ACCESS TIME REDUCTION OF THE CAUSE OF SUBSTATION EQUIPMENT PROBLEMS WHEN ANNUNCIATOR ALARM HAS NOTIFIED AT THE NORTHEASTERN CONTROL CENTER, ELECTRICITY GENERATION AUTHORITY OF THAILAND

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Abstract

This study focuses on the response procedure of the operators at the Northeast Control Center, Electricity Generating Authority of Thailand. In the case when warning signal has been notified at the control center and to improve efficiency of problem cause finding method by reducing access time. In the conventional method, when operators at the control center have been notified by a group of alarms, i.e. 7 groups at a substation, they have to contact the local responsible operator of the alert substation to find the cause of problems. However, in some cases, the local officer is far away from the problem substation during unmanned period and may take much time to reach the substation. If the problem could not be solved in an appropriate period of time, it may cause unpredictable consequence effect to the electrical power system. This study uses the knowledge of operation management, information technology, and engineering in order to investigate, analyze, and improve the operation procedure of the operators.

The results of this study indicate that after the improvement, the access time to the cause of problem of high voltage equipment in substation can be reduced 94.3% and in the case of alarm group, can be reduced 97.69%. Additionally, this led to the development of a model for all Regional Control Centers (RCC) in Thailand.

Keywords: Time Reduction, Supervisory Control and Data Acquisition (SCADA), Control Center, Substation, Operator, Group Alarm, Major Alarm, Minor Alarm, Unman Period

Introduction

Electricity Generating Authority of Thailand (EGAT) is responsible for electricity generation and transmission to distribution sectors, Metropolitan Electricity Authority (MEA) and Provincial Electricity Authority (PEA), and industrial sector. The generated electrical power is controlled and transmitted through high voltage substations all over the country. Each substation primarily consists of high voltage equipment, protection system, and communication system and its main functions are to control voltage level corresponding to distribution requirements and to protect transmission system equipment in its responsible area. Important information such as an equipment status and measured values is transmitted through the communication system to Computerized Control Substation (CCS), Group Control Center (GCC), and Regional Control Center (RCC), but in different amount scale of information, in order for operators at each area to monitor and control. All information at a substation cannot be sent to RCC due to the limitation of communication system and the importance of each information type. As a result, the information that cannot be sent will be grouped into two types of information, major and minor alarms, and then sent to RCC. In the conventional process, when alarm at the control center occurred, the operator at RCC will report a local operator who is in charge of the alert substation to investigate and solve the problem , e.g. gas pressure of a circuit breaker reaches low limitation. However, in most substations, there is an unmanned period during the night. In that case, it may take much time for the local responsible operator to reach the substation depending on the distance between the operator current location and the problem station. Consequently, if the problem cannot be solved in an appropriate period of time, it may cause unpredictable effect to the electrical power system such as electricity outage.

Principles of operation management, information technology, and engineering knowledge can be applied to improve problem accessing time and efficiency.

Objectives

To reduce problem accessing time by improving the response procedure of operators at a northeastern control center, Electricity Generating Authority of Thailand in the case that a notification from a high voltage substation to the control center is notified.

Methodology

This study focuses on the response procedure of operators at the control center since an alarm signal is notified until the problem has been solved in order to improve the efficiency of problem accessing procedure. Furthermore, this can also improve stability and reliability of electrical power system.

The study indicates that alarm notification at the control center [1] can be classified into 2 types:

1. The alarm when primary equipment at a substation has a problem: In this case, the equipment with problem will be forced to “Lockout” status and cannot be operated. The operators at the control center will report a local-substation operator and co-operate together

to investigate the cause of the problem. When the problem is corrected, the local-substation operator will reset the "Lockout" status of the equipment and then restore the equipment into the power system. All events including causes of the problem will be reported into a logging system.

2. The alarm grouped by types of annunciators: The alarm of each group is initiated by annunciators in the group which, in this case, is classified into 2 types, major and minor alarms. When this type of alarm, e.g. a problem of electrical high voltage transformer or circuit breaker, occurs, the operators at the control center will report a local-substation operator to investigate, analyze, and correct the problem. When the problem has been corrected, the local-substation operator will report to the control center.

Using Work Flow Process Chart [2][3] on collected data, we can clarify working steps of each procedure and note that the average values of the problem accessing time for alarm type (1) and (2) are 45.12 minutes as in Table 1 and 129.76 minutes as in Table 2, respectively.

Applying Why-Why Analysis method [2][4] to find the root cause of the problem and found that the control center cannot see the details of the problem equipment since not all information at a substation is not sent to the control center. At both local substation and control center, there is no relational lockout logic diagram in order for operator to reset "Lockout" status of the equipment. Additionally, alarm group displays for the control center and local substation are not appropriate and can be simplified. For the conventional method, extra skills and experiences of the operators are required.

From the causes of the problem, using 5W1H [2] and ECRS [2] methods, we can summarize into 4 solutions as follows:

1. Develop Virtual system display for GCC in order for the control center to monitor problem details in each substation. A Group Control Center or GCC is a substation acquiring information of all other substations in its zone and can be used as a backup system of the control center. Basically, the amount of information between GCC and local substation is the same and typically identical including displays for operator. Accordingly, Virtual system display for GCC utilizes existing data network to replicate information and displays from GCC to the control center so that the operators at the control center can monitor the details of a problem instantly.

2. Acquire and develop lockout logic diagrams in a display format for the operators at both local substation and control center. For the conventional method, the operators are required to understand and memorized all paper-based lockout diagrams in the substation in order to find the cause of equipment problems. The new method can provide online lockout logic diagrams for the operators to simply understand and be able to analyze the equipment problems faster and more efficient.

3. Create an appropriate alarm group display for the control center. Previously, at the control center, operators monitor major and minor alarms through each substation and alarm list displays which consist of several display pages. Additionally, sometimes, missing monitoring can occurs during more important events. A new display presents major and minor alarms of all substations in a single page which help operators to easily monitor the problems from all substa-

tions.

4. Create an appropriate alarm group display at a local substation. In the previous alarm group detail displays, at a local substation, there are 7 pages of annunciator displays corresponding of 7 alarm groups and it may take some time for the local operator to find a problem. A new display filters only the details with abnormal state relevant to the problem in a single page so that the operator can immediately investigate and find causes of the problem in each group. Note that, at a local substation, alarm group 1 – 3 will be grouped into major alarm and alarm group 4-7 will be grouped into minor alarm and then sent to the control center [5].

Results

Virtual system display for GCC was installed at GCC Khon Kaen1 and at the Northeastern System Control Center on March 3, 2015. After that when the Control Center received abnormal warning signal, the Control Center can basically checks the Lockout Logic Diagram of developed Virtual system display and they will correct the problem and lead to Lockout Reset Procedure and prepare for system restoration state.

After this improvement the trouble event data of substation equipment were collected between March to May 2015. It showed that the access time to the cause of problem was reduced from 45.12 minutes in average to 2.57 minutes which was 42.55 minutes (49.30%) reduction as shown in the table 3. For group alarm display, it can reduce the access time from 129.76 minutes in average to 3 minutes, or 126.76 minutes (97.69%) reduction as shown in table 4.

Conclusion

This study was conducted to apply the Theory of Operation Management for the work of the Northeastern Electrical System control center that was improved for more effective response procedure. After occurring the problems of equipment, we needed the substation technician operator to investigate and solve the problems. However, total access time during to investigate the cause and solve the problem is long and affect to the outage period. This cause the effect to households, business official and industrial sectors. We have studied and analyzed the historical data of the control center working procedure with Work Flow Process Chart to show the duration in each step to indicate the time waste in access to the cause of problem. In addition, Why-Why Analysis was applied to analyze the cause of problem and 5W1H and ECRS were also used to find the solutions conveniently. By importing data from substation to control center for simulating the display on the monitor for all of equipment alarms. Lockout Logic Diagram was added to display the relation among equipment to be simple to understand. More pictures to display all of Major and minor alarms of substation on one page at the control center and also addition picture to display filtered or selected alarms on one page were problem-solving guideline.

With these new methods, the control center can monitor abnormal-event conditions of equipment within a substation via a Virtual System Display for GCC and can understand the relation between equipment and relevant information. They also can analyze and decide which equipment the problem occurring with and how critical it was in order to decide whether it is necessary to urgently call for substation technician, or not, to reduce the risk of electrical power system failure due to a long accumulated time including waiting period. After improvement, the average spending time to reach the root cause of problem of high voltage equipment in substation was 2.57 minutes compared to the previous-method spending time of 45.12 minutes, 94.3% less time. In the case of alarm group, the average spending time to reach the root cause of the problem was within 3 minutes compared to the previous-method spending time of 129.76 minutes, 97.69% less time.

The advantage from this studies to shorten and reduce the access time to solve the problem by a new process in response to support the work of operators of control center with Lockout Logic Diagrams to display the relationship between equipment, and also support the core purpose of EGAT to provide and supply electricity along the transmission system with stability and reliability. Lockout Logic Diagram can be also applied to other 53 substations in Northeastern region and Virtual System Display for GCC can be developed to all Group Control Center in the Northeastern region. Additionally, the whole system solution can be applied to other.

Suggestions

This study utilized existing available resources to reduce implementation cost of a model of virtual system display for GCC. This model can be improved and further developed for additional processes to reduce the problem accessing time that may cause an outage such as the process of automatically sending SMS events directly to the accomplice and the development of online problem solving guideline for local-substation operators.

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Table 1 Work Flow Process Chart of response procedure to warning signal of substation equipment abnormal events in the power system

No.	Process description	Operation	Moving	Inspection	Delay	Storage	Average duration/Time (minutes)(1) Feb 14	Mar 14	May 14	Aug 14	Sep 14	Sep 14	Oct 14	Nov 14	Dec 14	Average	
1	Inform Substation technician to check up the problem	●	⇨	□	D	▽	1	1	1	1	1	1	1	1	1	1	
2	Substation technician goes to the substation	○	⇨	□	◗	▽	2	25	15	1	30	-	0.5	35	27	1.17	26.40
3	Co-ordination for checkup the problems	○	⇨	■	D	▽	7	7	23	3.5	35	2	8	52	22	17.72	
4	Correction process	●	⇨	□	D	▽	-	-	141	-	90	-	-	135	70	109	
5	Reset Lockout	●	⇨	□	D	▽	6	1	8	1	6	1	4.5	7	8	4.72	
6	System Restoration	●	⇨	□	D	▽	15	7	-	7.5	50	11	12	11	22	16.94	
	Number of events						1	1	1	2	1	1	4	1	1		
	Sub. technician is on duty						Yes	No	No	Yes	No	Yes	Yes	No	No	Yes	No

(1) from data collection by SCADA system of control center between January- December 2014

Table 2 Work Flow Process Chart of response procedure to warning signal of Group Alarm

No.	Process description	Operation	Moving	Inspection	Delay	Storage	Average duration/Time (minutes)(1) Feb 14	Mar 14	May 14	Aug 14	Sep 14	Sep 14	Oct 14	Average	
1	Inform Substation technician to check up the problem	●	⇨	□	D	▽	1	1	1	1	1	430	275	101.43	
2	Substation technician goes to the substation	○	⇨	□	◗	▽	-	25	30	-	30	-	-	-	28.3
3	Co-ordination for checkup the problems	●	⇨	□	D	▽	5	6	24	7.5	5	11	79	19.643	
4	Substation technician informs control center	●	⇨	□	D	▽	1	1	1	1	1	1	1	1	
	Number of events						1	1	1	1	1	2	1		
	Sub. technician is on duty						Yes	Yes	No	No	Yes	No	Yes	Yes	No

(1) from data collection by SCADA system of control center between January- December 2014

Table 3 Comparison of response time to abnormal condition warning of substation equipment in the power system between before and after improvement.

Before improvement		After improvement	
Process description	Average Time (minutes)(1)	Process description	Average Time (minutes)(2)
1. Inform Substation technician to check up the problem	1	1. RCC connect virtual system display of GCC	1.26
2. Substation technician goes to the substation	26.4	2. RCC checkup the problems	1.31
		3. Inform Substation technician	-
3. Co-ordination for checkup the problems	17.72	4. Substation technician goes to the substation	-
4. Correction process	-	5. Correction process	-
5. Reset Lockout	-	6. Reset Lockout	-
6. System Restoration	-	7. System Restoration	-
Total	45.12	Total	2.57

(1) from data collection by SCADA system of control center between January- December 2014

(2) from data collection by SCADA system of control center between March-May 2015

Table 4 Comparison of response time to abnormal condition warning of Group Alarm between before and after improvement.

Before improvement		After improvement	
Process description	Average Time (minutes)(1)	Process description	Average Time (minutes)(2)
1. Inform Substation technician to check up the problem	101.43	1. RCC connect virtual system display of GCC	1
2. Substation technician goes to the substation	28.33	2. RCC checkup the problems	2
		3. Inform Substation technician	-
3. Co-ordination for checkup the problems	-	4. Substation technician goes to the substation	-
4. Substation technician informs control center	-	5. Substation technician correct the problems	-
		6. Report to control center	-
Total	129.76	Total	3

(1) from data collection by SCADA system of control center between January- December 2014

(2) from data collection by SCADA system of control center between March-May 2015