AUTOMATIC ASSET OPTIMIZATION TO CONFIRM THE CHOSEN ASSET STRATEGY FOR AN ELECTRICITY GRID

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ABSTRACT

SÜWAG Netz GmbH has applied successfully the strategic asset simulation approach (based on the system dynamics methodology) to develop lasting maintenance and investment programs for its electricity and gas grid. Based on the proper understanding of future impacts on CAPEX/OPEX and quality of service over the asset life cycle an asset optimization should be conducted. The target is to approve scheduled investment and maintenance measures as well as the defaults of the asset strategy and if necessary to "optimize" under technical aspects. For this purpose the „asset optimization" approach (based on "evolutionary strategies" methodology) is used. Thus several technical target values can be "optimized" by given restrictions. Based on the resulting knowledge long-term conclusions concerning costs and quality of service can be analyzed and appropriate choices of action can be derived.

INTRODUCTION

Süwag Netz GmbH as leaseholder operates the electricity and gas grid of the Süwag Energie AG since 1st of April 2005, i.e. it operates an ultra modern grid, ensuring low priced, safe and efficient energy supply.

The current investment and maintenance program consists of maintenance-, reconstruction-., renewal- and relocation-measures: the modern grid system is permanently monitored. Lines are renewed, replaced, repaired, relocated, if necessary, complete transformer stations are relocated.

Right from the start SÜWAG Netz GmbH has successfully used the strategic asset simulation approach (based on the system dynamics methodology) to develop lasting asset strategies for its electricity and gas grid. Asset simulation is an established and acknowledged method to control the complexity of these multivariate and multiperiod decision problems. It helps to derive sustainable and sound asset strategies. In a first step the target dimensions, accompanying parameters and possible measures of an asset management program are recorded, the dependencies between these dimensions are then analyzed and displayed in a cause-effect diagram [1].

The simulation results of the target dimensions are displayed in the form of a diagram or a value table. The high impact levers can be identified by parameter variations and sensitivity analyses. By using the asset simulation the asset manager has a risk-free tool to gain a substantially better understanding of the possible long-term effects of its planned catalogue of measures. Asset Simulation is a great leap forward, the asset manager is now in a position to formulate and implement sound and sustainable investment and maintenance programs [2;3].

But still, the formulation of a superior and sound asset strategy is a cumbersome process, since the asset manager has to take into account and to adjust hundreds of decision parameters. To get a good understanding of the outcomes' sensitivity to changes in different decision parameters, the simulation process has to be repeated after every slight change in the chosen asset strategy or the underlying constraints. Thousands of decision parameters have to be adjusted "manually" to achieve acceptable results.

Süwag Netz has developed better and better asset strategies using Asset Simulation starting in 2005. In 2010 Süwag Netz decided to make the next great leap forward by shedding the cumbersome "try-and-error" of finding better asset strategies by trying out marginally different parameter settings. In order to do so, it combined the dynamic asset simulation approach and the „asset optimization approach" [fig.1].

The "asset optimization approach" works based on evolutionary algorithms and helps to find robust asset strategies for possible investment and maintenance measures taking into account all given restrictions [4;5]. By combining these two methods, dynamic asset simulation and asset optimization based on evolutionary algorithms (both methods are established and acknowledged for a long time) a whole new set of questions can be answered. [6;7]. A true quantum leap forward.

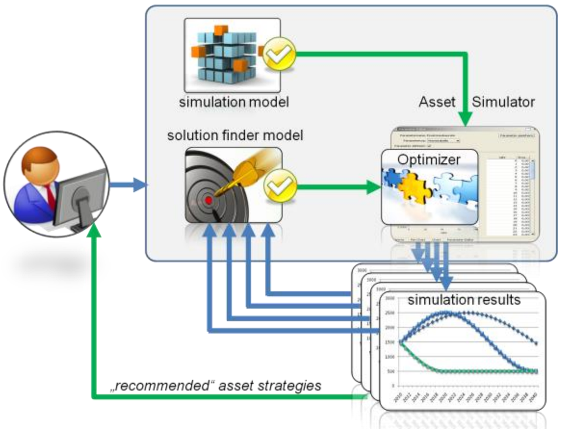

Fig.1: Asset simulation combined with asset optimization based on evolutionary algorithms

PROCESS AND INSIGHTS OF FINDING A SUPERIOR ASSET STRATEGY USING THE "ASSET OPTIMIZATION APPROACH"

The starting point of the analysis is SÜWAG Netz´s actual investment and maintenance program. The goal was to find a long-term stable and sustainable relation between OPEX and CAPEX to fulfil future requirements and challenges with respect to the grid quality and performance [fig.2].

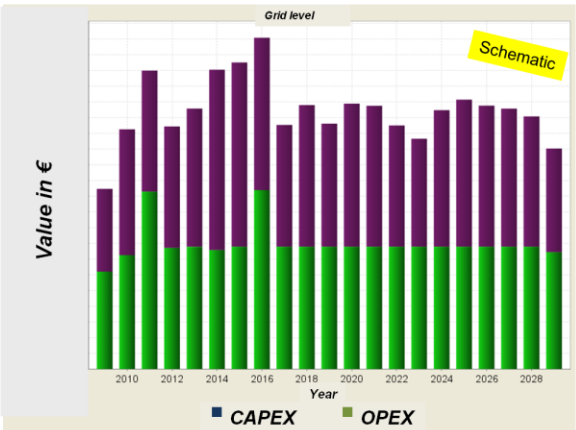

Fig. 2: Schematic example of a CAPEX and OPEX composition p.a. for the whole simulation period

The challenge is to find an appropriate investment and maintenance program for SÜWAG Netz among the various good or excellent recommended asset strategies. To find a long-term sustainable relation between OPEX and CAPEX with respect to the grid quality/performance, is a very complex problem because of the large variety of types of assets and possibilities of measures over the whole asset life-cycle of the different asset types. At this point the "asset optimization approach" supports the asset manager efficiently by automatically calculating these valid investment and maintenance programs which fulfill a set goal best and do not breach any restrictions. The restrictions have to be defined beforehand. An additional benefit is that the asset manager learns in the process, which restrictions and parameter settings have the highest influence on the suggested investment and maintenance programs.

The "asset optimization approach" helps to find a best valid investment and maintenance program based on 3 evolution-operations: a) mutation (generation of alternatives and variants), b) re-combination (reproduction and sudden exchange of the genotype information) and c) selection (survival of the fittest). Usually 30.000 to 50.000 iterations are needed to find the best solution. The number of iterations depends on the number and type of restrictions.

Setting restrictions correctly and wisely is crucial for the calculation of valid asset strategies and for the quality of the "ideal" investment and maintenance program of all recommended asset strategies done on the basis of the "asset optimization approach" [figs. 3,5]. By choosing the restrictions too tight, no valid asset strategies can be calculated. By setting wrong restrictions, mathematically valid asset strategies will be achieved, which however won't be transferable into reality or don't make any sense. Responsible for evaluating recommended asset strategies in coordination with other related departments of the company is the asset manager.

In this example the goal for SÜWAG Netz was to find a long-term sustainable relation between OPEX and CAPEX with respect to future requirements and constraints concerning the grid quality. In a first step CAPEX got a top fixed limit as restriction while OPEX was allowed to vary. This proved to be unsuccessful as the restrictions have been reached or breached in every iteration [fig. 3]: No valid investment and maintenance program exists. This could have been expected since a lot of the maintenance measures are partly OPEX and partly CAPEX. In this case the restrictions have been set too tight. Limiting CAPEX restricts the number of possible maintenance measures too much. Varying OPEX alone does not deliver long-term sustainable asset strategies regarding grid quality.

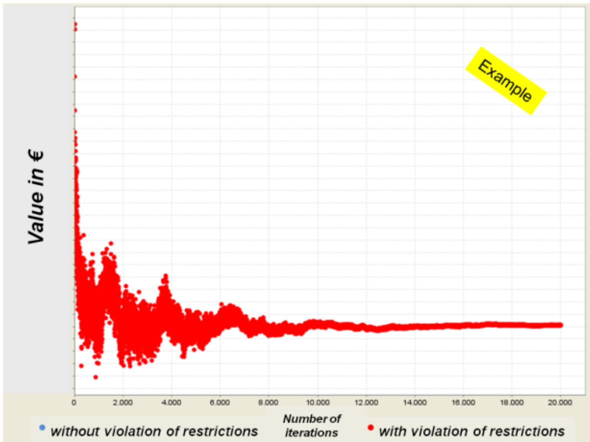

Fig. 3: Red dots mark invalid asset strategies. The example shows the situation, where the restrictions were "to tight"

There was one additional insight confirmed: In case of certain assets, e.g. old assets in poor conditions, only OPEX measurements are not enough to enhance grid quality significantly and sustainably. Spending only higher OPEX (with fixed CAPEX) after half of the simulation period keeps the number of damages constant first and then slows the increase in the following years compared to the first simulation years [fig.4]. As a result it can be seen that spending just higher OPEX could not increase grid quality when assets are passing a critical point in time.

Fig.4: Exemplary and schematic interaction of increased OPEX and grid quality for certain assets

In a second step the restrictions have been eased, both CAPEX and OPEX have been allowed to vary somewhat with regard to grid quality. After implementation of the new eased restrictions, the "asset optimization approach" has been able to find the right balance between CAPEX and OPEX during the analyzed time frame [fig. 5].

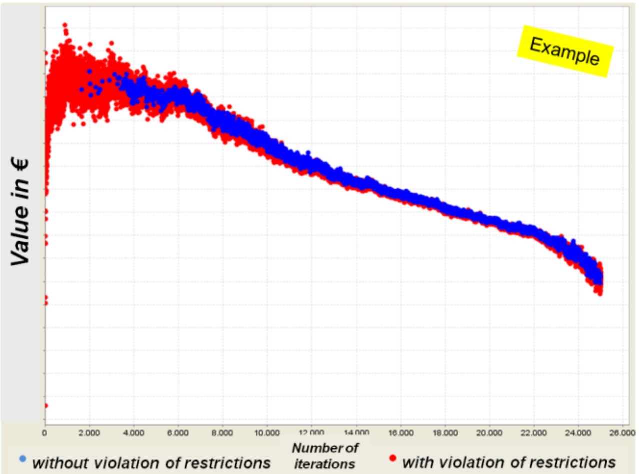

Fig. 5: Red dots mark invalid asset strategies and blue dots valid asset strategies.

In addition to easing the restrictions in the asset optimization approach the underlying asset simulation model was adapted, too. Based on the discussions with regard to fig. 3 it turned out that one of the possible asset strategies to exclusively implement OPEX measures were not represented in the underlying asset simulation model. This is the so called "rehabilitation" program. This program enhances the condition of the assets and all costs are booked to OPEX accounts. In the following years expenditure decreases significantly since a lot less repairs are necessary, because of the improved condition of the asset park. After a few years the quality of the grid decreases significantly and again a big "rehabilitation" program will become necessary [fig.6]. An asset strategy of this kind is not sustainable since variations in grid quality and level of expenditure are too high. Restrictions preventing this effect have then been formulated and implemented.

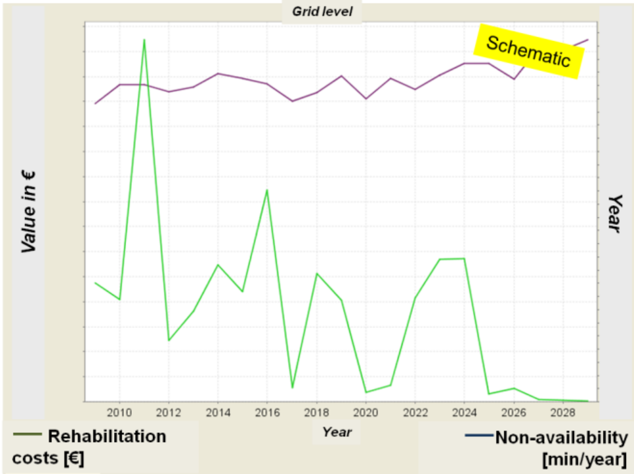

Fig.6: Exemplary and schematic effect of the measure „rehabilitation" on OPEX and on grid quality

This loop of adjusting restrictions in the asset optimization approach and/or adjusting the underlying asset simulation model has to be repeated until valid asset strategies are found.

The number and the form of the restrictions in the asset optimization approach which have to be chosen depend very much on the given total budget, on the required grid quality and the composition of the current investment and maintenance program. The goal, with respect to the grid quality, to find a long-term sustainable relation between OPEX and CAPEX demonstrated also very clearly, that the restrictions to find valid asset strategies can be formulated only together with the other company departments. External limiting conditions, e.g. regulatory guidelines or limitations concerning capacity limits of service companies, have to be considered and illustrated accordingly. The asset manager has to combine these information and the guidelines of the different company departments and to copy the restrictions in the asset optimization approach in order to obtain realistic and realizable investment and maintenance programs, which then will generate the basis for further discussions. Setting the "correct" restrictions and the intensive coordination and communication with the other company departments is therefore task of the asset manager.

Furthermore the asset optimization approach leads under certain conditions to a re-sharpening of the underlying technical asset simulation model. If some parameters in the technical asset simulation model are not or insufficient set, the asset optimization approach indicates these "gaps" by calculating valid asset strategies, but these will fail by being evaluated as "not realizable" or "not useful". These "gaps" have to be closed then directly in the technical asset simulation model or with corresponding restrictions.

CONCLUSIONS AND OUTLOOK

In addition to a lot of fundamental technical insights [see fig. 3,4,6] the following superordinate results can be concluded:

1. The implementation of the "asset optimization approach" fundamentally changes the process of developing robust investment and maintenance programs. The process now starts with the definition of the target function and the applicable restrictions. Then the asset optimization approach is searching for valid asset strategies, if none are found, either the chosen restrictions have to be reassessed and modified or the underlying simulation model has to be adapted. This course of action is repeated until valid asset strategies are found. The recommended amount of valid investment and maintenance programs are the basis for a discussion, which of them is the most applicable for SÜWAG Netz.

2. Intensive coordination and consultations within the technical departments (e.g. evaluation of recommended "best" technical investment and maintenance program) as well as between the technical and other company departments within SÜWAG Netz (e.g. to formulate SÜWAG Netz specific restrictions) are a prerequisite to develop robust investment and maintenance programs [8,9]. The use of the "asset optimization approach" fosters "bottom-line" an interdisciplinary / cross-divisional approach for asset management issues.

3. The demand on the skills of an asset manager has increased substantially. The setting of "correct" restrictions and the evaluation of the amount of valid investment and maintenance programs requires profound mathematical skills as well as a lot of practical technical experience. On top of that the asset manager needs to be an excellent communicator and negotiator: he needs to explain the new approach, to reconcile the different requirements/restrictions and to reach agreement on one of the recommended asset strategies not only within his own technical division, but as well with colleagues from non-technical departments.

The implementation of the "asset optimization approach" combines asset simulation, based on system dynamics, with an optimization methodology based on evolutionary algorithms. This approach sets new standards for an integrated asset management approach [10].

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