Strategic asset management for infrastructure systems- Effects of different maintenance and redevelopment strategies on entrepreneurial objectives and enterprise value

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Abstract

For the German water industry high operating efficiency and high quality standards are generally acknowledged. Over the last years, efficiency has increasingly been challenged by changing basic conditions. Strategic asset management approaches facing these challenges are required ensuring sustainable infrastructure systems. This paper outlines present investigations of different maintenance and redevelopment strategies and their consequences on entrepreneurial objectives and enterprise value of the infrastructure service provider. The investigations focus on the special basic conditions of declining population and decreasing demand in Germany. Different assessment tools are employed and discussed taking account of the special conditions in the water sector. The theoretical investigations are applied to an urban sewer network system. Planning scenarios are set up to review the economic consequences of different maintenance and redevelopment strategies on the sewer network system under unstable conditions. The results are expected to be useful for promoting retroactively strategic investment decisions.

Keywords. asset management, maintenance strategies, infrastructure systems, quality of supply

1 Introduction

Infrastructure service providers are facing great challenges maintaining ageing and partly underutilized infrastructure systems. Appropriate strategies meeting these challenges have to be applied ensuring reliability of the infrastructure systems in a long term way considering next generations interests. Therefore the paper outlines currently applied asset management systems for sewer network systems in Germany assessing their ability of efficient using of financial resources and involving strategic aspects. Enhancements of the discussed asset management approaches are carried out taking special account of the consequences of different maintenance strategies on entrepreneurial objectives and enterprise value of the infrastructure service provider.

2 Strategic asset management for sewer network systems

Asset management involves efficient planning of economic and technical performance characteristics of infrastructure systems [3]. Efficient use of financial resources plays a key role in maintaining infrastructure systems challenging the conflicting goals of reducing costs while preserving or increasing reliability. This forms the basis for a reliable and high-performance supply with infrastructural services. Appropriate objectives, strategies and programmes of maintenance contribute to improve the efficiency of maintenance planning irrespective of the type of enterprise. The choice of an appropriate type of maintenance strategy in adapting to the local conditions is important for asset management. In the following theoretical basics of maintenance planning are outlined and discussed for their use for sewer network systems. After that possible enhancements of asset management approaches are indicated.

Maintenance strategies are a part of an asset management system. They can basically be divided into the following ones:

- Corrective maintenance
- Time based maintenance
- Condition based maintenance and
- Reliability centred maintenance. [3]

In the following, these maintenance strategies are briefed considering their application for sewer network systems.

Corrective Maintenance or break-down-strategy includes no preventive maintenance measures. Maintenance measures will be done firstly when a break-down happens. Corrective maintenance is an unplanned maintenance leading to random (stochastic) maintenance requirements. Because of costs connected to those break-downs this strategy normally is not the most economic one [3]. Furthermore this strategy results in reduced quality of supply [3]. On a long term basis a decreasing quality of supply will occur.

This strategy corresponds to the „fire fighting strategy“ as it is described in the technical instruction ATV-DVWK M 143-14. The technical instruction does not recommend this strategy taking into account requirement of high quality of supply and environmental compliance. Either is impaired by break-downs. Nevertheless lots of maintenance measures are based on this strategy [5].

The following descriptions cover planned strategies dealing with preventive respectively condition based maintenance planning. These strategies aim at averting unexpected break-downs. However unplanned break-downs will occur causing stochastic maintenance requirements [5].

Time based maintenance represents one kind of preventive maintenance. High reliability and availability is achievable by this strategy because of implemented preventive measures. Maintenance measures are characterised to be high predictable. Unplanned break-downs and linked costs occur only to a minor degree [2].

Planning and acquisition of information about failure analysis require high effort. Sufficient basic statistics of service life and failure analysis are often not available. For example indications of service life are crucial and can cover several decades [5]. Additional criteria are necessary to determine the service life considering economic, safety-related as well as risk-related aspects leading to different results.

Condition based maintenance can tackle the problem of identification of an optimal (minimum cost) maintenance interval. Maintenance measures based on this strategy are orientated on actual condition of the maintenance objects. Appropriate monitoring systems enable acquisition of information about the actual performance of the system. Definition of actual conditions and their assessment proves difficult and is often linked with subjective rules [3]. Further investigations are needed gathering information on correlation between condition and probability of loss as well as linked effects and consequential costs.

Reliability is promoted by information on actual condition and connected risks of break-downs as well as following effects. Unplanned maintenance measures are scarcely to be expected. However recurrent maintenance operations can occur [4].

Well predictable measures and steady maintenance operations lead to certainty of organizational arrangements. Forecasts of needed finance requirements are possible. Concurrent high reliability and availability of the infrastructure system can be ensured. For this reason condition based maintenance strategy is proper for maintenance of sewer network systems and recommended in the technical instruction ATV – DVWK M 143- 14.

Progressive limitations of financial resources require prioritization of maintenance operations. Prioritization can be based on the impact of several components of the system on the reliability of the total system. **Reliability centred maintenance** refers to condition and importance of components of the system[1]. [3] Reliability centred maintenance is not common maintaining sewer network systems in Germany. However limitations of financial resources results in considerations of prioritization of maintenance operations also in the water sector. For sewer network systems prioritization is currently often realized by carrying out unavoidable repairs. Beyond determining the importance of components could be done by aspects of quality of supply or costs resulting from break-downs. In this case feasibility of prioritizations respectively their acceptance as well as effects on underprioritized components has to be discussed.[2]

The outlined maintenance strategies take primarily into account technical performance characteristics of the sewer network systems. In addition, economic aspects have to be included aiming at efficient maintenance and redevelopment of the system. Currently applied approaches involving economic performance characteristics are the cost comparison method[3] and the net asset value strategy[4].

But taking into account the net asset value of sewer network systems is not sufficient for assessment of maintenance strategies[5]. That applies to the cost comparison method too. Enhanced approaches involving additional target figures have to be defined, especially considering economic and strategic aspects associated with maintenance of sewer network systems. This is generally important but

[1] Reliability centred maintenance is common for maintenance planning of energy network systems.

[2] The introduced strategies already implement prioritizations to a certain extent. Prioritizations of RCM are enhanced and more differentiated.

[3] Approach estimating different appropriate maintenance operations.

[4] In the technical instruction ATV-DVWK M 143-14 net asset value strategy is recommended to integrate economic aspects. In that way effects of maintenance strategies on net asset values are monitored. Steady budgets for maintenance operations are aimed at. Furthermore requirements concerning needs of future generations are supposed to be met preserving a defined net asset value of the sewer network system.

[5] Especially under conditions of decline.

especially under conditions of decline and resulting consequences on the sewer network systems as well as the infrastructure service provider. Strategic maintenance planning has to promote efficient and cost-effective preservation of existing sewer network systems. In this connection enhanced approaches as common in the energy sector involving tools of business and risk assessment can contribute to optimize maintenance strategies meeting entrepreneurial objectives of the infrastructure service provider.

Such asset management approaches build on information on quantity and age structure of the several components and the total system. According to the chosen strategies the deterministic costs can be calculated for the period of assessment. Uncertainties can be considered by suitable modelling approaches. Modelling of stochastic costs requires appropriate approaches of risk-analysis. Iterative modelling are used to optimize implemented criteria minimizing total costs.[3] These asset management approaches normally apply reliability centred maintenance. Thereby the complex interrelations between costs, quality and maintenance strategy are of vital importance. However adequate information in quality, quantity and continuous collection of data is normally not available for sewer network systems hampering the modelling of the mentioned interrelations.

Asset management aims at using financial resources efficiently challenging the conflicting goals of reducing costs while preserving or increasing reliability. Thereby costs of maintenance and capital costs including depreciation make up about 80 percent of total costs [1] in the water industry. Because of that asset management approaches focus on maintenance and capital costs to minimize the arising costs of particular components and the total system. Therefore approaches considering all costs during life (life cycle costs) are preferably applied. Furthermore asset management contributes achieving entrepreneurial objectives owing to the high capital intensity facing the infrastructure service provider. For this purpose development of quality and quantity of invested capital is calculated for the period of assessment. Calculations include scientific-technical evaluations as well as economic feasibility and effects of maintenance and reinvestment planning.

The following chapter illustrates the implementation of an enhanced asset management system applying the outlined maintenance strategies and enhanced asset management approaches.

3 Implementation

Present investigation is carried out aiming at developing an assessment tool for the estimation of effects of strategic maintenance and reinvestment planning on the infrastructure service provider taking account of different scenarios of development of settlement structures and demand. The main aim of the associated empirical studies is arranging an capital expenditure programme for the related infrastructure service provider. A methodological background adapted to the specific local conditions and the needs of the infrastructure service provider is to be developed enabling efficient long-term maintenance planning under unstable conditions.

At first, appropriate objectives are set specifying related entrepreneurial objectives. Key figures are defined and quantified assessing consequences of different maintenance and redevelopment strategies on the specified entrepreneurial objectives including the enterprise value of the infrastructure service provider. Amongst others return on invested capital is checked. Interrelations between enterprise value and strategic maintenance planning are supposed to be demonstrated.

The empirical studies are carried out at a certain part of an urban sewer network system implementing and enhancing theoretical studies outlined in chapter 2. Different approaches of maintenance strategies and scenarios of population development and budget amendments are joined by a scenario matrix. Three different scenarios of population development are set up. The infrastructure assets of the study area are collected and modelled. Prognoses of development of demand are implemented taking into account population, industry, climate, paved areas and urban settlement structures. Requirements of

technical transformations of the sewer network system within the period of assessment[6] are investigated and determined. The involved maintenance strategies are based on the maintenance strategies outlined in chapter 2 enhancing the strategies introduced by the technical instruction ATV-DVWK M 143-14. Budget amendments vary in amount as well as allocation in time and place including asset prioritizations. The consequences of different maintenance and reinvestment strategies of the selected part of the investigated sewer network system on entrepreneurial objectives and enterprise value of the infrastructure service provider are reviewed. The results are expected to be useful for promoting retroactively strategic investment decisions.[7] Based on this, a capital expenditure programme for the investigated study area is to be arranged.

The urban study area represents a certain type of urban settlement structure and is characterized by conditions of decline and resulting technical and economic consequences. The projected approach is to be applied to other parts and study areas of the urban sewer network system representing certain types of urban settlement structures. Thereby particular requirements of different types of urban settlement structures are involved estimating the application of the projected methodological background of enhanced strategic maintenance planning to different types of urban settlement structures respectively the total sewer network system.

4 Outlook

The described implementation is expected to provide a helpful tool enabling efficient long-term maintenance planning under unstable conditions. Efficiency of maintenance and reinvestment planning is supposed to be increased. The investigations emphasis strategic aspects. In doing so, profound information on equipment, its condition and associated service life plays a crucial role for strategic maintenance planning. But provision of needed information stays challenging. Influences of particular

[6] Prognoses are carried out until 2030.

[7] Significant changes in the structure of the sewer network system are not proposed. Therefore it is not placed special emphasis on adaptation processes and their economic implementation.

components connected with their condition on reliability of the total system can thus hardly be predicted. Consequently, implementation of new asst management approaches involving strategic maintenance planning is hampered by insufficient information. Within the present research project, the sewer network system is managed independently. Integration of renewal planning of other infrastructure systems (water and road) requires additional approaches[8]. Strategies integrating different infrastructure assets are supposed to increase efficiency and cost-effectiveness [4]. Economic consequences on the infrastructure service provider implementing integrated municipal asset management systems remain to be investigated.

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