ASSET SIMULATION
AN APPROACH TO PREDICT THE LONG TERM MONETARY CONSEQUENCES OF MAINTENANCE AND RENEWAL STRATEGIES FOR ELECTRICAL GRIDS

Armin J. Gaul	Joachim Nilges	Esko Nockmann	Heiko Spitzer
RWE Energy AG - Germany	RWE Energy AG - Germany	RWE Energy AG - Germany	BT – Germany
armin.gaul@rwe.com	joachim.nilges@rwe.com	esko.nockmann@rwe.com	heiko.spitzer@bt.com

ABSTRACT

Deregulation and an increasing competition in electricity markets urge energy suppliers to optimize the utilization of their equipment, focusing on technical and cost-effective aspects. The bulk of costs in electrical grids can be found in costs for maintenance and capital depreciation. A comprehensive approach for an asset management of electrical grids thus focuses on the "life-cycle costs" of the individual equipment. The objective of the life management process is the optimum utilisation of the remaining physical life time regarding a given reliability of service and a constant distribution of costs for reinvestment and maintenance ensuring a suitable return.
As a respond to these requirements utilities introduce methods formerly used by investment managers or insurance companies. The article describes the usage of one of these methods, particularly with regard to asset management and risk management of electrical grids. The essential information needed to develop an appropriate asset management system is discussed.

CURRENT CHALLENGES

Grid operators today are facing a number of new challenges. Some of them are more technical while others deal with the demography or the political or regulatory framework. As an example for a technical challenge the age distribution of the assets in the grid has to be taken into account.

The assets in the grid usually have an expected life time of 25 to 60 years depending on the specific equipment. In many utilities a large number of these assets have been installed in the grid in the 60ies and 70ies of the last century. This means these assets are about to reach their end of life in the near future (Fig. 1).

While the ageing assets give a need for a suitable renewal strategy for the grid at the same time there are great changes in the age structure.

National targets enforce investments in CO_2 reduction and promote renewable generation. Challenging targets for the increase of power distribution will generate a need for major changes to the grid. Additionally there are lots of structural changes to the industry through out Europe. For example the German Rhine Ruhr area the economy was based on coal and steel production for more than 50 years, in the meantime all the coal mines and steel works have been closed that makes major changes to the electricity grids necessary.

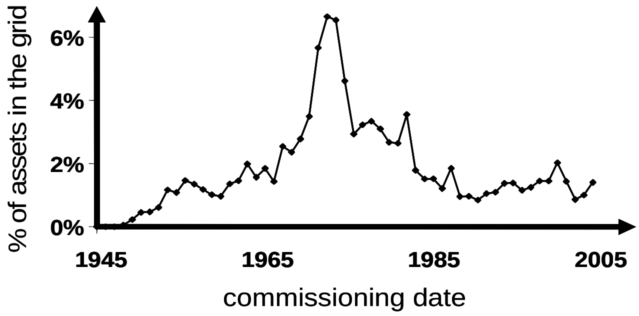

Figure 1 example for an asset group showing major investments in 1970

At the same time the regulatory framework has changed dramatically. Traditionally integrated utilities had to undergo severe cost cuts and reorganizations due to regulatory changes. Recent publications of governments and other regulatory bodies give the impression that further major grid fee reductions are planned. But so far it is still unclear how and when this will be achieved. All this shows the need for asset management models and tools to calculate the monetary and technical impacts of different asset strategies.

STRATEGIC ASSET MANAGEMENT

Asset management means operating a group of assets over the whole technical lifecycle guaranteeing a suitable return and ensuring defined service and security standards [2].

To secure a reliable grid infrastructure over a long-term period is an important task for grid operators. This is increasingly difficult since the dynamic complexity has grown enormously over the last couples of years. Finding an optimal investment plan is influenced by lots of technical and economic requirements and interdependent targets. For instance strategic asset management must reflect the interests of shareholders, customers and technology constraints which are often contradictory. In addition the regulator imposes constraints in terms of costs, quality of supply and sustainability of the asset strategies to be chosen [3].

Current questions are:

- What are the long-term impacts of an asset strategy on the ongoing development of the „Regulated Asset Base“?
- How important is one specific asset segment for the complete grid?

- What are the contributions of a specific asset segment towards the overall targets?
- How can different asset segments compare their asset strategies and targets?
- What are the consequences of not meeting or exceeding regulatory requirements?

Balancing commercial aims, favourable regulatory treatment and customer satisfaction over a specific period is the main responsibility of strategic asset management.

Because of the long-term nature of the grid business the entire asset life-cycle has to taken into consideration. Strategic asset management plays a key role regarding the „economic importance" and „potential risk" of asset decisions. Decisions made by Strategic Asset Management have a much higher economic impact (= effectiveness) than the decisions of the asset service-provider, who generally focuses on operational tasks (= efficiency). Asset decisions taken at the beginning of the asset life-cycles more or less define future outcomes, there is little scope for corrections later on.

Complexity and long-term nature of the grid business require new approaches in order to develop successful asset strategies. Dynamic asset simulation is such an approach. It predicts the long term monetary consequences of maintenance and renewal strategies for electricity grids. They can be modelled by the use of system dynamics. The system dynamics approach has also shown its strength in other sectors of the economy. It is a dynamic modelling approach that enables building of a formal representation of a dynamic behaviour of a business system, where the behaviour of the system is a direct result of causal relationships between different elements of the system. The effects of causal relationships are based on assumptions and decision rules, which are then formalized by using mathematical equations. Fundamental to system dynamics is the idea that all dynamic behaviour is a consequence of the structure of the system, where the structure refers to how the elements of the system are put together. Unlike the linear flow of spreadsheet models, system dynamics focuses on interrelationships rather than linear cause and effect and regards change as a process rather than a series of snapshots. It operates with feedback loops [1].

Dynamic asset simulation of different maintenance or renewal cycles is a fundamental approach to find the optimal investment plan. It helps strategic asset management to enhance its understanding of the long-term impacts and risks of planned measures without actually taking any risks. This enables strategic asset management to conceptualise and implement balanced and sustainable long-term asset strategies.

In general the results of dynamic asset simulations are the starting point for intensive discussions and analyses. The following example illustrates how dynamic asset simulation supports sustainable asset decisions (Fig. 2).

The current asset strategy 1 focuses on preservation of substance without considerably increasing the overall costs. The alternative asset strategy 2 emphasises on reduction of overall costs (meaning event-driven renewal of line assets as well as doubling cycles of inspection and maintenance).

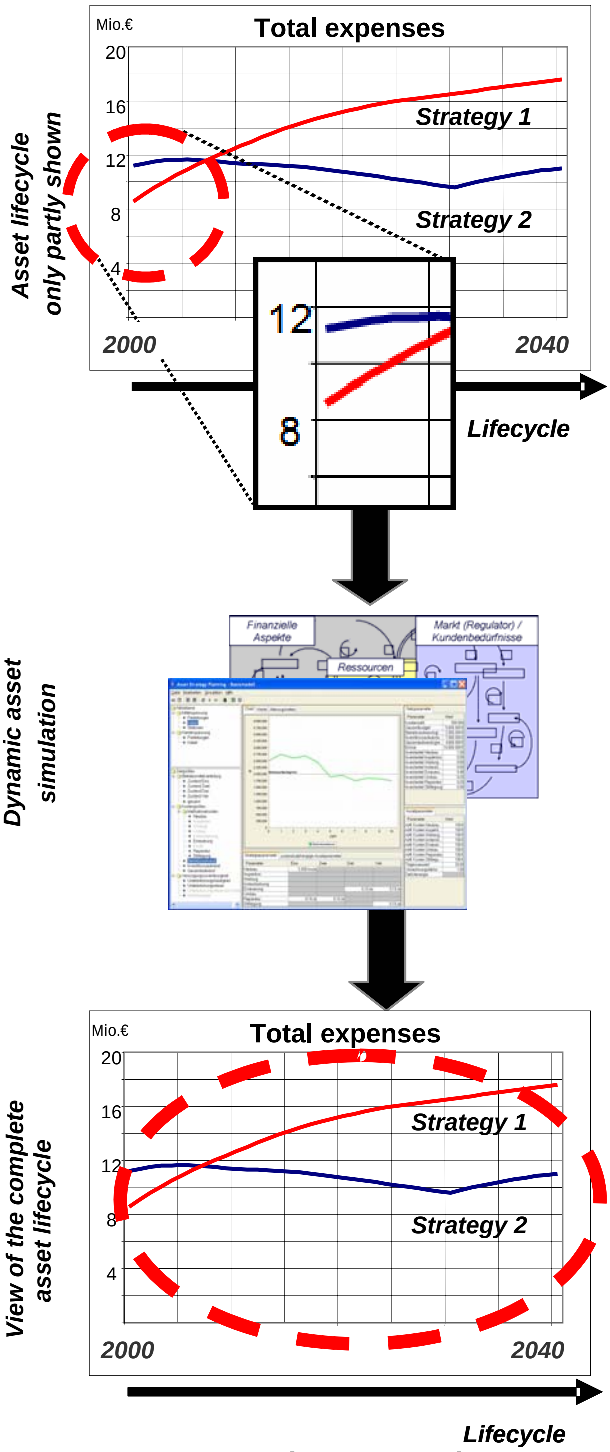

Figure 2: Dynamic asset simulation supports the Strategic Asset Management

The alternative asset strategy 2 shows to be more favourable in short-time until the year 8, but is in economic terms considerably inferior for the grid operator. Taking the whole asset life-cycle into account by using dynamic asset simulation, it turns out that the current asset strategy 1 is the more sustainable asset strategy in this example [4].

It is very important to have or to develop the capability to analyse the complex dependencies between maintenance and renewal as well as the costs and the quality to derive the right asset decisions. The capability to assess different strategies for the whole grid or parts of the grid having the same structure or technology (asset segments), is a major competence in strategic asset management. These assessments provide extensive knowledge about the effects of alternative strategies on the asset base. Based on this knowledge, strategic asset management can take active part in ongoing development of the grid, spending the money in a way that the long term targets are reached as well as the short term budgets.

Therefore the results of the dynamic asset simulation are taken as the basis for fulfilling the task of strategic asset management (asset segmentation, technical regulations and strategies for investments and pricing-base) [1].

ENHANCING AND USING DYNAMIC ASSET SIMULATION IN PRACTICE

When exploring complex systems like electricity grids it is very easy to confuse symptoms and the resulting actions with the basic root causes of the problem. Developing complex dynamic asset simulation models, it is essential to proceed in a logical, staged way, starting with the very basic underlying 'physics' of the situation. The development of a dynamic asset simulation model by controlled expansion enables a global perspective to be constructed [1].

An essential and critical success factor for developing dynamic asset simulation models is the "Step-by-Step" approach. By means of a graduated project approach the complex reality with its competing requirements and targets can be pictured step by step. Crucial in this process is the limitation of the substantial cases at the very beginning, then getting experienced in developing and improving the dynamic asset simulation model over time.

The original dynamic asset simulation models place main emphasis on mapping the technical interrelations. To meet the new challenges explained in chapter 1 major extensions had to be implemented. The system boundaries have been extended by integrating new modules and extensions of existing ones (Fig. 3).

Estimations of long-term impacts on the regulated asset base, quality and the resulting development of pricing (grid fees), expenditures and revenues can now be evaluated.

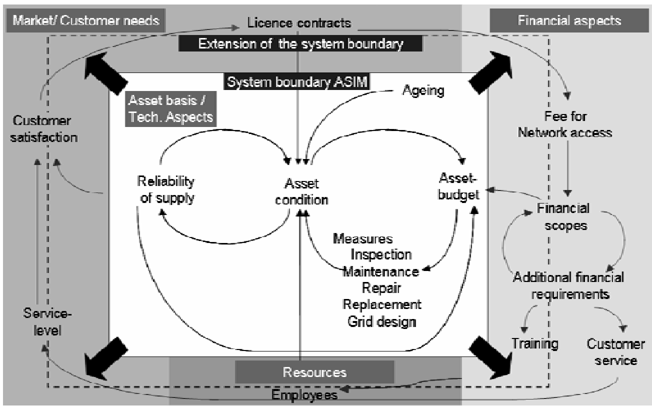

Figure 3: Extension of the existing dynamic asset simulation model: current and future system boundaries

The following objectives are achieved:

- Extension of the dynamic asset simulation model by financial and external aspects (for example regulatory guidelines and market requirements)
- Extension of the current views „ranges of fees" and „task portfolio" by the "asset segment view".
    - How important is one specific asset segment for the entire grid?
    - What happens if different asset strategies are applied on different asset segments?
- Creation of a base for estimating the medium to long-term impacts of current asset decisions on asset-base, quality and development of pricing (expenditures, revenues)

The integrated asset loop is now complete (see Fig. 4).

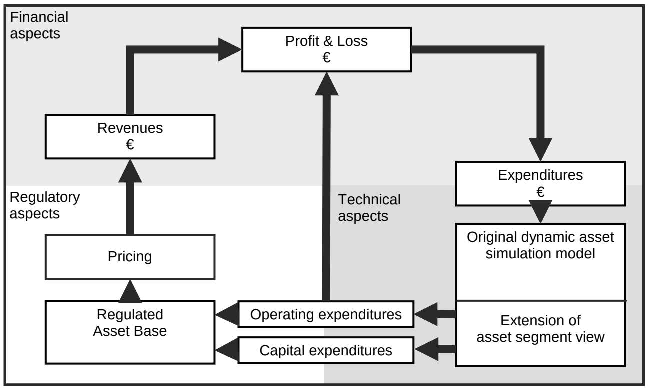

Figure 4: Integrated asset loop (schematic)

RESULTS

The extended dynamic asset simulation model maps the regulatory aspects of the electricity grid business. Based on the technical focussed original dynamic asset simulation model the "regulated asset base" yields predictions of pricing and revenues for the next regulatory period as well as the profit and loss account of the grid operator. The profit and loss account and the expenditures are interdependent, both are simulated by the extended dynamic asset simulation model.

A further extension is the consideration of asset segments and postponed measures. Asset projects are now prioritised on asset segment level. If not all necessary measures can be taken due to resource restrictions the asset simulation tool stores the postponed measures.

The expenditures influence the "regulated asset base" itself. The development of the „regulated asset base" is one of the premises of incentive regulation. Altogether the integrated asset loop of regulatory, financial and technical aspects is completed.

Simulating "incentive regulation" creates an additional dynamic and complex relation. Based on this a range of new scenarios for dynamic asset simulations arise:

- What are the needs to design an asset strategy to hold the number/value of postponed measures at a certain level?
- What are the consequences of a permanent increase of postponed measures?
- What is the optimal investment structure? Equity versus debt?
- How sustainable are the different asset strategies and what impacts do they have on the „regulated asset base"?

EXAMPLE

Here -as an example- two asset management strategies are compared:

- Strategy 1 (the broken line) is solid reinvestment to achieve a stable asset base for the grid.
- Strategy 2 (the solid line) tries to spend less money on the grid.

Since the scenario assumes an aged grid, the total expenditure of both strategies have to grow during the next years due to capital expenditures. (Fig. 5)

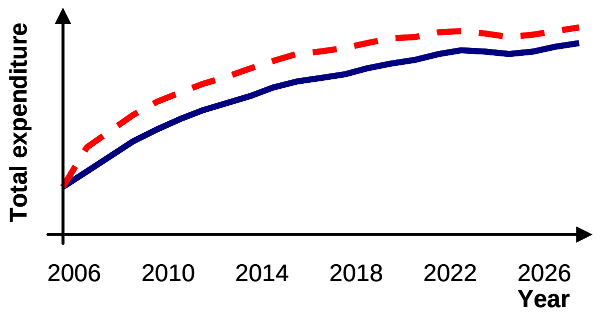

Figure 5: Example: Impact on the „Total expenditure"

Strategy 1 stabilizes the asset base at the current level, while strategy 2 which implements further cost reductions is not capable of stabilizing the asset base. As a result the asset base is decreasing immediately. (Fig. 6)

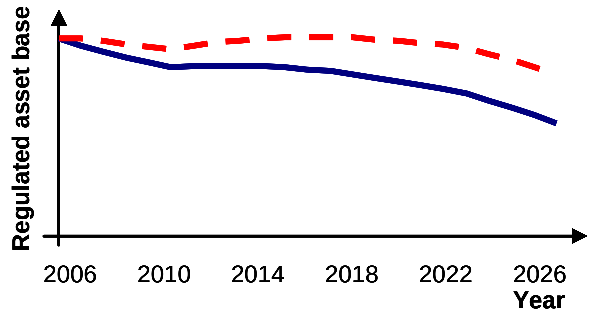

Figure 6: Example: Impact on the „Regulated Asset Base"

Considering the quality, changes in the investment strategy are not so easy to recognize in the first few years, but after some years the differences of the achievable quality of the two strategies become obvious (Fig. 7).

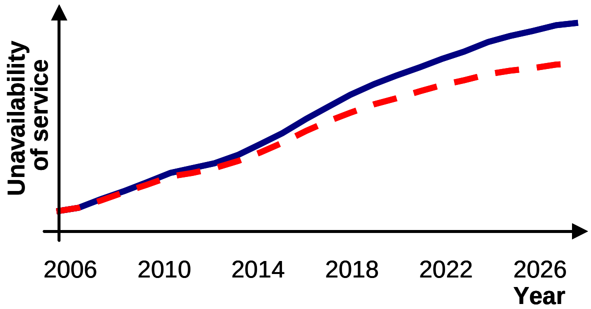

Figure 7: Example: Impact on the „Unavalability of service"

SUMMARY

This promising approach is used by RWE Energy for the asset management. It is applied to decision support in asset strategy evaluation. Analysis on different scenarios to asset investment planning leads to a transparent and reproducible basis for the quality of a asset strategy and its resulting costs. That way the long term asset costs can be influenced by strategic asset investments. For RWE Energy the use of this model improves the quality of asset investment decisions.

REFERENCES

[1] A. J. Gaul, J. Nilges, E. Nockmann, R. Thurlby, 2005, " STRATEGIC INVESTMENT PLANNING", CIRED, 18th International Conference on Electricity Distribution, Turin, 6-9 June 2005
[2] J. Schneider, A. Gaul, C. Neumann, J. Hogräfer, W. Wellßow, M. Schwan, A. Schnettler, „Asset Management Techniques"
[3] T. Kallweit, U. Schwarz, H. Spitzer: „Asset Strategy Planning – Simulation als Basis fundierter und nachhaltiger Asset Strategien" Energiewirtschaftliche Tagesfragen, 55. Jg. (2005), Heft 7, S. 488-489.
[4] G. Balzer, T. Benz, C. Schorn, H. Spitzer: "Asset Management in Energieversorgungsunternehmen", Energiewirtschaftliche Tagesfragen, 55. Jg. (2005), Heft 8, S. 552-555.