Chapter 2
Asset Management

Expectation from stakeholders drives utility industry to maximize the utilization of their assets while maintaining minimal risks and costs. The asset-intensive power delivery industry is also subject to increasing stakeholder pressure to improve performance. Shareholders demand for higher earning per share (EPS); employees require job security, good welfare and convenient and safe working environment; customers need reliable power with lower price and excellent services; and regulator wants utility to improve asset performance with proper investment. Furthermore, public community wants to live with an environment-friendly and aesthetic power delivery plants. This is where an asset management plays an important role. Power utilities have moved towards implementing formal asset management concepts in order to manage an array of potentially conflicting business objectives, including the needs to maintain competitive economic performance, improve customer satisfaction, maintain high reliability, address regulatory uncertainty, and comply with increasing environmental regulation. A structured asset management approach can provide the process and tools to develop the most effective programs for building, operating, and maintaining today's power delivery infrastructure.

Figure 2.1 indicates the potential stakeholders in utility industry comprising customers, employees, shareholders, regulator and public sectors. It is the responsibility of the utility to compromise all the requirement of each stakeholder.

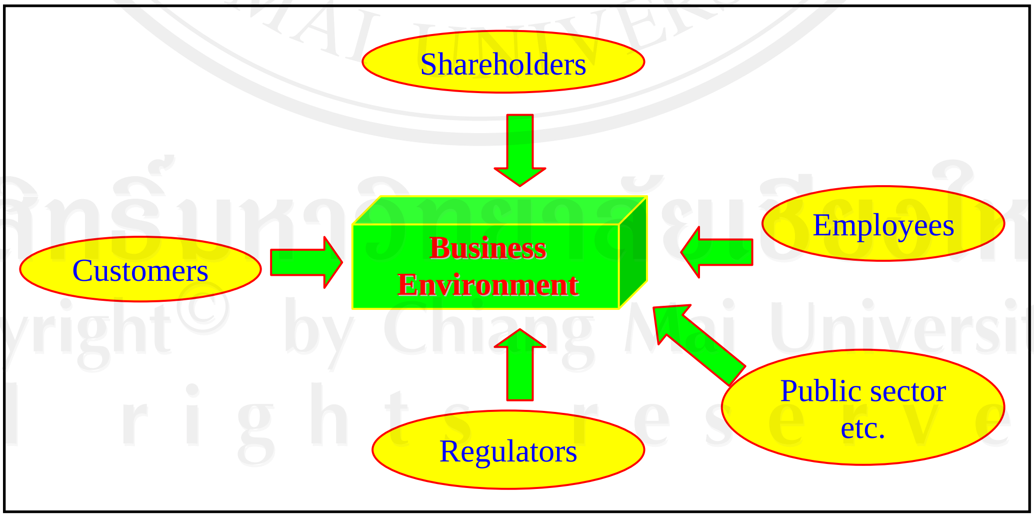

Figure 2.1 Stakeholders in utility business

Although asset management concept has been around for quite some times, still many utilities have run their business in such a way to achieve their short-term cost reduction objectives, but at the expense of long-term asset management goals such as improved performance, sustainable cost savings, improved reliability levels, etc. So to renew their asset management efforts towards a more effective approach, utilities must now examine long-term asset performance and risk tolerance with cost efficiency in mind. The answer to a more effective asset management approach is a holistic approach that considers both short and long-term objectives and integrates business and technology strategy with a comprehensive lifecycle asset plan. Decision involved with asset spendings shall take into account the full asset life cycle, i.e. planning, acquisition, operation and maintenance and disposal of assets. Most important, however, is a continued focus on service levels and risk, as well as cost reduction and efficiency. The end result is improved efficiency, reduced risk from unplanned events, greater assurance that service level objectives will be met, and better overall responsiveness to the needs of regulators, customers, the environment, the public, and ultimately shareholders. A truly effective asset management approach must also be flexible in order to meet the ever-changing needs of stakeholders. Asset management is not a one-time effort, but is a structured approach that allows a utility and its asset strategy to evolve and improve over time.

Asset management is really a matter of understanding the risk first followed by developing and applying the correct business strategy and the right asset model to solve the problem, all supported and delivered by organization process and technology [18]. The main contribution of the thesis is to identify and analyze risk and then propose the solutions to counteract with such risk.

2.1 Chapter Overview

In this chapter, all the terminologies and methodologies related to utility asset management will be discussed. The chapter starts with the discussion on definitions, methodologies and standard on asset management. It then turns to focus on the utilization of asset management framework in power delivery business in general and the framework proposed by this thesis in particular. The last section deals with the general concept of risk management.

2.2 Asset Management

Asset management is not a new concept to the utility industry. Over the past decade, many utilities began to develop well-structured asset management programs to improve performance, manage risk, reduce long-term costs, and maximize their return on investment. However, the pace of multiple mergers and acquisitions in the industry placed a heavy focus on short-term cost reductions that left many utilities with underfunded asset management programs, some of which were then abandoned. This has placed many utilities into the reliability situations caused by ageing assets. Therefore, many utilities are now re-grasping asset management methodology to sustain their long term business achievement. In this section of the thesis, the concept of asset management will be reviewed and application in utility business will be discussed.

2.2.1 Asset Management Definition and Terminology

The term "asset management" has many interpretations and meanings to different utility managers, consultants and vendors. To some it is the timely maintenance of the installed assets. To others the term defines the asset information architecture and data availability. Others would say it's the long-term and short-term planning of the product delivery systems.

What should an asset management really means? In global view, the most common definition of asset management is simply "getting the best return from investment" [10]. This simply means that every dollar spent shall return with the maximum payback to the investor. The definition is straightforward but may lack a concrete framework when comes to real implementation. So, in order to gain insightful understanding and provide conceptual framework on an asset management methodology, definitions given by well-known researchers and institutes will be addressed as the followings.

The World Road Association (PIARC) [19] has put "a systematic process of effectively maintaining, upgrading and operating assets, combining engineering principles with sound business practice and economic rationale, and providing the tools to facilitate a more organized and flexible approach to making decisions necessary to achieve the public's expectations" while the [20] expressed alternative view by phrasing "the process of organizing, planning and controlling, the acquisition, use, care, refurbishment, and/or disposal of an organization's physical assets to optimize their service delivery potential and to minimize the related risks and costs over their entire life". The above mentioned definitions are in conformity with the opinion of expert group [21] that addresses an asset management as "a business discipline for managing the lifecycle cost of infrastructure assets to achieve a desired level of service and reliability while mitigating risk".

In deregulated business environment where organizations are pushed to justify their asset related spending, the definition given by [22] seems to fit in the context. That is "the set of disciplines, methods, procedures and tools to optimize 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". It is accordingly endorsed by Publicly Available Specification (PAS55) on Asset Management (AM) [2]. PAS55 has defined asset management as "systematic and coordinated activities and practices through which an organization optimally manages its physical assets, and their associated performance, risks and expenditures over their lifecycle for the purpose of achieving its organizational strategic plan" while further describing an organizational strategic plan as "the overall long-term action plan for the organization that is derived from and embodies its vision, mission, values, business policies, objectives and the management of its risks".

In power delivery business, the CIGRE Joint Task Force JTF23.18 [3] has given that "the asset management of transmission and distribution business operating in an electricity market involves the central key decision making for the network business to maximize long term profits, whilst delivering high service levels to customers, with acceptable and manageable risks."

There are keywords embedded in those definitions which needed to be further examined. These keywords include *asset*, *costs – benefit*, *risk*, *performanc*e, *optimization*, *lifecycle*, *decision making*, and *systematic process*.

Asset: Any resource that is important to an organization's functions and requires management. The organization's assets are used to service and supply end users or to facilitate performing such services.

Performance: An ability of asset to perform its intended functions. These functions are specified based on reliability, quality, safety as well as environment aspects.

Risk: A chance that asset cannot perform its intended functions. It could be best thought of as the risk of not meeting performance targets (for example, reliability, environmental, and safety). If performance, for example, is defined with expected reliability then risk is regarded as volatility of reliability [23]. Risk could be caused by either intrinsic property of asset or operational and environmental stresses.

Costs – benefit: A consideration on asset related spending and profitability that those asset can deliver in return.

Optimization: The best value compromise between conflicting factors such as performance, costs and retained risk within any non-negotiable constraints. The optimization could be achieved by a quantitative or qualitative method as appropriate.

Lifecycle: Time interval that commences with the identification of the need for an asset and terminates with the decommissioning of the asset or any liabilities thereafter.

Decision making: An allocation of resources to achieve specified objective which be considered in twofold: the study of identifying and choosing alternatives based on the values and preferences of the decision maker and the process of sufficiently reducing uncertainty and doubt about alternatives to allow a reasonable choice to be made from among them.

Systematic process: A systematic process involves the definition of a problem, the searching of alternative solutions in general through models, and the selection of the best alternative that will eventually decide the course of action.

In essence, an asset management strategy is employed to systematically optimize costs, risks, and performance along the asset life cycle through the effective investment decision.

2.2.2 Asset Management Framework

Asset management is systematic and coordinated activities and practices through which organization optimally manages its physical assets, and their associated performances, risks and expenditures over their lifecycle for the purpose of achieving its organizational strategic plan. On the other hand, it involves in the central key decision making for the network business to maximize the long term profits, whilst delivering high service levels to customers, with acceptable and manageable risks. The global idea of asset management is to deal with asset related decision making. Furthermore, such decision must have been made considering corporate activities taken along entire asset life [2, 24, 25, 26]. As shown in figure 2.2, starting from planning, by trying to answer why assets are needed; what strategic plan corporate should direct; what is the goal of occupying such asset; what are financial, technical and risk criteria for implementation; what costs that utility has to bear. These questions have to be thoroughly studied and answered. The plan sets the framework for project budgeting and funding as well as directing the remaining process in AM cycle. Then how the asset is acquired is to consider rigorously. The activities that develop asset acquisition include design, specification, investment analysis, procurement, construction, installation and commission. The acquisition stage plays major role in AM circle since asset acquired directly results to operation and maintenance (O&M) expenditures and system performance. After asset has been placed in operation to produce the intended products, an appropriate O&M strategy has to be selected and implemented until it reaches its designed life. When the asset reaches its intended life, which measures are appropriate to deal with it: modification, replacement or just disposal have to be strategically chosen. Asset management model has designed around the asset-related decision based on the concept of systems thinking. That is, when each of AM phases is to be implemented, it should not be isolated from the others. Instead, it must take into account the feedback relationships between itself and the other parts of the asset management system, and propose what is the best to be brought about.

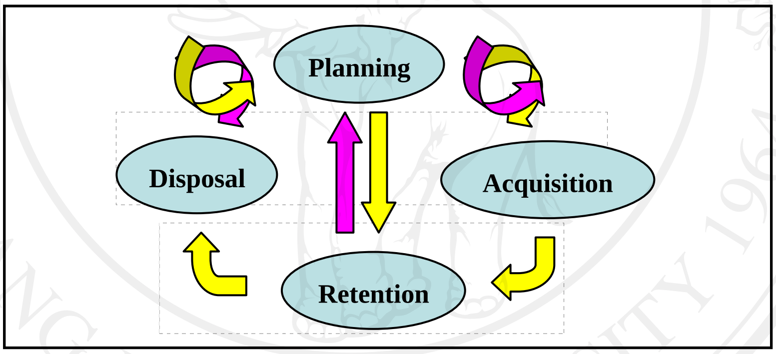

Figure 2.2 General asset management framework [25]

In terms of business objective, asset management is an approach designed to align the management of asset related spending to corporate goals. Typically, organizations adopt an asset management approach to either reduce spending, more effectively manage risks, or drive corporate objectives throughout an organization [27]. These are good things, but an overall result of asset management should be considered rather than its single objective. For example, asset management should not concentrate only on the reliability-centered maintenance; the equipment condition monitoring; the loading equipment to higher levels; the risk reviews for cancelled projects; or the "black box" that tracks assets and prioritizes spending requests. Rather asset management methodology should be applied to balance cost, performance, and risk; align corporate objectives with spending decisions; create a multi-year asset plan based on rigorous and data-driven processes [10].

In order to fully realize the benefits of employing asset management solutions, one must first examine the people and process changes. As an asset management is maturing into a recognizable set of business processes, disciplines and professional practices, there are certainly various flavors and interpretations but the *integrated*, *performance-focused*, *whole life costed*, *data-based*, *people-inclusive* and *risk-*

managed spectrum of modern methods is undeniably showing massive benefits. This makes asset management embraces technical and engineering issues, value-for-money, human factors (such as motivation and communications) and complex process or systems integration [28]. Naturally each functional entity in asset management arena needs particular skills, awareness of best methods or tools, and an appreciation of what the others do. It would be perfect if personnel belonging to certain group are aware of knowledge or possess skills required to perform other functions, for example, the business skills for engineers, cost awareness in operators/maintainers, or engineering understanding of management team. However, it is unlikely to have everybody to be able to do every job. On the other hand, in order to find the balanced point in responsibilities and skills; two features are to be determined: where the natural responsibility boundaries lie, and what 'competitive edge' characteristics make for good performance within or across these boundaries. Figure 2.3 depicts the responsibility border lines and skills needed to fulfill such responsibility. In this framework, a role of asset manager is crucial in asset management circle since it acts as an enabler in transitioning from conceptual policy into technical/financial framework and further into day-to-day operation.

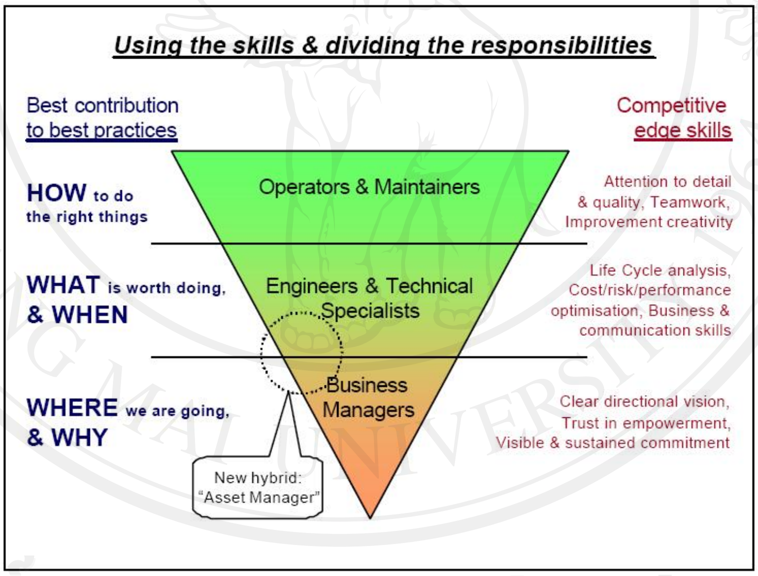

Figure 2.3 Skills and responsibilities in asset management circle [29]

In utility industrial arena, the business environment has transitioned from vertically integrated monopolized to deregulated market. It is worth examining the de facto asset management model being endorsed by many organizations and experts in the field today [3, 10, 18, 30]. This asset management model disintegrates the previous coupled organization into three distinct entities: asset owner, asset manager, and service provider. In addition, there are contractual relationships among these entities, i.e. service level agreement (SLA) [30], to track the performance of each entity. The asset owner is responsible for setting financial, technical, and risk criteria. The asset manager is responsible for translating these criteria into an asset plan. The asset service provider is responsible for executing these decisions and providing feed-back on actual cost and performance (risk is determined through variation in performance). This decoupled structure allows each asset function to have focus:

owners on corporate strategy, managers on planning and budgeting, and service providers on operational excellence (see figure 2.4). The asset owner sets the business values, corporate strategy, and corporate objectives in terms of cost, performance, and risk. The asset manager identifies the best way to achieve these objectives and articulates this in a multi-year asset plan. The service provider executes the plan in an efficient manner, and feeds back asset and performance data into the asset management process.

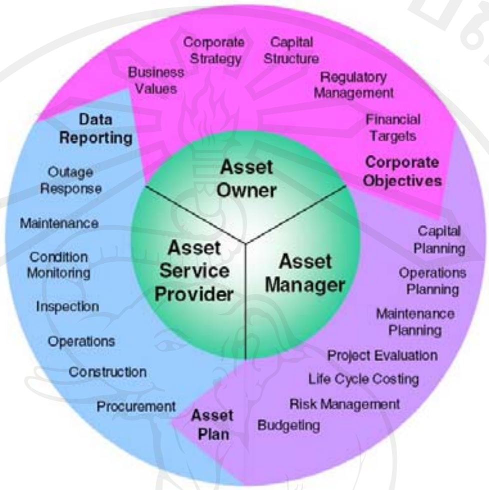

Figure 2.4 Asset management framework [10]

Essentially, asset management is also about process. Instead of a hierarchical organization where decisions and budgets follow the chain of command into functional silos, asset management is a single process that links asset owners, asset managers, and asset service providers in a manner that allows all spending decisions to be aligned with corporate objectives supported by asset data.

2.2.3 Publicly Available Specification: PAS55

As an asset management is about process, it is worth discussing an available standard that outline the procedure on the implementation of asset management in utility business. The Institute of Asset Management (IAM) [2], British organization in conjunction with the British Standard Institute (BSI) as well as in response to demand from industry for a standard for carrying out asset management, has been developing a Publicly Available Specification (PAS55) on Asset Management (AM). PAS55 is specifically intended to cover "the management of physical infrastructure assets and in particular the assets that form the main element of our built environment, such as utility networks, power stations, railway systems, oil and gas installations, manufacturing and process plants, buildings, airports, etc". PAS55 states that the objective of asset management is "to ensure (and to be able to demonstrate) that assets deliver the required function and level of performance in terms of service or production (output), in a sustainable manner, at an optimum whole life cost without compromising health, safety, environmental performance, or the organization's reputation". PAS55 is based on the PDCA (plan, do, check, act) cycle, meaning that measurable continuous improvement is an integral part of the approach. This makes PAS55 the ideal complement to certified management systems that may already be in place, such as ISO 9001, ISO 14001 and/or OHSAS 18001.

PAS55 also states that the management of the "physical assets" is only one of the five broad categories of assets that have to be managed collectively in order to achieve the organizational strategic plan. These other categories are: human assets, information assets, intangible (reputation etc) assets and financial assets. The scope of this PAS has been limited to "physical infrastructure assets". Nonetheless, the management of these assets is inextricably linked to these other categories of assets; however within this PAS they are only considered where they have a direct impact on the optimized management of the "physical assets". The scope of this PAS in relation to the other critical categories of assets is illustrated in figure 2.5.

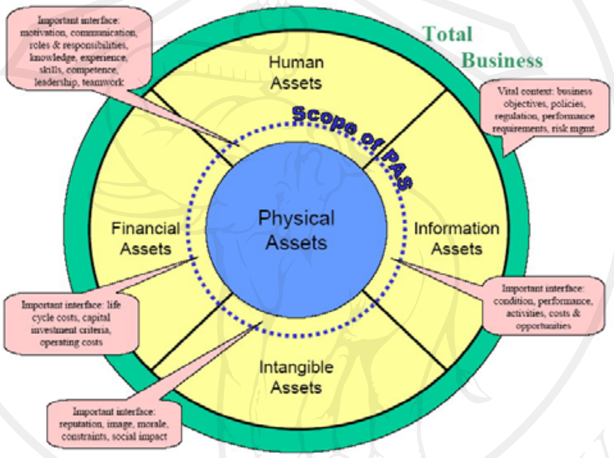

Figure 2.5 Scope and vital business context of this PAS in relation to the other critical categories of assets [2]

It is clear form the definitions given in section 2.2.1 that the scope of PAS55 is broad and requires taking a holistic approach across the full life cycle of an asset, from business strategy through to and including operations. This holistic approach can be illustrated as in figure 2.6. In addition to the broadness of the scope, two important additional elements of the diagram (below) are the feedback loops (performance review and management review) which ensure continuous improvement (this underpins PAS55) and the data element (quality and consistency) which support good asset management decisions throughout the life of the asset.

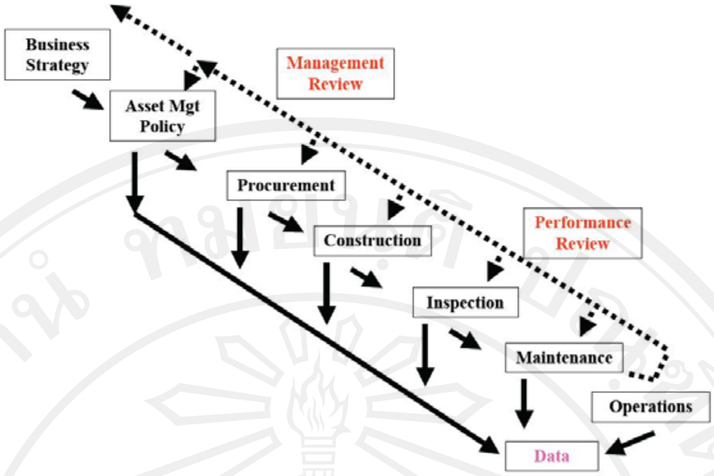

Figure 2.6 Holistic approach asset management [31]

Based on the familiar BSI format, PAS55 starts with introduction followed by defining scope of its application, normative and terms and definitions. But the core content is stated in section 4: asset management system elements which graphically illustrated in figure 2.7.

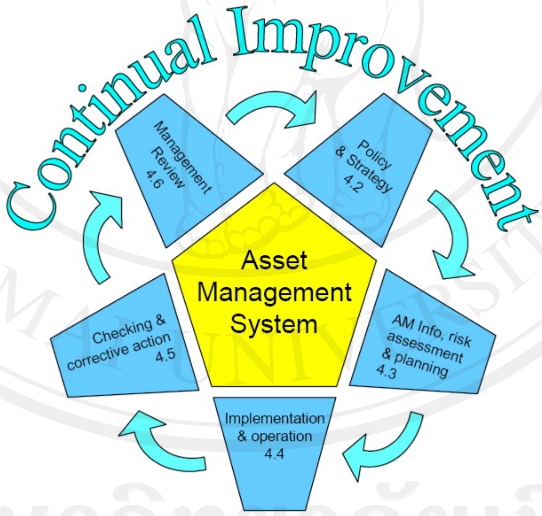

Figure 2.7 Asset management system elements [2]

PAS55 specifically lay out the implementation procedure in the form of 21 requirements, grouped under six system elements as shown below:

4.1 General Requirements
4.2 Asset Management Policy and Strategy
 4.2.1 Asset management policy
 4.2.2 Asset management strategy
4.3 Asset Management Information, Risk Assessment and Planning
 4.3.1 Asset management information system
 4.3.2 Risk identification, assessment and control

4.3.3 Legal, regulatory, statutory and other asset management requirements
4.3.4 Asset management objectives
4.3.5 Asset performance and condition targets
4.3.6 Asset management plans
4.4 Implementation and Operation
4.4.1 Structure, authority and responsibility for asset management
4.4.2 Training, awareness and competence
4.4.3 Consultation and communication
4.4.4 Documentation
4.4.5 Document, data and information control
4.4.6 Operational control
4.4.7 Emergency preparedness and response
4.5 Checking and Corrective Action
4.5.1 Performance and condition measurement and monitoring
4.5.2 Asset related failures, incidents, non-conformances and corrective and preventive action
4.5.3 Records and records management
4.5.4 Audit
4.6 Management Review and Continual Improvement

The procedure outlined in PAS55 is compatible and able to complement other quality management system such as ISO 9001, etc. This make PAS55 rapidly gain recognition as the standard to identify best practice. This assertion is backed up by a letter from Ofgem (British regulatory body), in April 2006, that encourages all electric and gas Network Companies to undertake voluntary certification to PAS55 by April 2008 [31].

2.3 Asset Management in Power Distribution Industry

The power distribution business is naturally physical asset intensive; a large portion of company annual budget has allocated into the acquisition and retention of these network components; this will thus result in profit or loss of the business. Decision to be made on asset-related investment must take into account all aspects related to distribution network asset management; that is the decision maker has to be well-informed on technical, economic, societal, and environmental issues involved in network management activities. On the other hand, asset management in electric power delivery industries plays a key role in the detection and evaluation of decisions leading to long-term economical success and best possible earnings [32]. For asset management to live up to these expectations, it has to meet a number of challenges. The four key challenges are (a) alignment of strategy and operations with stakeholder values and objectives; (b) balancing of reliability, safety, and financial considerations; (c) benefiting from performance-based rates; and (d) living with the output-based penalty regime [33]. For this reason fundamental asset management tasks cover aspects from technical issues like network planning or the definition of operational fundamentals to more economical themes like planning of investments and budgeting, and end up in strategic planning issues.

In managing distribution utilities as business entities, capital investment in power network reinforcement must be efficiently linked with the management of network assets throughout their useful life. In this context, asset management strategy can be divided into maintenance, refurbishment and strengthening [34]. Maintenance is fundamental for asset to realize its useful life. This involves the re-instatement of network plant to its intended condition and performance through corrective action. Refurbishment is a special case of maintenance and refers to the replacement of equipment in compliance with current technical practice, reliability and safety standards and desired operating performance. While maintenance focuses on supply service enhancement, refurbishment focuses on the replacement of components of particular equipment or entire equipment. Asset strengthening (or re-engineering) refers to the expansion, upgrading or re-design of network plant to improve the capacity or the quality of supply to existing customers. In a re-engineering process, the task is often taking place to upgrade or up-rate the plant or convert the plant design when there exist pressures from external stakeholders. For example, the sensitive customers may need supreme supply reliability or public community may require environment-friendly network plants. This would make distribution utilities to re-engineer their network design in order to comply such demand.

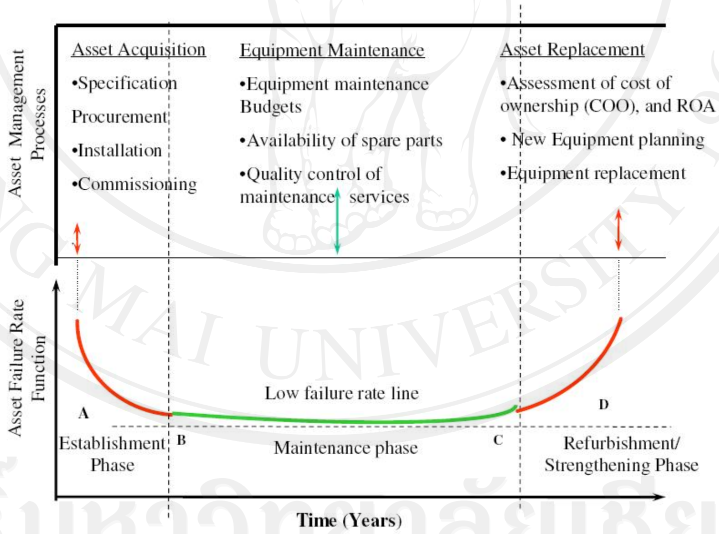

Figure 2.8 Bathtub curve and asset management processes [34]

Figure 2.8 shows the bathtub characteristic of network asset performance which indicates the declination in performance as the age increases. An optimal point exists in the life of the asset where a decision must be made to either retain it or refurbish it. Where there is a marginal difference between the “maintain or refurbish” decision, the cost of the damage, should be considered as a motivation. Finally, a holistic view of the system must be taken and re-engineering should be considered, provided a new income steam is achieved. It is therefore the main contribution of this thesis to seek for the optimal point *when*, *why* and *how* power distribution network will be reinforced.

Since the core concept of asset management involves with balancing cost, risk and performance, the distribution utilities usually takes into account network reliability and the cost of obtaining such reliability when comes to make decision on network reinforcement. So several asset management methodologies [1, 10, 11, 12, 13, 14, 15, 16, 17] have been developed to indicate the reliability figure of different alternatives of network realization and translate it into measurable terms, e.g. reliability indices or monetary values; the most suitable implementation action can then be evaluated and justified.

Accordingly, there are two main methods being introduced by above mentioned literatures to evaluate and justify asset related spendings: dollar conversion and incremental reliability improvement.

Dollar conversion approach involves with quantifying monetary loss caused by asset failure. It can be obtained by developing methods to determine an asset failure rate and cost of failure if such failure actually taking place; then the predicted cost of failure can be estimated by multiplying failure rate with cost of failure. This predicted cost of failure will be consequently used to justify the appropriate countermeasure, i.e. what action to be taken in order to alleviate such failure.

Incremental reliability improvement method computes the relative increment in reliability improvement (or risk reduction) gained against alternative asset spendings. This method is performed by firstly introducing alternative resolutions that can lessen risk of failure (or increase the reliability) of distribution network; then evaluate the potential risk of network failure on such solution and compare to the risk figure of existing network; finally, compute the ratio of risk reduction gained versus the amount of money spent on such. By comparing incremental reliability improvement among solutions, the best possible reliability enhancement alternative could be justified.

The asset management methodologies discussed above can help utility asset manager in deciding whether to maintain, replace or strengthen his distribution network. However, in order to implement in real world situation, asset manager has to select one that most suit his operational environment.

2.4 New Thought in Power Distribution Feeder Rehabilitation

The asset management strategies discussed in previous sections can be generally applied to any utility business. As also previously mentioned that in real world situation asset manager shall seek the asset management system that is truly practicable to his area problem. In managing distribution network, the decision on rehabilitation of distribution feeder shall not only depend on the cost of reliability, but also take into consideration every relevant issue (i.e. stakeholder’s requirements) and eventually bring about the most suitable solution to the considered problem. This thesis attempts to propose a new tool to assist asset manager in evaluating and justifying the feeder rehabilitation options. The proposed tool provides asset manager with all information needed in making asset related investment decision. Furthermore, it does not need large amount of historical data; provide comprehensiveness; and use simple knowledge representation and decision tools. The decision support system (DSS) composes of four main modules: risk module, cost module, decision module and asset categorization module. The architecture of the proposed decision support system is shown in figure 2.9.

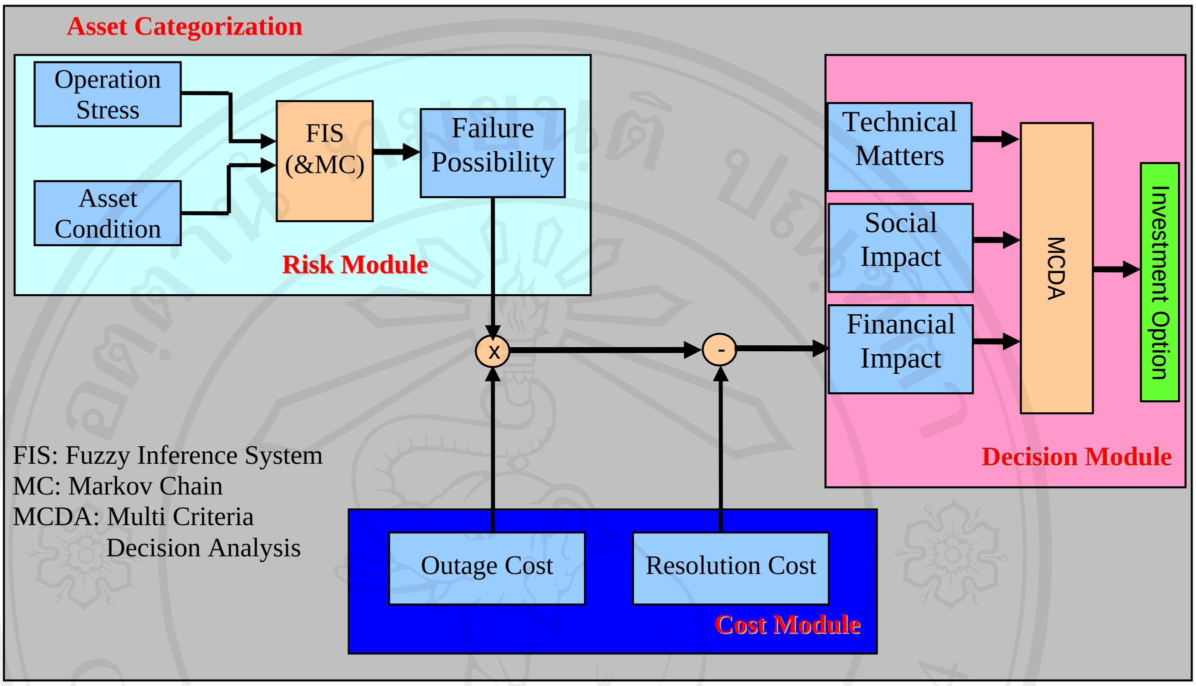

Figure 2.9 The architecture of DSS for power distribution network asset management

In risk module, the possibility of network failure, either present or future, will be quantified. The prominence of the risk module is twofold: the exploitation of an already available data and the employment of fuzzy reasoning process. Fuzzy reasoning process is very similar to the reasoning process of human expert. Most of information used in evaluation process is somewhat vague and imprecise whereas the fuzzy technique is immune to these obstacles. In addition, the Markov chain technique is employed to predict the possibility of failure that may occur in the near future. Markov chain makes it possible to predict the future asset condition based on the known present condition without regard to how the system reached its current state. The predicted asset conditions will in turn be used for calculating the feeder failure possibility.

The cost evaluation focuses on two main cost components: *outage* and *resolution* costs. Both customer and utility outage costs are computed based on customer types and reliability indices of existing feeder. The interrupted energy rate (IER) is use to quantify the outage cost. The resolution cost is the expenses that utility spends to reinforce its distribution network. It depends on the type of network reinforcement. Work breakdown structure (WBS) is employed to break down the feeder into individual components and calculate its associated costs to obtain the overall cost of each resolution option.

In the final decision process, the multicriteria decision making technique called Analytic Hierarch Process (AHP) is used. The advantage of this technique is it involves in structuring multiple choice criteria into a hierarchy, assessing the relative importance of these criteria, comparing alternatives for each criterion, and determining an overall ranking of the alternatives. By using the AHP, all key factors associated with power distribution network asset management such as technical, financial, social and environmental aspects are taken into account; it thus makes the proposed DSS comprehensive and rigorous.

Underpinning the previous three assessment modules is the information and knowledge utilized in assessment process. By using the knowledge engineering methodology together with ontology modeling technique, the asset categorization of the distribution network asset is hence established. The asset categorization module provides all key attributes of the network assets, either concrete or abstract, operational stresses and external environments of power distribution system implementation. This information is modeled into classes and attributes using the common information model (CIM) specification. The CIM bases itself on the renowned technology of resource description framework (RDF) which allows both the syntax and semantic modeling. Apart from its interchangeability, the CIM also allows expressivity, reusability, extensibility and integratability of the models. When applying in distribution network modeling, the use of CIM facilitates the possibility of existing ontologies reuse and of model extension and integration.

The rest of this thesis document is dedicated to provide the discussion on development, examination, and simulation of the DSS proposed framework. Chapter 4 deals with the asset categorization. Chapter 5 attempts to determine the risk potential while chapter 6 is trying to quantify the associated costs. Chapter 7 discusses the multicriteria decision making methodology before assembling the decision support system in chapter 7.

2.5 Risk Management

Since risk management is the core element of asset management process, it is worth examining and discussing the main concept of risk management methodology. This section provides a brief discussion on risk and risk management process. Risk involves two things: uncertainty and loss [35]. Risk tends to be viewed in a very negative sense. It is something that might occur to adversely affect the achievement of goals. It may turn out differently to how people expect or plan for. Risk is potential or possible event, it may not be possible to know in advance if it will actually occur. Probability of occurrence of risk is always less than 100%. However, if it is 100% occurrence; it is not a risk; it is a problem and people normally know how to deal with it. Risk also has the potential for causing loss which means if the risk does not occurs, then there is no loss. Essentially, risk cannot be eliminated, but can be managed.

Diagram in figure 2.10 illustrates the standard assessment risk model. It comprises of three main components: risk event, risk impact and total loss.

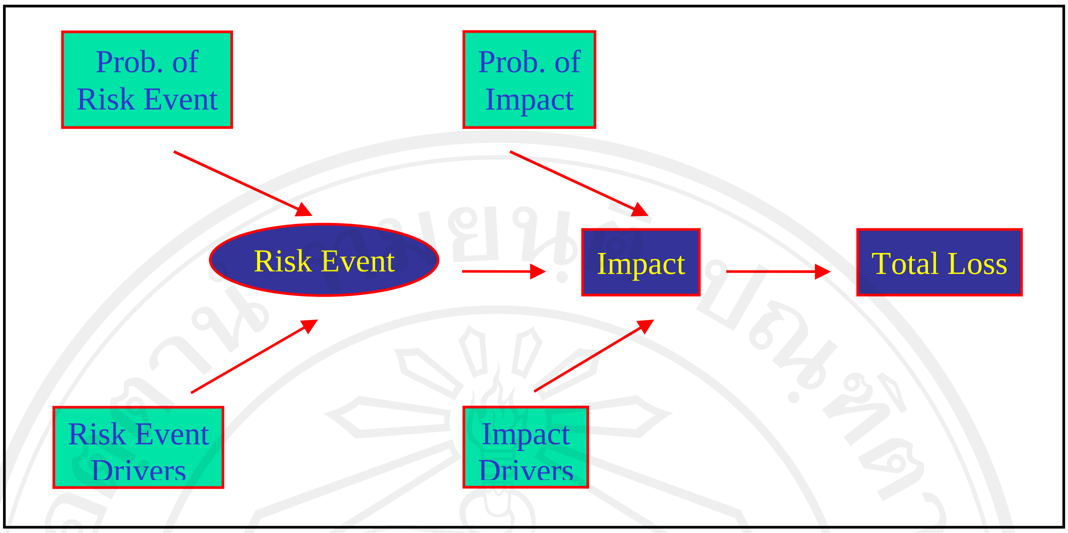

Figure 2.10 Standard risk assessment model [36]

Risk event is a matter or issue that concerns people. For example, risk event might be a breakdown of transformer, relay malfunction or failure of power line. The next component is the impact of the risk. It is the loss that could result if the risk event occurs. For example if the transformer or power line breaks down, it could cause the power blackout to the customers. And the last component is the total loss. It is a number that represents what would be lost if the risk event and its impact occurred. The example of this may be a money loss to power company and its customers which could be the power company cannot sell their electricity or if the customer is a kind of production factory their production process would be stopped, posing unnecessary higher costs to their products.

The lower parts of the figure are two critical ingredients: risk event drivers and impact driver. Risk event driver is the fact in the business environment that causes people to believe that event will occur. In the above mentioned case might be the ageing of power system components, over exploitation of the equipment, and so on. Similarly, risk impact driver is the facts in the business environment that make people to believe that the impact will occur. Impact drivers could be a repair time of a failed component or the power restoration process. The upper parts are the probability that risk event and impact is likely to occur. It is usually measured in some quantifiable value (percentage). For example, it could be 30% of probability that under current operational condition and environment the distribution feeder would fail. In addition, it would be 50% of chance that this failure creates money loss to users. Finally, the expected loss could be estimated by multiplying these two probabilities together and then multiplied by total loss.

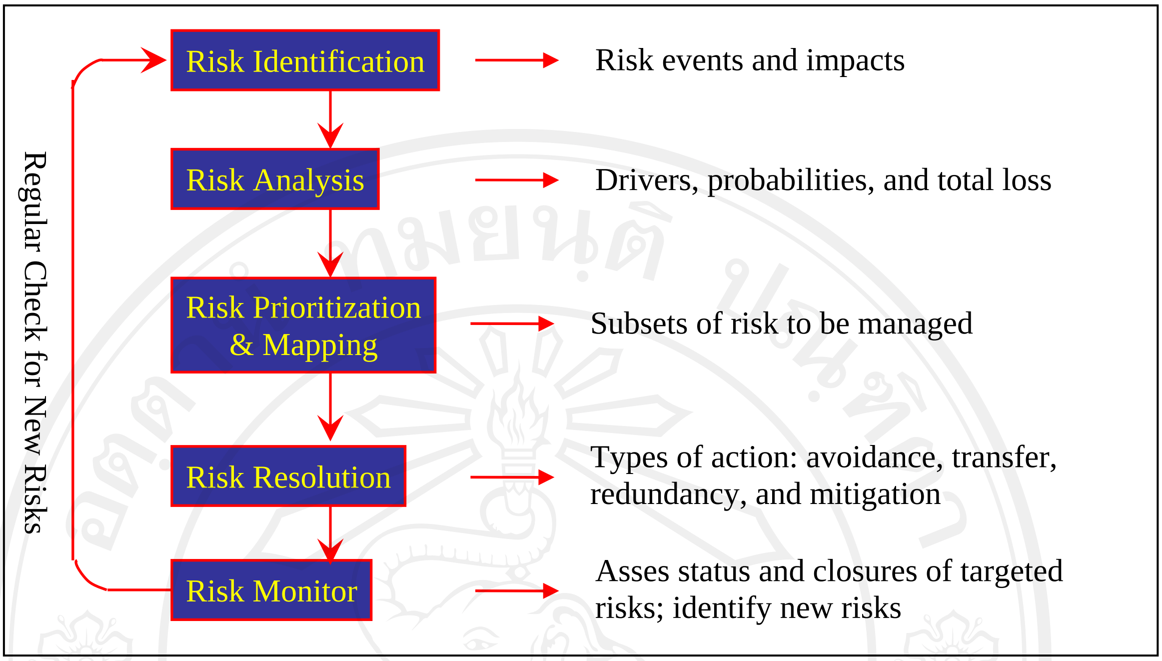

Figure 2.11 Generic risk management process [35]

Risk management is the term applied to a logical and systematic method of identifying, analyzing, evaluating, treating, monitoring and communicating risks associated with any activity, function or process in a way that will enable organizations to minimize losses and maximize opportunities [37]. Risk management is as much about identifying opportunities as avoiding or mitigating losses. Risk management is considered as consisting of the five main processes: identification, analysis, prioritization and mapping, resolution and monitoring and review. In order to gain understanding of how risk management works, a generic risk management process as shown in figure 2.11 will be used for discussion.

Risk management process starts with risk identification: what would be the risk events and what impacts would arise if the risk event is actually occurring. The effective risk management cannot be achieved if risk event and its impact are not able to identify.

The next step is to perform risk analysis. Risk analysis is performed to determine the risk event drivers and the impact drivers. If there are no facts that lead to believe that the risk event could occur or its impact could occur if the risk event occurs then it could be concluded that there would not be any risks occurring. After all risk and impact drivers are listed, the occurrence probability of both risk and impacts must then be evaluated. The evaluation process takes the level of contribution of each driver as well as operation condition and environment led to the occurrence of such driver into consideration, the probability of occurrence can then be derived. And finally in this step, the expected loss would be estimated by multiplying those two probabilities together and then multiplied by total loss.

The remaining steps involve risk prioritization and mapping by ranking the importance or severity of each risk and formulate a risk map. Followed by planning and taking the action with regard to their prioritization; it is whether to avoid, accept, transfer, or mitigate them. And the final step is monitoring the development of risk and its operational environment. However, if there is something making to believe that it is going to be a new risk, all 5 steps will then be gone through again.

In this thesis however, the methodologies for risk identification and risk analysis will be addressed and incorporated into proposed asset management framework which will be totally examined in the latter chapters.