A SURVEY OF COMPUTER ASSISTED PRODUCTION OPERATIONS IN THE GEYSERS

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ABSTRACT

In the decade of the 1980s, computer assisted operation of geothermal production facilities was extensively utilized in The Geysers. All companies which operate production facilities utilize computer-based Distributed Control Systems (DCS) to monitor and control the current conditions at physical entities such as production wells, injection wells, condensate vessels, and pressure relief vent valves. Some of these systems also provide extensive real-time data collection, reporting, and supervisory control features. In May of 1989, a survey of five operating organizations was performed to determine what features and benefits are currently provided by their DCS systems and to identify additional DCS features and benefits which are desired for the future. The results of the survey are documented in this article. It is hoped that companies and individuals involved in the development or operation of new or existing geothermal production facilities will benefit from the experiences of the organizations which participated in this survey. These organizations collectively represent a total of over 30 calendar years of geothermal production facility DCS operations experience.

INTRODUCTION

In May of 1989, a survey of five companies which operate geothermal production facilities in The Geysers was performed. These were GEO Operator Corporation, Freeport McMoRan (Geysers Geothermal Division), Northern California Power Agency, Santa Fe Geothermal, and UNOCAL Corporation. Each of these companies has at least 4 calendar years of operating experience utilizing a Distributed Control System (DCS).

Representatives of these companies were interviewed about their current system(s). The results are presented in this article and include the following:

- a comparison of features provided by each company's system(s),
- an evaluation of the benefits received from using these systems,
- an analysis of each company's level of satisfaction with itsr system(s), and
- a description of the relative desirability of future enhancements to each system.

The author was requested not to identify by company name the features, benefits, and future enhancement plans associated with each company. Thus, all interview results are presented generically as Companies A, B, C, D, and E. In addition, the interview results presented for companies having more than one DCS system have been consolidated and are presented as though each company has a single system.

DEFINITION OF TERMINOLOGY

One of the most difficult aspects of comparing technical products, capabilities, and procedures is the uncommon use of common terminology. Many terms are widely used which often mean different things to different people. Thus, in an attempt to establish a basis for a common level of understanding of how certain terms are used in this article, the following definitions are presented:

Distributed Control System (DCS)

A collection of one or more processing units which monitor and/or control selected physical entities and display and/or print the results on one or more operator stations containing at least one CRT/keyboard device and printer.

Entity

1. A physical object which is monitored and/or controlled.
2. A person who provides information or instruction to the computer system.
3. A person or organization who receives information generated by the computer system. Examples include wells, tanks, steam separators, operators, engineers, and managers.

Display

A collection of information presented on a CRT as graphic and/or alphanumeric representation of conditions which exist at selected physical entities. Typically, information on displays is refreshed every few seconds or when the conditions being displayed change.

Report

A collection of historical information printed at some time after the data were collected. A report typically covers a specific interval of time such as an hour, a day, or a month and includes items such as daily, weekly, and/or monthly values such as averages, totals, maximums, and minimums. Alternatively, a report may include tables of time-stamped values sampled over a specified period such as the total vent flow rate for each minute of a day or the total amount of steam produced for each day during a month.

Log

A chronological list of information in which each element is printed as soon as possible after it occurs. A typical log includes items such as alarm messages and description of operator entered values/commands.

Remote Manual Control

Action taken by a person usually located in a centralized control room. The control commands are typically entered via a CRT keyboard and transmitted electronically to the entity to be controlled. Examples include the entry of a command to start a pump or open a valve.

Automatic Control

Action taken at a specific physical entity such as a valve or pump based on conditions associated directly with that same entity. Examples include flow control of individual wells, a stand-alone pressure controller to perform high pressure relief at a rock muffler, and level control of a condensate vessel. Automatic control requires no manual (operator) action other than the establishment of the desired set points.

Supervisory Control

Action taken at one or more physical entity based on conditions associated with other physical entities. An example would be reduction of flow at all production wells to automatically eliminate venting of steam detected at the rock muffler vent valves. Supervisory control requires no manual (operator) action other than the establishment of desired set point(s).

BASIC FUNCTIONS AND ADVANCED FEATURES

All of the surveyed production facility DCS systems perform essentially the same basic functions. The differences among the systems are found in the type and effectiveness of the advanced features which are provided. Table 1 presents a comparison of the basic functions and advanced features which are performed and provided by each of the surveyed systems.

Figure 1 contains a Data Flow Diagram which illustrates the basic functions of a typical Geysers production facility DCS. It shows the physical entities associated with the system and illustrates the information flow between the system and each of these entities. Figure 1 illustrates the following functions:

- Monitoring of current conditions of production wells, separators, the gathering system pipeline, condensate sumps/tanks, plant inlet valves, condensers, vent valves, etc.
- Issuance of control signals to production wells, injection wells, separators, vent valves, and condensate sumps/tanks
- Generation of displays of current conditions and historical information to operators and engineers
- Acceptance of operating commands from operators and engineers
- Generation of reports for operations, engineering and management personnel

The results of this survey indicate that the companies which are most satisfied with their production facility control system are those whose system includes advanced features such as supervisory production control. Figures 2 and 3 illustrate how supervisory production control is

Table 1. Comparison of DOS functions and features.

PRODUCTION WELL INSTRUMENTATION MONITORING	COMPANIES: A	B	C	D	E
Well-head pressure	■	■	■	■	■
Well-head temperature	■		■	■	
Well-head differential pressure	■	■	■	■	■
Well control mode switch (hand/ auto)	■	■	■	■	■
Well control valve position (% open/closed)	■	■	■	■	■
Well control valve open/closed status	■			■	
Pipeline pressure	■	■	■		■
Pipeline temperature	■	■			
Calorimeter			■		
Separator levels	■				
Corrosion probe		■	■		
Well-pad pressure				■	
Well-pad temperature				■	
Well-pad differential pressure				■	

INJECTION WELL INSTRUMENTATION MONITORING	COMPANIES: A	B	C	D	E
Inlet pressure	■	■	■		
Control mode switch status (hand/auto)	■	■	■		■
Control valve position (% open/ closed)	■	■	■		■
Control valve open/closed status			■		
Pressure	■	■	■	■	■
Temperature	■	■	■		
Differential pressure	■	■	■	■	■

VENT SYSTEM INSTRUMENTATION MONITORING	COMPANIES: A	B	C	D	E
Vent valve control mode switch status (hand/auto)	■	■	■	■	
Vent valve position (% open/ closed)	■	■	■	■	■
Vent valve open/closed status		■	■	■	
Vent valve pressure	■	■		■	
Vent valve temperature	■	■			
Vent valve differential pressure		■		■	
Vent relief pressure		■	■	■	■
Vent relief high pressure status			■		
Vent hydraulic/pneumatic system status	■	■	■	■	■

POWER PLANT INSTRUMENTATION MONITORING	COMPANIES: A	B	C	D	E
Turbine megawatts	■	■		■	■
Turbine flow rate	■	■			
Turbine tripped signal	■	■		■	■
Turbine bypassed signal	■	■			
Turbine throttle differential pressure					■
Condenser back pressure		■	■		
Cooling tower flow rate		■			
Non-Condensible (N-C) gas concentration		■			
H2S concentration		■			
Condensate return pressure		■	■	■	
Condensate return flow rate		■	■	■	
Plant inlet pressure	■	■	■	■	■
Plant inlet temperature	■	■	■	■	
Plant inlet differential pressure	■	■	■	■	
Plant inlet flow meter	■				
Plant inlet N-C gas concentration		■			

CONDENSATE SYSTEM INSTRUMENTATION MONITORING	COMPANIES: A	B	C	D	E
Tanks/basin analog level	■	■	■	■	■
Tanks/basin flow meter		■	■		
Tanks/basin discharge (pumps) status	■	■	■		
Tanks/basin high level(s) status	■	■		■	
Tanks/basin low level(s) status	■	■		■	
Tanks/basin outlet valve status	■	■		■	
Tanks/basin inlet valve status	■	■		■	
Tanks/basin control mode switch	■	■			
Tanks/basin pump station alarm					■
Steam separator condensate flow meter	■		■		■
Steam separator condensate discharge pump(s) status	■				

Table 1 (continued)

	A	B	C	D	E
Steam separator condensate high level(s) status	■		■		
Steam separator condensate low level(s) status	■		■		
Steam separator condensate valve(s) status	■				
Steam separator analog level		■		■	■
Steam separator control mode switch		■			

MISCELLANEOUS INSTRUMENTATION MONITORING	COMPANIES: A	B	C	D	E
Main line corrosion probe		■	■		
Main line calorimeters					■
Facility door open/closed status indications		■	■	■	
Facility temperature (buildings, enclosures, etc.)		■		■	
Facility UPS status indications	■	■		■	■
RTU power supply status	■				

FLOW RATE AND VOLUME CALCULATIONS	COMPANIES: A	B	C	D	E
Production well flow rates	■	■	■	■	■
Injection well flow rates	■	■	■	■	■
Total well-pad (site) flow rate	■	■		■	
Total condensate collection/ return flow rate	■	■			
Total injection flow rate		■	■	■	■
Total vent flow rate		■		■	■
Daily volumetric accumulations for each flow rate		■		■	
Weekly volumetric accumulations for each flow rate		■			
Monthly volumetric accumulations for each flow rate		■		■	

MASS BALANCE CALCULATIONS	COMPANIES: A	B	C	D	E
(Total production) - (total delivery + total vented)		■		■	
(Total condensate collection) - (total injection)		■			
(Sum of wells at a well-pad) - (measured total at well-pad)				■	
Steam/condensate ratio		■			

CORROSION RATE CALCULATIONS	COMPANIES: A	B	C	D	E
Main-line corrosion rates		■			
Production well pipeline corrosion rate		■			

SUPERHEAT LEVEL CALCULATIONS	COMPANIES: A	B	C	D	E
Production well superheat levels	■	■		■	
Production well-pad superheat level				■	
Plant inlet superheat level	■	■		■	■

MAXIMUM/MINIMUM/AVERAGE CALCULATIONS	COMPANIES: A	B	C	D	E
Hourly maximum value of instrument signals and flow rates					■
Daily maximum value of instrument signals and flow rates		■		■	
Daily minimum value of instrument signals and flow rates		■		■	
Hourly averages of instrument signals and flow rates	■		■		
Daily averages of instrument signals and flow rates	■	■		■	
Weekly averages of instrument signals and flow rates		■			
Monthly averages of instrument signals and flow rates	■				
Yearly averages of instrument signals and flow rates	■				

HIGH/LOW LIMIT VIOLATION ALARM DETECTION	COMPANIES: A	B	C	D	E
Pressures	■	■	■	■	■
Temperatures	■	■	■	■	
Flow rates	■	■	■	■	■
Superheat level	■	■		■	■
Condensate levels	■	■	■	■	■
High H2S concentration		■			
Pipeline corrosion rate		■			

CONTROL ERROR ALARM DETECTION	COMPANIES: A	B	C	D	E
Deviation from setpoint (i.e., actual vs commanded)	■	■		■	■

Table 1 (continued)

STATUS CONDITION VIOLATION ALARM DETECTION	A	B	C	D	E
Invalid valve positions (e.g., vent valves open)		■		■	■
Abnormal pump conditions (e.g., running)	■	■	■	■	■
Abnormal plant conditions (e.g., turbine trip)	■	■		■	■
STATUS CONDITION VIOLATION ALARM DETECTION (continued)	**A**	**B**	**C**	**D**	**E**
Facility status checks (e.g., doors, mode switches, etc.)	■	■	■	■	■
COMMUNICATION ERROR ALARM DETECTION	**A**	**B**	**C**	**D**	**E**
Loss of RTU communications	■	■	■	■	■
Invalid remote access attempt	■				

REMOTE MANUAL CONTROL	A	B	C	D	E
Production well valve position	■	■	■	■	■
Injection well valve position	■	■	■	■	
Vent valve position	■	■	■	■	
Condensate tank pump on/off	■	■	■		
Condensate basin pump on/off	■	■	■		
Steam separator condensate discharge pump on/off	■	■			
Condensate tank valve open/close		■			
Condensate basin valve open/close				■	
Separator condensate discharge valve open/close		■	■		
Fresh water injection system pump on/off					■
De-superheat injection pump on/off					■
De-superheat injection valve position (%)					■

AUTOMATIC CONTROL	A	B	C	D	E
Production well pressure				■	
Production well flow rate	■	■	■	■	
Injection well pressure					■
Injection well flow rate	■	■			■
Vent relief pressure	■	■	■	■	■
Condensate tank level	■	■	■	■	■
Condensate basin level	■	■	■		
Steam separator condensate level	■	■	■	■	

SUPERVISORY CONTROL	A	B	C	D	E
Total production flow rate to one or more plants	■	■		■	
Delivery pressure to one or more plants	■		■	■	
Production curtailment to eliminate venting	■	■		■	
Vent elimination at 1 plant while continuing delivery at 2nd	■			■	
Injection well control based on plant cond. return pressure		■			
Injection well control based on desired total flow rate	■	■			■
Steam quality - H2S concentration					
Steam quality - superheat level					
Steam quality - corrosion mitigation					
Automatic conformance to defined well production guidelines	■	■		■	
ON-LINE DISPLAY GENERATION	**A**	**B**	**C**	**D**	**E**
Overview of entire gathering system	■	■		■	■
Overview of all production wells	■	■		■	■
Overview of conditions at or near plant	■	■		■	■
Overview of venting system		■		■	■
Overview of condensate collection/injection	■	■		■	■
Overview of all wells at a well-pad		■		■	
Current mass balance information		■		■	
Conditions at specific well	■	■	■	■	■
Conditions at specific tank/basin	■	■	■	■	■
Conditions at vent system	■	■	■	■	■

Table 1 (continued)

	A	B	C	D	E
List of unacknowledged alarms	■	■	■	■	■
List of all current alarms	■	■	■	■	
PID control loop tuning information	■	■	■	■	
ON-LINE REPORT GENERATION	**COMPANIES: A**	**B**	**C**	**D**	**E**
Production well snapshot history	■	■		■	■
Production well pressure build-up test history	■	■		■	■
Alarm/event history	■	■		■	
Shift production summary		■		■	
Daily production summary	■	■		■	
Monthly production summary	■	■		■	
Shift venting summary	■			■	
Daily venting history	■	■			
Monthly venting history	■	■		■	
Yearly venting history	■				
Analog calibration		■		■	
Royalty and revenue accounting	■	■			
Start/end of shift report		■			
Daily injection history	■				
Monthly injection history	■	■			
Yearly injection history	■				
Daily meter report	■	■		■	
Daily analog report	■	■		■	
ON-LINE STORAGE/EDITING OF REPORT IMAGES	**COMPANIES: A**	**B**	**C**	**D**	**E**
Reports automatically stored for at least 1 day		■			
Reports automatically stored for at least 7 days		■			
Reports automatically stored for at least 30 days		■			
Reports automatically purged at pre-specified time		■			
Reports can be edited on-line via Text Editor software		■			
Reports can be re-printed before editing		■			
Reports can be re-printed after editing		■			

(continued)	**COMPANIES: A**	**B**	**C**	**D**	**E**
Reports can be transmitted to other computer systems		■			
REAL-TIME TREND PLOTTING	**COMPANIES: A**	**B**	**C**	**D**	**E**
Operator selection of items to be trended	■	■	■	■	
Can plot 1 variable on a CRT screen	■	■	■	■	■
Can plot 2 variables simultaneously	■	■	■	■	
Can plot 3-4 variables simultaneously		■		■	
Can plot >4 variables simultaneously					
Plots samples taken as fast as every 5 seconds				■	
Plots samples taken as fast as every 10 seconds		■		■	
Plots samples taken as fast as every 60 seconds	■	■	■	■	■
Feature usable from remote terminal via telephone lines		■		■	
Can print hard-copy of plot	■	■	■	■	■
ON-LINE DATA ARCHIVING	**COMPANIES: A**	**B**	**C**	**D**	**E**
Supports sample rate as fast as every 10 seconds		■			
Supports sample rate as fast as every 60 seconds	■	■		■	
Archived data can be copied to permanent storage	■	■		■	
Archived data can be transmitted to other computers	■	■		■	
Data can be stored on-line for at least 1 day	■	■		■	
Data can be stored on-line for at least 7 days		■		■	
Data can be stored on-line for at least 30 days		■		■	
ON-LINE ARCHIVED DATA PLOTTING	**COMPANIES: A**	**B**	**C**	**D**	**E**
Can plot multiple variables per plot		■		■	
High resolution plotting		■			

Table 1 (continued)

	A	B	C	D	E
Can display plot on CRT screen		■		■	
Can produce "hard-copy" of plots		■		■	
Can produce "hard-copy" of plots in color		■			
Feature usable from remote terminal via telephone lines		■		■	
CURRENT CONDITION LIST GENERATION	**COMPANIES: A**	**B**	**C**	**D**	**E**
List of current alarms	■	■	■	■	
List of inhibited alarms	■	■		■	
List of analog point factors		■		■	
List of meter point factors		■		■	
List of points "out-of-service"		■		■	
List of current production well operation guidelines		■		■	
MISCELLANEOUS	**COMPANIES: A**	**B**	**C**	**D**	**E**
Supports on-line addition/definition of new wells	■	■	■	■	
Supports simultaneous delivery to multiple plants	■			■	■
On-line remote/external facility access	■	■		■	■
Supports unattended operation	■	■		■	
On-line re-calibration of analog/digital signal conversion		■		■	■
Logging of operator commands/entries	■	■			■

performed by the systems installed at companies B and D. Figure 2 shows that:

1. An operator enters a **production set point** (assumed in this example to be the desired total flow of steam to be delivered to the power plant served by the production facility).
2. The system measures the **total production flow** and, using the **production set point**, performs a supervisory **PID** control loop to calculate the **total required change** in production.
3. The system then allocates the **total required change** among all wells which are currently in supervisory control mode. This allocation is performed for each well according to specific production guidelines previously specified by the reservoir engineer and stored in the system's memory.
4. The system issues **valve position commands** to each well until the **total production flow** matches the **production set point**.

Figure 3 illustrates how the production of steam from five hypothetical wells might be automatically adjusted by the supervisory production control feature when the total desired flow to the plant(s) (i.e., **production set point**) is changed three times. A description of Figure 3 is as follows:

1. At time 8:01 the total flow from the five wells is 600,000 pounds per hour. It is assumed that at this time the **production set point** was also 600,000 pounds per hour.
2. At time 8:03 the **production set point** was changed by the system operator to 750,000 pounds per hour. The system responded as described in the narrative associated with Figure 1 to adjust the production rate of each of the five wells as shown in Figure 3.
3. At time 8:08 the total flow from the five wells matches the 750,000 pounds per hour **production set point**. The **production set point** is then changed again by the operator to 100,000 pounds per hour.
4. At time 8:13 the total flow from the five wells again matches the **production set point** (i.e., 100,000 pound per hour).
5. At time 8:14 the **production set point** is then changed again by the operator to 350,000 pounds per hour and by time 8:19 the total flow from the five wells again matches the **production set point**.
6. It is important to observe that the steam flow rate from each well is determined from predefined production guidelines which specify the maximum, minimum, and preferred flow rates for each specific well. Thus, the system not only adjusts production to match the operator entered **production set point** but also automatically conforms to the reservoir engineer's production guidelines for each well.

BENEFITS

All of the company representatives interviewed unanimously stated that significant benefits are being realized from the use of their DCS system. The most commonly stated benefits are as follows:

Increased Revenue

- allows faster response to changes in plant demand
- allows higher production rate
- increases plant/production rate efficiency ratio

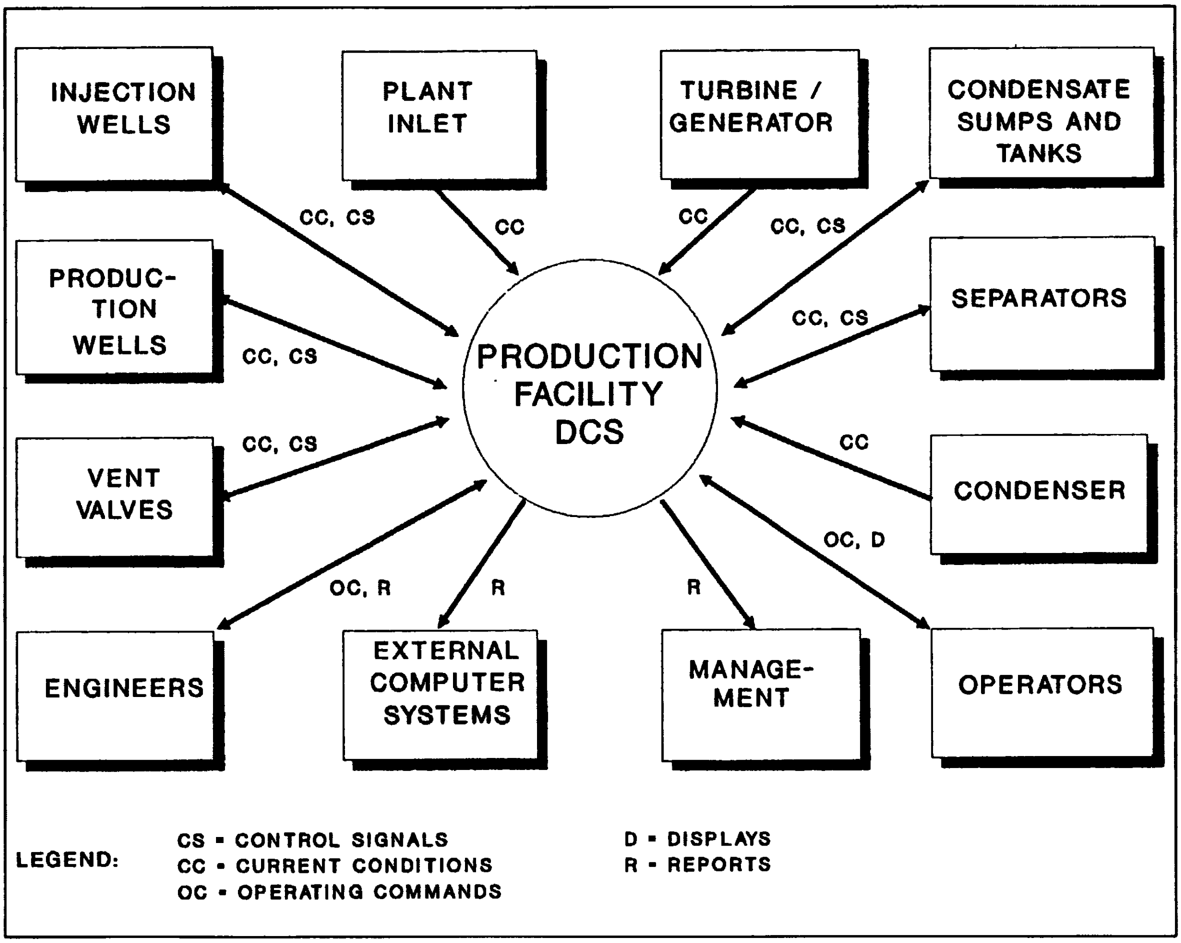

Figure 1. Typical system data flow diagram.

Reduced Expenses
- reduces operating costs
- reduces management costs
- reduces maintenance/repair costs

Facility Protection
- helps protect gathering system equipment
- insures that wells are operated according to defined guidelines (min/max production, rate of change, preferred flow, etc.)
- protects plant equipment by controlling superheat level, noncondensible gas concentration, etc.
- improves quality of data to reservoir engineers

Safety
- reduces amount of manual interaction with potentially dangerous equipment
- monitors and alarms potentially hazardous conditions
- reduces travel to instrument sites during bad weather
- reduces use of hazardous materials

Environmental Compliance
- improves ability to conform to emissions regulations
- provides record of actual emissions
- helps to reduce number of condensate spills
- reduces uses of hazardous materials

Each company was asked to quantify the importance of the benefits they receive from use of their DCS system from both an operations staff perspective and from a management perspective. This quantification was done by assigning a percentage of total benefits received to each of the major category groups listed above. A composite graph of the responses from the five companies is presented in Figure 4.

SATISFACTION INDEX

Each company was asked to describe its satisfaction level with each of several categories of features; the reliability of the functionality and equipment; the ease of use and support; and the costs associated with the operation, maintenance, and enhancement of the systems. Table

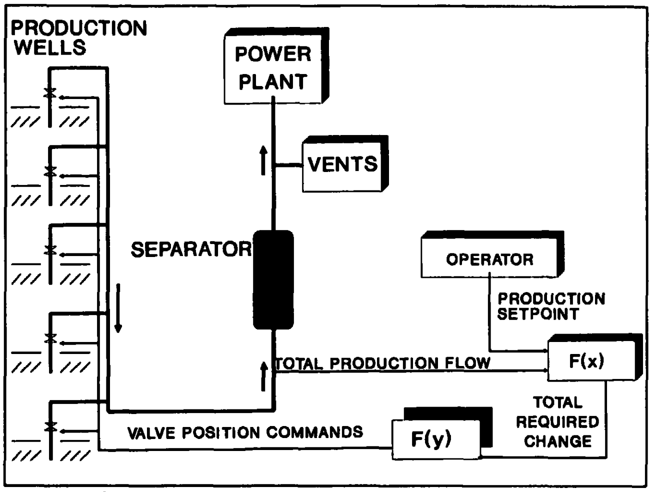

Figure 2. Supervisory production control overview.

2 contains a summary of the responses presented in a "Consumer Reports" magazine style.

COMPUTER SYSTEM SUPPLIERS

The systems described in this article were supplied by Honeywell, Systems Application Engineering (SAE), and Tano Corporation. One of the five operations organizations has recently installed two DCS systems from another supplier. These two recent systems were not included in this article because no information about them was provided to the author.

FUTURE ENHANCEMENTS

Each of the five operations organizations was asked to rate the desirability of future enhancements to its system for each of the features previously described in this article. These organizations were asked to classify the desirability of addition/ enhancement of each feature as "not desired at all," "possibly desired," "definitely desired," or "urgently desired." The results are presented in Table 3. A numeric "need factor" ranging from 0 to 3 was then assigned to each of the four different classifications, respectively. A comparison of the relative total "need factor" for each company is presented in Figure 5.

Improved Reporting Capabilities Urgently Desired

From the answers received in response to the request to rate the desirability of specific enhancements, it is clear that improved reporting capability is the most urgently needed system enhancement. Two of the five companies

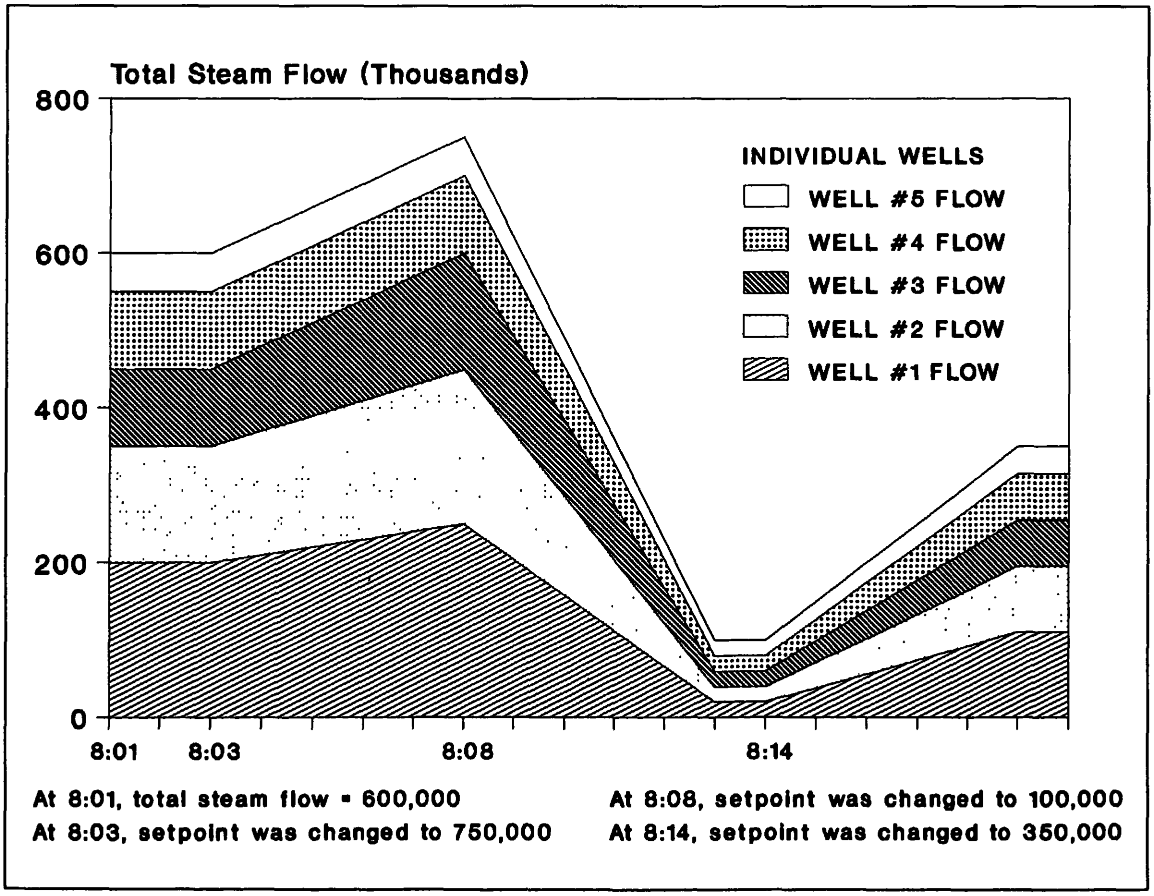

Figure 3. Effects of production set point changes.

Table 2. Satisfaction index.

FEATURES	COMPANIES: A	B	C	D	E
Instrumentation monitoring	⊖	⊖	⊖	●	⊖
Continuous data calculation	○	●	⊖	●	○
Alarm detection	⊖	●	○	○	⊖
Remote manual control	⊖	●	⊖	●	⊖
Automatic local control	⊖	●	⊖	⊖	⊖
Automatic supervisory control	⊖	●	•	●	⊖
Displays (content/ease of use)	⊖	●	⊖	⊖	○
Reporting	○	●	•	⊖	•
RELIABILITY	**COMPANIES: A**	**B**	**C**	**D**	**E**
System accuracy	⊖	●	⊖	○	⊖
RTUs/local controllers	○	●	⊖	⊖	⊖
Host computer/supervisory station	○	⊖	–	⊖	⊖
Operator Stations	⊖	●	●	⊖	⊖
Instrumentation	⊖	●	⊖	⊖	○
EASE OF USE AND SUPPORT	**COMPANIES: A**	**B**	**C**	**D**	**E**
Adding enhancements	○	●	⊖	○	⊖
Adding new wells	○	⊖	⊖	⊖	•
Training new operators	○	●	⊖	⊖	○
Operation	⊖	●	⊖	⊖	○
Maintenance	⊖	⊖	⊖	○	⊖
COSTS	**COMPANIES: A**	**B**	**C**	**D**	**E**
Operation	⊖	⊖	⊖	⊖	⊖
Maintenance	⊖	⊖	⊖	○	⊖
Enhancements	•	⊖	•	•	•

LEGEND

- ● Totally satisfied
- ⊖ Largely satisfied
- ○ Moderately satisfied
- • Largely dissatisfied
- – Not applicable

Table 3. Desirability of future enhancements.

ENHANCEMENT	COMPANIES: A	B	C	D	E
Replacement of aging equipment	•	•	•	⊖	○
Correction of existing features	○	○	●	•	○
Monitoring of more instrumentation	○	⊖	⊖	○	⊖
Calculation of more information	⊖	⊖	⊖	○	●
Addition of new alarm logic	○	○	•	•	•
Addition of automatic control features	○	●	⊖	⊖	○
Addition of supervisory control features	○	○	●	○	○
Addition of remote manual control features	•	•	•	⊖	⊖
Addition of new operator displays	•	•	●	⊖	•
Addition of new reporting capabilities	○	○	●	○	●
Addition/enhancement of remote access capability	○	•	○	•	•
Addition of support of unattended operation	•	•	⊖	•	•
Addition of on-line re-calibration of A/D conversion	⊖	•	•	•	•
Addition of on-line storage/editing of reports	●	•	●	⊖	●
Addition of real-time trend plotting	•	•	⊖	•	○
Addition of data archiving/ plotting	○	•	●	•	⊖

LEGEND

- ● Urgently desired
- ⊖ Definitely desired
- ○ Possibly desired
- • Not desired/needed

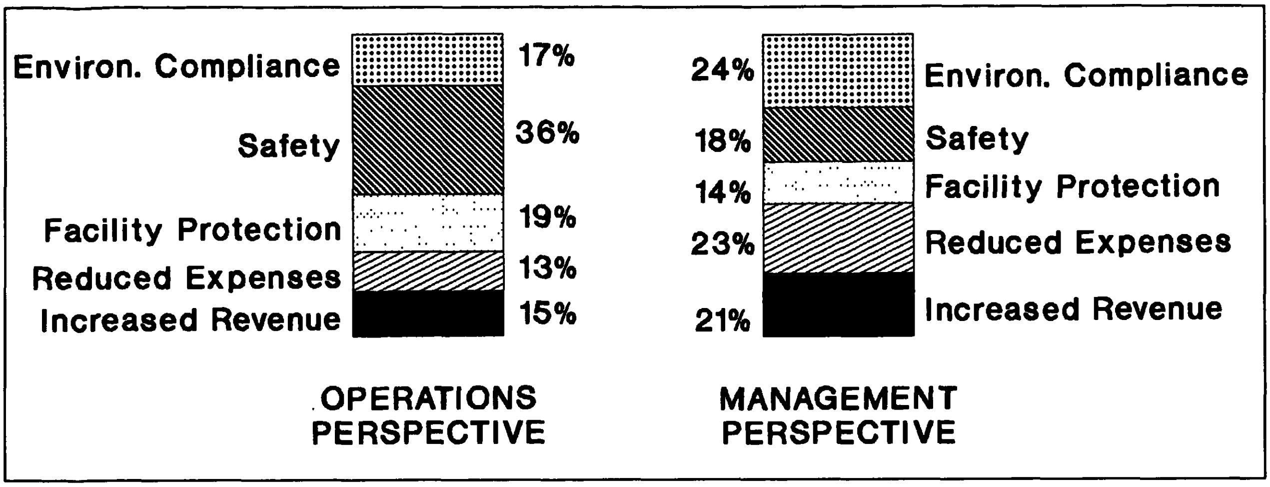

Figure 4. Composite percentage of total benefit from using DCS as rated by five Geysers area production operations companies.

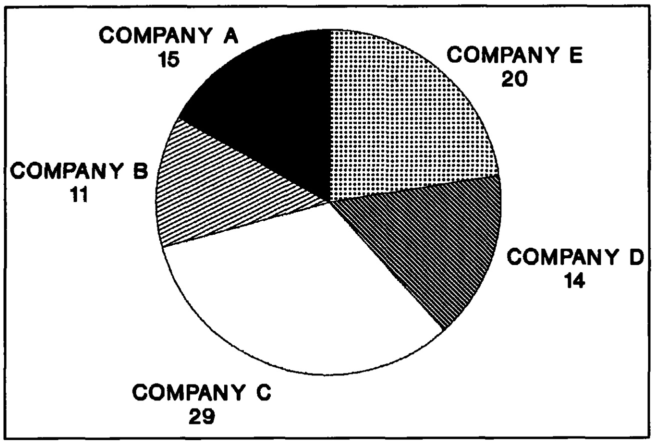

Figure 5. This chart quantifies the enhancement needs presented in Table 3 as follows: Urgent need = 3, definite need = 2, and possible = 1 point.

have very little or no report generation capability at the current time. Both of these companies rate this feature as "urgently required." In addition to the capability to generate reports, four of the five companies rated on-line storage and editing of actual report images as either "definitely desired" or "urgently desired." The only company not including on-line storage and editing of report images as a desired enhancement already has this capability.

Monitoring, Calculation, and Storage of More Data Highly Desired

A second group of highly desired enhancements included the monitoring of additional instrumentation, the calculation of additional information, and the storage of more historical data. Only one company did not rate one or more of these enhancements as "urgently desired" or "definitely desired."

CONCLUSIONS

The production facility operating organizations are generally pleased with the features and benefits currently provided by their DCS systems. However, some of the companies are very displeased with the absence of many features which they now desire. The two areas of highest dissatisfaction are as follows:

1. Inadequate collection, storage, reporting, and analysis of historical data, and
2. Lack of desired automatic and supervisory control capabilities.

Some companies are much more pleased than others with their DCS system capabilities. One has already enhanced its system and two more have major projects underway to address the two areas of dissatisfaction described above. These companies have discovered that functionality enhancements to an existing DCS are very difficult and costly to implement properly. Some companies are having to settle for a less than totally satisfactory enhancement solution.

Every company involved in development or operation of a new geothermal production facility or the assumption of responsibility for operating an existing facility should carefully evaluate the results of the survey described in this article. Much can be learned from the experiences of the organizations interviewed.

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