Chapter 1

Introduction

Early power system was composed only of generation and distribution sectors operating as the Direct Current (DC) system. When the transformer was later invented, an Alternative Current (AC) system was introduced to the power system with the benefit of the transmission voltage. As a result, the power system became bulk network which were subdivided into generation, transmission and sub-transmission, distribution, and loads. An engineering and economics were concerned from planning, design, implement, operate and maintenance stage in order to transmit and distribute bulk energy to load with low losses, stable frequency, acceptable voltage regulation, and low numbers of system interruptions.

Moreover, the new vision of power system operation, so called the Smart Grid, which covers an infrastructure ranging from the Micro Grid, Renewable Energy Source and IT system for self heeling, islanding, and contingency planning to avoid cascade trip (blackout) will come along with environmental consideration. Digital technology is also used to provide and support energy saving, cost reduction and increase reliability and transparency. The Supervisory Control and Data Acquisition with Distribution Management System function (SCADA/DMS) is one of an advanced control technology that will be implemented in many distribution utilities.

With this technology oriented situation, utilities need to learn how to manage their specific system (as a whole) in cooperation with their special operational tools. This thesis focuses on this issue and aims to provide utility with an alternative method to overcome this situation by utilizing knowledge management methodology in designing and maintaining their SCADA/DMS system. Especially, power system operation with an appropriated decision support tool will be more essential matter for utility to get system work properly as everyone needed. The research will introduce the knowledge management methodology for utility to get useful organization knowledge for managing their distribution system.

1.1 Chapter Overview

This chapter gives an introduction to the thesis and overall framework presented in this research. It begins with the introduction to the Thailand Energy Supply Industry (ESI), the power system operation, and the modern utility with the smarter network operation. Then, the research theme and the list of publications are mentioned to show the significant of this research. Finally the overview of the thesis is also given at the end of this chapter.

1.2 Electricity Supply Industry of Thailand

Similar to Electricity Supply Industry (ESI) in other countries, ESI of Thailand comprises of 3 major sectors including generation, transmission and distribution networks. Basically, bulk electricity is produced at the generation level, transmitted through transmission system nationwide at very high voltage level, and then distributed to end customers through lower voltage network system. These responsibilities to provide electricity to customers are divided among 3 utilities in Thailand. These include, Electricity Generating Authority of Thailand (EGAT), Provincial Electricity Authority (PEA), and Metropolitan Electricity Authority (MEA). The provision of electricity in Thailand can be illustrated in figure 1.1.

EGAT is responsible for electricity generation utilizing its power plants with diversified technologies, and the transmission of this bulk electricity via very high-voltage networks. MEA is then responsible for the distribution of this transmitted electricity via its lower-voltage network to customers in Bangkok, Nonthaburi and Samutprakarn provinces. Similarly, PEA is also responsible for the distribution of electricity to customers in the remaining areas of the country.

Although the provision of electricity in Thailand with three utilities mentioned previously has worked well to serve customers with good Quality of Service (QoS) and reliability, the trend of the ESI toward a more competitive environment cannot be ignored. This new environment is perceived to provide better incentive to hold price down to marginal cost and minimize cost. Thailand is no exception, and in the transitional period from monopoly to competitive environment. The Thai government has encouraged the participation from the private sector in the new generating capacities with “Small Power Producer” (SPP), “Independent Power Producer” (IPP), and recently “Very Small Power Producer” (VSPP) schemes. This is seen by the Thai government as a way to reduce government spending in the industry, and promote more competition in the generation sector. Hence, the current ESI structure of Thailand is illustrated in figure 1.2.

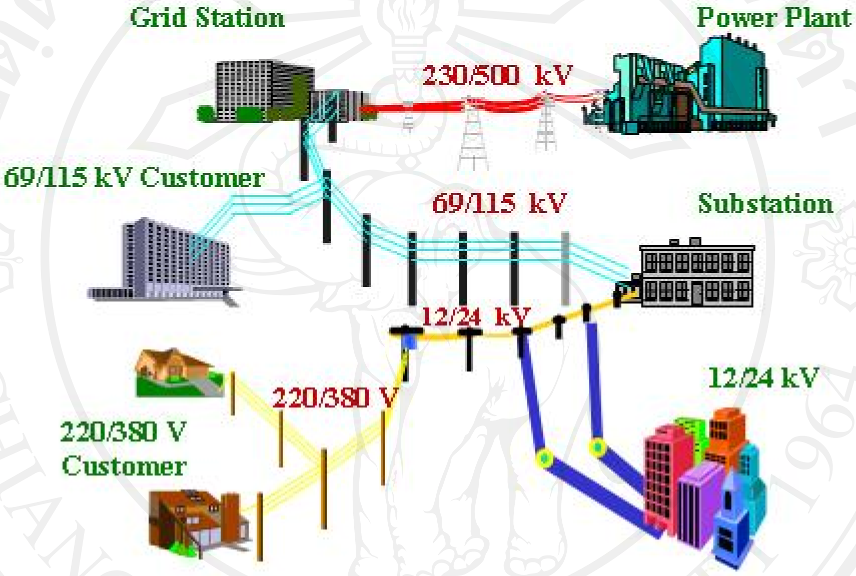
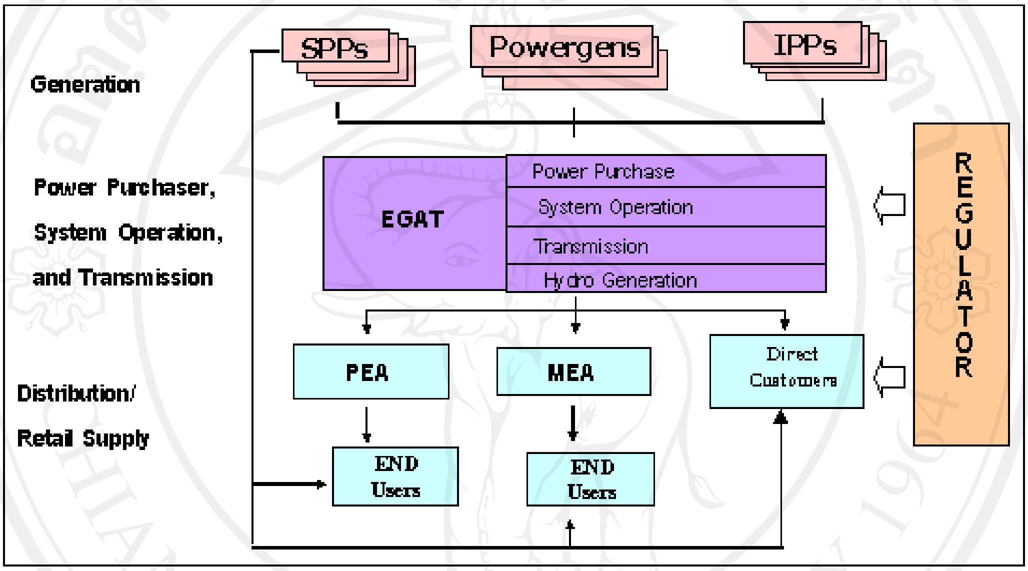


Figure 1.1: Electricity Provision of Thailand

Both SPPs and IPPs will generate electricity and sell to EGAT, who will further sell the electricity to the MEA and PEA. Still, almost all consumers nationwide will have to depend only on the services of the MEA and PEA, without other options since there is no competition in the service provision and distribution of electricity. This is known as the Retail Market for electricity where consumers can change their electricity supplier. The two main aspects of the impact of the above-mentioned ESI structure on consumers are electricity tariffs and supply & service quality.

Beside the increasing liabilities of the three state enterprises in the power sector, the lack of efficiency in the organizational and human resources management is also a major problem affecting the operation and management of the individual utilities. Although these three state-enterprise power utilities are considered to be more efficient than many other state enterprises, problems still prevail. The lack of operational efficiency of state enterprises, causing similar problems, may result from two major factors, i.e. the large organizational size with centralized management and the politicized management policy.



Figures 1.2: Current ESI structure of Thailand in 2009

Source: www.nepo.go.th [1]

Privatization of state enterprises will bring about more efficiency of the organizations and reduce duplicated work procedures while staff members will be awarded according to their performance merits. The restructuring and privatization of the ESI in Thailand has systematically been implemented over a number of years. Under this ESI reform plan, greater competition and more participation from the private sector are expected. Inevitably, this will result in changes in the ESI structure of Thailand to allow the deregulation or the restructuring of the industry. Hence, this requires better, transparent regulatory which promotes competition, creates level-playing field, and prevents market from being manipulated. The future of the ESI structure as depicted in the reform plan is shown in figure 1.3.

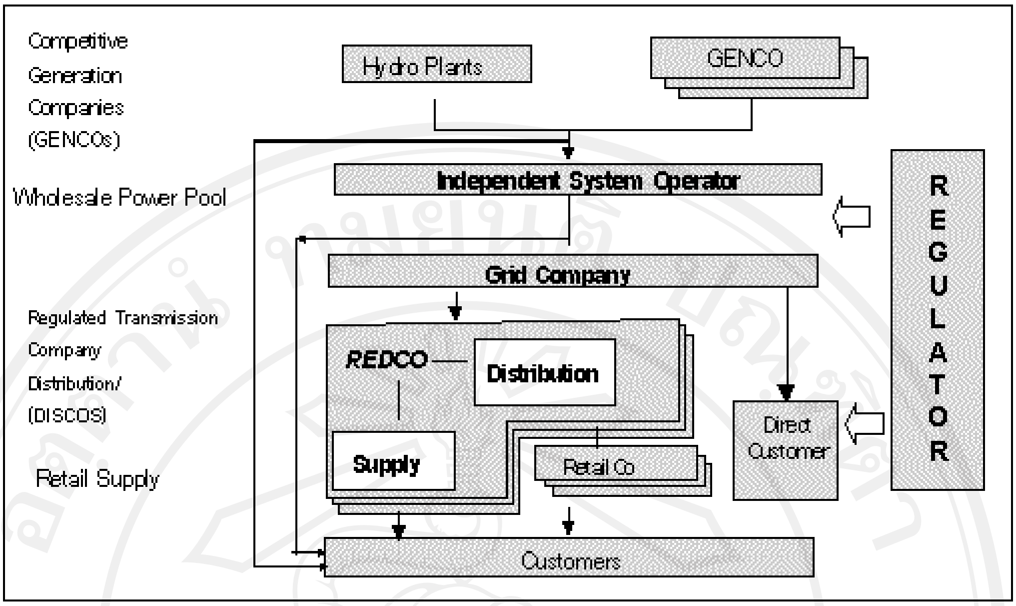


Figure 1.3: Future ESI Structure of Thailand

Source: www.nepo.go.th [1]

Figure 1.3 shows the future ESI structure of Thailand as depicted in the reform plan. An Independent System Operator (ISO) and Grid Company will be separated. Competition can be introduced to generation sector, but not all. However, for certain natural monopoly businesses, like power transmission and distribution systems for which new investment would duplicate the existing ones and hence would not be cost-effective, they will be subject to regulation so as to protect consumers' benefits.

Regardless of the Thai ESI structure, the reliability and the quality of service to end customers are of such important issues to the utility. Similarly, the efficiency improvement is also concerned by the utility either for the cost minimization in the monopoly structure or the profit maximization under competitive environment. All of the issues mentioned above are typically overcome by the advance in the power system technologies and implemented by the utility inevitably. These include for examples: power quality monitoring and control, asset management, and the application of SCADA (Supervisory Control and Data Acquisition).

Electrical power is not easily stored so it is normally the 'Just in Time' (JIT) service to the point of consumption. The quality of service depends on a trust and approved supplier with no requirement for ‘goods in’ inspection. A good quality power supply should be available within voltage and frequency limit. It should have also a pure sinusoidual wave shape. The problems of power quality are service interuption, under or over voltage, surge and transient, under or over frequency, and harmonic distortion.

The most obvious problems are complete interruption (which may last from a few seconds to several hours) and voltage dips or sags where the voltage drops to a lower value for a short duration. Normally, long power interruptions are a problem for all users, but many operations are very sensitive to even very short interruptions. [2]

Metropolitan Electricity Authority (MEA), for example, has their service standard to guarantee the customer satisfaction. This is shown in table 1.1 for city or business customer, industrial customer, suburd customer, and overall. The overall MEA customer should not experience the System Avarage Interruption Frequency Index (SAIFI) more than 2.79 times per year. And the system should not have the System Average Interuuption Duration Index (SAIDI) more than 62.07 minutes per customer per year. With this service standard, the appropriate monitoring and management system is necessary for their operation.

Table 1.1: MEA Service Standard

Source: MEA

Service Area	**SAIFI** (times/cust./year)	**SAIDI** (minutes/cust./year)
City/Business	2.46	54.86
Industrial	2.63	54.23
Suburb	4.32	100.37
Overall	2.79	62.07

Today the transmission and distribution business is asset intensive, and many feel that asset management is the best way to address these fundamental issues. The result is a multiyear investment plan that maximizes shareholder value while meeting all performance, cost, and risk constraints. The goals of asset management are to:

- balance cost, performance, and risk

- align corporate objectives with spending decisions
- create a multiyear asset plan based on a rigorous and data-driven processes

Asset management is ambitious in scope and requires supporting metrics, organizational design, processes, information systems, and corporate culture. Successful implementation can be quite disruptive and requires the involvement and support of top management, sufficient resources, and effective change-management skills. Canned approaches are doomed to fail, but thoughtful approaches can help utilities reach the next level in business success. [3]

The Asset Management of Transmission and Distribution business operating in an electricity market involves the central key decision making for the network business to maximise long term profits, whilst delivering high service levels to customers, with acceptable and manageable risks. It is the set of disciplines, methods, procedures and tools to optimise the Whole Life Business Impact of costs, performance and risk exposures (associated with the availability, efficiency, quality, longevity and regulatory/safety/environmental compliance) of the company’s physical assets.

In the context of an Electricity Distribution Utility, asset management can be defined as a systematic process of, costeffectively, operating, maintaining and upgrading of electrical assets by combining engineering practices and economic analysis with sound business practice. Any given electrical distribution network is made up of the primary and secondary plants hence these assets too can be classified as either primary or secondary plant assets. The rapid rates of technology developments as well as technology integration have continued to pose challenges to asset management in the global electrical power sector. The rehabilitation of weak or dilapidated electric power distribution infrastructure in several countries across Africa is long overdue. With the incremental addition of intelligent, distributed data servers to existing field devices one can:

- Extend the life-span of existing equipment,
- Avoid the exorbitant costs of total system refurbishment,
- Expose currently inaccessible data to more users,
- Distribute intelligence throughout the network and reduce overload on the communications network

This will involve a hybrid of system architectures, centralized, and decentralized as well as peer-to-peer. During the transition to fully automated and integrated solutions, a number of obstacles have to be overcomed before or during the implementation phase. Some of these factors are generic to all utilities and some are very specific. It depends on the operation, engineering practices, business practices, and culture. [4]

Unlike financial and safety, operation and reliability risks in electric utility lack a framework for regulator to assess or define the standard for the utilities to take responsibility. Public Available Specification (PAS) 55 or PAS-55 is growing to help this problem. It codifies standards in decision making, defining and clarifying the competencies required for technical and operational risk management in business, and driving transparency in capital investment and system performance reliability. It is being advocated and adopted by many regulators and utilities around the world to serve as the organizing framework to ensure better operational performance and lower reliability risk in business. [5]

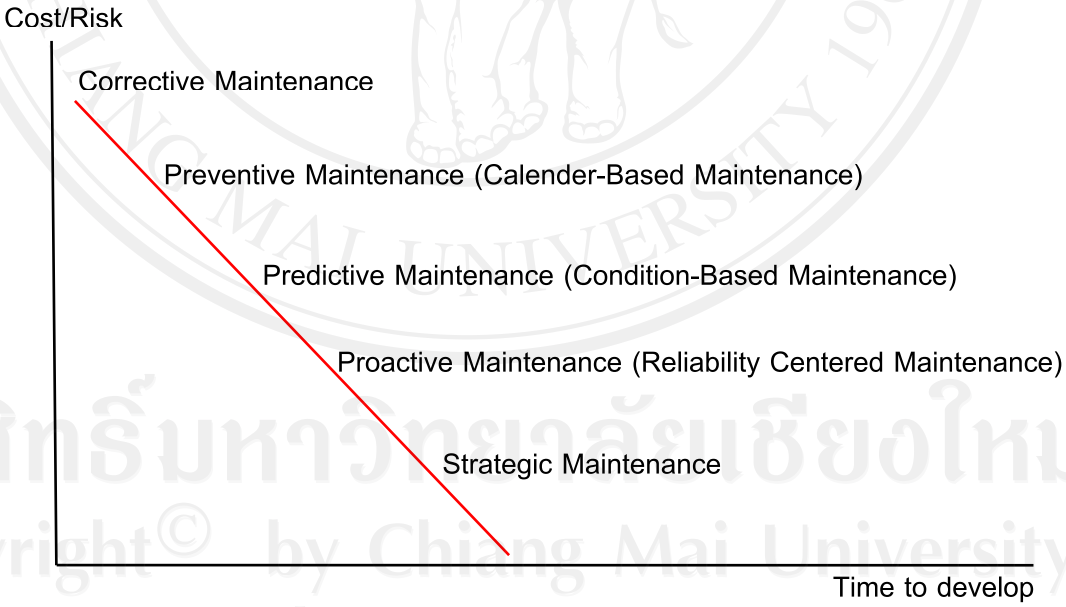


Figure 1.4: The evolution of asset maintenance

The evolution of asset maintenance in the electric industry (figure 1.4) has gone from corrective, calendar-based, condition-based, reliability centered, and strategic. This should reduce cost and risk to power system; however, take time and need new information technology to develop the system. Today SCADA Application like EMS and DMS has many useful functions that can help utilities for the operation and maintenance of the transmission and distribution system.

1.3 Overview of Power System Operation

Since this research focuses on the distribution network and distribution utility, MEA is then used as a case study. In more detailed explanation, MEA is a state-owned utility established under the Metropolitan Electricity Authority Act B.E.2501 (1958), and Amendments B.E.2530 and 2535 (1987 and 1992). The main objectives of the MEA are to acquire and supply the electricity to its customers as well as to carry out the business related to electric energy and other business incidental thereto, or that which is beneficial to the MEA in the areas of Bangkok Metropolis, Samut Prakan and Nonthaburi provinces, covering approximately 3,192 square kilometers (figure 1.5).

As of December 2005, MEA has 18 districts and 13 service stations in figure 1.5. MEA’s distribution system is able to serve the power demand of 15,305 MVA. The maximum demand in 2005 was 7,338 MW. Energy sales in FY 2005 totaled 40,100 GWh, an increase of 2.5% over the same period of the previous year. The total number of MEA's customers in 2005 was 2,554,980 and is projected to increase by 2.9% during the 2005 – 2007 period. The growth of energy sales during 2005 – 2007 is estimated to be approximately 6.25%. MEA customers are divided into five major categories: Residential, Small general service, Medium general service, Large general service, and Other (Specific Business, Government Institution, Non-Profit Organizations, and Public Lighting).

In order to cover its area with such high population density, MEA operates its distribution system with different network configurations utilizing both overhead and underground networks. These network configurations include radial, loop, primary selective, and special spare line, and can be schematically demonstrated in figure 1.7.

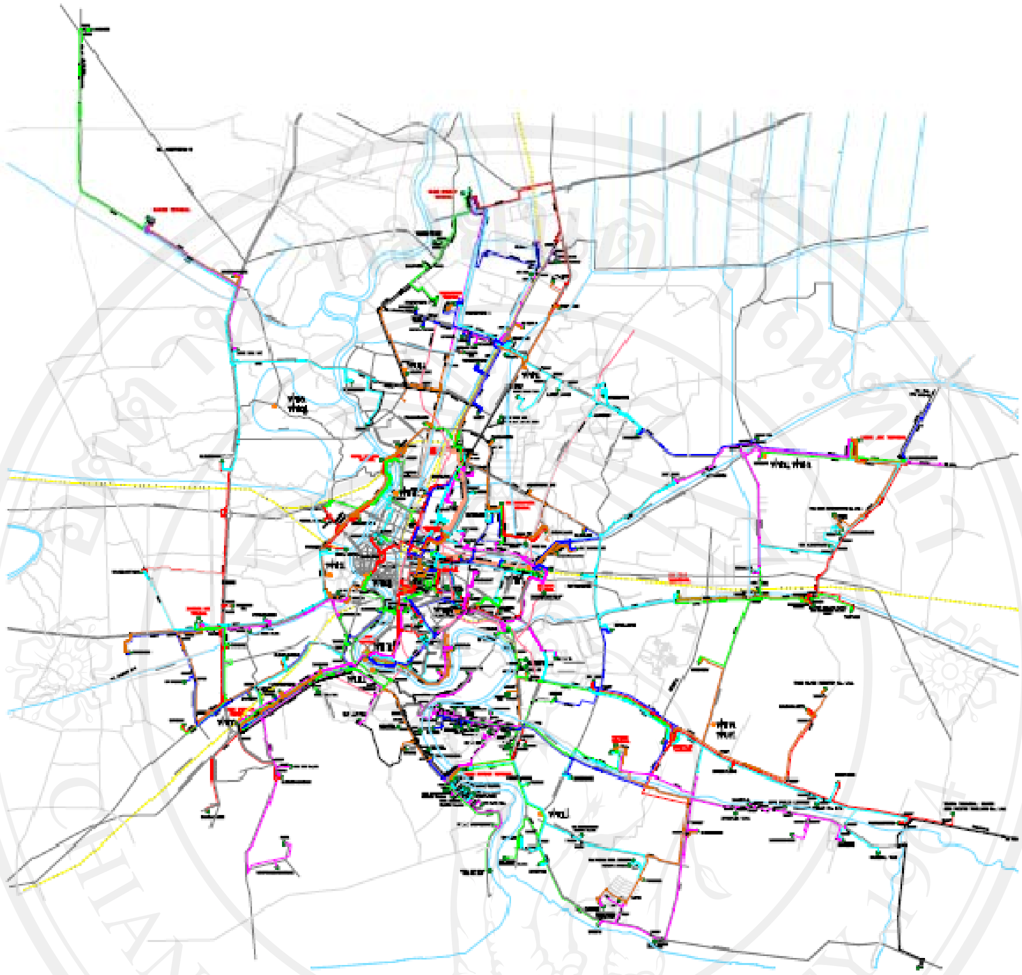


Figure 1.5: MEA Distribution System (Service Area)

Source: MEA

Figure 1.5 and 1.6 shows the service area and the schematic diagram of the MEA distribution system configuration. The scope of distribution is from power transformer in substation down to distribution transformer in the primary feeder which has four typical schematic diagram:- radial, loop, primary selective and special spare line. Table 1.2 is the summary of MEA distribution system configuration. For overhead distribution system, radial with tie switch or loop with open section is normally used in MEA. However, MEA primary distribution feeders are usually mixed with overhead and underground system. Fully underground system is only in some special area. To ensure that the power distribution system meet international standard in the reliability, quality and security, therefore the implementation of distribution system development has been undertaking critically and continuously.

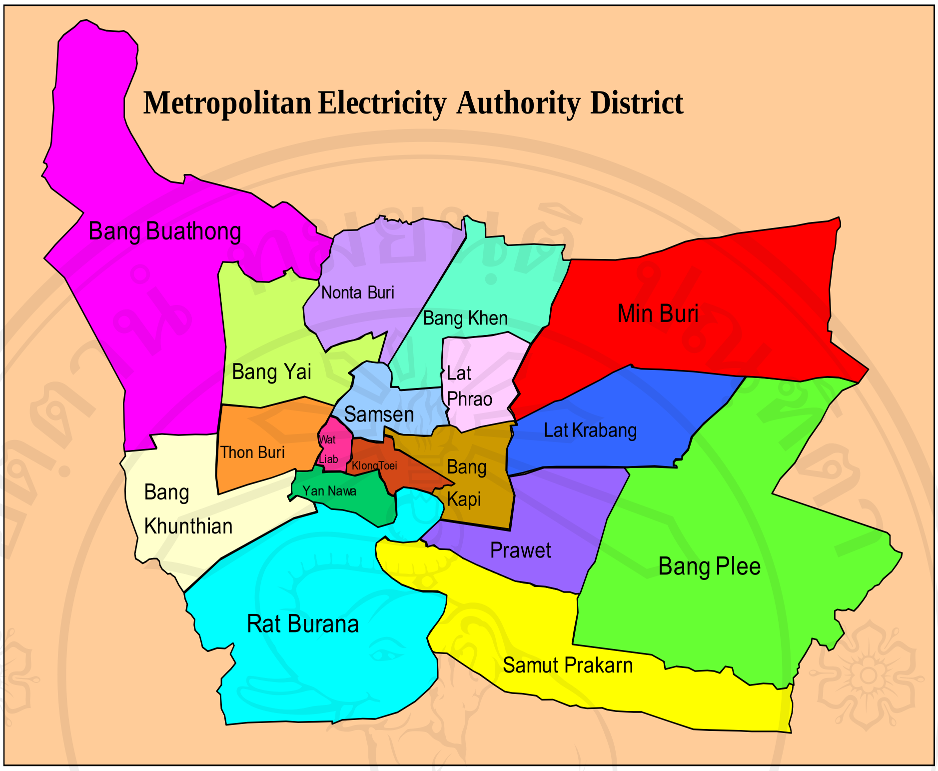
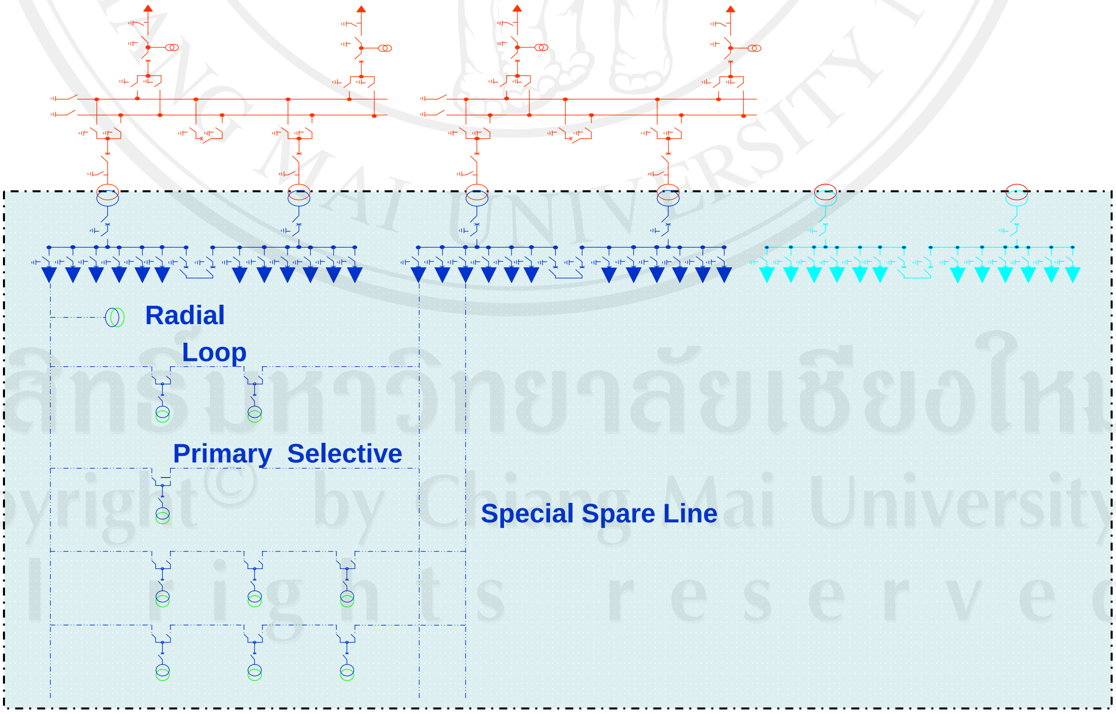


Figure 1.6: MEA district area



Figures 1.7: MEA Distribution System (Schematic Diagram)

In MEA, the implementation of distribution system development has been undertaking critically and continuously. These include the construction/ improvement/ expansion of terminal stations and substations, construction/ improvement of transmission lines and feeder lines systems, voltage conversion from 12 kV to 24 kV and the replacement of overhead lines system with underground cables system. In addition, new technologies have been introduced such as the Supervisory Control and Data Acquisition/ Energy Management System (SCADA/EMS) and the Distribution Automation System (DAS), etc. These performances helped to support operations in 2008 to cope with the maximum power demand of 7,584.82 MW, sustaining the power system stability of the System Average Interruption Frequency Index (SAIFI) of 2.30 times/ customer/year and the System Average Interruption Duration Index (SAIDI) of 50.65 minutes/ customer/ year, recording a good performance above the target level.

Table 1.2: Summary of MEA distribution system configuration

Configuration	**Distribution System (12,24kV)**	
	Overhead System	**Underground**
Radial	✓ (simple, with-tie, express feeder)	✓ (with secondary network)
Loop		✓ (open loop)
Primary Selective		✓
Special Spare Line		✓

These include the construction/ improvement/ expansion of terminal stations and substations, construction/ improvement of transmission lines and feeder lines systems, voltage conversion from 12 kV to 24 kV, installation of transformer and meter, etc. In addition, new technologies have been introduced such as the Supervisory Control and Data Acquisition/Distribution Management System (SCADA/DMS) and Substation Automation (SA), etc.

1.4 Modern Utility and Smarter Network Operation

As mentioned previously, the ESI of Thailand is slowly undergoing the transitional period to more competitive environment. Utilities operating in Thailand need to improve its efficiency while maintaining the reliability and the quality of service by implementing different advanced technologies. In other words, this is to better manage its business and become Modern utility.

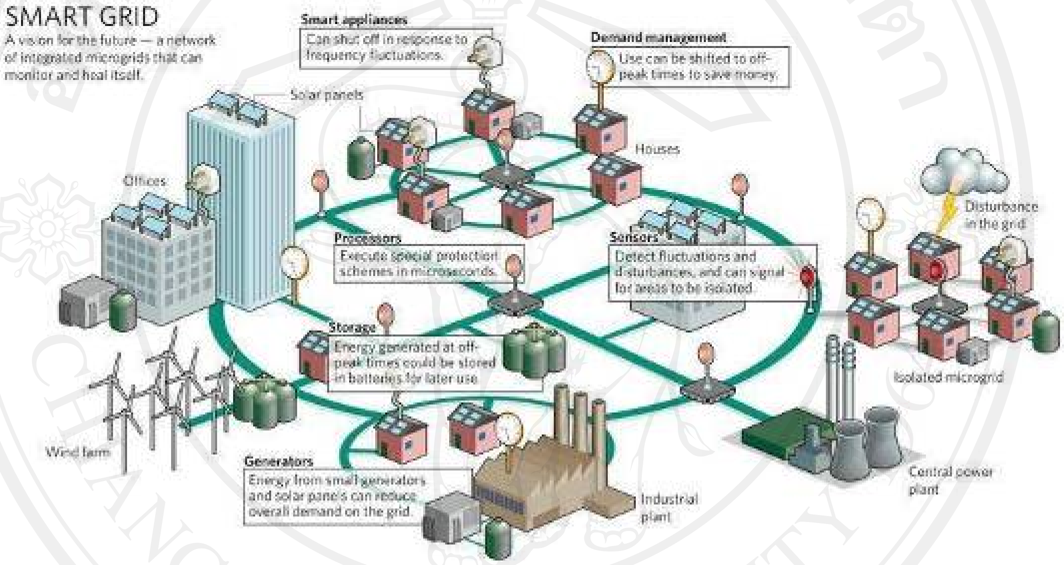
With the competition being introduced into the generation sector of the Thai ESI, it is expected that there is growing numbers of participants in the forms of Distributed Generation (DG) across the network nationwide. DG is new generation plant that is smaller, more flexible, more environmentally friendly, and closer to the load demand. Along with global environment issues from 'Kyoto' protocol which bring utilities more attention into any renewable energy resources so that it is normally used a renewable energy such as biomass, fuel cell, wind, solar and so on which is good for environment as a whole. However, power system operation has to concern about many issues in the future when more DG comes into the power system. This is due to the fact that with DG on the network the flow of electricity could be bi-directional whereas the initial distribution network was designed to handle only one direction. Hence, the distribution utility needs better network operation.

The problem can be indentified in to two categories: voltage and frequency. For example in Japan, there is a plan to use renewable energy in the form of distributed solar-cell and wind power generations, and the final plan is to have their power demand reach more than 20% of the total power demand by 2030. The goal is to accelerate the use of renewable energy and to mitigate global warming. However, the power system may suffer from voltage and frequency regulation issue that mention in table 1.3.

Table 1.3: Trend of solar power in Japan [6]

Year	Solar Power	Problem Issue	Solution
2009	4 GW (2.2%)	-	-
2020	2 GW (16%)	Voltage Regulation	STATCOM
2030	50 GW (29%)	Frequency Regulation	Energy Storage System

After blackout situation around the world in 2002, the term, “Smart Grid” has been introduced. A smart grid is a universal term and implies the future vision of the power system and its operation that covers modernization of both the transmission and distribution grids. The architecture of the smart grid concept is illustrated in figure 1.8.



Figures 1.8: The Idea of Smart Grid

Source: www.nature.com [7]

With the same basic infrastructure as of now, the grid will be a two-way system where power generated by many micro distributed sources across the network in addition to bulk plants, flows across a grid based on a network rather than a hierarchical structure. Consequently, this presents additional control problems for existing distribution transformer with fix tap. By drawing on advanced control, monitoring and communications technology that is presently only beginning to be applied, it will bring quantum benefits to grid operators, utilities, customers, and environment such as efficiency, reliability, and pollution reduction.

Some of smart grid technologies [8] today are:-

- Real-time situational awareness and analysis of the distribution system can drive improved system operational practices that will, in turn, improve reliability.
- Fault location and isolation can speed recovery when outages do occur by allowing work crews to drastically narrow the search for a downed line.
- Substation automation (SA) enables utilities to plan, monitor, and control equipment in a decentralized way, which makes better use of maintenance budgets and boosts reliability.
- Smart meters allow utility customers to participate in time-of-use pricing programs and have greater control over their energy usage and costs.
- SCADA/DMS (distribution management systems) put more analysis and control functions in the hands of grid operators.
- Voltage control, through reactive power compensation and the broader application of power electronics, increases transmission capacity of existing lines and improves the resiliency of the power system as a whole.

This modernization is directed at a different set of goals for different entities relating to power system. These include facilitating greater competition between service providers, enabling greater use of variable energy sources, establishing the automation and monitoring capabilities needed for enabling the use of market forces to drive energy conservation. While demand has increased, the need for a steady power supply with minimum power interruptions and fast restoration has also increased. To meet these demands, automation of the power distribution system needs to be widely adopted. All switches and circuit breakers involves in remote operation (motor drive or actuators). The control interface equipment (RTU) must withstand extreme climatic conditions. Also, control equipment at each location must have a dependent power source. To cope with the complexity of the distribution network, the computer, communication and distribution technologies need to be employed. At the same time, a specialized software package must be carefully selected.

In summary, the Smart grid (“Intelligrid”-EPRI, “Gridwise”- DOE) concept along with utility reorganization and deregulation period brings utilities to consider closely important and critical issues. These are engineering, economics, and environment which govern major key decisions not only on the investment but also the operation and maintenance of the network.

1.5 Energy Supply Industry Requirement and Research Justification

Utilities in Liberalization Market will be confronted with many critical issues within the next decade. According to their uncertain earnings and annual budget limitation, many utilities are required to reduce their costs while still providing good Quality of Supply (QoS) in order to maintain their customer satisfaction. Technically, this becomes more and more difficult since some mature primary equipments approach the end of their life. Hence, they require some forms of life extension. Normally, system operators make their decision and control the system from their operation manual. With greater network complexity of power distribution, this makes it more difficult for them to manage their network.

Supervisory Control and Data Acquisition for Distribution Management System (SCADA/DMS) features that included Substation Automation allows simplified management for large distribution networks with frequent modifications and updating operations. This concerns focus on system reliability, power quality, system losses, customer communications and customer billing. The DMS functions include VAR dispatch, Voltage dispatch, Automatic Meter Reading (AMR), transformer load management, outage management and fleet management. SCADA/DMS usage is nearly universal in Europe and North America. Application functions are such as Connectivity Analysis (CA), Power Flow (PF), Demand Estimation (DME), Fault Level Analysis (FLA), Fault Isolation and System Restoration (FISR), Volt and Var control (VVC), Trouble Call and Outage Management (TCOM), Switching Management System (SMS), Load Shedding and Restoration (LSR), etc.

DMS is such complex issue. Its capabilities vary from system to system. Unlike most main transmission systems, a typical distribution system is subject to constant expansion and rearrangement. Model exchange and coordination has become a priority. Among these are model versioning and version control, migration of model between different schema, the transformation of model for different applications. Operational power system model is involving in many classes of information. Utility industry standards already use knowledge representation (KR) concept to represent power system models such as common object broker architecture data access facility (COBRA DAF) which is common information model in extensible markup language (CIM XML) and resource description framework (RDF). [9]-[11] An International Electrotechnical Commission (IEC) TC57 WG14 is focused on identifying and establishing requirement for standard interfaces related to distribution management system (DMS). In fact, the cost of designing and implementing a single data model for the control center is prohibitive. Key to successful implementation is an enterprise level architecture describing how information is shared. It is critical that utility managers understand the issues at hand as they adopt integration strategies. [12]

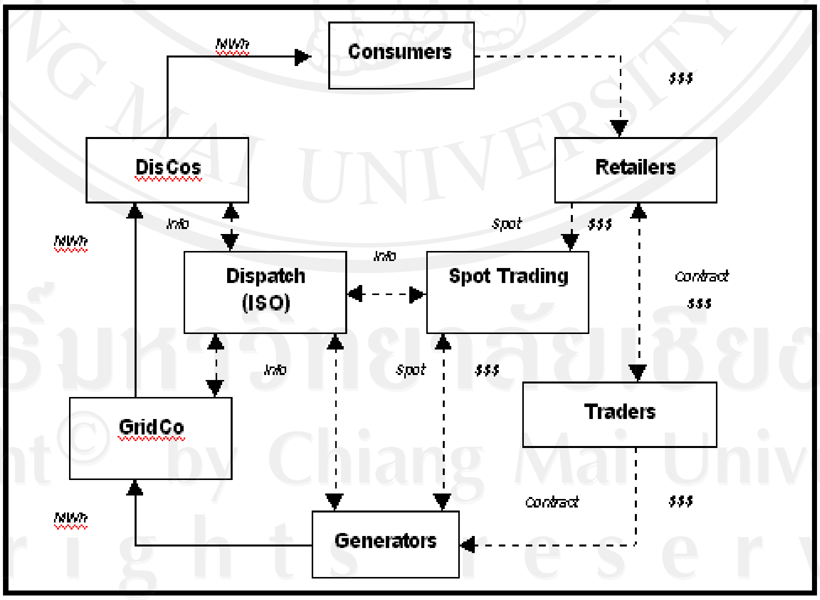
Object-Oriented (O-O) methods recognize and analyze the real world in a way that is very close to that of human being. The fundamental objective of using an expert system is to mimic the intelligent behavior of the human experts. By this type of knowledge representation (O-O) enables the knowledge engineer to recognize the objects in the way that similar to the domain engineer. Three kinds of interfaces are provided to link the expert system with the outside world: Power system operators, SCADA, other expert system. Inference engine is the core of expert system. [13]-[14]

An efficient information exchanging and sharing infrastructure is a key to the success of an electric utility (figure 1.9). To facilitate the integration, a common data model is needed as a common language by which systems and applications can talk with each other. The research [10]-[11] focuses on creating four common data model for the electrical distribution, which are the line model, the distribution load model, the voltage regulator model, and the distribution feeder model. These models are the CIM extensions for the electric distribution system. The proposed CIM models will provide an initial basis to encourage future efforts to modify and extend this model to a comprehensive common distribution model.

Distribution has a very large data model, with size on the order of 500,000 to 10,000,000 objects. DMS systems have more external data sources and more application interactions. Typical applications and systems include OMS, CIS, GIS, network management, and network analysis. Balanced three-phase modeling is assumed in transmission. Unbalanced three-phase, two-phase, and single-phase must be modeled in distribution analysis. Distribution needs details about the feeder model, which is usually modeled simply as a substation load in classical transmission models.

With the above complexity and difficulty in the implementation of the DMS along with other advanced power system technologies, utility normally outsources this activity to the external consultant company as a one-off project. The advantages are that all this complexity is dealt with by the experienced consultant while the utility only acts as the project supervisor. However, the disadvantages are that the knowledge in designing and implementing the DMS cannot be retained and reused within the organization.

The web-bases Design Engineering Knowledge Application System (DEKAS) and case based reasoning (CBR) functionality are used to address the knowledge management and decision support requirement of each company design process in protection arena. This process relies upon the knowledge and experience engineer.



Figures 1.9: Basic Function in Future Thailand Competitive Market

Source: www.nepo.go.th

Capture tacit knowledge from utility and vendor design experts to create the knowledge model for decision support system providing design engineers with access to the right data, information and ultimately knowledge at the right time. [15]-[19] Also Knowledge Engineering provides an approach to capture, analyze, model and utilized expert's knowledge within the organization. IT-Based Knowledge Management can be designed and implemented by using Knowledge Engineering Methodology such as CommonKADS. This research proposes knowledge and communication modeling for DMS configuration design by using the synthesis task knowledge management techniques.

1.6 Research Theme

Short term solution is to become better project management. This is achieved by constructing knowledge model by knowledge engineering methodology.

Long term solution is to be able to design and modify the DMS system by using the communication model to elicit consultant knowledge and retain in the knowledge model.

This research will apply Knowledge Engineering (KE) and Knowledge Management (KM) to Distribution Management System (DMS) as shown in research problem and strategy on figure 1.10. Heuristic knowledge and requirement on utility distribution system (such as distribution equipment, protection and control, operation) will be captured by standard CommonKADS template in order to propose a DMS functions, standard and technology, and architecture. KBS for DMS design will be initially developed for integrating DMS functions, checking standard compatability, and selecting system architecture. With KM, KBS is a man-machine collaboration tools to create, acquire, and disseminate DMS knowledge within the organization. The propose DMS configuration is then designed and verified with their requirements in order to get the organization design best practice.

The objective of research is to capture existing heuristic domain knowledge and requirement for the better project management of DMS Design for DMS life cycle assessment.

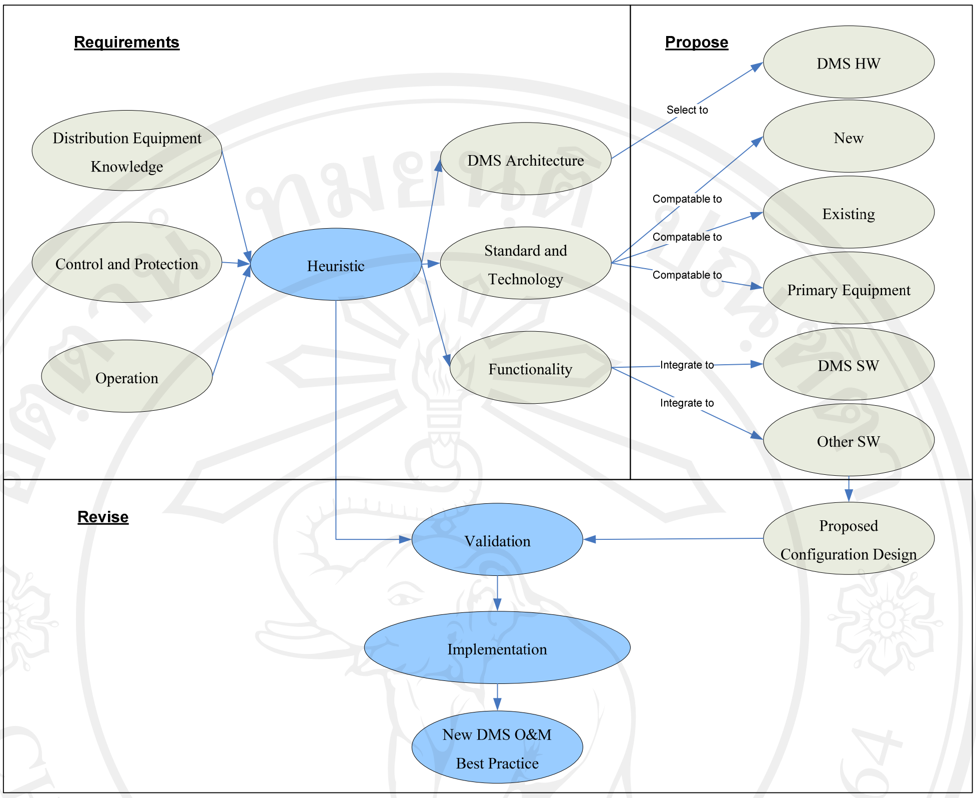


Figure 1.10: Research problem and strategy

In this research, the framework is classified into 3 areas which are:-

1. Distribution System Theory and Concept
    - Primary Equipment
    - System Operation and DMS function
    - Protection and Control
2. Knowledge Management Theory
    - Fifth discipline: System Thinking
    - Knowledge Creating Company
3. Knowledge Engineering
    - Determine Knowledge Map and Gap
    - Knowledge acquisition and elicitation
    - Knowledge Representation and Model

- Knowledge intensive task
- Knowledge Based System
- Knowledge Dissemination and Knowledge life cycle

The scope of this research is to apply knowledge management and knowledge engineering methodology that used to communicate among DMS design agents, model the DMS design knowledge, and keep the DMS design knowledge within the specified organization knowledge system. By the scope of the primary distribution system on this study is 12 or 24 kV system from substation transformer to distribution transformer. Because DMS is a complex computer system, normally utility required a technical assistance from professional expert. Although it is a complete package, it still depends on their service for the future modification. Utility will not have their internal knowledge (‘know how’ and ‘how to’ maintain and modify the DMS system). From this research theme, utility still have a short term solution with consult and supplier. Moreover, utility will be able to solve some DMS problems along with supplier and consult. And future knowledge can be within the organization. We assumed that utilities required an effective DMS to operate their distribution system, to learn and improve their system performance, and to get their customer satisfaction.

The outcomes of the research are knowledge model, communication model, and knowledge system specification for DMS design. The novelty of the research is the approach process and tool for DMS design organization which help utility to do better DMS project management in short term and gain more design knowledge in long term.

1.7 List of Publication

The followings indicated the publication results in this research:-

- K.Spuntupong, T. Chandarasupsang, N. Chakpitak, “Alternative Design Approach for DMS Using Knowledge Engineering”, CEPSI 2006
- K.Spuntupong, T. Chandarasupsang, N. Chakpitak, “Advantage of DMS Design Using Knowledge Engineering”, CMD 2008

1.8 Thesis Organization

This thesis is organized into seven chapters which are:-

Chapter 1 gives an introduction to the overall. It describes on Thailand Energy Supply Industry (ESI), power system operation and modern utility operation which explains the idea of smart grid and presents Thailand electric distribution utility situation, asset management and power quality, research justification and theme, list of publication, and thesis organization.

Chapter 2 describes about SCADA/DMS definition, scope, function from the view of power system operation. The benefit of SCADA/DMS will be grateful for electric utility in the future especially for the liberalization electric distribution market. With DMS utility can further integrate application software and go along with Smart Grid concept. However, some technical issues still in doubt and need help from the expert to clarify and specify the suitable SCADA/DMS for the specific power distribution utility.

Chapter 3 explains the selected knowledge management theories such as type of knowledge, knowledge creation (SECI model), Ba, system thinking, and and expresses on the selected knowledge engineering tools that will use in this research.

Chapter 4 explains the standard methodolgy of DMS design and then expresses the CommonKADS template as propose methodology using for capture knowledge and requirement for DMS design and communication plan for capture future knowledge.

Chapter 5 identifies general issues and characteristic of four case studies which are base case, propose DMS design knowledge model, propose design DMS communication model, and propose DMS knowledge management system.

Chapter 6 focuses on results and discussion of the four case studies in term of DMS project management and organization DMS knowledge creation, storage, distribution, and application.

Chapter 7 concludes the finding and the difficulties in this research and recommends for the future work.