Appendix 1: Documentation of Expenditure Functions - General

1 Introduction

One of the key features of FEASIBLE is the use of generic expenditure functions. Generic expenditure functions are used to estimate the cost of given type of infrastructure. Usually, there are only one or two variables as determinants in the functional form.

Generic expenditure functions imply a simplification of the reality, but they limit the data collection effort and, more importantly, they allow for quick scenario analysis by which the cost of alternative environmental or service targets can be assessed.

The expenditure functions are based on international prices and a standard set of technological assumption. In FEASIBLE, the user is required to make entries on local prices. The model then modifies the cost results to reflect the local prices. The user has the option to enter technical correction factors for some of the most important assumptions where the local conditions may vary from the standard assumption included in the expenditure functions.

In appendices 1-4 to the user manual and documentation, the generic expenditure functions are described in detail. Appendix 1 (this appendix) describes the general principles of expenditure functions and price correction . The subsequent appendices each describe the expenditure functions of one module, viz. water supply, wastewater and municipal solid waste.

2 General Principle of the Generic Expenditure Functions

Project-based costing

Assessment of expenditure needs at project level is typically done by describing the components of a project, calculating the costs (and deriving there from the year-by-year expenditure) related to each component and adding the components. This may be done for investment, maintenance and operational expenditure needs. On a national basis, one may similarly add all the identified projects (and all their components) to form a national assessment of expenditure needs.

has pros and cons at national level

There are pros and cons to this approach. At the project level, it provides a good opportunity to take specific circumstances related to a particular municipality and its infrastructure into account thus providing a more precise estimate of expenditure needs for that particular municipality. In principle, this advantages is transferred to the national level. However, the data requirements of this approach are very large, and the approach is not very robust to shortcuts in data collection. Furthermore, a bottom-up project-based costing approach is cumbersome to work with in policy scenarios.

FEASIBLE is based on generic expenditure functions

In FEASIBLE expenditure needs are based on estimates generated by generic expenditure functions. The expenditure of a particular investment, the annual maintenance expenditure or the annual operational expenditure is function of a few key variables. For example, the investment expenditure of establishing groundwater supply (well fields and treatment) is a function of the total annual water production. FEASIBLE includes such a function and, when entering the total water demand (= total water production) of a given town, the investment expenditure for groundwater supply can be calculated. Similar expenditure functions are included for each of the technologies covered by the model.

The key variables (included in the expenditure function) have been chosen in order to best express the totality of expenditure that arise from a complexity of reasons. One may say that the key variables act as proxies for a large number of variables, all of which have impacts on "real life" expenditure.

2.1 Transparency in Documentation

Illustrations

In this appendix, we provide illustrations of the expenditure functions used. These illustrations are useful tools in the dialogue with national experts on the characteristics and structure of the expenditure functions used.

Specific documentation

While we have developed and recommend use of the generic expenditure function approach, the expenditure functions have been based on engineering considerations of the same sort as one would employ in a project-based costing approach. Thus, the expenditure functions have been developed with reference to assumptions about standard technical components and a corresponding database of expenditure for alternative scales of operations. The assumptions that underlie the generic expenditure functions have been presented in this appendix.

Price correction factors

The underlying calculations of the model are in international prices, and a set of price correction factors is used by FEASIBLE to convert results from international prices to local prices. The user is therefore required to enter data concerning the local cost of key cost components such as land, power, fuel, labour, equipment, building materials, etc.

The expenditure functions are given as the generic functions without correction factors. Technical and price correction factors can be applied as described in the user manual.

2.2 Service Extensions, Renovation, Reinvestment and Operation and Maintenance

Types of expenditure

There are four types of expenditure needs that can be defined and estimated in FEASIBLE. These annual expenditure needs are derived from the following four types of costs:

- Service extensions
- Renovations
- Re-investments
- Operation and maintenance

Cost and expenditure

The assumption behind the transformation from costs to expenditure for operational costs is that all of the annual costs are also annual expenditure. The estimation of annual maintenance expenditure is based on the same assumption that the estimated costs will also appear as expenditure for a given year. Although this may not be the case for a given plant in a specific town, it is a reasonable assumption of an area covering a large number of towns. Renovation and investment costs are also assumed to lead to expenditure of the same size and the time profile of this expenditure is described below. The term "investment cost" is sometimes used to denote the annualised investment expenditure. However, in this report, investment costs and investment expenditure functions denote the total investment expenditure resulting from the construction of new infrastructure or facilities.

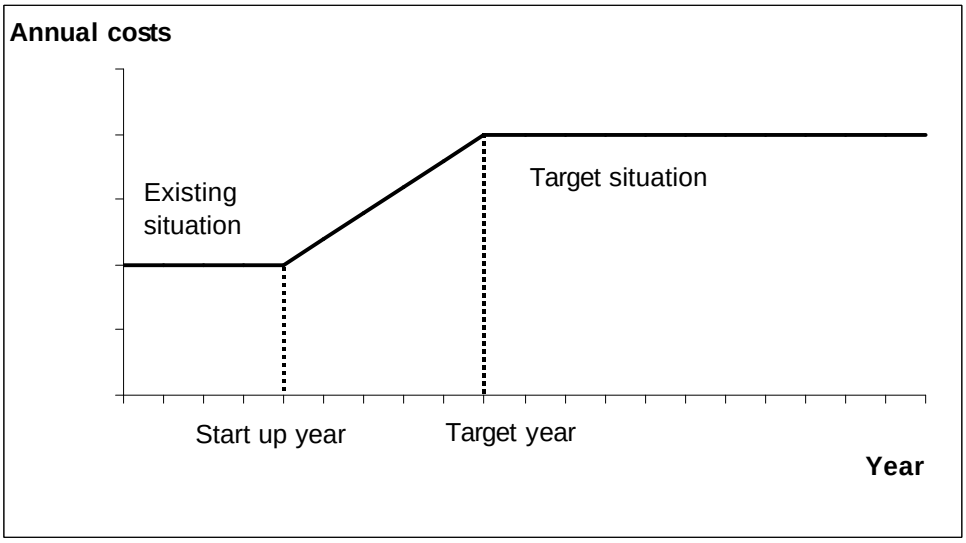
The input data for FEASIBLE are given for two situations, the existing situation and the target situation. Based on that, the model estimates the annual expenditure for a planning period of up to 20 years. In order to generate time profiles of the costs over the whole planning period, a start up year and a target year have to be specified.

Time profiles

Below, a typical time profile is shown for operational costs. The input data on the existing situation determines the level of costs in first period, while the data on the target situation determines the last period. Between these points in time, the investment and/or changes in the mode of operation to achieve the target take place.

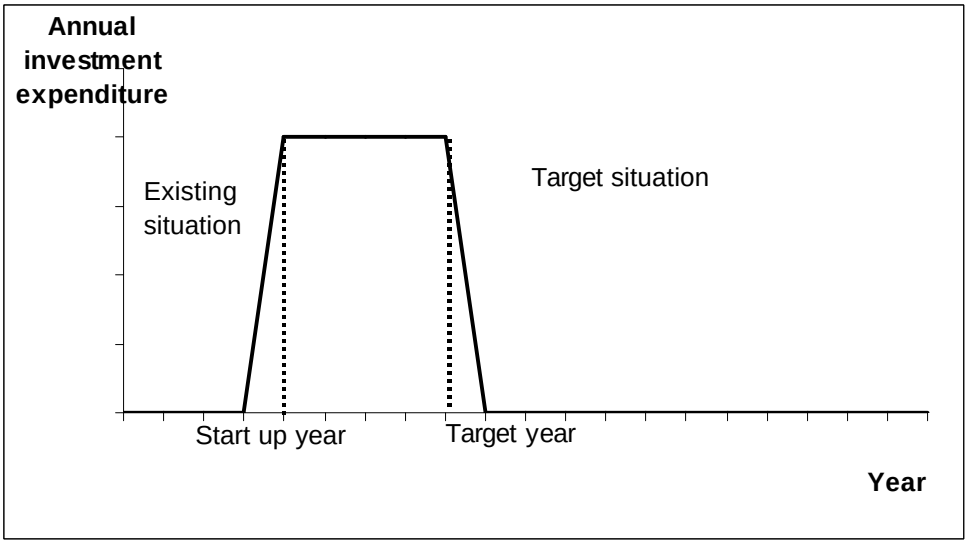
The time profile shown below illustrates the case where the target implies extension of the infrastructure causing gradually increasing annual operational costs as the new infrastructure is being constructed.

Appendix figure 1 Time profile for operational costs



Investments are assumed to be implemented in equal shares over the implementation period. In this case, the investment expenditure can be illustrated as shown in the figure below

Appendix figure 2"Standard time profile for implementation of investments

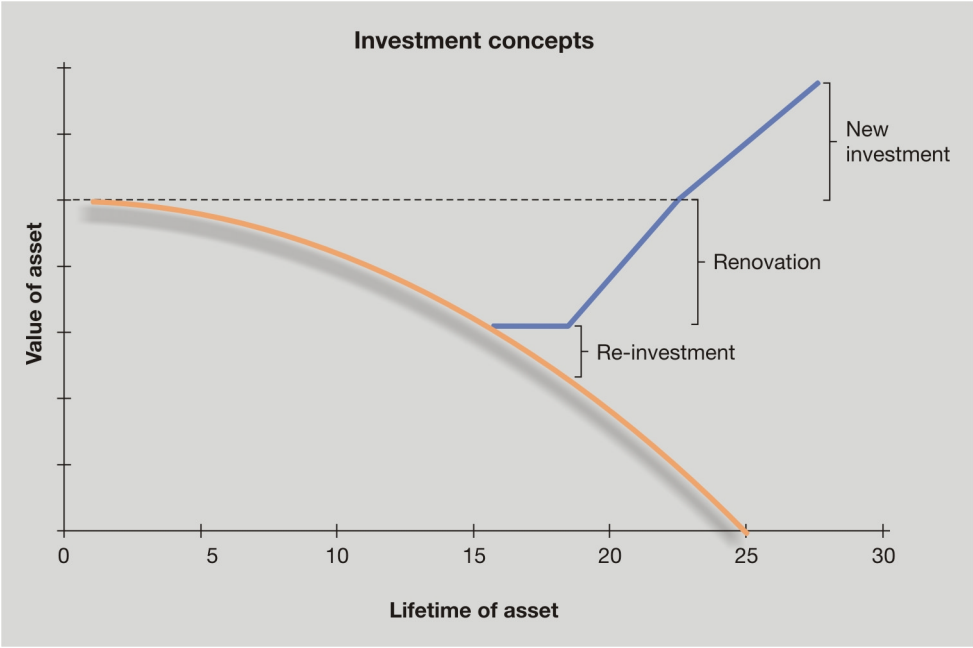


The limitation on specifying investment profiles only concerns the profile for a given town or a category of towns. The start-up and target years are specified separately for each town/category of towns. Then, the profile for total investment expenditure will appear as the sum of the profiles for each town or category of towns, and a more gradual phase in of new investments is possible.

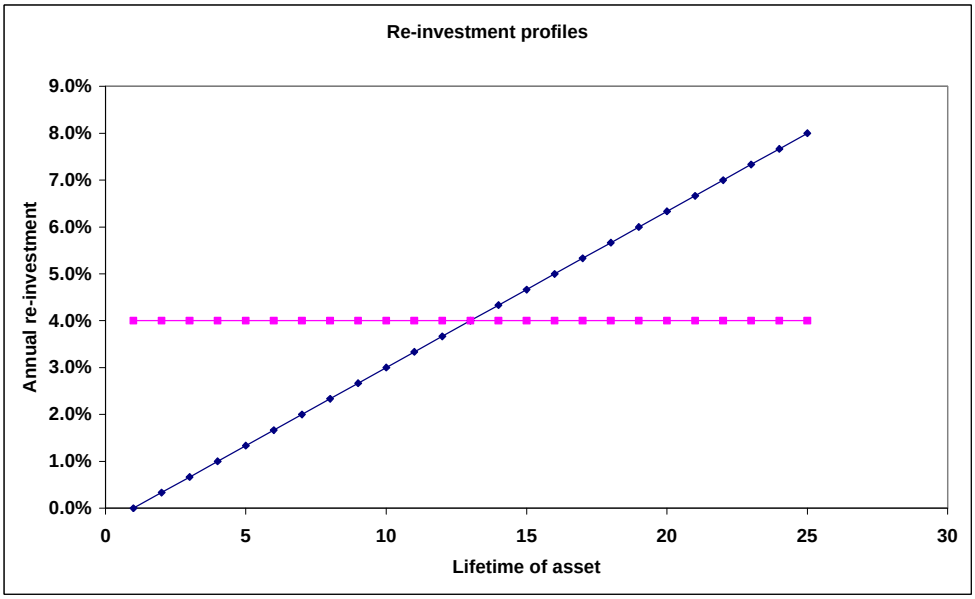
Value of infrastructure, re-investment and renovation

The relationship between maintenance costs, renovation and new investments can be illustrated by showing how the value of the infrastructure develops over time.

Appendix figure 3 Relationship between service extensions, renovation and reinvestment and the asset value of the infrastructure



The re-investment costs are estimated as the annual depreciation of the infrastructure. It is assumed to be increasing over the lifetime of the asset. In the first year there is no re-investment. Then there is a constant increase during the life time of the infrastructure. Below, this illustrated in the case of life time of 25 year.



Renovation costs are the investments that will increase the value of the system reaching partly or fully the originally designed level, while re-investment just keeps the value constant. In our definition of reinvestment, there is a close link between reinvestment and renovations/rehabilitation. If reinvestment is not carried out over a period, then renovation at the same amount as the accumulated re-investment is needed in order to restore the value of the system.

Backlog of maintenance

The accumulated value of reinvestment not carried out is called "backlog of maintenance". This is a key indicator of the value of the infrastructure and its operational effectiveness. Operational costs will increase if the necessary re-investment is not carried out, and after some time, operations will even start to cease. FEASIBLE does not include any automatic relation between the backlog of maintenance and operations. Post-model analysis will be needed to establish the effect on the service level, if the infrastructure is not sufficiently maintained.

Service extensions are extensions or improvement of the infrastructure. Investments in service extensions will increase the annual depreciation and thus the annual re-investment costs. In the figure above, reinvestment is shown at three levels. Reinvestment at the current level and re-investment at the design level imply costs of the same size, while extension of the infrastructure implies higher reinvestment costs.

Investment and upgrading

There are basically two functions related to each type of technology. An investment expenditure function that is used as a basis for assessing expenditure related to the new investments, but also to estimate renovation, upgrading and reinvestment expenditure. The other function describes operational expenditure.

Renovation

Regarding renovation, the basis of the expenditure assessment is the cost of a new system. Thus, the renovation expenditure will be estimated as a share of the investment expenditure. Establishing the necessary level of investment will be based on pre-model data from the specific region or country.

However, it must be envisaged that the full set of data needed for the pre-model evaluation of the renovation needs will not be available. In that case, decision rules have to be employed based on experience from other regions.

2.3 Operation and Maintenance Expenditure

Operational expenditure depends on local conditions and practise to an even higher degree than investment expenditure. The experience gained from actual implementation or from feasibility studies concentrates on investment expenditure, and limited data has been collected on actual operational procedures and associated expenditure.

From the design of the infrastructure or abatement equipment, only part of the operational input, such as energy and chemicals, can be estimated. The manpower input depends on the local management practises.

Operational expenditure include all the expenditure related to the daily operation of the infrastructure or equipment. Replacement of equipment is considered to be part of the maintenance if the replacement extends the lifetime of the system. All the maintenance that is necessary to operate the infrastructure, but do not extend the lifetime of the infrastructure as such, is included in the operational expenditure. In practice, however, it may not be possible to separate all minor replacements from operational procedures.

The operational expenditure of existing infrastructure or equipment will be estimated based on the operational expenditure of new equipment. Using a standard breakdown of the expenditure on items like energy, chemicals and labour, and price indicators that incorporate the local price level for the each expenditure item, a correction for local prices can be established. Additionally, a scaling factor is included to account for specific local conditions which otherwise cannot be included.

The estimated operational expenditure should be compared to the actual recorded expenditure. This is part of the price correction and calibration of the model.