at well sites, and at pumping, compression and valve stations.

Combining a digital map of your site with multiple camera information and other site specific sensor information, SiteIQ^{tm} allows you to establish virtual barriers and create intelligent policy zones.

Sensing Fiber Security

Siemens can integrate a Fiber Optic Sensing System for gathering systems and pipelines. This system detects and locates intrusions and third party interference anywhere along a buried pipeline, and in real-time before actual pipeline damage occurs. It consists of a sensing cable buried near the pipeline and a sensing control unit.

The system can use the existing fiber optic communication cable as the sensor, dramatically reducing both the time to install and the overall installation cost. A laser is transmitted along the fiber optic cable; the returned signal is automatically monitored and analyzed by the sensing control unit.

This all operates as a single system. Monitoring takes place up to 40Km, with an event localization accuracy up to150 m. Multiple sensing fiber systems can be tied together to monitor longer pipelines (thousands of kilometers).

Why Siemens?

Siemens offers a unique approach to DCS systems that combines the flexibility of a PLC with the data handling and optimization functions of the DCS system. With the introduction of PCS 7 Telecontrols, the customer now has the ability for a single seamless system across the entire production field.

Siemens PCS 7 can offer:

- A single integrated system for the entire field
  - Controls needed for well site monitoring and control
  - SCADA, control and optimization across the field
- Proven Network Security
- Integrated Diagnostics
- Asset Management
- Integrated Electrical Components
- Integrated Safety

Implementation Options

Siemens can work with you in a variety of ways to make sure the packaging and integration of the systems are completed to your satisfaction. Choose the method that is right for your project and operating style.

- **Siemens can supply products**
  Siemens can work with your engineering and integration team and supply the required control system products.

- **Siemens can provide turnkey control system**
  Siemens can provide a turnkey control system with integration into panels and system programming provided.

- **Siemens can provide full system requirements**
  Siemens can provide a complete Automation and Electrical package including equipment, control rooms, integration, programming, commissioning, and startup services.

For More Information

Siemens Website:

- www.siemens.com/simatic-pcs7

Siemens Brochures:

- Totally Integrated Automation for the Oil & Gas Industry
- SIMATIC PCS 7 Process Control System
- SIMATIC PCS 7 Process Control System
  Intelligent Maintenance Products
- SIMATIC PCS 7 Process Control System
  Plant automation and telecontrols in one system: SIMATIC PCS 7 TeleControl