

ASSET MANAGEMENT ARGUMENTS FOR SMART GRIDS

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ABSTRACT

This paper describes how Essent Netwerk has developed a strategy for the automation of its medium voltage network. Using Asset Management techniques, it was demonstrated that the application of a new distribution automation concept results in an improvement of network reliability and enables the temporisation of asset replacement programs. Both these benefits were quantified and appeared to outweigh the cost of the new strategy by far.

INTRODUCTION

In the past the design and operation of the medium voltage (MV) grid has been optimised for the main function of transmission of power from the high voltage grid, where large-scale power plants feed in, to the low voltage grid, where mainly power consumption takes place.

Nowadays a number of trends can be identified that will result in a different use of the power grid (e.g. distributed generation) and different demands of stakeholders (e.g. information requirement of customers and regulator). These trends may lead to different requirements on the design and in particular on the operation of the MV-grid.

Being aware of these changes, Essent Netwerk has analysed the different trends and their effect on design and operation of the MV-network. In order to meet the future requirements, a new strategy for operation of the MV-grid had to be developed. This paper describes how the risk analysis and the development of the mitigating strategy was carried out, using Asset Management principles that are incorporated in Essent Netwerk's Risk Based Asset Management (RBAM) process.

ASSET MANAGEMENT

Since 2004 the RBAM process is being used and further developed at Essent Netwerk. In 2006 full certification of this process according to the standards ISO 9001:2000 and PAS 55-1 was reached.

The Asset Management Organisation Model

In the Asset Management organisation model three different roles can be distinguished, namely the Asset Owner, who is responsible for budget and target setting, the Asset

Manager, whose task is to formulate policies and resulting workload, and finally the Service Provider, whose task is the execution of the work.

Risk Based Asset Management

In the RBAM-process, as depicted in figure 1, the Asset Manager fulfils his task by identifying and analysing risks that threaten the performance of the networks as expressed by the business values of the Asset Owner. Next the Asset Manager formulates strategies to reduce these risks. The strategies with the highest expected yield, in terms of risk reduction per Euro spent, are selected to be implemented. After implementation the effectiveness and efficiency of the strategies are evaluated.



Figure 1: The RBAM-process used at Essent Netwerk

The risk analysis and strategy development that were carried out for the case "New future requirements on the operation of the MV-grid", as described in the introduction, are discussed in more detail in the following.

FUTURE DEMANDS ON MV-NETWORK

In order to explore the future demands (at about 2020) on the MV-network, first some general social trends of today that might be of influence here, were listed. The most relevant trends are mentioned here.

General trends

- Increasing shortage of (fossil) energy sources because of continuous growth of global population and new growing economies. This shortage results in an increase of energy cost.
- Increasing social awareness that energy availability is no longer unconditional. This awareness results from the energy shortage and common recognition of the negative environmental and climatological effects of energy consumption.
- Further increase of computerisation and automation of society. People are getting used to the easy accessibility of data and will claim the same easy access in fields where this is not yet available now.
- Persistent and maybe even increasing lack of qualified

technical personnel.

Future demands

These general trends are enabling or promoting factors for some more specific developments that directly influence the demands on the MV-network. These developments are:

- Strong growth of distributed generation is expected. This type of generation often utilises sustainable energy sources and economically mostly depends on governmental subsidies. Because of the high cost of conventional energy, distributed generation will become profitable by itself and will more and more replace centralised production. The MV-grid then should be capable of facilitating bi-directional power-flows, balancing local power surpluses and deficits. The function of the MV-grid will thus shift from power distribution to power balancing.
- Society is becoming more demanding as to network reliability, as the dependence on electricity is growing. Power interruptions are no longer accepted as inevitable or inherent to the supply of electricity. Today, as appears from figure 2, the major part of the customer minutes lost (CML) originate from power interruptions in the MV-network. This is not a desirable situation when the MV-grid will gain importance in its new role of power balancer.
- Public information supply during power interruptions is getting more important. Because of the dependence on electricity on the one hand and the ease of public availability of information in other sectors at the other, a more complete and fast information supply on the size and expected duration of interruptions will be demanded.

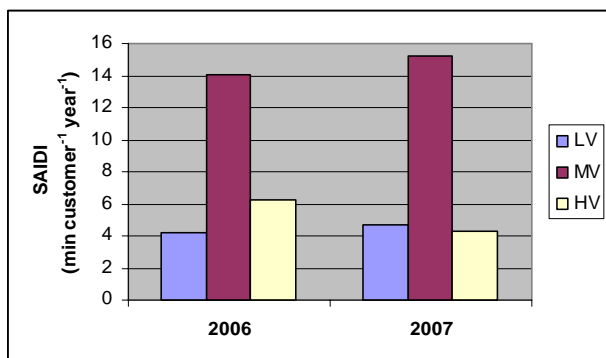


Figure 2: Essent Netwerk's CML per customer per year (SAIDI): break down into voltage levels for the past two years

RISK ANALYSIS

The question is whether the current design and operation of the MV-network still is appropriate for these new demands (power balancing function, increased reliability, enhanced information supply). This question can be rephrased into a risk, to enable the application of the RBAM-process. This risk can be defined as "Robustness of the design and operation of MV-networks to new future demands". An estimation of the magnitude of this risk can be established by a confrontation of the future demands and the current situation of the MV-grids in the light of the business values.

From this analysis it appears that mainly the business values 'Reliability' and 'Reputation' are affected. Reliability is affected because the information on power-flows in the MV-network is not sufficient to facilitate the variable flows that come with distributed generation. This can for instance result in unnoticed overloading of electrical components. Reputation is at stake when the demands of society concerning reliability and information supply are ignored and not incorporated in network operation.

Using the Risk Matrix of Essent Netwerk the categories of the effect and the frequency of occurrence of the risk can be determined. Figure 3 shows an example of a simplified version of the Risk Matrix, including only the business values 'Reliability' and 'Finance'.

Category	Potential consequences		Probability		
	Business value		Probable	Regularly	Annual
	Reliability (CML x 1000)	Finance (Euro x 1000)	>= 0.01/yr	>= 0.1/yr	>= 1/yr
Serious	2,000 - 20,000	1,000 - 10,000	M	H	VH
Considerable	200 - 2,000	100 - 1,000	L	M	H
Moderate	20 - 200	10 - 100	N	L	M

Figure 3: Relevant part of Essent Netwerk's Risk Matrix

The combination of effect and frequency results in the risk level per business value involved. In this way the level of the risk involved here was established to be 'High' (H) with respect to both Reliability and Reputation. This level is not considered intolerable, but it indicates the criticality of this risk in relation to other risks and is used to select the risks to be reduced, i.e. to assign priority in the process of strategy development.

STRATEGY DEVELOPMENT

The new functions of the MV-network ask for a more flexible operation at even higher reliability and enhanced information availability, while at the same time labour-intensity of network operation needs to be reduced. These demands quite logically lead to some form of automation.

Distribution automation

The MV-networks of Essent Netwerk typically consist of a transmission part, that is redundant in design (n-1 secure), and a distribution part, that has a ring-configuration, but is operated as a radial grid. In case of a failure, the fault is cleared automatically, however the isolation of the faulty section and the restoration of power is executed manually.

This implies a great potential for improvement of both reliability and labour-intensity by applying distribution automation. Moreover, distribution automation will also facilitate information supply. Therefore, a concept of remote control switching and fault location in the MV-distribution grid was developed. Many variants of remote control are possible: in theory all circuit breakers and

switch-disconnectors could be equipped with remote control, but at a certain point the additional reliability improvement is no longer worthwhile, i.e. the additional investment does not pay off.

Alternatives

For several alternatives the yield (risk reduction per Euro spent) can be calculated in order to find the optimal degree of remote control. This will be illustrated here for two alternatives.

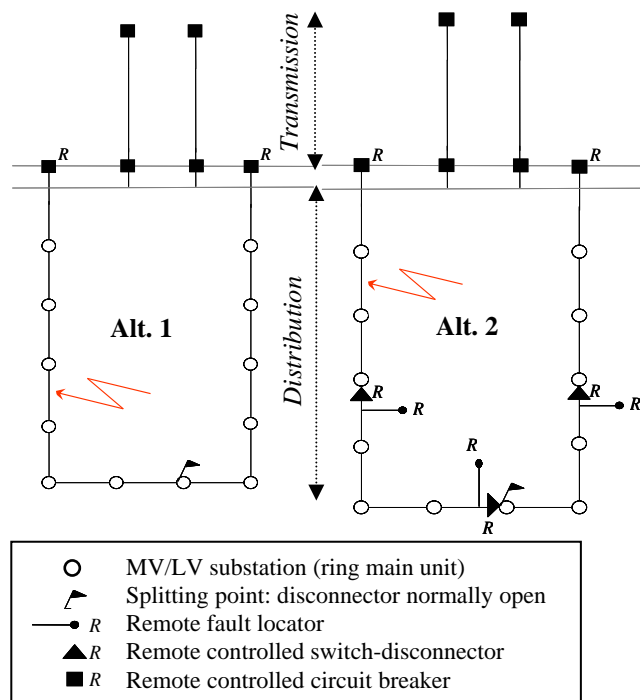


Figure 4: Two alternative concepts for remote control

As can be seen in figure 4, in alternative 1 only the circuit breakers at the origin of the distribution ring are remote controlled. Alternative 2 additionally includes remote control of the switch-disconnectors at the splitting point and halfway each distribution feeder.

Risk reduction

The reduction of risk normally is determined for each business value separately and then added to obtain total risk reduction. For the sake of brevity, in this paper only the risk reduction for the business value Reliability will be explained.

In alternative 1, in case of an outage of a feeder, fault isolation is still carried out manually, but power restoration can partly be executed remotely (only the first part of the feeder towards the faulty section). This saves time and reduces total CML in the MV-grid by approximately 10%, i.e. a decrease of SAIDI by 1.5 minutes.

In alternative 2, supply to half of the outaged distribution feeder can be restored at once, as the fault is located in the

other half. After the fault has been isolated manually, power to the remaining part of the feeder is also restored remotely. This alternative will reduce total CML in the MV-grid by at least 40%, which means a SAIDI decrease of 6 minutes.

Yield

To be able to judge whether the risk reduction of the different alternatives outweighs the cost of each alternative, it would be useful to express the risk reduction of the non-financial business values (in this case only Reliability) in Euro as well. In that way reliability improvement can be compared to investment cost. In the Risk Matrix in figure 3, it can be observed that each row represents one effect-category for all business values. This means that the CML-effect is equivalent to the financial effect in the same row, in other words: 1 CML equals 0.5 Euro.

Table 1 now shows the annual risk reduction for both alternatives, expressed in SAIDI, CML and Euro.

Table 1: Annual risk reduction

Reliability	Alt 1	Alt 2
SAIDI	1.5	6
CML (x 1000)	3,800	15,000
Euro (x 1000)	1,900	7,500

Because these are monetarised annual risk reductions, it is possible to translate the future annual risk reductions to the present, using the net present value (NPV) technique. The values that are acquired in that way represent the economic value of the total risk reductions of both alternatives. These values can be divided by the total investment cost (also NPV) of both alternatives to deliver the yield, expressed as risk reduction in Euro per Euro spent, as shown in table 2.

Table 2: Yield of each alternative

Yield	Alt 1	Alt 2
Risk reduction in Euro per Euro invested	1.3	2.5

The yield of both alternatives exceeds 1, which means that both alternatives are attractive investments, but alternative 2 has the highest yield: for each Euro spent, 2.5 Euro of risk reduction is returned. Also in comparison with other possible variants, that have not been discussed here, alternative 2 proved to be the most profitable one.

INTERACTION WITH OTHER STRATEGIES

Because many risk mitigating strategies already exist, one needs to check to what extent a new strategy influences the effect of existing ones. In this case a strong interaction with Essent Network's strategy for long term asset replacement exists, which will be discussed in the following.

Replacement wave

The major part of the assets in the electricity networks of

Essent Network have been installed within a short period of time, with a peak in the 1970's. It is expected that these assets will also reach end-of-life within a short time span. This may affect future network reliability and additionally the necessary replacement of these assets may result in a huge workload, while a lack of technical personnel exists.

To determine the expected size and steepness of this replacement wave, simulations were carried out, based on asset failure models. The simulation model was used to assess different replacement strategies, to find an acceptable balance between network reliability and the workload involved with the replacement activities.

Figure 5 shows the investment volume in the past and a prognosis for the future. With this rate of replacement future network reliability is expected to stay at approximately the same level as today.

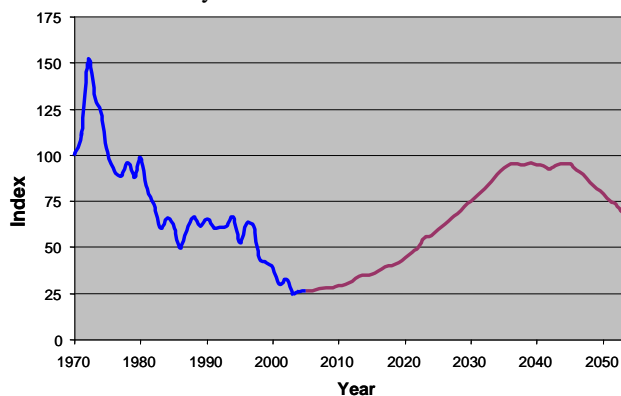


Figure 5: Investment volume over time (1970 = index 100)

Effect of distribution automation

The improvement of network reliability through the application of distribution automation in the MV-networks directly influences the balance between reliability and workload that has been established in the long term replacement strategy.

This reliability improvement enables a delay of replacement activities, thus flattening the replacement wave and reducing the peak-workload.

Simulations show the expected development of network reliability as depicted in figure 6. The red line represents the deterioration of reliability when no active replacement strategy is put in place. The green lines represent a preventive replacement strategy, the upper without and the lower with the application of distribution automation, as from a certain point in time. The possible delay in replacement programs also delays the investments involved and in that way saves money. When this is also taken into account in determining the yield of distribution automation, it will be even more profitable.

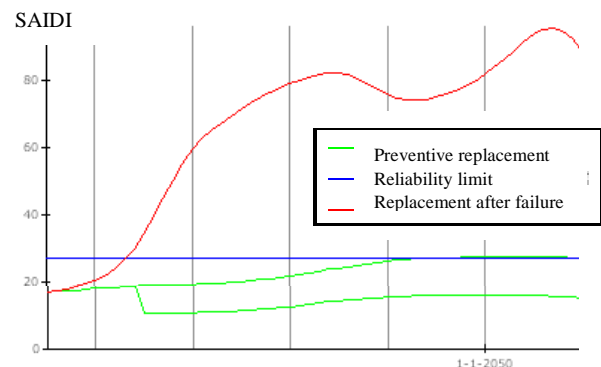


Figure 6: Reliability prognosis

CONCLUSIONS

This paper presents the development-process of a new strategy for operation of the MV-network. Application of the RBAM-process has led to the following conclusions:

- Distribution automation in the MV-network has proven to be profitable, using Asset Management techniques.
- Remote control switching in distribution grids will result in a significant reduction of customer minutes lost.
- Because of this enhancement of network reliability, future replacement programs, that are anticipated to maintain the reliability level, can be delayed.

The concept of distribution automation that has been presented in this paper is the basis for a new strategy for operation of the MV-network. This strategy will, in addition to changes in the network itself, also lead to changes in other areas. It for instance also involves adaptation and integration of IT-systems and changes in working processes that are related to network operation. An important result of this strategy is that network operation, which can now be characterised as 'network surveillance', in the future will shift to 'network control'.

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