CHAPTER 1
Overview

1.1 Chapter Overview

This chapter presents the overview of the thesis. It starts by explaining the Electricity Supply Industries (ESI). Then it shows the overview of the current human resource development method and its problem. This chapter also presents the evolution of learning. Furthermore, it defines the research justification and solution, objective, hypothesis, research novelty, scope of work, and the expected outcome. The overall thesis structure and details of the chapters are also described.

1.2 Electricity Supply Industry

ESI is an electric energy production system which consists of activities including power generation, electricity delivery, and energy sale. Generally, the electricity supply originates from a power plant, which is usually located far away from the city and then high voltage level energy is transmitted via transmission lines. After that the electric power is reduced from high voltage level to suitable voltage as it gets nearer to the community center and distributed to consumers through low voltage distribution network. Considering the features of the supply activities, the structure of the ESI can be divided into four main systems: generation system, transmission system, distribution system and the retail system.

In many countries, electric power companies own the entire system from generations to transmission and distribution systems such as Kyushu Electric Power in Japan, Tenaga Nasional Berhad (TNB) in Malaysia, FirstEnergy in USA, CLP Power in Hong Kong. However, these companies cannot set up the electricity price by themselves. Usually, the electricity price is controlled by the government or regulator.

ESI of Thailand is comprised of 3 major sectors including generation, transmission and distribution networks. The electric power companies are divided into Generation Company and Retail Company. Basically, the bulk electricity is produced by Electricity Generating Authority of Thailand (EGAT). The electric energy is then transmitted to the consumers through network of two power distribution utilities: Provincial Electricity Authority (PEA) and Metropolitan Electricity Authority (MEA). Figure 1.1 shows the power system of Thailand.

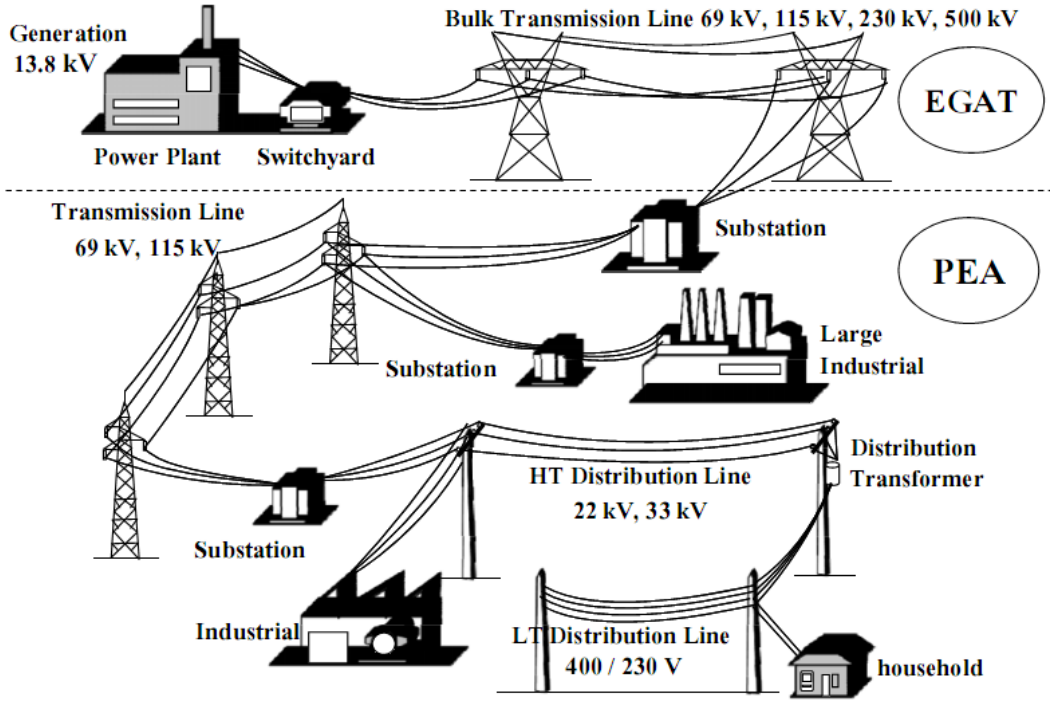

Figure1.1 Power System in Thailand

- EGAT is the power producer and supplier. It is responsible for producing the electric energy, and then selling and transmitting this bulk electricity via very high-voltage networks (500 kilovolt, 230 kilovolt and 115 kilovolt) to the retail utilities.

- MEA is responsible for the distribution of electricity to the customers in Bangkok, Nonthaburi and Samutprakarn provinces via its low voltage network. The MEA receives the electricity from EGAT via

sub-transmission system with various voltage such as 12, 24, 69 and 115 kilovolts and then delivers the electricity to customers through its distribution network by transforming the high voltages to the low voltage of 400/230 volts for household usage.

- PEA is responsible for the distribution of electricity to customers in the remaining areas of the country. There are 74 provinces in its service areas. Generally, PEA buys electrical energy from EGAT's transmission network at the various high voltage levels of 22, 33, 115 kilovolts, and then delivers the electricity to customers through its distribution network by transforming the high voltages to the low voltage of 400/230 volts for household use.

The ESI structure in Thailand is summarized in figure 1.2.

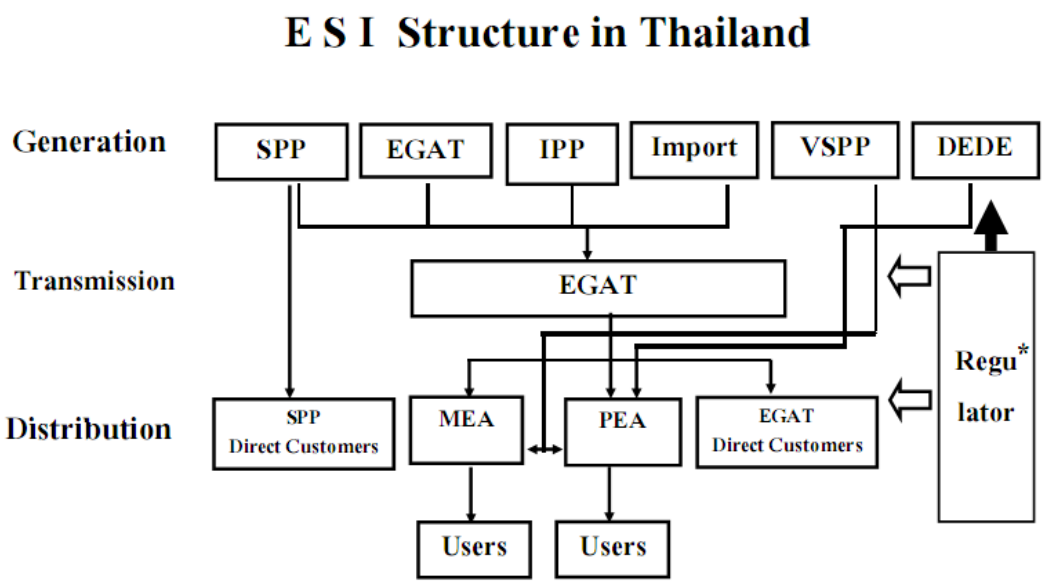

Figure 1.2 ESI Structure in Thailand

The figure shows most ESI activities are done by three main state-owned enterprises. However, the government gives an opportunity for the private sector to participate in the generation business in the form of Small Power Producers (SPPs) and

Independent Power Producers (IPPs). SPPs and IPPs generate the electric energy and sell directly to EGAT. Then EGAT sells the electricity to the MEA and PEA. Finally, MEA and PEA supply energy to all consumers nationwide without other utilities or companies. Therefore, it can be summarized that the current electricity supply and service systems are operated in a monopolistic manner. However, these utilities cannot set up the electricity price by themselves. The government control and set up the electricity price via the regulator committee as shown in figure 1.2.

As mentioned before, ESI transmits electricity to end consumers via many systems. These systems can be called power system which can be divided into 4 major parts: generation, transmission, distribution, and load.

1.3 PEA Overview

As one of the main state enterprises of Thailand, PEA is responsible for generation, transmission and distribution of electricity to domestic, commercial and industrial customers throughout Thailand. It was established on September 28, 1960 by nationalizing all private and municipal electric works in provinces. The PEA service area is approximately 510,000 km^2, accounting for 99 percent of the country. There are 74 provinces which fall under its service areas. In 2011, there are 894 sub-offices scattered throughout the country. PEA has grouped its service areas into 4 regions which is shown in figure 1.3.

Figure 1.3 PEA Service Areas

Source: PEA Annual Report, 2011

For the year 2011, PEA installed 9,697 circuit-km of transmission systems, 296,215 circuit-km of high voltage distribution systems, and 456,667 circuit-km of low voltage distribution systems. PEA enhanced their power system security by constructing more power stations.

PEA is a government enterprise under the Ministry of Interior. Most of electricity energy sold to customers are purchased from EGAT. The PEA's three major objectives are:

1) To continue to improve its provision and distribution services of electrical energy to customers: to achieve the highest possible level of sufficiency, efficiency and reliability in power distribution commensurate with safety practices; to meet the timely need of customers; and to keep pace with changing circumstances.

2) To optimize its business and operations in order to be more profitable and thereby achieve sufficient revenues to facilitate further development.

3) To develop its organizational structure, man power and resources management in order to achieve the highest level of efficiency and effectiveness.

PEA buys electric energy from EGAT's transmission network at the various high voltage levels of 22, 33, 69, 115 kilovolts, then deliver the energy to customers through its distribution network by transforming the high voltages to the low voltage of 400/230 volts for household use. For large customers, like industrial plants, PEA supplies electricity for them at the voltage level of 22, 33 and 115 kilovolts. PEA's power system consists of three main parts:

- Transmission System: The almost transmission system of PEA are overhead line. The purpose of this system is to transfer electrical energy from generating systems at various locations scattered around Thailand to the distribution system. Transmission voltage lines operate at 115 kilovolts.

- Distribution System: The distribution system connects the substations to the consumers' equipment. The voltage of PEA high tension distribution lines are 33 kilovolt in the south of Thailand and 22 kilovolt in the remaining areas. The low tension distribution lines serve most of the customer at levels of 400/230 V. Distribution lines of PEA include both overhead and underground system.

- Loads: Loads of PEA power systems are divided into industrial, commercial and residential loads. Most of large loads for industrial and large commercial usage are served directly through transmission lines.

- PEA also has other types of generators such as mini hydropower, disease generator, solar panel to supply energy in remote areas like islands, and villages in the mountains where the power systems are not able to connect to the main grid.

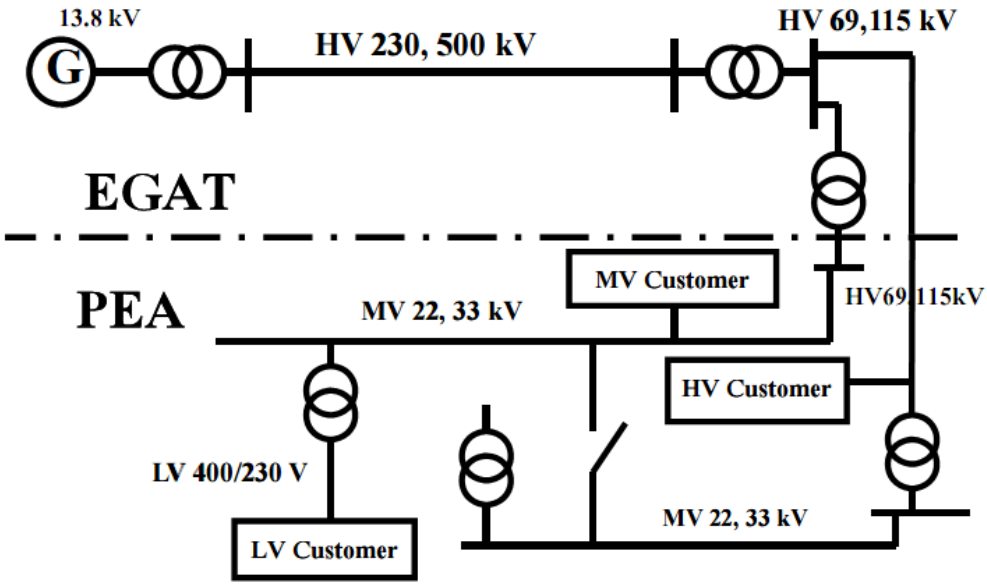

Figure 1.4 Single Line Diagram of PEA Power System

The substation is the portion that connects the transmission system to the distribution system. The transmission lines are terminated in substations. The high voltage of transmission system is reduced by step-down transformers which are installed in the substations to the suitable voltage before being passed to the distribution system. The substation is used to control and operate electricity flow and adjust the voltage level. There are many kinds of equipment installed in it such as the capacitor bank, protective devices, disconnecting switch, and the power transformer. The capacitor banks are used for maintaining the transmission line voltage while the protective devices are installed for protecting the system from fault in the grid. The protective devices connected to the circuit in substations are called switchgear. They include with instrument transformer, circuit breakers, disconnect switch and lightning arrester. Table 1 shows the list of equipments which are installed in substations.

Table 1.1 List of Equipments in Substation

Equipments in Substation		
115 kV Substation	115kV/22-33 kV	22/33 kV
115 kV Circuit Breaker	115 kV Circuit Breaker	22-33 kV Circuit Breaker
Battery	22-33 kV Circuit Breaker	Battery
Charger	Battery	Charger
AC Board	Charger	AC Board
DC Board	AC Board	DC Board
Disconnecting Switch	DC Board	Grounding System
Grounding System	Disconnecting Switch	Conductor
Conductor	Capacitor Bank	Lightning Arrester
Lightning Arrester	Grounding System	CSCS System
CSCS system	Conductor	Protective Relay
Protective Relay	Lightning Arrester	Instrument Transformer
Instrument Transformer	CSCS System	
	Protective Relay	
	Power Transformer	
	Instrument Transformer	

The substations can be divided according to the functions they serve. The substation whose function is to switch circuits in and out of the service and to protect against uncertain events is called the switching substation. The substation which steps voltage down to a suitable level for the distribution system is called the primary substation. The substations can be divided by the switchgear position. If the switchgear is installed in the building, it is called indoor substation. Meanwhile, if the switchgear is installed in the field, it is called outdoor substation.

The power substation is the most important part of the PEA dispatching system. The performance of these physical assets directly affects the reliability and stability of PEA power system as well as its revenues. As a result, maintenance activities are regarded as an important task, and consequently a proportion of annual budget is allocated for the replacement, repairing and relocation of these assets. However, with

the limitation and constraints on the available budget, strategic maintenance is required in order to balance costs, performances and risks associated. This is also known as Asset Management Framework. Since there is limitation on information available for maintenance decision, experiences of staff working on the assets on daily basis become even more essential.

The maintenance objectives are to ensure maximum availability of equipment in the substations and maintain proper maintenance long-term to conserve and increase their life-span. The maintenance process can be classified as follows:

1) Breakdown Maintenance

   Breakdown maintenance, also refer to as repair maintenance, is performed when the equipment is incapable of further operation. The concept of breakdown maintenance is that the maintenance operators do not do anything until the machine ceases to function. The maintenance action is started only when the system experience failure.

2) Corrective Maintenance

   Corrective maintenance is defined as the activities of maintenance carried out to restore system which has ceased to meet acceptable condition. This activity includes the failure diagnosis and the system repairing.

3) Preventive Maintenance

   Preventive maintenance is the planned maintenance. It is performed to counteract the equipment failures. It might be called calendar based maintenance because the maintenance is performed on the run or calendar basis. It needs a high level of planning.

4) Predictive Maintenance

   Predictive maintenance is carried out based on the equipment condition. The condition of equipment is determined by monitoring

the key parameters of equipment or system. These values are affected by the condition of the equipment.

5) Proactive Maintenance

Proactive maintenance is the assessment of equipment condition based on the historical records of equipment failures and its design information. This assessment information includes the equipment life time and its parts life-cycle, and the decision making process of the utility companies to refurbish or replace some equipment proactively before its expected lifetime. 'Risk Based Inspection' and 'Reliability Centred Maintenance' methods are utilised within this maintenance scheme.

According to ISO55001 and ISO55002 (2014), the asset management international standard, one key element for the successful asset management activity is the continuing development of an organization's human assets. The organization should provide the personnel an opportunity to enhance their ability by human resource development (HRD) intervention, and provide them with the lifelong learning program. The organization has to make the personnel believe that the workplace is the site of learning.

In the past, the 22 kV parts of substation maintenance jobs have been done by Substation Maintenance Division staff. The area office staff cannot do this job by themselves. Therefore, many problems occurred as the area office personnel were not able to maintain equipment. Nowadays, PEA needs to disperse 22 kV parts of substation maintenance jobs from head office to the area offices. Therefore, PEA has to develop and enhance the maintenance skills of concerned personnel in order to do this job.

1.4 Human Resource Development

Human resource development (HRD) is the method to enhance the knowledge, skill and attitude of employees. It is a set of activities to develop employees in order to promote them become more proficient in their jobs. As a result, human resource development became one of the important factors to run businesses successfully.

In this research, the scope and aspects of human resource development which will be discussed include training and development, organizational development and career development. The training and development activities including with:

- Job Analysis
- Task Analysis
- Setting up the competency model
- Selecting the Development Method
- Development Process
- Evaluation

PEA provides many training courses for enhancing the employee's performance. At the present, PEA has tried to develop the knowledge, skills and attitude of staff using several methods such as in-class training, e-Learning, video conferences, learning by doing and on-the-job training.

In 2011, the PEA developed the HRD blueprint system to be the training guideline. This system provides the systematic human resource development in PEA. It also covers all levels of PEA's employees to develop the specified knowledge and skill. In this project, PEA conducted a survey to investigate the preferred learning style of PEA employees. The results from the survey showed that the majority of PEA employees prefer the learning by doing style. The results of the preferred learning styles in percentage are shown in figure 1.5.

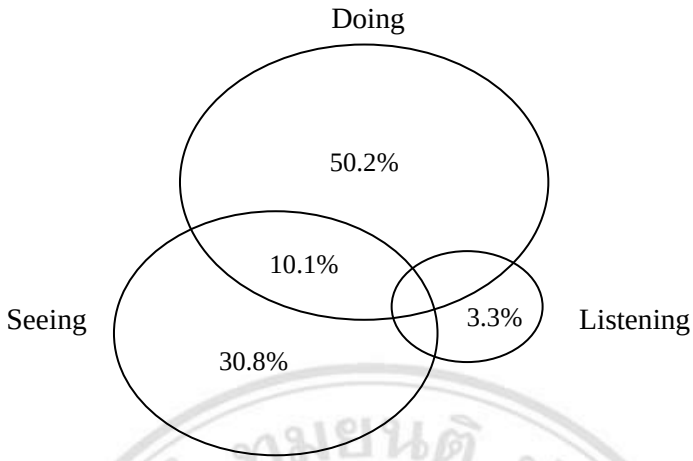

Figure 1.5 Preferred Learning Style of PEA Employees

Source: PEA HRD Blueprint Project: Final Report, 2010

This survey also revealed the learning style preference of each career which is shown in table 1.2.

Table 1.2 The learning style preference of each career in PEA

Career	Seeing	Listening	Doing	Seeing & Listening	Seeing & Doing	Doing & Listening	Doing & Listening &Seeing	No Answer
Financial	33.3%	6.7%	40%	0%	6.7%	6.7%	0%	6.7%
Accounting	32.4%	1.5%	52.9%	0%	11.7%	1.5%	0%	0%
Economy	33.3%	0%	33.3%	33.3%	0%	0%	0%	0%
Engineering	16.5%	3.2%	73.7%	0%	6.6%	0%	0%	0%
IT	9.1%	18.2%	54.5%	0%	9.1%	0%	0%	9.1%
HR	38.9%	0%	50%	0%	11.1%	0%	0%	0%
Technician	20.8%	5.2%	56.3%	1.6%	7.8%	3.1%	0.5%	4.7%
Other	31.7%	1.3%	50.6%	1.3%	10.1%	2.5%	0%	2.5%

Source: PEA HRD Blueprint Project: Final Report, 2010

Referring to results of the survey, it means that PEA employees especially technical personnel prefer to learn by doing and practice. Therefore, PEA has to focus more in training and development programs which give their personnel opportunities to practice and make decisions by themselves.

In 2013, PEA sets up 145 million Baht fund for the overall training activities. This budget was divided into two portions: 84 million Baht for technical training, and 61 million Baht for non-technical training. With conventional training methods, the allocated amount was proved insufficient, and presented PEA with difficulties in practical implementation. The main reason of this due to the fact that PEA's 28,000 employees are scattered throughout the service areas. Under technical training budget, over 10 million Baht is allocated specifically for substation maintenance related tasks. This includes all levels of trainees with an aim to cover as many staff as possible. As a result, most courses are attended by trainees with varied technical backgrounds, and which caused disparity between the proficiency levels and the training materials.

At the present, many training methods have been deployed by PEA to increase knowledge and skill relating to substation maintenance task. These include for example, in-class training, coaching, and on-the-job training. Although these methods are effective to some extent, they failed to provide appropriate environments, essentially to learn maintenance knowledge and skill. Learning visual inspection skill is a complex process that utilizes problem-solving and insightful thinking in addition to repetition of stimulus response chain. Therefore, the maintenance personnel should have chances to do and learn by trial and error in real situation (Siang and Rao, 2003). Unfortunately, the real fault events are very rare for training event, and can be very costly. Hence, this presents a challenge for PEA to develop alternative training method with the right balance between skill and difficulty.

This research focus to enhance the knowledge and skill of substation maintenance staff. In order to do efficient maintenance, the staff must be trained in many skills necessary for maintenance work. Nowadays, the modern systems are precise and capable of sustained output but they have become more complex equipments. In order to do maintenance task, the staff need to have high degree of technical skill and knowledge. Therefore, maintenance staff need the skill and knowledge in a variety of complex field. Hence, they require better education to be able to absorb the technology and to understand the equipment, it's functioning and controls, and its maintenance tasks. Presently, the various HRD methods are used to develop

maintenance staff knowledge and skill. The example methods are classroom training, simulator, wall diagrams and chart, maintenance manual, case studies, coaching and on-the-job training.

1.5 Justification and Proposed Solution

One of the important skills of maintenance task is the visual inspection skill. This skill is instrumental to help the staff understand about the condition of equipment. The development of personnel performance in visual inspection is very important for enhancing substation maintenance process as the first step of the maintenance process is the decision of staff. The staff need to have the expertise to know the component which needs reparing. It means that the visual inspection is the first and important process of maintenance staff. However, traditional training, like classroom training, is not an effective method to enhance the visual inspection skill of the staff. For training the staff in this skill, real events or simulations of real events are necessary to train the staff in visual inspection skills.

Due to the learning in visual skills is more complex process that utilizes problem-solving and insightful thinking in addition to repetition of stimulus response chain. Therefore, the staff should have the chance to do and learn by trial and error with real situation. Unfortunately, the real fault events are very rare for training event. Therefore the PEA needs a new method or tool for developing the skill of the staff which will give the staff opportunities to practice making decisions in the visual inspection job independently.

The problems of this research is summarized and shown in figure 1.6 as follow:

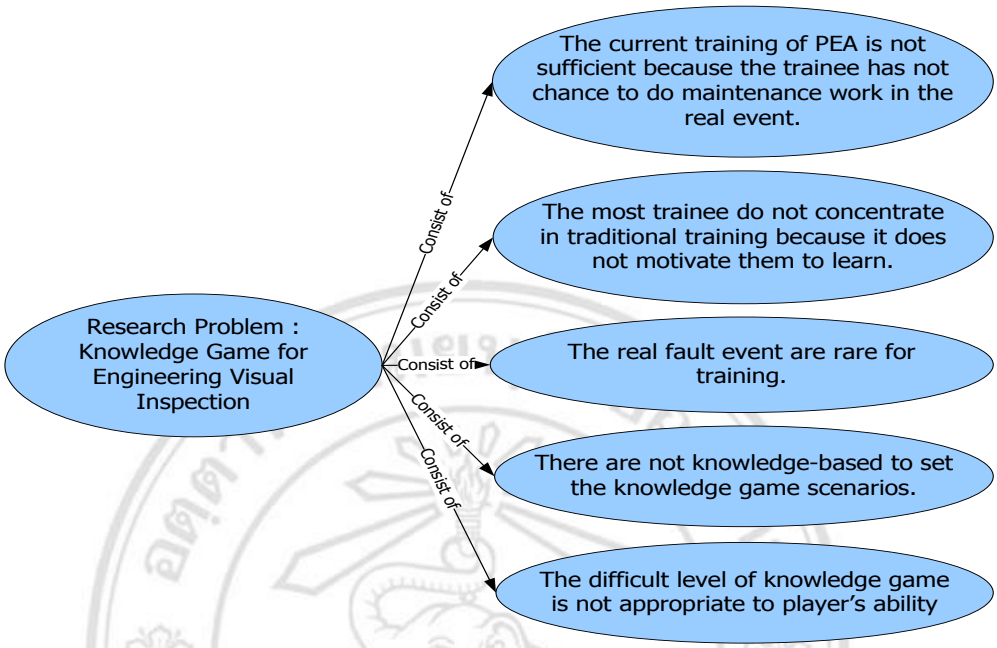

Figure 1.6 Research Problem

This research proposes to find the new practical method called "Game Based Knowledge Management" or "Knowledge Game" to solve the problem shown in figure 1.6. Game based knowledge management is a computer game which can be used for transferring the knowledge and experience from experts to another employees in an organization. The employees will be able to make their decisions and exercise their abilities in the virtual world. Therefore, the knowledge game can promote employee learning with a fun and engaging approach.

This knowledge game is developed based on serious game concept. The objective of knowledge game design is for training the staff and not only for entertainment. Based on the knowledge and experience of PEA substation maintenance experts, it will be able to collect the mistake made by the game players as the case study for analysis and for building up the PEA substation maintenance best practice.

The knowledge game teaches the know-how and experience to the personnel. With this knowledge, the personnel will know how to think to do the maintenance of the substation. Therefore, the proposed knowledge game is different from the general serious games which focus on the knowledge in engineering detail.

This research explores the new practical method for enhancing the maintenance skill of the PEA substation maintenance staff, especially in the electrical power system substation maintenance section in regional office. This research will prove that the knowledge game is an effective learning tool for transferring and sharing the visual inspection skill knowledge to PEA's staff. Due to the knowledge game gives the staff a chance to make decisions and undergo experiences not usually available to them in the real world. The staff can play the game as many times as they desired. They are free to explore, to try difference approaches, without fear of breaking the equipment. This game also motivates the staff to learn about substation maintenance by playing game. Therefore the knowledge game is an efficiency tool for developing the skill of the staff in organization better than other methods.

Referring to the problem in the research problems map, the research questions are as follows:

- How can the knowledge game be developed and constructed to enhance the visual inspection skills of employees?
- Can the knowledge game enhance the substation maintenance engineers' performance better than traditional training methods such as in-class training, coaching, on-the-job training, e-learning?
- Can the knowledge game motivate the staff to learn about substation maintenance?
- How does the knowledge game increase the player's motivation to play it again?
- What is the proper architecture of knowledge game for training in visual inspection?
- How can we use the knowledge game for building up the PEA substation maintenance best practice?

- Is there any change observed in staff behavior in work after they play the knowledge game?

According to research question above, the research objectives can be stated as follows:

- To develop the framework which can be used to develop the knowledge game for enhancing the visual inspection skill
- To use the knowledge game as the tool for transferring the visual inspection knowledge from experts to other staff members
- To motivate the staff to learn by using knowledge game
- To develop the tool for classifying the trainees' ability
- To develop the selection engine for selecting the appropriate game level for individual player

1.6 Research Hypothesis

This research proposed the game as the alternative training tool for enhancing the skill and knowledge of the staff especially inspection maintenance skill. However, the current game framework is not appropriate to construct the contents for developing this maintenance skill. Therefore this research also proposed the framework for developing the knowledge game. Referring to research questions and objectives as mentioned in last section, the hypotheses of this research is set up as follows:

H1 The proposed framework can be utilized to identify the capability level of the individual personnel better than traditional method.

H2 The proposed knowledge game framework can be used to develop the game scenario.

H3 The proposed game development framework and knowledge engineering methodology are the proper methods for capturing the knowledge and experience of experts to develop the game scenario.

H4 The game based knowledge management is the suitable method for enhancing visual inspection maintenance skill and knowledge than traditional HRD methods.

H5 The proposed knowledge game framework can be efficiency used to select the appropriate game level to individual player.

1.7 Scope of work

This research studies the knowledge game development which is used for visual inspection maintenance skill enhancement. In this study, the maintenance competencies are comprised of maintenance planning, coordination, maintenance operation, corrective maintenance, measuring, and monitoring. Referring to the competency analysis in this study, it is found that the inspection maintenance skill can be developed by enhancing the maintenance planning, maintenance operation, corrective maintenance, measuring, and monitoring. Therefore, the knowledge game in this research focuses on developing these mentioned competencies. Furthermore, this research constructs the prototype of the training game in order to prove the game development framework concept.

1.8 Research Limitation

This study is done based on the knowledge and experience of PEA N3 experts. Therefore, the contents of game prototype are limited to information, knowledge, and experience captured from the PEA N3 experts. It means that some scenarios cannot be used for developing the personnel of the other area offices. Moreover, the knowledge of PEA N3 experts do not cover the whole process of maintenance system. Thus the contents of prototype game are limited to these criteria. The proactive maintenance process is not developed as the scenario in this research. Other limitation of this research is the prototype development. The prototype of this research is developed by applying the pen-and-pencil testing method. The game is developed by using Microsoft Powerpoint program. Therefore, some animations, game environment, game activity, gameplay patterns are limited.

1.9 Expected Research Output

The research presents the knowledge game development specifically for training purposes for the 22kV switchgear maintenance process. Therefore, this research directly beneficial for the PEA, Thailand. The Electrical Substation Maintenance Division and Training Division of PEA are the key beneficiaries of this research project. In this research, the knowledge game has been developed as an efficiency tool to enhance the performance of the engineering visual inspection staff. By using the knowledge game, the staff will be motivated to learn. Therefore, the learning atmosphere can be created within the PEA. Even though this knowledge game is developed based on circuit breaker maintenance process, the framework can be adapted to develop the knowledge game in another maintenance task. Moreover, the concept of developing knowledge game can be used for applying in another areas work of PEA. Furthermore, the concept of research can be used for developing the new learning tools which give knowledge and motivation to the learners. This concept can be applied in education as well.

1.10 Research Novelty

This research is aimed to explore the new practical method for enhancing the inspection maintenance skill of the PEA substation maintenance staff. In this study, the proposed framework was utilized to construct the PEA's 22kV switchgear maintenance game prototype. Then the case studies were done for the prototype testing. The results of case studies show the new findings of the HRD intervention. These novelties found in this research can be summarized as follows:

1) The research proposed the competency analysis table as the originality. This table is the tool for holistic competency analysis which integrates human resource development with knowledge management, risks management and management information system.
2) The application of the capability maturity model to classify knowledge and skill of the maintenance tasks into maturity level is another academic value presented in this research. The proposed model gives the benefit to PEA in

order to classify the capability of the switchgear maintenance personnel. This is potentially beneficial to the human resource development staff than traditional methods (current competency model) in the senses that it provides the information on how to develop the specific skill of the employees.

3) The game scenario development by knowledge engineering is the another originality of this research. This novelty is concerned the knowledge collected and stored in KM cycle. The knowledge engineering methodology has been used for eliciting the knowledge and experience from the subject matter experts. By this knowledge engineering technique, the knowledge elicitation needs the effort of subject matter experts only in knowledge capture meeting and case study meeting. This implies that the proposed framework consumes less of the experts' time. Moreover, the study proposes to structure the storyboard of game scenarios based on knowledge engineering. Due to the knowledge engineering allows the organization add the new knowledge into knowledge model. Therefore, game scenarios can be systematically constructed and provided flexibility for future modification.

4) The next originality is the plug-in game structure. This research proposes to develop the game narrative with the plug-in structure. The story line of the game is cut into sub parts. This plug-in structure allows trainer to assign the most appropriate content for an individual trainee. Moreover, this structure also benefit the game developer in that additional game scenarios can be added without changing the entire content of the training program.

5) The knowledge transfer evaluation method in game is another benefit of this framework. This research proposes to manage the knowledge by developing an alternative method to share the knowledge from the experts to employees.

6) It evaluates the knowledge sharing and transfer by comparing the decisions made and time taken by trainees and expert. The time and score are set up based on performance of subject matter experts. It means that the personnel

performance is evaluated by comparing to the maintenance expert, or in other words, how close it is to the performance of the experts.

1.11 Chapter Review

Chapter 2: Literature Review

This chapter reviews the concerning theories, existing literature and prior research carried out on similar subject area. These theories include professional development, human resource development, learning theory, Capability Maturity Model (CMM) and knowledge engineering. In the human resource development section, the history of HRD, the methods which are used in power industries, HRD of PEA and the problem of existing HRD will be discussed. The section of Capability Maturity Model (CMM) will present the model which is used for managing and developing the capacities of organization. Learning theory section defines some of importance learning theory and motivation theory which is related to adult learning. The last section of the literature review chapter will explain knowledge engineering. The CommonKADs methodology will be presented in this section as well. It also presents why CommonKADS is selected in this research over other knowledge engineering methodologies such as Model-based and Incremental Knowledge Engineering (MIKE).

Chapter 3: Research Methodology

This chapter presents the detail of the research methodology.This chapter is divided into 4 main parts. The first part presents the research methodology. The second part describes the proposed knowledge game framework. It gives the detail of the knowledge game model which is divided into three main parts: Knowledge Base and Scenario, Scenario Selection Machine, and Knowledge Game Interface. After that, it presents the processes to develop the prototype of PEA's 22 kV switchgear maintenance game.Then the final part presents the testing and data analysis phase of the research methodology.

Chapter 4: Case Study

This chapter presents the case studies in order to prove the research framework and the hypothesis of the thesis. PEA and the 22kV switchgear maintenance task are used as case studies. This study is comprised of 3 case studies. The first case study shows that the framework can be efficiency used to identify the personnel ability especially for specific knowledge and skill like visual inspection skill. The second case study proves that the research framework is the proper method for capturing the knowledge and experience of expert to develop the game scenario. Final case study shows that this knowledge game is the proper method for enhancing visual inspection skill than traditional training.

Chapter 5: Results and Analysis

This chapter presents the results and analysis of the case studies. The results of each case studies are analyzed to discover the evidence for proving the research hypothesis. These results show that the research framework is the proper method for enhancing the performance of switchgear maintenance staff. This framework can be used to develop the knowledge game based management which provides the learning motivation, learning environment, learning contents, and learning pattern.

Chapter 6: Conclusion and Future Work

This chapter presents the conclusion of the research. It also presents the novelties which were discovered. This main objective of this research is to explore the new practical method for enhancing the inspection maintenance skill of the PEA substation maintenance staff. The game based knowledge management framework is proposed as a new practical method. The results of studying show the new findings of the HRD interventions especially in the engineering knowledge development field.