



018530 - SWITCH

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Integrated Project
Global Change and Ecosystems

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1 Development and testing of a life-cycle cost calculation tool

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1.1 Abstract

Switching a city's stormwater management strategy from a "disposal mentality" towards a more sustainable, source control oriented approach is a difficult task. To convince decision makers, not only ecological but also financial arguments are necessary.

Within the SWITCH work package Stormwater Management a Life-Cycle-Cost-Assessment (LCCA) -Tool has been developed. With this tool called Eco.SWM, decision-makers can easily calculate Net Present Values (NPV) for different water management alternatives. The results for different alternatives can be visualized and break even point can be calculated. To overcome the practical problem of unknown unit prices especially for new innovative solutions, the tool is connected to a web-based database. To support knowledge exchange, all users can not only retrieve information but also enter their own costs in this database.

Eco.SWM is currently used by approx. 30 end users mainly in the area of the Emscher region, a demonstration project in the SWITCH project. Until now only used in the field of stormwater management, the tool is ready-for-use in other fields, e.g. eco-sanitation.

The tool is available for download on the SWITCH-website.

1.2 Introduction

Switching a city's stormwater management (SWM) approach from a "disposal mentality" towards a more sustainable, source control- oriented mentality is a difficult task. To convince decision makers, one has to bring forward not only ecological arguments. Sooner or later financial aspects play a very important role in every decision making process.

In many cases, stormwater source control has economical advantages compared with conventional stormwater drainage systems. However, this is not only a question of implementation cost. Other important factors are

- Operation and maintenance (O&M) cost,
- Life time
- Time of investment,
- Interests rates and price increase and also
- Flexibility regarding changes of influencing factors.

The first four aspects can be considered by using the so-called Net Present Value (NPV) method. This is a standard method, where future payments are discounted to a present value. Also stepwise implementation of small-scale measures - usually a financial benefit of SW source control - can be taken into account by discounting investment depending on the time implementation.

1.3 Net present value calculation

The NPV method is a standard method in business economics. The NPV - also called “net cash flow” - measures the total cost of a long-term investment (machine, project, etc.) Future payments like yearly cost for O&M and reinvestments after expected life time, or more precisely all future cash flows, are discounted back to its present value. Also stepwise implementation of small-scale measures - usually a financial benefit of SW source control - can be taken into account by discounting investment depending on the time of implementation. By computing the NPV for different alternatives, the method helps to compare different scenarios. Figure 1 explains basic terms for the NVP calculation. The following equation shows the formula for computing Net Present Values.

$$NPV = I_i + \sum_{t=1}^{t=EoP} \frac{CF_t}{(1+r)^t}$$

With: NPV: Net Present Value
 I_i: Initial Investment
 EoP: End of Project

CF_t : Cash Flow in year t
 r : Interest rate

Input parameters for the NPV-calculation are the different cash flows (CF) until the end of the project (EoP) including the initial investment (I_i). The discounting is done based on the interest rate (r). Further information including several examples can be found at wikipedia.

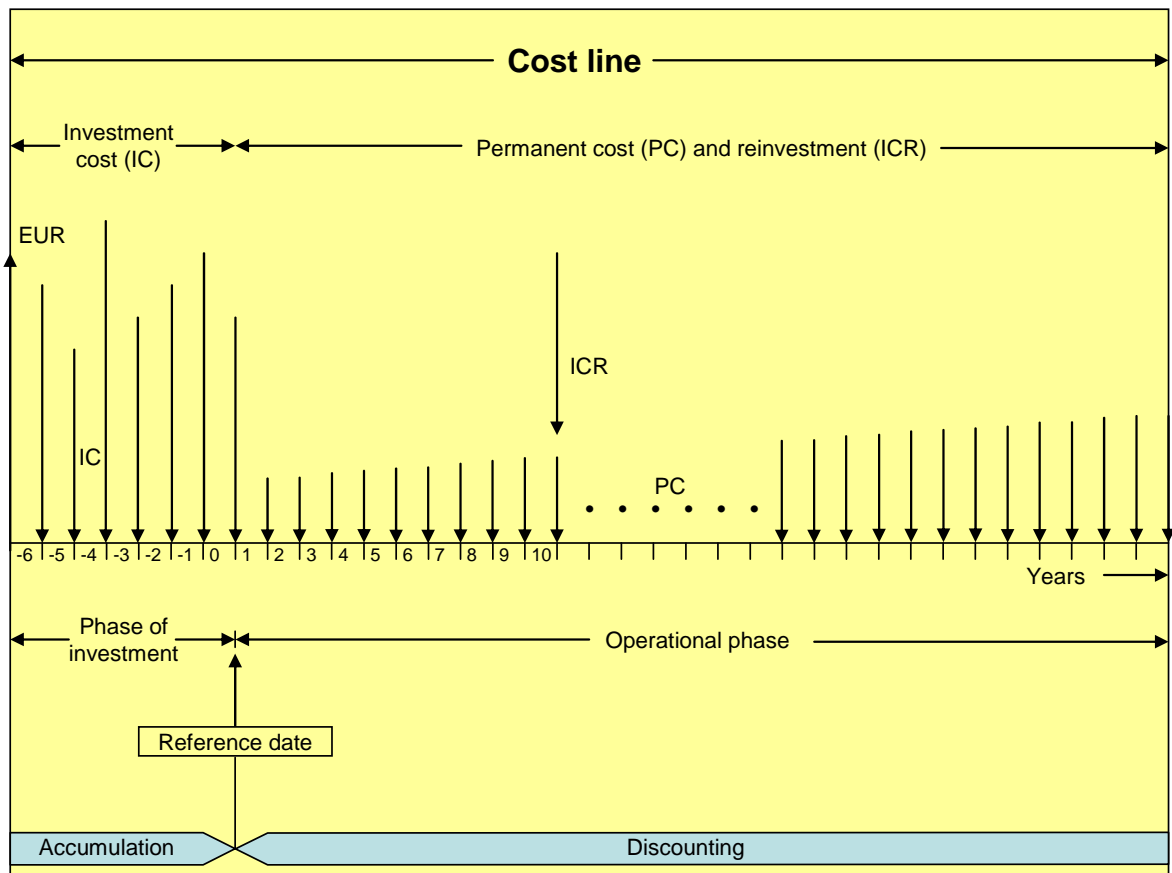


Figure 1: Basic terms for NVP calculation (LAWA, 2005)

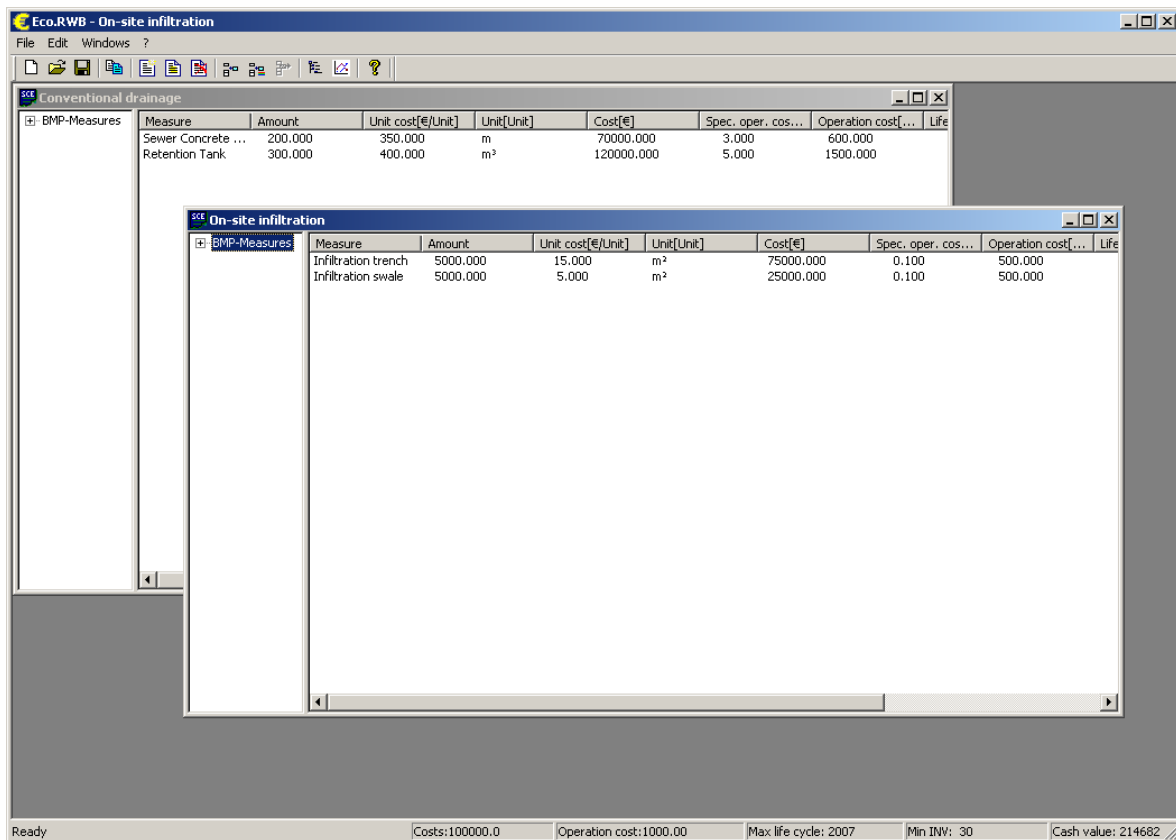
1.4 The Eco.SWM Tool

First of all, Eco.SWM is a standalone Windows software for computing net present values for different alternatives/scenarios. Each scenario can contain multiples measures like shown in figure 2. For example the conventional drainage scenario can be composed of a storm

sewer and a retention pond while the source control scenario consists of different infiltration devices like swales or trenches. The user can enter the following parameters:

- Measure: Name of the measure.
 Unit: Unit, in which the amount is measured.
 Amount: Number of measures that are implemented, e.g. 300 m³ of retention volume.
 Unit cost: Initial investment for each single measure in €/unit.
 Year of investment: Year in which the initial investment takes place.
 Life span: The mean life expectancy for the measure, e.g. 60 years for a sewer.
 Spec. oper. cost: Specific operation cost for each single measure in €/unit/year.

Beside of the scenario specific data the user has to enter some project specific data, like the interest rate, the project duration and an average price increase.



The screenshot shows the 'Eco.RWB - On-site infiltration' software interface. It features two data tables:

Conventional drainage

Measure	Amount	Unit cost[€/Unit]	Unit[Unit]	Cost[€]	Spec. oper. cos...	Operation cost[...]	Life
Sewer Concrete ...	200.000	350.000	m	70000.000	3.000	600.000	
Retention Tank	300.000	400.000	m ³	120000.000	5.000	1500.000	

On-site infiltration

Measure	Amount	Unit cost[€/Unit]	Unit[Unit]	Cost[€]	Spec. oper. cos...	Operation cost[...]	Life
Infiltration trench	5000.000	15.000	m ²	75000.000	0.100	500.000	
Infiltration swale	5000.000	5.000	m ²	25000.000	0.100	500.000	

The software interface also includes a status bar at the bottom with the following information: Ready | Costs:100000.0 | Operation cost:1000.00 | Max life cycle: 2007 | Min INW: 30 | Cash value: 214682

¹ An international version for other currencies than Euro is under development.

Figure 2: Screen shot of Eco.SWM

With this information, the software computes the net present value for each scenario simply by adding the NPVs of all measures. The results are presented in tables (figure 2) and in a graphical view (figure 3). The graphical view visualizes the developing of the NPV over the project duration.

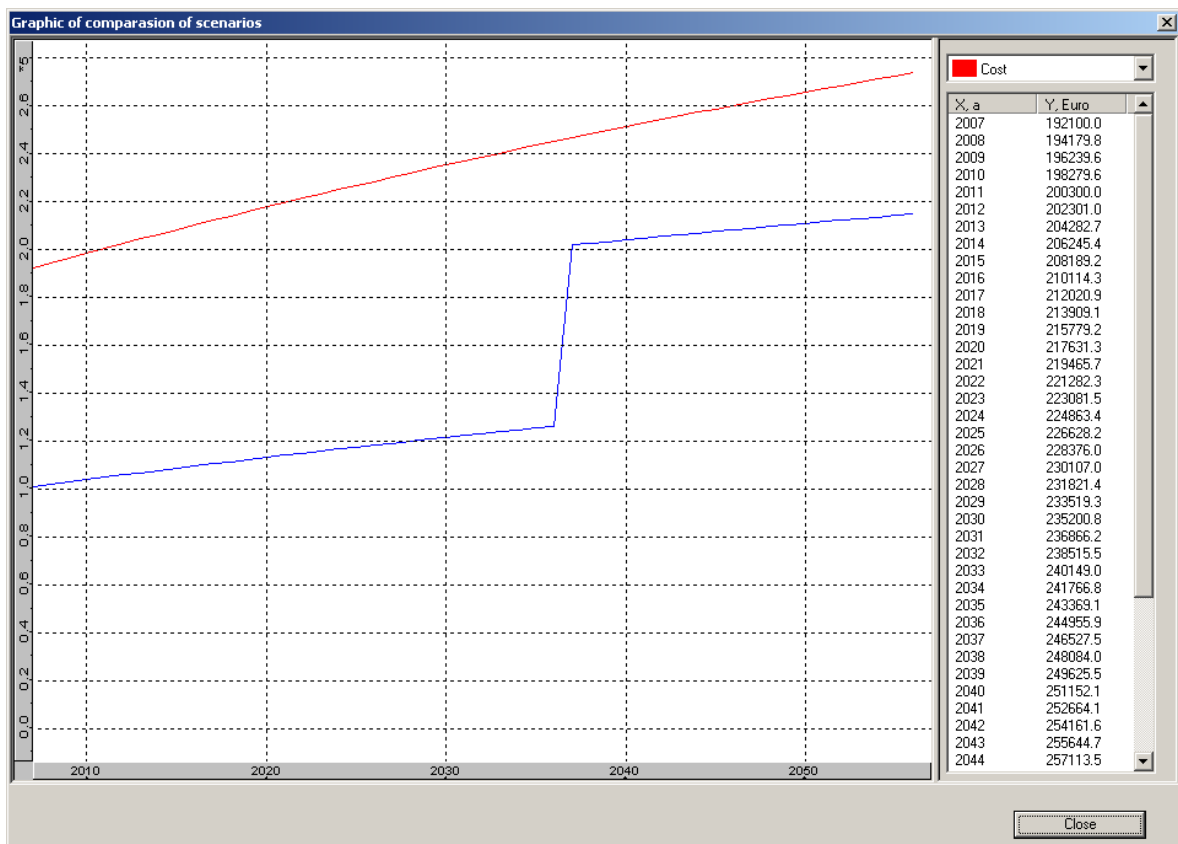


Figure 3: Screen shot with results from Eco.SWM

While the NPV-calculation itself is relatively easy (it can also be done with Excel), it is often time consuming to collect prices for different alternatives and to present results properly. Especially for new innovative solutions like stormwater source control techniques or eco-sanitation, there is often a lack of information about investment and operational costs.

Therefore, Eco.SWM has been developed as an application with access to a web-based database. In the database unit prices, operational costs per unit and lifetime expectancies for

many different measures are stored. Figure 4 shows the connection of Eco.SWM with the database.

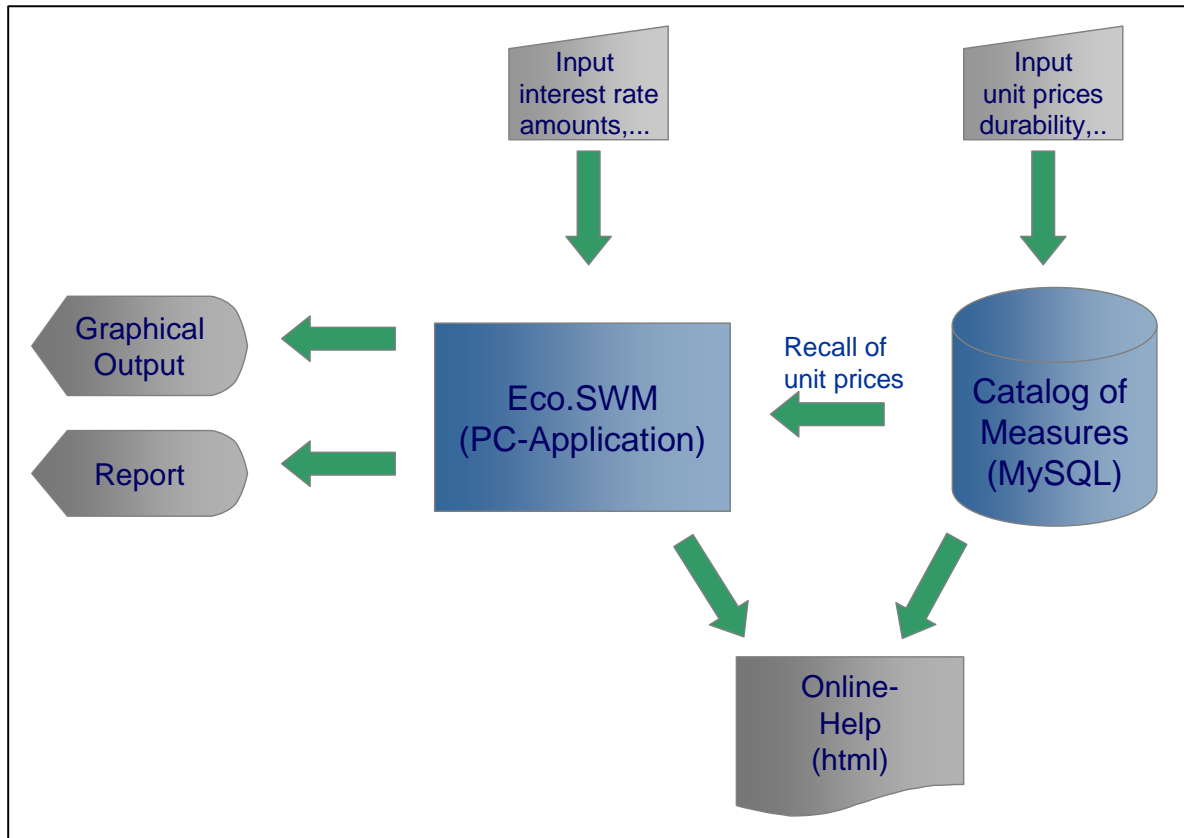


Figure 4: Flow chart showing the connection of Eco.SWM with the database

The database has been implemented by using MySQL. The structure of the database (figure 5) enables to have multiple users and multiple profiles. This structure was selected with respect to the application within the Learning Alliances. It is possible for example to define a profile for each demonstration city with having several users (members for the LA) access to this profile. Users from outside can be offered to have read-only access to the database but no right for changing the data. Adding new data to the MySQL can be done from within the Eco.SWM software (figure 6). It is also possible to download parts of a full profile to be independent from a Web access. To meet the demand of proper presentation, a report of the results can be generated by the software. This report can be printed or exported into a pdf-file.

Currently approx. 30 profiles with 40 users are defined in the database. Until now the profiles are containing more than two hundred entries for different measures mainly in the field of stormwater management. Most of these entries come from users from the Emscher region, a demonstration project in the SWITCH project (Sieker et. al., 2006). It is expected that the database will grow fast with more people using it in practical projects.

Although Eco.SWM until now is only used in the field of stormwater management, it is ready-for-use in other fields, e.g. eco-sanitation. Partners from other work packages are invited to enter unit prices of technologies from their fields into the database. With all this inform the tool can support the work of the Learning Alliances.

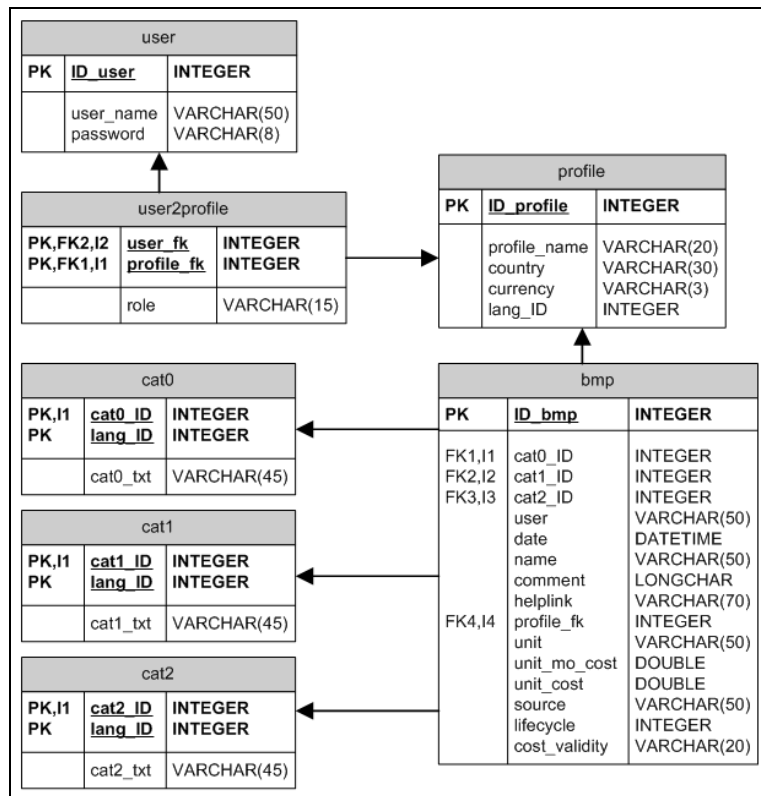


Figure 5: Structure of the MySQL database of Eco.SWM

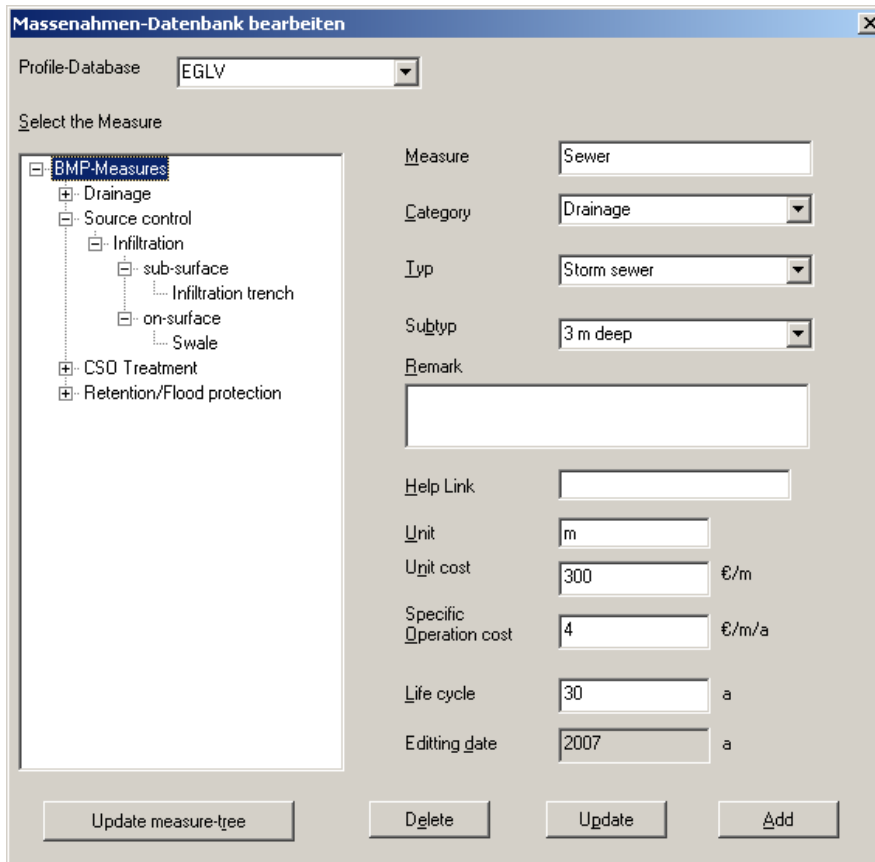


Figure 6: Dialog for database editing

1.5 Download and Installation

The software can be downloaded on the SWITCH-Website or directly using this link:

http://h83667.serverkompetenz.net/downloads/sieker/setup_ecoswm.exe

You may also visit the company's website: www.sieker.de

Install the software by starting setup.exe. The program will be installed under c:\program files\ips\Eco.SWM. A demo file (sample.kvr) is stored in the samples folder.

To connect to the web-based cost-database the user needs an internet connection and a user account. For SWITCH partners the following login data can be used:

Username: switch



Password: switch

The version 2.1 is the final version within the SWITCH-research project. Feel free to test ECO.SWM in your projects.

Please report bugs and suggestions for improvements to:

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1.6 Thinking out of The Box: Net Present Values in a Multi-Criteria Analysis

The NPV method considers several economical aspects (O&M cost, lifetime, time of investment, Interests rates and price increase). Nevertheless, flexibility as another important economical aspect is neglected by the NPV method. Assuming two alternatives, from which one has higher investment cost but a longer time. This is typical for sewers which have life expectancies of 80 years and more. The NPV for this durable investment may be relatively low because reinvestment is discounted so much. The other alternative, e.g. an infiltration device, maybe is cheaper but due to a shorter life time of 40 years a reinvestment has to be considered. This reinvestment after 40 years increases the NPV. Consequently, a comparison of the NPVs of the two alternatives, leads to a decision in favor of the long-lasting alternative - which is correct, if the measure will serve the purpose for the next 80 years.

But let's assume in 30 years from now the design storm is different because of climate change or more impervious surface is connected due to urbanization, then the shorter life time of the infiltration device can be an advantage because adjustments before reinvestment are possible. In this case, a conventional NPV comparison would have lead to a wrong decision.

One way to overcome this disadvantage of the NPV comparison is to use the life cycle cost as one indicator in a utility value analysis (UVA). With the UVA approach, an aggregated system value (the sum of the weighted utility values) for indicators from the environmental, economical and social sector is used to compare different scenarios (Peters et. al., 2007). Flexibility can be introduced as another indicator for the economical sector.

However, in the classical UVA approach flexibility is still a very subjective indicator. In contrast, the COFAS method (COFAS: Comparing the Flexibility of Alternative Solutions) involves applying statistical methods to the level of variation associated with the utility values under different conditions. A useful way to visualize this variation is in a sector diagram (see figure 7).

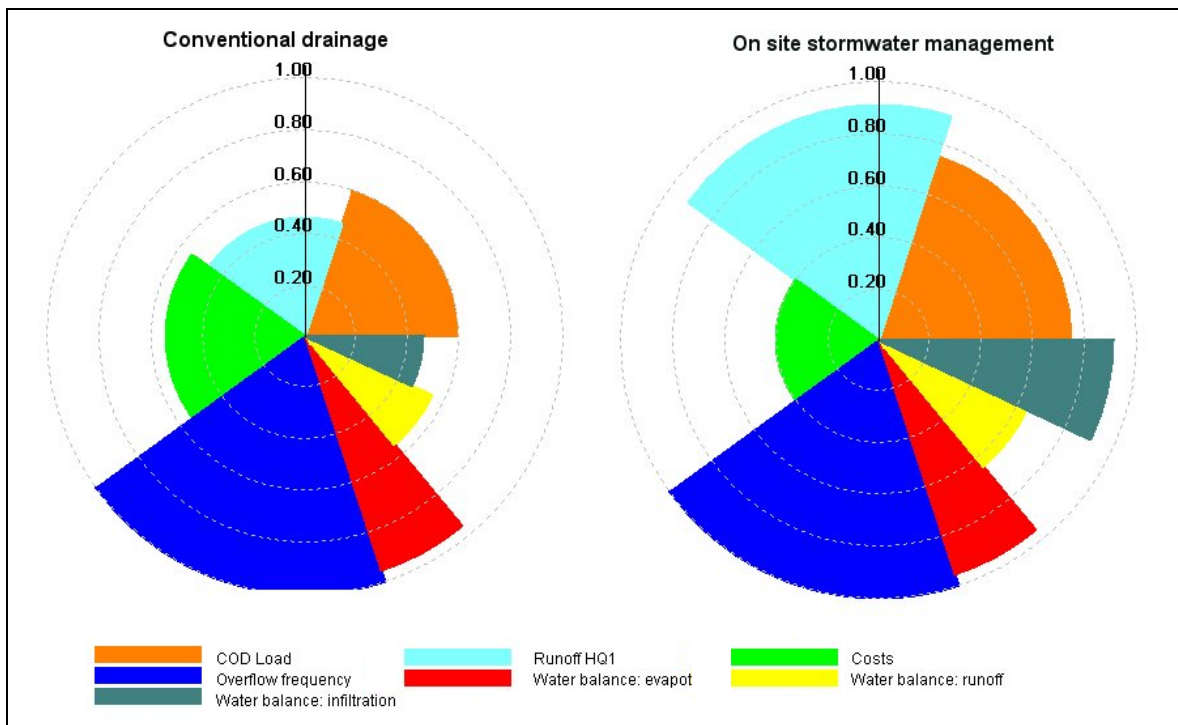


Figure 7: Sector diagram for weighted utility values

In this diagrammatic, the radius of a sector represents the utility value while the aperture angle shows the weighting factor. In the example shown in Figure 7, it is clear that the variation in the utility values associated with the conventional drainage solution (left-hand chart) is greater than those associated with an on-site stormwater management solution (right-hand chart). The variation of utility values can be measured by introducing a homogeneity factor (inHom), calculated as the standard deviation of the utility values. Combining the homogeneity factor and total utility values (tUV) results in the development of a “multi-dimensional Degree of Target Achievement (dDTA)” value (Schlottmann et. al, 2007).

$$dDTA = \sqrt{tUV * inHom}$$

A comparison of alternatives utilizing dDTA values has the advantage is that it avoids the potential drawback of a highly negative aspect of a solution (e.g. water pollution) being compensated for by a highly positive attribute (e.g. low cost). However, a comparison of alternatives by dDTA is still only based on information about the actual situation.

To take into account the flexibility of alternatives regarding their ability to cope with future changes (e.g. changing conditions associated with climate change, increasing urbanization etc), an additional parameter *exHom* was introduced to the previously developed approach. For each alternative solution, utility values were computed for different future scenarios. The external homogeneity is defined as the standard deviation of the variation of the utility values for the different scenarios. Combining this parameter with the mean total utility value and the mean internal homogeneity leads to the “multi-dimensional, multi-variant Degree of Target Achievement (dvDTA)” (Helm, 2007).

$$dvDTA = \sqrt[3]{mUV * minHom * exHom}$$

This parameter is hence a measurement for the flexibility of an alternative to react to future changes.

The development of the COFAS-Method by IPS was initiated by one of the outcomes of “Deliverable 2.1.1: Review of the adaptability and sensitivity of current stormwater control technologies to extreme environmental and socio-economic drivers”, that it is extremely difficult to make robust predictions with respect to all possible future changes and therefore flexibility should be introduced as a planning criterion. The development of a software tool for COFAS-Method is recommended.



1.7 References

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2 Organise and facilitate workshops in selected demo cities to train LAs in use of life-cycle cost calculation-tool

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2.1 Belo Horizonte

LA Members in Belo Horizonte were trained on the use of the LCCA-Tool “Eco.SWM” in September 2007. A Report on the Belo Horizonte workshop will be given as part of the report on Task 2.1.1c

2.2 Emscher Region

The Emscher-region and its communities were beta users of the LCCA-Tool “Eco.SWM”. Continuous meetings were held with the beta users during all year in order to train them, to obtain feedback and to improve the software.

A final training with a larger number of participants from the Emscher-region and their associated municipalities was carried out on January 15th 2008. During one day, Mr Sieker trained the participants on the use of the program and on life-cycle cost calculations in general. The training included the following content:

- General information on SWITCH
- Theory of life-cycle cost calculations
- Outlook: Multi Criteria Analysis
- Introduction of the LCCA-Tool
- Case study example
- Practical training on the use of the tool, including the use of the unit-cost database

Some of the beta users gave their remarks and requests. This valuable feedback led afterwards to further improvement and the release of a new update.



2.3 Further Dissemination Activities

- Presentation of the LCCA-Tool at the SWITCH-workshop at the "11th International Conference on Diffuse Pollution" in Belo Horizonte in Aug 2007
- Delivery of a free CD containing the Tool to all participants of the Tel-Aviv annual meeting in Nov 2007
- Presentation of the tool at the final conference of the Interreg IIIB projects NORIS (No Rain In Sewers) and UWC (Urban Water Cycle) in Amsterdam September 2007
- Presented in lectures to students at Berlin Technical University
- Presented as a part of a seminar on "computer aided urban drainage master planning" at "Technische Akademie Esslingen" in April 2007
- Tool is distributed to the company's clients
- Tool will be presented an the 15th "IFAT" (International Trade Fair for Water – Sewage – Reuse – Recycling) in Munich, 2008