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Guidelines for performance evaluation of treatment technologies for water reuse systems —

Part 8: Evaluation of treatment systems based on life cycle cost

Lignes directrices pour l'évaluation des performances des techniques de traitement des systèmes de réutilisation de l'eau —

Partie 8: Évaluation des systèmes de traitement fondée sur le coût global

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 282, *Water reuse*, Subcommittee SC 3, *Risk and performance evaluation of water reuse systems*.

A list of all parts in the ISO 20468 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The purpose of this document is to more specifically define a methodology for evaluating the economic performance of treatment systems, which is covered in ISO 20468-1:2018, Clause 7. The background to this document is the need to promote water reuse projects with cost-effective treatment systems in communities and industrial facilities in order to achieve sustainable water supply. A variety of stakeholders, including managers of water reuse projects and owners of water infrastructure and facilities, can select appropriate treatment systems through comprehensive performance evaluations using this document and the ISO 20468 series.

The concept of the economic performance evaluation methodology has already been established based on life-cycle cost (LCC), comprising capital, operation and maintenance (O&M), and disposal costs in IEC 60300-3-3. The economic performance evaluation methodologies of the petroleum and natural gas industries and building and constructed assets are defined in ISO 15663 and ISO 15686-5, respectively, based on the general standard of IEC 60300-3-3. The importance of the economic evaluation, based on LCC considering the environmental impact, is also described in guidelines for selecting high-quality water infrastructure and facilities.[14] With reference to these existing standards, this document provides a customized evaluation methodology for treatment systems in water reuse projects based on LCC, taking environmental impact into consideration. In this document there are no restrictions on applicable treatment systems, such as biological, physical or membrane separation.

Guidelines for performance evaluation of treatment technologies for water reuse systems —

Part 8:
Evaluation of treatment systems based on life cycle cost

1 Scope

This document provides life-cycle cost (LCC) methodology for treatment systems for water reuse for initial planning as well as later performance evaluation. LCC analysis provides valid information to determine whether the objectives have actually been accomplished and how operations are improved and optimized. Environmental impact is also taken into account in the LCC evaluation.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 20670, *Water reuse — Vocabulary*

3 Terms, definitions, symbols and abbreviated terms

For the purposes of this document, the terms and definitions given in ISO 20670 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1 Terms and definitions

3.1.1
capital cost
money used to purchase, install and commission a capital asset

3.1.2
disposal cost
money used to demolish and rehabilitate a capital asset at the end of its life

3.1.3
operation and maintenance cost
cost incurred in running and managing the facility, labour, material and other related costs incurred to retain a building or its part in a state in which it can perform its required functions

3.1.4
life-cycle cost
total cost incurred during the life cycle

[SOURCE: IEC 60300-3-3:2017, 3.1.13]

3.1.5
life-cycle costing
process of evaluating the difference between the life-cycle costs of two or more alternative options

[SOURCE: ISO 15663:2021, 3.1.27, modified — Note to entry removed.]

3.2 Symbols and abbreviated terms

For the purposes of this document, the following symbols and abbreviated terms apply:

C LCC, LCY/year

C_a LCC of alternative system, LCY/year

C_b LCC of baseline system, LCY/year

C_d disposal cost, LCY/year

C_i capital cost, LCY/year

C_o operation and maintenance cost, LCY/year

$C_{o(w)}$ cost for water input or water output in O&M, LCY/year

ΔC cost reduction in water use, LCY/year

η_h heat output recovery ratio

η_w water recovery ratio

LCC life-cycle cost

LCY local currency

O&M operation and maintenance

Q_{outa} heat output in alternative system, J/year

Q_{outb} heat output in baseline system, J/year

u unit cost, LCY/m^3

w water consumed, m^3/year

W_{ina} water input in alternative system, m^3/year

W_{inb} water input in baseline system, m^3/year

W_{outa} water output in alternative system, m^3/year

W_{outb} water output in baseline system, m^3/year

4 Concept of economic evaluation

4.1 General

The concept of life-cycle costing is applied to evaluate the economic performance of treatment systems in a water reuse project. An economic evaluation procedure using the total cost of the treatment system throughout a project's life can be applied to estimate the cost difference between each alternative system to select an appropriate water reclamation technology, while satisfying the project's requirements.

This document describes the economic evaluation methodology for treatment systems based on the following concepts according to existing standards:

— The LCC of an alternative treatment system with water reclamation process (in both cases of new installation and renewal or modification) is compared with that of a baseline system.[3],[15]

— The economic evaluation procedure includes definitions of the boundary of a treatment system, cost elements, calculation and evaluation.

The following characteristics should be especially considered:

— The boundary of an economic evaluation can include an entire treatment system consisting of water supply process and wastewater treatment process, as well as water reclamation process, when a reduction in the total amount of required water is expected by the reclamation process.[16]

— Heat recovery and recovery of valuable materials can be included in the evaluation.

— Environmental impacts can also be included in the evaluation, along with an economic evaluation.

4.2 Timing of the evaluation

A water reuse project requires a careful evaluation of goals, including an assessment of technology feasibility and relative costs to achieve the objectives. The evaluation can be conducted at the planning stage, O&M stage and disposal stage. The assumed data at the planning stage can be replaced with actual and more accurate data at the other stages. This can provide stakeholders with a greater opportunity of understanding the project status.

4.3 Consideration of water quality

Generally, the construction cost and the operation cost of a water reclamation facility differ greatly depending on the water quality of the wastewater supplied and the reclaimed water quality required. When a water reclamation facility is adopted, it is important to evaluate and select appropriate technologies to satisfy the requirements of water quality and quantity that are specified by users (see ISO 20468-1:2018, Clause 6).

5 Economic evaluation procedure

5.1 Boundary definition

For the economic evaluation of treatment systems, it is necessary to accurately define the boundary in accordance with the characteristics of an individual water reuse project. In particular, relevant facilities that will be affected by the project should be included in the boundary. For example, if heat recovered by the water reclamation process is utilized for a heating system, the facilities for heat recovery, such as a heat pump, should be within the boundary. In general, heat pump and heat exchanger equipment are widely applied for the heat recovery facilities in municipal sewage plants. Direct reuse of hot water is often applied in industrial facilities.

In the definition of the boundary, it is important to properly define the alternative system and the baseline system. For example, if the alternative system is defined with the installation of a new water reclamation process, the baseline system does not need the reclamation process. The boundary can be defined for each of several systems with different water reclamation technologies as candidates and compared with a baseline system.

An example of the boundary of an alternative system and a baseline system in a water reuse project utilizing treated municipal wastewater is shown in Figure 1. Treated water with its quality improved by a reclamation process in the alternative system can be used for building and landscapes. Heat recovered by the facility with the water reclamation process can be used for air conditioning systems and other purposes. As a result, an alternative system can achieve cost reduction for water and energy supplies compared with the baseline system. An example of facilities and items in the defined boundary in a case study on a water reuse project using treated municipal wastewater is shown in Annex A.

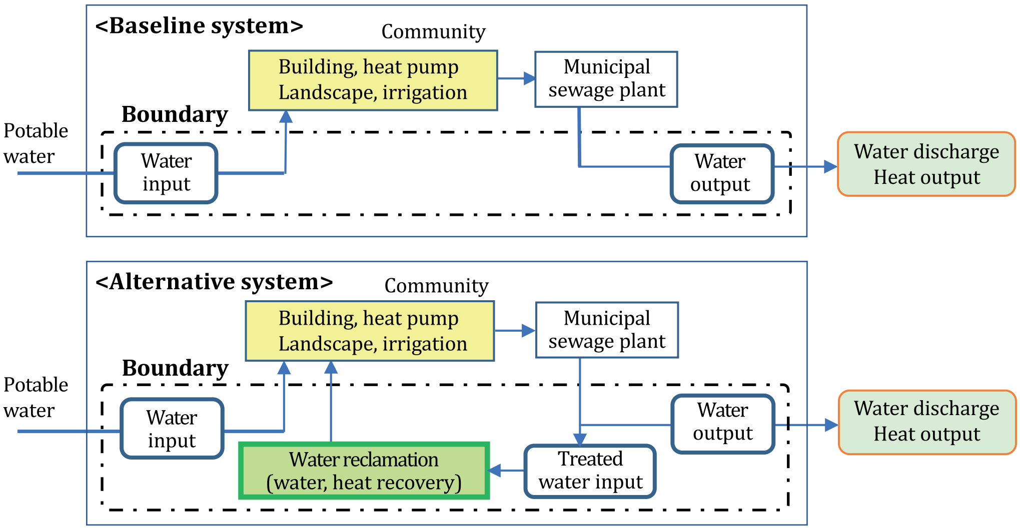

Figure 1 — Example of boundary of treatment system in a municipal water reuse project

Another example of the boundary of an alternative system with a water reclamation process and that of a baseline system are shown in Figure 2. The boundary in the baseline system consists of the water supply process, including water treatment and wastewater treatment processes. In addition, the boundary in the alternative system includes the water reclamation process. The water reclamation process improves treated water quality to meet the needs of domestic use and heat supply facilities, thus enabling heat recovery and recovery of valuable materials, along with water recovery. Consequently, the benefits of cost-effectiveness are estimated from the reduction in the amount of the water supply and water treatment in the alternative system. An example of facilities and items in the defined boundary in a case study of a water reuse project using industrial wastewater is shown in Annex B.

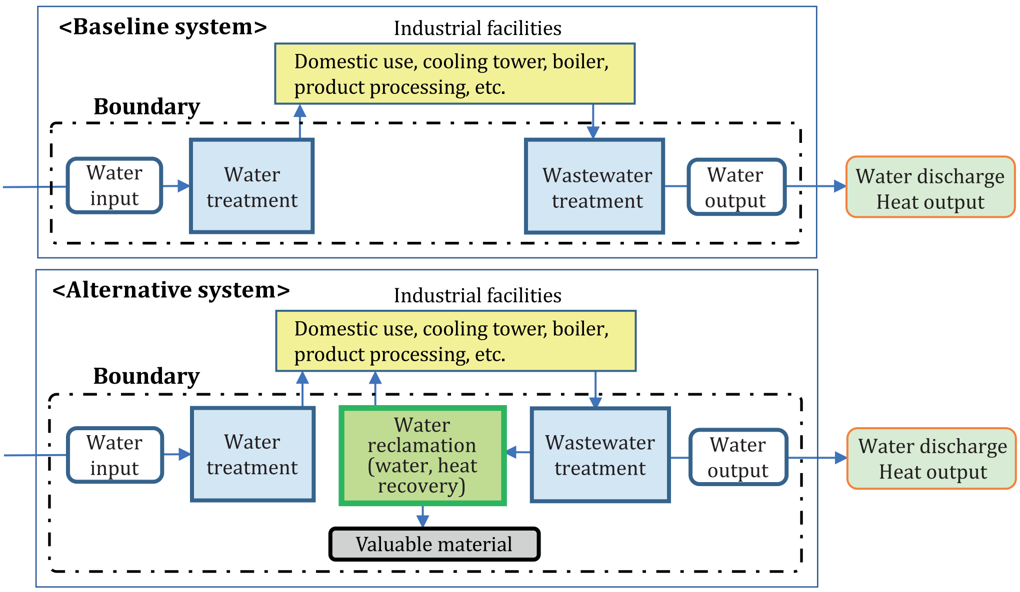

Figure 2 — Example of boundary of treatment system in an industrial water reuse project

Figure 1 and Figure 2 show examples of the boundary of a baseline system and an alternative system with a newly installed water reclamation process. The process can be a renewed or modified one when the baseline system includes an existing reclamation process. The boundary of the treatment system can also include related processes in different communities and industrial facilities, when water and heat are exchanged between them, while transportation costs should be considered in the evaluation.

5.2 Cost elements definition

It is important to accurately define cost elements in the water reuse project, which will have a large impact on the economic evaluation. To avoid missing important elements, it is recommended that the cost elements are defined using systematic procedures. Generally, cost elements are set up under the categories of capital cost (C_i), O&M cost (C_o) and disposal cost (C_d), as shown in Table 1, based on existing standards. The cost elements need to be set in consideration at least of the levels of detailed items required to determine differences between each alternative system or the difference from the baseline, and the cost-related data to be collected.

Indirect damage cost in C_o is composed of warranty expenses, including damage compensation due to a stoppage of facility operation caused by failure and detriment costs, such as damage to credit or reputation. Indirect damage cost should be considered for the convenience of warranty and exemption from legal liability. This is a kind of uncertainty cost that is affected significantly by objects and purposes, therefore it is defined as a recommendation.

Table 1 — Example of cost elements

Cost category	Cost elements
Capital cost, C_i	Design and development cost
	Manufacturing cost
	Transportation, installation and commissioning cost
O&M cost, C_o	Operation cost — energy: electricity, fuel — consumable materials — workforce — chemicals — sludge disposal cost — monitoring cost
	Maintenance cost — periodic inspection — replacement mechanical parts
	Indirect damage cost (recommendation) — warranty cost — liability cost — cost for providing an alternative service
Disposal cost, C_d	Retirement cost
	Disposal and recycling cost

5.3 Calculation

The LCC of each facility or item in the boundary defined in 5.1 can be calculated with Formula (1).

$$C = C_i + C_o + C_d \tag{1}$$