SIMILARITIES AND DIFFERENCES IN THE STRATEGIC ASSET SIMULATION FOR ELECTRICITY AND GAS DISTRIBUTION GRIDS

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ABSTRACT

Objective of this paper is to find similarities and differences in the strategic asset simulation for electricity and gas distribution grids.

Basis for this comparison is the intensively used strategic asset simulation for the gas distribution grid at RWE Rhein-Ruhr: renewal and maintenance strategies are analyzed in detail, based on individually shapeable target values - with special regard to the relations between quality and costs. A new subject matter has been entered in particular by the introduction/development of a benchmark methodology for the evaluation of asset strategies and/or asset segments by means of structural, budget and quality ratios. The achieved insights are the basis for an improved asset strategy development which produces a huge number of feasible renewal and maintenance asset strategies. The application of "automatic asset optimization" supports to find "robust" asset strategies.

The transferability of the developed methods to the electricity sector will be discussed. Furthermore conclusions for integrated electricity and gas distribution provider will be drawn.

INTRODUCTION

Since the beginning of deregulation asset management capabilities in the electricity as well as in the gas sector have reached a new level. The main challenge for the asset manager is to balance conflicting targets over time. General targets are for instance defined by:

- save revenue, minimize costs and increase profits
- ensure asset availability and quality
- obey regulatory constraints
- (re)consider maintenance strategies

Especially maintenance strategies are of particular importance for gas distribution grid provider because of existing technical rules, e.g. defined by the DVGW (German Technical and Scientific Association for Gas and Water).

DYNAMIC ASSET SIMULATION

Asset simulation is a comprehensible and proven methodology, which helps to control the existing complexity of decision making and enables asset manager to derive sustainable asset strategies. First of all it is necessary to define the level of detail regarding the available assets, which has to consider aspects of different aging models, geographical impacts, operational costs, available data and needs of different strategic decisions. Additionally, it is necessary to define measurable targets chosen from different dimensions (e.g. costs, quality, technical risk, customer impact), which allow to determine the quality of a specific strategy. The relationship between the defined input parameters and the expected output values ("targets") has to be described mathematically. This step is supported by a cause-effect diagram, which helps to display the essential dependencies between the considered objects and existing non-linear connections, delays and enforcing or non-enforcing feedback-loops. [1,2]

Based on the description of the parameters, targets and its mathematical context, a dynamic asset-simulation model will be developed and transferred in a manageable computer application ("asset simulation tool"). This application has to be filled with the corresponding data, divided into data regarding the assets (amount, condition and age), marginal conditions (e.g. parameters for measure costs, aging models) and the representation of the current behaviour (e.g. amount of recent renewal). Based on the imported data different asset-strategies can be set, calculated, analyzed and interpreted within the asset simulation tool. This includes gathering essential information about the long-term effect of the current strategy in the defined targets as well as for different asset strategy approaches. It allows the asset manager to identify essential parameters and get knowledge about the how and when changes of certain parameter values will take place and effects the regarding targets by performing sensitivity analyses. By using the asset simulation, the asset management creates a substantially better understanding about the long-term effects of its planned measures, and therefore will be able to develop, define and implement sustainable asset-strategies. [3]

Asset simulation for gas distribution grids has to take count of specific marginal conditions which derive from different technical rules (e.g. from DVGW) and plant safety aspects. This will limit some parameters to a specific valid range of values (e.g. for inspection or maintenance), but still having options open for different asset strategies, especially for the renewal of older assets shown in Figure 1. [4]

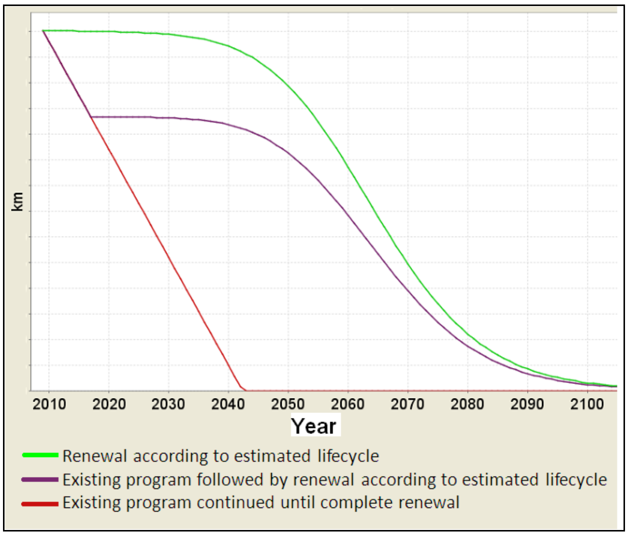

Figure 1: Three different strategies for the renewal of ductile cast iron pipes.

APPLICATION FOR ELECTRICITY AND GAS

Despite from several specific aspects, the need for understanding the long-term effects of today's decisions for different targets like cost, leakages/quality of service, technical risks and profit are almost identical for a gas grid distribution operator and an electricity grid operator. Differences in distribution grids - independent of electricity and gas – are the result of different measures in the past and lead to different positions in the grids lifecycle, regarding the view of a complete grid as well as sub-grids or asset groups. Due to the different history of the development of gas and electricity distribution grids in Germany, the chance of the existence of a steady state for asset renewal in its lifecycle is unequal. [7,8]

Because of the technical-driven differences between electricity and gas distribution grids, the importance for specific targets is obvious. The estimation for the development of quality aspects is – especially in context of the regulatory system - SAIDI (System Average Interruption Duration Index) for the electricity grid operator. Despite this is a key figure for a gas distribution operator in the regulatory context as well, for the improvement of a technical strategy it is more important to observe the development of leakages.

The development of leakages for different sub grids was one of the challenges which the RWE Rhein-Ruhr Verteilnetz GmbH has to face: the existing grids consists of an inhomogeneous structure of own and leased sub grids, having a mixture of different technologies (ductile cast iron pipes, steel pipes, polyethylene pipes) and having the need for a specific asset strategy (maintenance and renewal) for several sub grids.

DEVELOPING ASSET STRATEGIES AND ENFORCING STRATEGY BENCHMARKS

The development of different strategies has to consider certain boundary conditions of the gas distribution grid operator. This enables the asset management to create different scenarios: cash-in, technical foresight, low-invest, necessary investments, optimized technical strategy for system usage charge, strategies regarding the position of a grid benchmark.

Using the asset simulation every different approach could be transferred into a set of measures and led to an output of targets under investigation. Therefore it is necessary to take existing renewal programs into account (e.g. existing renewal program for ductile cast iron pipes and bitumen coated steel pipes).

On the one hand, the asset simulation tool has to be able to differentiate between certain asset groups and sub grids; on the other hand a set of targets has to be defined in order to break down target values to specific sub grids and enables values to be comparable. This is achieved by creating a method for benchmarking different strategies, based on key figures for comparing structural different grids (e.g. development of operational costs per km as shown in Figure 2, investment per km or leakages per km.)

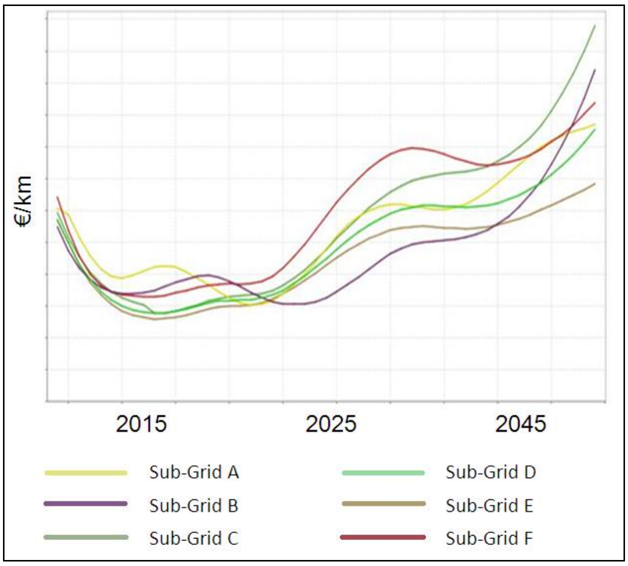

Figure 2: Development of target "opex/km" for several sub grids over the next 50 years.

Key figures can be evaluated over the complete period of time which is forecasted or – to highlight certain years – with time slices as shown in Figure 3.

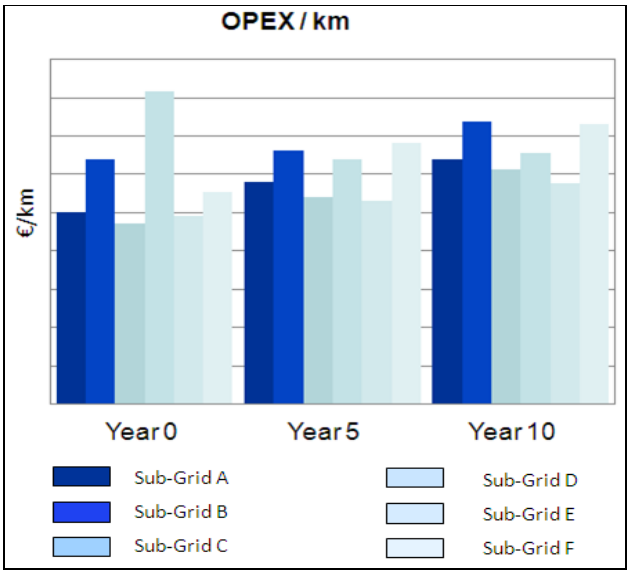

Figure 3: Development of target "opex/km" for several sub grids for important time slices.

This enables the asset management of the RWE Rhein-Ruhr Verteilnetz GmbH to develop a sub grid specific asset strategy which takes the individual demand of an asset group or a sub grid into account as well as the financial consequences for the whole grid while retaining existing renewal programs in detail.

USING ASSET OPTIMIZATION WITH EVOLUTIONARY ALGORITHMN

One strategy consists of hundreds of decision parameters. Settings these parameters to represent a certain strategy can be done manually, but of course should be supported by an automated function. This can be done by combining the asset simulation tool with optimization techniques using evolutionary algorithms. Evolutionary algorithm use mechanism inspired by the evolution, which are reproduction, mutation, recombination and selection. This approach of automated optimization first needs an objective to optimize supplemented with a set of constraints. Constraints are needed to describe ranges of possible solutions, disallowing strategies which cannot be realised because of financial, technical or other reasons. [5,6]
After setting an objective and appropriate constraints, the optimizer takes control of the asset simulation tool and tries to achieved the target set by varying input parameters (mutation), analysing simulation results (selection), again varying input parameters (reproduction, mutation and recombination) and so on. After thousands of loops ("generations of strategies") the asset manager receives an optimized asset strategy regarding his objective and the given constraints as shown in Figure 4.

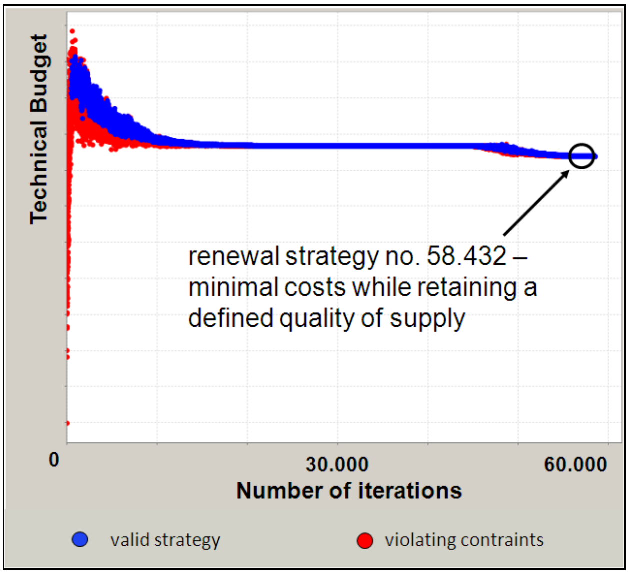

Figure 4: Result of asset optimization. Red dots represent strategies violating one/more constraint(s), blue dots are valid strategies.

For RWE Rhein-Ruhr Verteilnetz GmbH the optimizer was used to develop alternative strategies and to compare them to the chosen renewal strategy for ductile cast iron pipes. Therefore the objective was to minimize leakages using constraints of budget and amounts of measures. The optimizer was able to relate to the chosen strategy on the one hand, but showed the possibility of increasing the minimization of leakages by shifting amounts of renewals through a period of 5 to 10 years to be done earlier on the other hand. This lead to an improvement of the existing strategy by adjusting renewal amounts as shown in Figure 5.

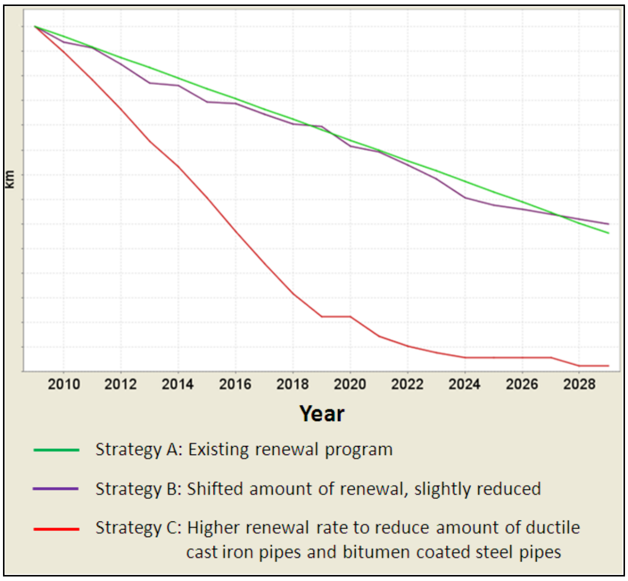

Figure 5: Improvement of the existing strategy by adjusting renewal amounts (Comparing three strategies with different renewal amounts)

Combining both existing methods of benchmarking strategies and optimizing strategies opens a wide range of new possibilities. Key figures developed for a strategy benchmark can be used as an objective for the automated optimization, as well as constraints. In this way structural different asset groups or sub grids retaining existing renewal programs can be used as an input of an automated optimizing, developing robust strategies for highly complex demands. This will be the next step in further appliance of the existing tools and methodologies.

CONCLUSION

Despite several differences between electrical and gas distribution grids (position of the grid in general in its lifecycle, technical rules (VDE/DVGW), specific problems or targets, external requirements (e.g. regulatory aspects or requirements through EEG (Renewable Energy Sources Act)) there are also a lot of similarities concerned the asset management and the appliance of the tools and methodologies discussed in this paper. Asset simulation and automated asset optimization as well as the methods described in this paper are absolutely independent of its sector and can be used for electricity and gas as well, as long as the individual parameters, targets and dependencies are represented in an appropriate way. The approach of strategy benchmark can be easily adapted to the needs of an electricity distribution grid provider and may be enhanced with other required key figures. With this combination of tools and methodologies asset managers will be enabled to focus on their core competences while regarding a wider range of requirements.

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