International Standard

ISO 9111

Water reuse in urban areas — Guidelines for benefit evaluation of reclaimed water use

Recyclage des eaux dans les zones urbaines — Lignes directrices concernant l'évaluation des avantages de l'utilisation d'eau réutilisée

First edition
2024-06

Reference number
ISO 9111:2024(en)

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

Page

Foreword iv

Introduction v

1 Scope 1

2 Normative references 1

3 Terms and definitions 1

4 Abbreviated terms 2

5 General 2

6 Indicators of benefit evaluation of reclaimed water use 2

6.1 Holistic indicator system 2

6.2 Resource benefits 3

6.2.1 Conventional water resource savings 3

6.2.2 Energy resource recovery 3

6.2.3 Carbon resource recovery 4

6.2.4 Phosphorous resource recovery 4

6.3 Ecological and environmental benefits 5

6.3.1 Reduction of contaminants 5

6.3.2 Reduction of electricity use 5

6.3.3 Reduction of greenhouse gas (GHG) emissions 6

6.3.4 Achievement of E-flows 6

6.3.5 Ecosystem protection/restoration 7

6.4 Social benefits 7

6.4.1 Improvement of local natural environment 7

6.4.2 Improvement of regional natural environment 7

6.5 Economic benefits 7

6.5.1 Avoided cost 7

6.5.2 Net present value (NPV) 8

6.5.3 Internal rate of return (IRR) 8

7 Procedures of benefit evaluation of reclaimed water use 9

7.1 Benefit evaluation flow chart 9

7.2 Procedures and considerations of benefit evaluation 10

Annex A (informative) **Indicators for the evaluation of natural environment improvement by reclaimed water use in the social benefit category** 12

Annex B (informative) **Recommended evaluation indicators for different scenarios** 13

Bibliography 15

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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).

ISO draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). ISO takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, ISO had not received notice of (a) patent(s) which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at www.iso.org/patents. ISO shall not be held responsible for identifying any or all such patent rights.

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

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 2, *Water reuse in urban areas*.

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

Water shortages are recognized to be some of the most crucial threats to sustainable development of society. Reclaimed water is a safe, reliable and sustainable water source to help satisfy water demands, especially in many water-scarce areas. Today, reclaimed water is used in urban areas, including agricultural irrigation, ecological or environmental flow replenishment, landscape irrigation, toilet flushing, firefighting, and car washing amongst other uses. Implementation of principles of benefit evaluations can create thorough, comprehensive, systematic, and sustainable reclaimed water use. However, the intrinsic values or the benefits of reclaimed water use are not clear. There are limited guidelines or regulations currently available, specifically regarding the benefit evaluation of reclaimed water use in urban areas at a global level.

It is important to establish a systematic, scientific and holistic benefit evaluation system for reclaimed water use. Based on the different applications of reclaimed water and the varied water quality requirements linked to the intended use, it is important to evaluate the benefits of various indicators for reclaimed water use. The benefit evaluation should take into account various indicators such as the resource, ecological and environmental, social, economic and other benefits, including the reduction of global warming.

Water reuse in urban areas — Guidelines for benefit evaluation of reclaimed water use

1 Scope

This document provides guidelines to evaluate the benefits of reclaimed water for applications requiring different levels of water quality and for beneficial use in urban areas.

This document is applicable, among others, by practitioners and authorities to assist water reuse planning, design, operation and management.

This document provides evaluation indicators, procedures and examples of reclaimed water use benefits.

Design parameters and regulatory values of different reclaimed water uses as well as risk or safety evaluation of reclaimed water use are out of scope of this document.

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 and definitions

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
benefit evaluation
analysis contributing to decision-making on whether to adopt a project or a plan by quantifying and comparing its benefits

3.2
ecological or environmental flow
E-flow
water flow and level that allows to sustain aquatic ecosystems which, in turn, support human cultures, economies, sustainable livelihoods, and well-being

3.3
avoided cost
benefits occurred as a result of avoiding unnecessary costs while meeting demand requirements and thereby avoiding the additional resources and service waste

Note 1 to entry: This concept is from least cost or integrated resource planning.

4 Abbreviated terms

COD chemical oxygen demand

CO_2-eq CO_2 equivalent

GHG greenhouse gas

IRR internal rate of return

LCC life cycle cost

LCY local currency

NCF net cash flow

NPV net present value

P phosphorous

5 General

Ensuring safety of reclaimed water is crucial to protect the environment and human health from the adverse effects of toxicants and pathogenic microorganisms. Generally, the reclaimed water safety assessment (e.g. ecological and human health risk assessment) can be conducted before implementing benefit evaluation of reclaimed water use. For detailed information on risk assessment and management, ISO 20426 and ISO 20761 can be used as references. Moreover, the supplied reclaimed water quality should also meet the requirements of local specifications and end user demands.

In principle, benefit is evaluated based on the comparison between the water reuse option and the business-as-usual or other method using alternative water resources, which are referred to as baseline. The relevant option and baseline are evaluated under the same conditions with the same indicators. The baseline can include a do-nothing scenario where no solution other than water reuse can realistically be envisioned and the baseline is to do nothing. The benefit of water reuse is expressed as the difference between the indicators for the relevant water reuse option and the baseline.

The benefit evaluation of reclaimed water use should comprehensively consider resource, ecological and environmental, social and economic benefit aspects.

The benefit evaluation of reclaimed water use includes quantitative and qualitative analyses, with corresponding indicators. The indicators should be set specifically, objectively and easily for calculation and/or comparison.

Wastewater treatment plants can be included in the boundary if necessary, as is often the case in comprehensive evaluations. The baseline scenario and the evaluation boundary including conventional wastewater treatment processes should also be determined for the benefit evaluation which is based on comparisons with the water reuse scenario.

Different water reuse projects and different utilization scenarios can be evaluated separately. Afterwards, the overall evaluation or comprehensive evaluation results can be obtained.

6 Indicators of benefit evaluation of reclaimed water use

6.1 Holistic indicator system

The indicators for benefit evaluation of reclaimed water use can be classified in four categories: resource, ecological and environmental, social and economic.

The main indicators for different benefit evaluation categories are listed in Table 1. If necessary, other indicators can be considered and incorporated for evaluation. Annex A provides examples of indicators for the evaluation of natural environment improvement by reclaimed water use in the social benefit category.

Evaluation indicators can be selected according to the evaluation needs and reclaimed water use characteristics. A comprehensive evaluation system should contain a reasonable number of indicators in terms of different aspects and avoid repetition.

Table 1 — Example of main indicators for benefit evaluation of reclaimed water use

Category	Indicators
Resource benefit	Conventional water resource savings, energy, carbon, and phosphorous resource recovery, etc.
Ecological and environmental benefit	Reduction of contaminants, electricity use, greenhouse gas (GHG) emissions, and achievement of E-flows, ecosystem protection/restoration, etc.
Social benefit	Improvement of local natural environment, improvement of regional natural environment, etc.
Economic benefit	Avoided cost, net present value (NPV), internal rate of return (IRR), etc.

6.2 Resource benefits

6.2.1 Conventional water resource savings

Reclaimed water can be an alternative water resource for many activities that do not require potable water quality. The amount of conventional water resource (i.e. surface water, rivers and lakes and groundwater that are naturally available) savings due to the substitution by reclaimed water and other water-saving activities can be calculated using Formula (1):

$$Q_t = A_1 - Q_s \tag{1}$$

where

A_1 is the amount of conventional water resource savings, expressed in m^3;

Q_t is the amount of reclaimed water use, expressed in m^3;

Q_s is the amount of water savings from water-saving activities and measures, expressed in m^3.

6.2.2 Energy resource recovery

Reclaimed water contains energy resources which can be further extracted and utilized. The amount of energy (heat or cold) resource recovery during water reclamation and reuse processes can be calculated using Formula (2):

$$A_2 = Q_w \times \rho \times \Delta t \times C$$

$$A_c = \frac{A_2 \times F}{F + 1} \tag{2}$$

$$A_h = \frac{A_2 \times H}{H - 1}$$

where

A_2 is the amount of heat or cold energy recovered during water reclamation and reuse processes, expressed in kJ;

Q_w is the amount of reclaimed water used during the process, expressed in m^3;

ρ is the density of reclaimed water, expressed in kg/m^3;

Δt is the temperature difference of extracted reclaimed water, expressed in °C;

C is the specific heat capacity of reclaimed water, 4,19 kJ/(kg·°C);

A_c is the amount of cold energy output of the reclaimed water heat pump system, expressed in kJ;

A_h is the amount of heat energy output of the reclaimed water heat pump system, expressed in kJ;

F is the performance coefficient of reclaimed water heat pump unit for cooling;

H is the performance coefficient of reclaimed water heat pump unit for heating.

6.2.3 Carbon resource recovery

Reclaimed water contains carbon resources which can be further extracted and utilized. The amount of carbon resource recovery during water reclamation and reuse processes can be calculated using Formula (3):

$$A_3 = \sum_{i=1}^{n} A_{3,i} \tag{3}$$

where

$A_{3,i}$ is the amount of carbon resource recovery during water reclamation processes (e.g. sedimentation, settling and fermentation processes) via physical separation, hydrolysis and/or fermentation approaches, expressed in kg COD;

n is the number of water reclamation processes with carbon resource extraction and recovery.

6.2.4 Phosphorous resource recovery

Reclaimed water contains phosphorous resources which can be further extracted and utilized. The amount of phosphorous resource recovery during water reclamation and reuse processes can be calculated using Formula (4):

$$A_4 = \sum_{i=1}^{n} A_{4,i} \tag{4}$$

where

$A_{4,i}$ is the amount of phosphorous resource recovery during water reclamation processes (e.g. biological treatment and anaerobic digestion processes) via the formation of struvite, hydroxyapatite, etc., expressed in kg;

n is the number of water reclamation processes with phosphorous resource extraction and recovery.