"END-TO-END" STRATEGIC ASSET MANAGEMENT PROCESS TO SUPPORT ASSET SERVICE ON COMMUNITY LEVEL

Andreas EITING — KWH Netz GmbH – Germany — andreas.eiting@kraftwerke-haag.de
Günter SCHATZ — KWH Netz GmbH – Germany — guenter.schatz@kraftwerke-haag.de
Terence DÜRAUER — entellgenio – Germany — terence.duerauer@entellgenio.com
Heiko SPITZER — entellgenio – Germany — heiko.spitzer@entellgenio.com

ABSTRACT

KWH Netz, the electricity distribution net operator for Haag and surrounded communities in Upper Bavaria, faced the challenge to validate its long-term investment and maintenance policy both on KWH Netz level and on community level. This included on one hand to combine long-term asset management decisions with short-term measures in asset service and on the other hand to achieve transparency/sustainability of long-term and short-term asset decisions. To achieve this objectives it was agreed to implement an asset management decision support tool that facilitates the whole strategic and operational asset management process "end-to-end" (in line with the infrastructure standards). Based on observed data and expert assumptions about future developments concrete investments and maintenance measures are identified on community level considering all technical, financial and regulatory requirements. Building up the capability of infrastructure management strengthened communication with internal and external authorities.

INTEGRATED "END-TO-END"- ASSET MANAGEMENT PROCESS

Approach

KWH Netz used an integrated "end-to-end" asset management approach from integrating all necessary data to bringing an „optimised" infrastructure policy into action based on a prioritised list of measures (see figure 1). Core is the simulation model based on the method system dynamics combined with an asset optimization approach to define a sustainable investment and maintenance policy for its electricity infrastructure. Infrastructure simulation based on system dynamics is a transparent and practice proven method [1, 2, 8, 9] to control complexity and therefore to derive sustainable and sound infrastructure policies. In a first step, the relations of system elements with their associated parameters, possible measures and existing interdependencies and correlations between these factors are summarized and mapped in a causal loop diagram. In a second step, aging chains for single asset segments, respectively for asset groups are defined with stock and flow diagrams. These diagrams describe the life cycles of the assets and assets groups. Every aging chain is divided into single state categories which characterize the condition of the considered infrastructure. Depending on the condition category, the effects of investment and maintenance measures on the infrastructure is described. As such, dynamic feedback, delays and non-linear relationships between influencing factors and targets become transparent. In the third step, a dynamic infrastructure simulation model is developed – based on the description of mathematical correlations and the connection of causal loop, stock and flow diagrams. Based on the developed simulation model, different infrastructure policies can be calculated, evaluated, analyzed and interpreted in detail.

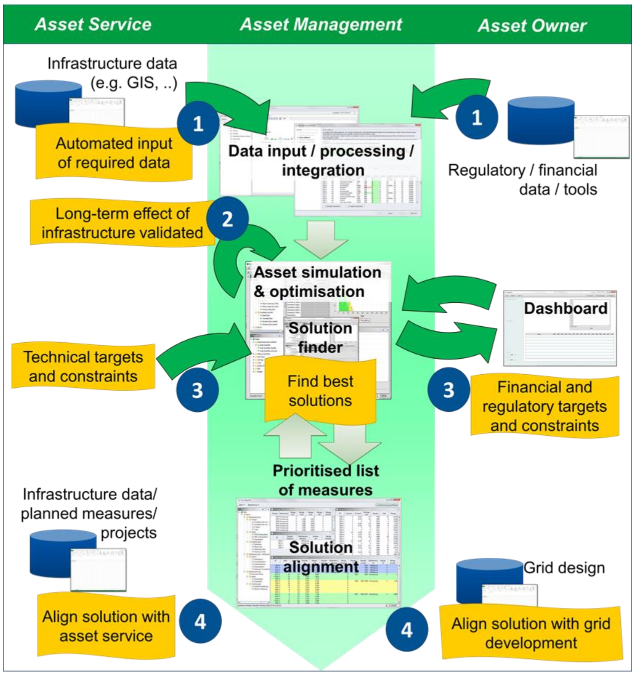

Figure 1- Integrated "end-to-end" asset management approach

What is the "best" infrastructure policy concerning business relevant constraints from finance or regulation? Finding the best infrastructure policy requires the adaption of several hundred decision parameters. When choosing an infrastructure policy, contrarily targets have to be considered and evaluated. Furthermore, each change of policy leads to a re-selection of the whole parameter set with regard to the considered time period. That means that over thousands decision-making factors have to be selected in the best way. Therefore, so called evolutionary optimization methods are built in the solutionfinder successfully [3]. The applied approach belongs to the general class of evolutionary computation created by Rechenberg [4] and Schwefel [5, 6].

Evolutionary algorithms are most suitable for optimizing systems including: nonlinear relations, step functions, many influencing variables, many restrictions, fast and dynamical (adaptive Optimization) and produce robust results [7]. The optimization of infrastructure policies requires economic and technical constraints (so called restrictions). An important task is the elaboration of the necessary restrictions. The optimization approach described here uses predefined "meaningful" restrictions with regard to infrastructure simulation.

Simulation Model for KWH Netz

The simulation model helps to understand the behavior of the considered electricity infrastructure of KWH Netz. Therefore "real world" relations are transferred into a "modelling world" using as much actual data as possible combined with well-grounded assumptions. In the first step, all important asset groups and asset types have to be identified to represent the existing electricity infrastructure of KWH Netz in a hierarchical asset tree (see Figure 2).

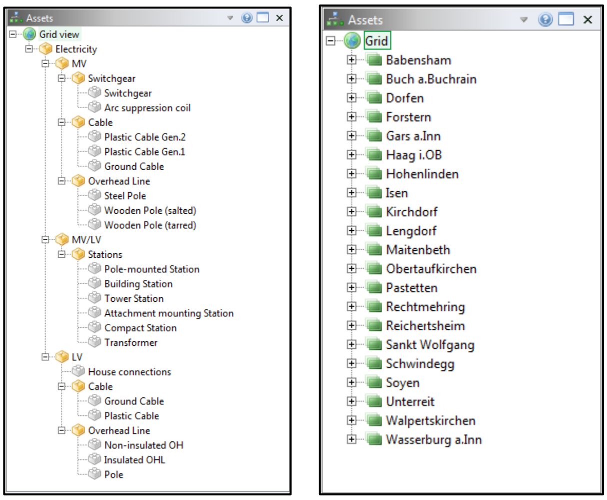

Figure 2 - Asset tree to represent KWH Netz' grid

An asset type as the elementary unit of the asset tree contains an aging chain, which represents the generic lifecycle of each asset type. An aging chain usually consists of four different conditions to represent the asset lifetime, a distribution function that ensures a change in condition according the given assumptions and measures as instruments for the asset management to influence age and condition. Every level of this asset tree can be used to extract key performance indicators, e.g. costs, risk, quality of supply. In this case it is necessary not only to create this tree according technical requirements (e.g. voltage levels, asset types) but also to separate according community borders. The result leads to an asset tree that represents the electricity infrastructure of KWH Netz with all its communities by a separate, but integrated asset (sub-)tree. This subtree contains all asset groups and asset types as containers for the assets in the communities of KWH Netz. This allows KWH Netz to differentiate key performance indicators on community level.

All relevant key performance indicators ("simulation targets") are defined within a target tree (see Figure 3). These indicators are used to evaluate the simulation results according to different requirements, such as technical, regulatory or financial. Therefore it is necessary to create mathematical descriptions, how parameter values are transformed to simulation targets so that KWH Netz can evaluate asset decisions on each level in the asset tree from KWH Netz level down to community level.

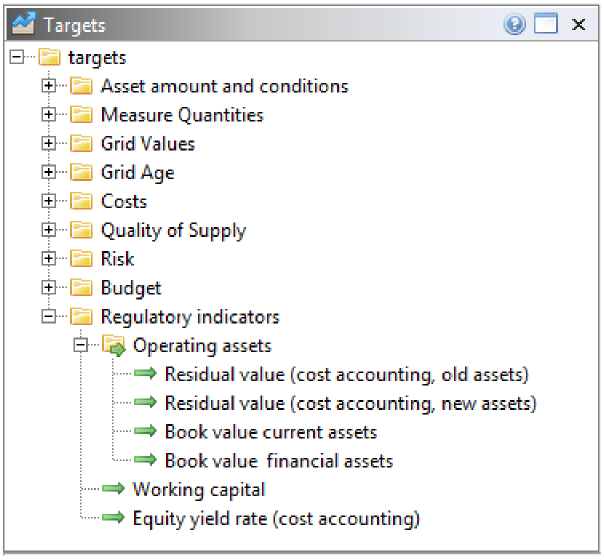

Figure 3 - Target tree with key performance indicators

Input Data and Assumptions

To fill such a large tree of asset groups and asset types, the use of an automated data import process is absolutely necessary. Asset data for all asset types are available within KWH Netz' geographical information system BavariaGIS (see Figure 4). The exported data need to be transformed to be used within the asset simulation model. In a data pre-processing step single asset data are aggregated into asset types. In addition existing data gaps (e.g. missing values for age or material) can be closed "per rule". In the easiest way, a missing value for field "year" might be set to a given value per asset type. In a more complex approach, other existing values can be taken into consideration, e.g. setting a missing year for cable according to the existing year of the according substation. This approach in general leads to a list of rules, which can be used to close data gaps automatically every time the asset simulation model needs to be populated with data.

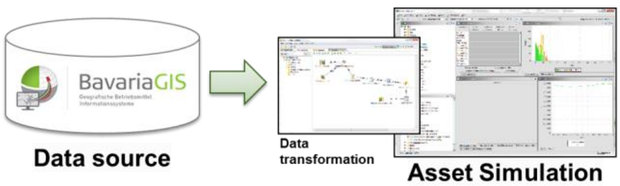

Figure 4 - Automated asset data import from GIS source system

As the source system does not have any information about current conditions of observed assets, it was also necessary to calculate conditions using existing values, such as age, amount of damages, information about manufacturer or operating experience. The calculation of conditions differs from a full assessment or detailed evaluation of asset conditions using complex algorithm, but gives an appropriate value estimation within a very short period of time. The chosen approach also leads to a first list of prioritized assets, which should be subject of an investment or maintenance measure.

Beside asset data concerning amount, length, age and condition, it was necessary to add additional assumptions to characterize asset types, such as development of assets in the future, probable damages and outages, average cost per measure and other financial parameters to be able to calculate financial and regulatory key performance indicators. Especially data collection for such types of parameters seems to be challenging at this first stage of implementation, but it turned out that be more data is already available than expected in existing databases or systems, e.g. calculating damages rates using data from the monitoring database which KWH Netz is obliged to collect for the monitoring report published by the German regulatory authority. In a next stage, the automated data import is extended to automatically import other parameter values, such as average cost per measure or amounts of planned measures.

Validating the Simulation Model of KWH Netz

After having the asset data in place, the existing asset plan of KWH Netz had been translated into values for simulation parameters, such as measures for renewal, replacement, maintenance. This led to the first asset simulation results, the long-term effects of the current investment and maintenance policy and the development of assets concerning age and condition (see Figure 5).

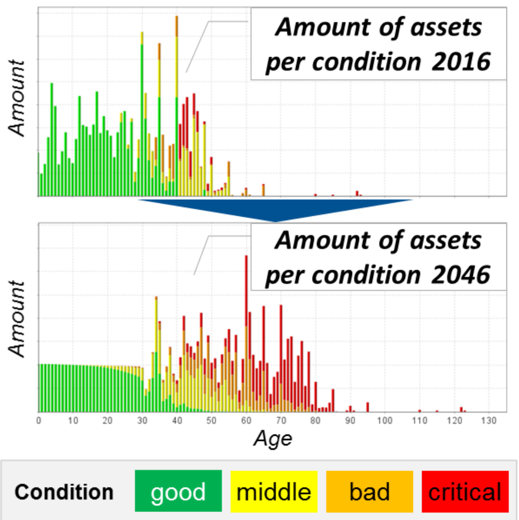

Figure 5 – Simulation development of age and condition

The outcome of this simulation had also been analyzed using key indicators like costs, risks and quality, showing different effects on community level (see Figure 6). As asset management faces conflicting targets such as quality and costs, it is essential to be able to see the impact of an investment and maintenance policy for those conflicting KPIs. In case of regulatory targets, often other departments and systems have to be involved, which makes it challenging to do thousands of integrated calculations. In this circumstances it is necessary to use the solutionfinder. Regulatory indicators are used as indicators so that the impact on financial targets such as an equity yield rate can be shown.

This enables KWH Netz to evaluate the development the key indicators asset base, costs, quality and risks for the electricity infrastructure on KWH Netz level and on community level. KWH Netz´s investment and main-tenance policy leads to different results on community level.

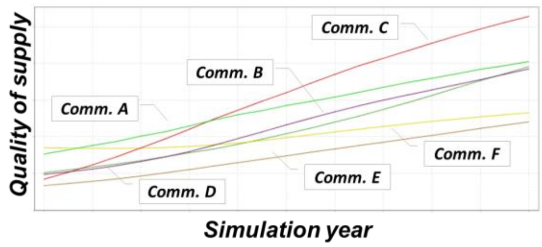

Figure 6 - Development "Quality of supply" on community level

The existing budget for the infrastructure has been con-verted into the asset simulation model and transferred into a validated current asset policy. In the next step, it was necessary to identify how to bring this asset policy into action. Therefore, a prioritised list of measures according to the results of the data integration and the asset policy was created (see Figure 7). This prioritised list of measures does not only consider technical requirements, but brings technical, financial and regulatory requirements created together in one list.

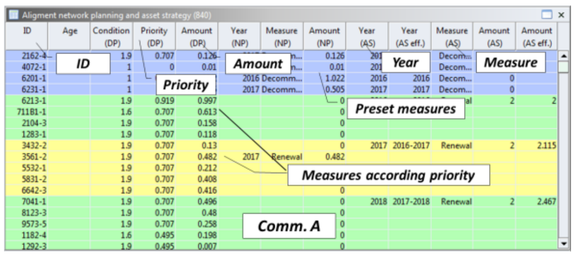

Figure 7 - Breakdown of investment and maintenance policy into a detailed list of prioritized measures on community level

FINDING BEST SOLUTIONS

After this validation, the current asset policy of KWH Netz was subject of an optimization computation. Objective was to find an improved quality of service (regarding SAIDI) with the given infrastructure budget while considering several constraints such as the maximal amount of renewals manageable by KWH Netz per year (see Figure 8).

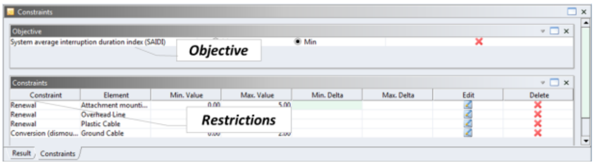

Figure 8 - Objective and restrictions of scenario

The optimization computation was composed of several thousand iterations (see Figure 9), having a high complexity by shifting over hundreds of decision parameters for 30 simulation year down to community level.

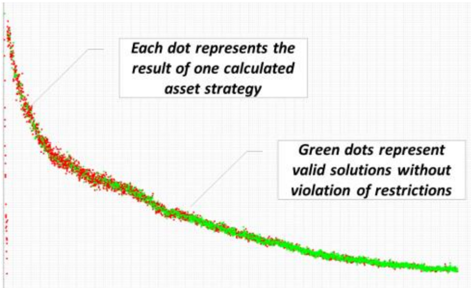

Figure 9 - Solutionfinder to find best solution for defined scenario

Reaching an improved overall value for SAIDI consequently leads to different investment and maintenance approaches on community level (see Figure 10), shifting measures among communities.

Community	Difference to overall SAIDI of KWH
A	-9%
B	5%
C	2%
D	-10%
E	-1%
F	-22%
G	0%
H	3%
...	

Figure 10 - SAIDI difference on community level

In the result, the overall improvement of SAIDI has different consequences on community level.

RESULTS

KWH Netz is now able to calculate different scenarios and evaluate its results in an adaptable time frame on community level (see Figure 11).

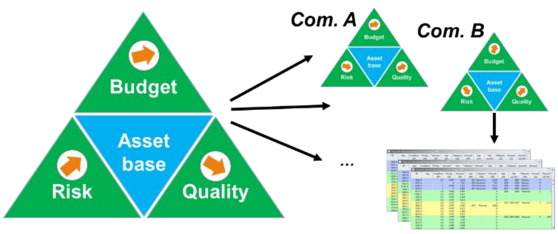

Figure 11-Results of KPIs/measures: overall/community level

In addition KWH Netz is able to manage its asset management process „end-to-end“, from integrating all necessary data to bringing an „optimised“ asset policy into action with a prioritised list of measures.
The impact of an investment and maintenance policy can be broken down to financial KPIs and evaluated, such as the equity yield rate (see Figure 12) and helps to manage financial results for the business of KWH Netz.

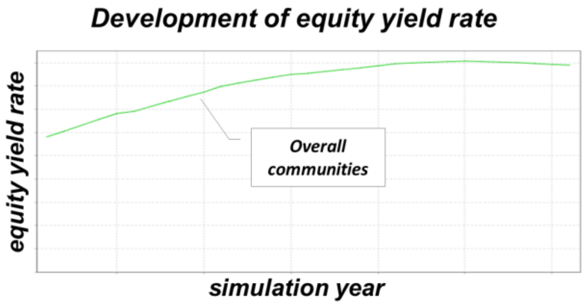

Figure 12 - Development of equity yield rate

CONCLUSION AND OUTLOOK

KWH Netz has started to combine long-term asset management decisions with short-term measures in asset service to achieve transparency/sustainability both on KWH Netz level and on community level. KWH Netz is now able to find best solutions for its electricity infrastructure balancing technical and business risks. A continuous improvement process in KWH Netz has been started to improve data quality, to underpin some critical assumptions and to establish further asset management processes.

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