RISK-BASED DISTRIBUTION SYSTEM ASSET MANAGEMENT

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ABSTRACT

This paper recommends a methodological framework to facilitate the integration of risk management into the overall distribution system asset management process. The paper emphasises relevant issues that are important when implementing risk management. The clarification of these issues is useful for distribution companies interested in implementing formal procedures and routines for risk-based asset management.

The framework presented here has been developed within an international research project involving researchers and distribution companies from Norway, France and Finland.

1. INTRODUCTION

In the recent years asset management has become an important activity in electricity distribution business. In general, asset management implies the rethinking and reorganization of the way distribution companies manage their assets.

This also concerns the way companies manage risk. Proactive asset management means to understand the risks associated with the distribution networks and how this affects the network performance and the achievement of company's values and objectives, the design of asset management strategies plans and actions. For this, new, formal procedures and routines for risk analysis and management are increasingly developed and implemented by distribution companies in order to cope with nowadays challenges and risks: regulatory and stakeholder requirements, aging networks, aging workforce, vulnerability to natural phenomena, etc.

The philosophy and implementation principles of a functional asset management system are provided by various standards for asset management and quality management [1,2] but in general, additional effort has to be made by distribution companies in order to 'translate' the standard specifications into everyday routines for risk management [3].

This paper presents a methodological framework to facilitate the integration of risk management into the overall distribution system asset management process. The framework has been developed at SINTEF Energy Research and applied to case studies involving Norwegian distribution companies. The issues discussed in this paper, although not exhaustive reflect the experience obtained.

2. FRAMEWORK FOR RISK MANAGEMENT

Asset management is the complex process of managing distribution system assets over their entire lifetime [1]. The process is generally decentralized on different decision levels (strategic, planning, and operational) and decisions (investment, maintenance planning, etc.). Many people within a distribution company will be involved in this process and will have different responsibilities. The same applies to risk management.

The following risk management framework (Figure 1) is derived from basic theoretical principles about risk management.

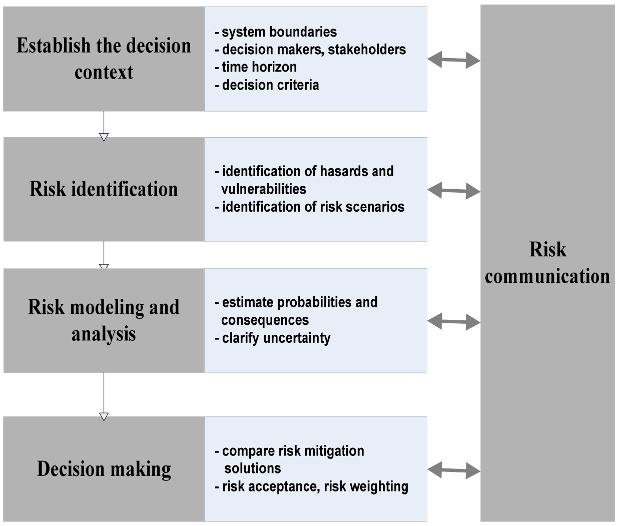

Figure1 Framework for risk management

This framework can be applied to practically any asset management decision situation involving risk. This feature is especially relevant because risk changes with time, and so risk analyses have to be updated to include new input information.

The following paragraphs point out and clarify several relevant issues to be considered in the practical implementation of this risk management framework.

2.1 Establish the context

For every asset management decision it is important to define and limit the problem in order to define, compare and communicate risk and alternative solutions, e.g. to clarify the main premises for risk analysis and management.

The decision context definition comprises several steps: the identification of the assets under study (system boundaries), the identification of the decision maker(s) and relevant stakeholders, the establishment of the decision criteria and the time horizon for the analysis.

2.1.1 System boundaries
Risks and risk mitigation decisions vary greatly with the assets being analyzed. Depending on its scope, risk analysis may concern: specific assets, specific asset groups, specific parts of the distribution system (e.g. the network supplying a town) or to the whole asset base. The system definition should include information about e.g.:

- Technical characteristics; voltage level, etc.
- Assets and their function(s)
- Geographical location of the assets under study
- How the asset (part of the system) connects to the rest of the system and influences system reliability
- Information about asset condition and previous decisions (maintenance, reinvestment etc.) made on the same assets (asset degradation)
- Number of customers served (affected by the failure of the asset/asset system under consideration)

2.1.2 Decision makers and stakeholders
In every decision process involving risk it is important to clarify who has the decision responsibility, and which other stakeholders are involved in and/or may be affected by the decision.

There are typically three main decision levels in distribution system asset management: the Asset Owner, the Asset Manager and the Asset Service Provider [3]. Each of these roles is in charge with different decisions and thus different risk mitigation responsibility.

At each decision level there may be several stakeholders involved. End-users, local authorities, regulatory agencies, company's personnel, etc. may exercise different roles in influencing asset management decisions at different levels. The identification of stakeholders and stakes is necessary in order to ensure that risk is properly communicated and that the risk mitigation solutions take all relevant considerations into account.

2.1.3 Time horizon
The network assets usually have long expected technical lifetimes, typically 20-70 years. The period of analysis for asset management decisions should hence be sufficiently long to assess the future effect of present decisions over the life cycle of the components.

Strategic, fundamental business objectives shall and must not change quickly, to ensure that the company is managed properly. This may give the impression that at strategic level objectives and risk acceptance levels are 'fixed', but this should not be the case. Risk analysis for strategic decisions may have variable time spans, depending on the external challenges the company faces. This may coincide for example with the regulatory periods when the company may need to revise their strategies in order to cope with changes in the allowed company income.

2.1.4 Decision criteria
The criteria or objectives for risk assessment have to be defined by the manager in charge with the decision and shall reflect stakeholders' expectations. The objectives refer to limiting the consequences of unwanted events in terms of: health and safety impact, reliability and quality of supply, costs and benefits, environmental impact and public opinion.

The way to measure and compare these consequences for different risk mitigation solutions have been thoroughly discussed in [5]. The cost (economy) of a risk treatment solution is the predominant criterion in asset management. Other consequences (safety, quality of supply, etc.) are more difficult to estimate although there is a general tendency of quantifying these aspects in monetary terms.

An important discussion often encountered in risk-based asset management is about the definition and use of risk indicators and risk acceptance values. These values provide information about risk and guidance on how to judge it, and are related with the way risk consequences are measured. It is therefore important that these parameters are relevant for the decision and have a meaning for the ones in charge with the decision.

As risk changes with time, the way to judge it should perhaps also be subject to revision and therefore risk indicators and risk acceptance values cannot simply be some 'universal' values which, once defined shall always be applied.

2.2 Risk identification
The risks specific to a decision context has to be identified. This step is very important in proactive asset management. However, for risks that one is not aware of, the risk situation may arise before the actual 'decision context' is defined.

The risk identification should be the result of a systematic search for undesired events that may happen in the system. An undesired event can be e. g., the failure of an asset to fulfill its required function, or the failure of the company to fulfill external obligations with respect to its stakeholders.

There are different kinds of threats related to the distribution system:

- Adverse weather etc
- Aged, deteriorated assets with increasing failure rates and maintenance needs
- Low energy or capacity margins
- Lack of personnel, personnel skills and competence
- Inadequate information and communication

technologies (ICT)

- Changes in legal, regulatory and structural framework
- System operating practices, standards, codes
- Market handling, coordination between system operators etc.
- Deliberate acts (terrorism, sabotage, etc.)

The present state of the distribution system is a product of the technologies used to establish the system (material and technology choice, layout, protection, construction methods) and the history of the system in terms of environmental and internal stresses, loading and the maintenance and renewal actions etc. [5]

The documentation of past events (faults, interruptions, accidents, complaints) can be an important information source to assess the undesired events. However, risk should not be identified only by looking at the past. Numerous techniques exist for taking into consideration combinations of possible threats in the identification of future scenarios. Some examples are: SWOT analysis, HAZOP, incident investigation, industry benchmarking. However, the methods used in practice often depend on the information available and the competence of personnel in charge with risk identification.

2.3 Risk modelling and analysis

Once the undesired events are identified, the next step is to estimate the risk in terms of how probable these events are and what would be their consequences.

Risk can be modeled for the present decision context and for the future (risk exposure), supposing that risk mitigation solutions can be identified.

Most publicly available standards and guidelines for risk management are rather unclear about the definitions/ interpretation of the concepts used in risk management, [5]. Some define risk quantitatively, as a product between probability and consequences, while others – e.g. ISO/IEC Guide 73:2002 - define it as a combination (qualitative or quantitative) of the two, as illustrated in Figure 2.

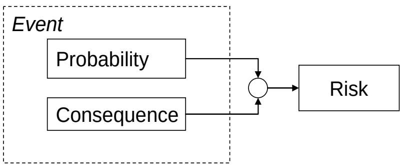

Figure 2 The relationship between event, probability, consequence and risk.

Irrespective to the definition used, the following aspects should be noted:

Probability can be interpreted as how likely an event is to happen. *Probability* can also be interpreted as a degree of belief that an event will occur and can be estimated based on some sort of 'background knowledge'- for example expert opinion.

Failure statistics, asset degradation and life estimation models, and expert opinion can be used to obtain probability estimates, as explained for instance in [6]. However because the available information and statistics might not be relevant enough in a given decision context, there will always be uncertainty in the probability estimates and this issue must be addressed.

Probabilities represent both input and output results for various risk assessment methods.These methods include: Event tree analysis (ETA), Failure mode and effects analysis (FMEA), Markov analysis, Petri net analysis, Truth table (structure function analysis), Reliability block diagrams (RBD), Bow tie model, Bayesian Belief Networks (and Influence Diagrams) etc..

Consequences are estimated in a decision context, supposing that an event will occur with a given probability. There are multiple consequences and risk dimensions in asset management decisions. For instance, adverse weather might lead to:

- Supplementary repair costs and reduced income for the distribution company.
- Reduced quality of supply
- Safety problems: personnel injuries during repairs, and public exposure to risk due to lack of electricity or due to unsafe assets (e.g. broken conductors, damaged poles and towers).
- Environment concerns due to oil leakages from transformers.
- Negative public opinion.

Various methods can be used to estimate consequences of different decisions: economic analyses, distribution system reliability tools and methods, etc. [7].

2.4 Decision making - risk treatment

When analysing risk treatment solutions several important issues have to be considered:

- There will always be uncertainty in the estimation of probabilities and consequences of unwanted events
- There will be multiple risk dimensions so that the total risk will equal the (conceptual) sum of all risks

  Risk acceptance values and decision support methods for multi-criteria analysis can be used to provide a unified evaluation and weighting of all relevant risk consequences categories [8].

- There will be several stakeholders involved

- The experience, expectations and judgements of the decision maker will always influence the decision

Decision making requires that all relevant information about risk gathered previously in the risk management process is available to the decision maker. This may include, for example simulation results from various software tools that might have been used at different steps in the process.

In general it is important that the decision process and the decisions made are well documented.

2.5 Risk communication

A correctly implemented risk based management routine shall facilitate risk communication at all risk management levels.

A requirement for this is to have a common terminology and understanding of the risk-related terms and. This is because the interpretation of risk can lead to different directions for risk assessment and modelling and perhaps different decisions.

Risk matrices and other graphical suggestive tools for sensitivity analysis have proven effective tools for the communication of risk assessment results at different steps in the process.

3. CONCLUSIONS

The philosophy and implementation principles of a functional asset management system are provided by various standards for asset management and quality management [2-4] but in general, additional effort has to be made in order to 'translate' the standard specifications into everyday routines for risk management.

This paper presents a methodological framework that can facilitate the integration of risk management into the overall distribution system asset management process.

The paper discusses relevant issues to be considered throughout the implementation of risk-based decision making into the overall distribution system asset management process.

The framework discussed can be used as background material in the development of formal procedures and routines for risk analysis and management for distribution companies.

The issues presented in this paper also serve as basis for SINTEF's input to the development of a 'Methodology for risk-based distribution system asset management' in the ongoing SMARTLIFE project, involving 26 participants from across Europe [9].

Acknowledgments

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REFERENCES

[1] The institute for Asset Management, *PAS 55 – 1, Asset management Part1: Specification for the optimized management of physical assets*, and *Part2: Guidelines for the application of PAS 55-1*, British Standards (BSi), 2008

[2] ISO 31000:2009, *Risk management – principles and guidelines.*

[3] J.H. Slootweg, G. Clemens, 2007, "Implementing and certifying a state of the art asset management approach – practical experiences", *Proceedings the 19th International Conference on Electricity Distribution*, CIRED

[4] B. Ale, T.Aven, 2010, "Review and discussion of basic concepts and principles in integrated risk management", *Proceedings European Safety and Reliability Conference*, ESREL, vol.1, 421-427

[5] K. Sand, O. Gjerde, D.E. Nordgård, 2007, "Current risk exposure in the distribution sector", *Technical Report*, SINTEF Energy Research, Trondheim, Norway.

[6] D.E.Nordgård, T.Welte, H.Heggset, 2010, "Using life curves as input to quantitative risk analysis in electricity distribution systems", *Journal of Risk and reliability (Accepted for publication).*

[7] D.E. Nordgård, K. Sand, I. Wangesteen 2010, "Risk assessment methods applied to electricity distribution system asset management", *Proceedings European Safety and Reliability Conference*, ESREL, 429-436

[8] M. Catrinu, D.E. Nordgård, 2010, "Incorporating risk and multi-criteria decision making in distribution system asset management", *Proceedings European Safety and Reliability Conference*, ESREL, 393-400.

[9] C. Gaudin et al, "SMARTLIFE: A European coordination project in networks asset management", *CIRED 2010 Workshop*, paper no. 0024.