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GPP CRITERIA

WASTE WATER INFRASTRUCTURE

Technical Background Report

Draft

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LIST OF ABBREVIATIONS AND ACRONYMS

BAT	Best Available Technology
BREF	BAT reference documents
BOD	Biological Oxygen Demand
CBA	Cost-Benefit Analysis
CEN	Comité Européen de Normalisation
COD	Chemical Oxygen Demand
COMMPS	Combined Monitoring-Based and Modelling-Based Priority Setting
CPR	Construction Product Regulation
DB	Design/Build
DBO	Design/Build/Operate
DEHP	Di(2-ethylhexyl)phthalate
DDT	Dichloro-diphenyl-trichloroethane
DS	Dry Solids
EEA	European Economic Area
EIA	Environmental Impact Assessment
EMAS	Eco-Management and Audit Scheme
EN	European Standard
EPD	Environmental Product Declaration
EQS	Environmental Quality Standards
ETS	Emission Trading System
EU	European Union
FAQ	Frequently Asked Question
FEASIBLE	Financing for Environmental, Affordable and Strategic Investments that Bring on Large-scale Expenditure
FIDIC	Federation Internationale des Ingenieurs-Conseils
GHG	Green House Gases
GPA	General Procurement Agreement
GPP	Green Public Procurement
ha	Hectare
ISO	International Organization for Standardization
IPPC	Integrated Pollution Prevention and Control
kWh	Kilo Watt Hours
LCA	Life Cycle Assessment
LCC	Life cycle cost
N	Nitrogen

MBR	Membrane bioreactor
mg	Milligram
MLSS	Mixed Liquid Suspended Solids
MTBM	Microtunnel Boring Machine
NPV	Net present value
O&M	Operation and Maintenance
P	Phosphorus
PAH	Polycyclic Aromatic hydrocarbons
PE	Person Equivalent
PFOS	Perfluorooctane Sulfonic Acid
RB	River Basin
RBMP	River Basin Management Plan
SBR	Sequencing Batch Reactor
SCADA	Supervisory Control and Data Acquisition
SCC	Social Cost of Carbon
SS	Suspended Solids
TBM	Tunnel Boring Machine
UV	Ultraviolet
UWWT	Urban Waste Water Treatment
UWWTD	Urban Waste Water Treatment Directive
WFD	Water Framework Directive
WLC	Whole Life Costs
WTO	World Trade Organisation
WWTP	Wastewater Treatment Plant

1 Introduction

1.1 Background

Green Public Procurement (GPP) is defined in the Communication (COM (2008) 400) “Public procurement for a better environment” as "a process whereby public authorities seek to procure goods, services and works with a reduced environmental impact throughout their life cycle when compared to goods, services and works with the same primary function that would otherwise be procured.”

Furthermore, green purchasing is also about influencing the market. By promoting and using GPP, public authorities can provide industry with real incentives for developing green technologies and products. In some sectors, public purchasers command a large share of the market (e.g. public transport and construction, health services and education) and so their decisions have considerable impact.

GPP is a voluntary instrument, which means that Member States and public authorities can determine the extent to which they implement it.

Presently, GPP criteria have been developed for 19 products, service groups and works. Additional GPP criteria are being developed. In 2010, a new procedure for developing EU GPP criteria was established to enhance the synergies among policy instruments such as EU GPP and EU Ecolabel.

Investments in wastewater infrastructure are substantial today and the use of GPP criteria is expected to have a high impact on the greening of infrastructure projects. Therefore, the GPP criteria are important to guide the investments in wastewater infrastructure in order to align the procurement with the Europe 2020 strategy.

This report presents the Technical Background Report for the GPP Criteria for Wastewater Infrastructure works based upon the "shortened procedure". For the purpose of this report Wastewater Infrastructure works are meant as wastewater collection system and wastewater treatment.

1.2 GPP criteria for wastewater infrastructure

Objective

The objective of this project "GPP Criteria for Wastewater Infrastructure" is to provide managing authorities, intermediate bodies and implementing agencies with adequate guidance to meet the environmental legal requirements, information about effective technological alternatives, as well as to inform them on best practices through the development of GPP criteria for the EU green public procurement of wastewater infrastructures.

Outputs

The project outputs will be the following items:

- Technical background report including:
  - Analysis of the proper wastewater treatment to fulfil existing regulations
  - Key environmental impacts/contribution to resource efficiency
  - Feasibility analysis of the different wastewater infrastructure technologies/scenario include methodology for Life cycle cost (LCC) and other conditions for implementation

- EU Green Public Procurement criteria with core and comprehensive criteria for each scenario assessed and type of contract identified.

The GPP criteria for wastewater infrastructure works will be developed for:

  - Construction/renovation of collecting systems
  - Wastewater treatment covering different level of treatment methods and technologies incl. treatment of sludge

1.3 Present wastewater handling in EU

In this section a brief overview of the present wastewater handling in EU is given as this is important for understanding the need for development and implementation of future wastewater infrastructure projects in the Member States where the use of GPP criteria can be incorporated. The information in this sections is mainly based on */EU. Commission Staff Working Paper. 6th Commission Summary on the Implementation of the Urban Waste Water Treatment Directive. 7.12.2011/*.

Implementation of the Urban Waste Water Treatment Directive (described in Section 2.7 in the present report) is essential for fulfilment of the water quality standards in the water recipients in the Member States. The objective of the Directive is to protect the water environment from the adverse effects of discharges of urban wastewater from settlement areas and some specific industries by requiring the Member States to ensure that such wastewater is collected and adequately treated. Full implementation of the Directive is a pre-requisite for meeting the environmental objectives set out in the EU Water Directive.

Below is given an overview of the fulfilment of the Directive in EU-15[1] and EU-12[2] Member States. The reference year is 2007/2008.

Wastewater collecting systems

In general wastewater collecting systems showed a very high level of compliance in EU-15 and slightly increased compliance for some EU-12 Member States.

Wastewater collecting systems were in place for 99% of the total polluting load of EU-15 and for 65% of the total generated load of EU-12. Most EU-15 Member States had almost fully implemented wastewater collecting systems except for Italy and Greece which have 93% and 87% of generated load collected in collecting systems, respectively. For EU-12, Bulgaria, Slovakia and Slovenia had a share between 70 to 80%, all other new Member States have a share of around 80% and Malta 100% of the generated load collected in collecting systems. Only Cyprus and Romania had only around 50% of their load collected in a collecting system.

Wastewater treatment

Secondary treatment was in place for 96% of the load for EU-15 and for 48% of the load for EU-12. As the wastewater treatment plants in operation cannot always achieve quality standards in line with the Directive's requirements due to for instance inadequate capacity, performance or design etc., only 89% of the total generated load for EU-15 and 39% of the total generated load for EU-12 were reported to work adequately showing compliant monitoring results for secondary and more stringent treatment respectively.

More stringent treatment, i.e. typically nitrogen and/or phosphorus removal, was in place for 89% of the load for EU-15 and for 27% of the generated load for EU-12. Again the WWTPs in operation cannot always achieve quality standards in line with the Directive's requirements (same reasons as for secondary treatment), 79% of the total generated load for EU-15 and 24% of the total generated load for EU-12 were reported to work adequately.

Need for infrastructure projects

Based on the above data, it is obvious that there is still a large need for new wastewater infrastructure projects, especially in some of the EU-12 countries, for fulfilment of the requirement in the UWWTD. The main purpose of procurement of the many wastewater infrastructure projects will hence be to fulfil the requirements in the Directive.

Beside there is a large need for rehabilitation projects. In many Member States (both EU-15 and EU-12 countries) part of the existing wastewater collection

[1] EU-15 refers to Member States which joined the EU before the 2004 enlargement: Austria, Belgium, Denmark, Germany, France, Finland, Greece, Ireland, Italy, Luxemburg, Portugal, Spain, Sweden, The Netherlands and United Kingdom; however it should be noted that, on what regards this Summary, EU-15 does not cover United Kingdom, referring therefore to 14 Member States only

[2] EU-12 refers to Member States who acceded to the EU in 2004 and 2007 enlargements: Czech Republic, Cyprus, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia, Slovenia, Bulgaria and Romania.

systems need severe rehabilitation and also several wastewater treatment plants needs rehabilitation and upgrading.

Use of GPP criteria

Implementation of wastewater infrastructure projects will of course have a significant positive environmental impact on the receiving water bodies.

The use of GPP criteria for wastewater infrastructure shall therefore be seen as an opportunity for wastewater managing authorities to supplement the basic requirement and specifications with some additional selection criteria either to ensure that wastewater infrastructure projects are procured and implemented as environmental friendly as possible or to give credit to innovative technical solutions that fulfil even stricter wastewater effluent values for the treated wastewater.

1.4 Present report

The present Draft Technical Background Report includes the following items:

- Description of the relevant European Environmental Policy and Legislation in relation to public procurement
- Description of the most relevant and used wastewater infrastructure technologies within the EU Member States
- Description of the normal wastewater infrastructure procurement methods, type of contract and commonly used design stages and where GPP criteria could fit in
- Key environmental impacts from construction and operation of wastewater infrastructure projects
- Definition and description of typical wastewater infrastructure project scenarios relevant for demonstration of GPP criteria
- Lifecycle costing considerations and suggested approach for applying LCC in relation to wastewater infrastructure projects
- Introduction to environmental criteria for wastewater infrastructure projects.
- Proposed core and comprehensive GPP criteria for wastewater infrastructure projects.

In the Product Sheet for GPP Criteria for Wastewater Infrastructure the core and comprehensive criteria will be further specified and described including a description of, how the criteria can be used for actual wastewater infrastructure projects.

2 Relevant European Environmental Policy and Legislation

2.1 Introduction

This chapter present the results of the desk study reviewing the legal framework, EU legislation concerning GPP, EU environmental policies and modalities of public contracts for wastewater infrastructure and related water specific regulations.

2.2 Legal Framework

The legal framework for public procurement is defined by the provisions of the Treaty on the Functioning of the European Union and by the EU Procurement Directives (Directives 2004/17/EC and 2004/18/EC). From an international perspective the EU is bound by the conditions of the General Procurement Agreement (GPA) of the World Trade Organisation (WTO).

The above-mentioned framework establishes a number of rules and principles which must be observed in the award of public contracts. Within this framework, environmental objectives can be implemented in a variety of ways.

Sector-specific EU legislation also creates certain mandatory obligations for the procurement of specific goods and services, for example, by setting minimum energy-efficiency standards which must be applied. Mandatory obligations currently apply in the following sectors:

- Office IT equipment - IT products purchased by central government authorities must meet the latest minimum energy efficiency requirements prescribed by the EU Energy Star Regulation (Regulation No 106/2008 on a Community energy-efficiency labelling programme for office equipment)

- Road transport vehicles - all contracting authorities must take into account the operational energy and environmental impacts of vehicles as part of the procurement process. (Directive 2009/33/EC on the promotion of clean and energy-efficient road transport vehicles)

- Buildings - From 2013 at the latest, minimum energy performance requirements will need to be applied in all new build and major renovation projects. From 1 January 2019 all new buildings occupied and owned by public authorities must be "nearly zero-energy buildings" (Directive 2010/31/EU on the energy performance of buildings)

In addition, some Member States have specific rules which create mandatory GPP standards for particular sectors or types of contracts.

/Source: Buying Green - A handbook on green public procurement, 2nd edition. EU, 2011/ http://ec.europa.eu/environment/gpp/buying_handbook_en.htm

2.3 GPP in EU policy

GPP has been endorsed in a number of EU policies and strategies to reflect its recognised potential to encourage a more sustainable use of natural resources, establish behavioural changes for sustainable consumption and production, and drive innovation. Europe 2020, the EU strategy for smart, sustainable and inclusive growth highlights GPP as one of the measures in achieving such growth.

In 2008 the European Commission adopted a Communication on GPP, which as part of the Sustainable Production and Consumption Action Plan introduced a number of measures aimed at supporting GPP implementation across the EU. Its key features are:

EU GPP criteria

To assist contracting authorities in identifying and procuring greener products, services and works, environmental procurement criteria have been developed for 19 product and service groups, which can be directly inserted into tender documents. These GPP criteria are regularly reviewed and updated to take into account the latest scientific product data, new technologies, market developments and changes in legislation.

Helpdesk

The European Commission established a Helpdesk to disseminate information about GPP and to provide answers to stakeholders enquiries.
Contact details are available on the GPP website at:
http://ec.europa.eu/environment/gpp/helpdesk.htm

Monitoring

The European Commission has commissioned several studies aimed at monitoring the implementation of GPP at all governmental levels. The most recent study was published in 2009, and examined implementation in seven countries – Austria, Denmark, Finland, Germany, The Netherlands, Sweden and the UK.
The results can be found on the GPP website:
http://ec.europa.eu/environment/gpp/studies_en.htm
A further monitoring study has been carried out in 2011.

Information

The GPP website is a central point for information on the practical and policy aspects of GPP implementation. It provides links to a wide range of resources related to environmental issues as well as local, national and international GPP information. This includes a News-Alert featuring the most recent news and events

on GPP, a list of responses to Frequently Asked Questions (FAQs), a glossary of key terms and concepts, studies and training materials. All are available for download from the website:
http://ec.europa.eu/environment/gpp

/Source: Buying Green - A handbook on green public procurement. EU, 2011/

2.4 Description of GPP relevant legislation for wastewater infrastructure

2.4.1 Key Environmental Impacts and how to deal with them

The establishment and operation of wastewater infrastructure triggers various types of environmental impacts. They can initially be divided into two groups. One group includes the intended impacts of the wastewater operation as such, namely to improve quality of discharge and ensure sludge reuse. The other group includes unintended environmental impacts connected with the materials, equipment and physical activities related to construction and operation.

2.4.2 Wastewater discharge and sludge reuse

The capacity of a wastewater infrastructure will need to be sufficient to handle the quantities and qualities of wastewater of the geographic area in question and provide adequate treatment. This again depends on population density and the general environmental sensitivity of the considered region.

2.4.3 The development of the wastewater infrastructure

The mere construction and occasional modernisation of the infrastructure will generate various “unintended” environmental impacts. These impacts are linked to construction materials used, noise control, waste generation during the construction process, the energy consumption, the recycling potential of equipment and other installations included under the construction process. Quite a few of these impacts would be similar to those applying for buildings in general so guidance can be found in the GPP material concerning construction. The importance of these impacts depends very much on the activities and decisions during the planning phase where the infrastructure and works process is being determined.

2.4.4 The operation of the wastewater infrastructure

The environmental impacts connected to operation of the infrastructure (beside environmental impact from the discharge of treated wastewater), including repairs and other maintenance, include energy consumption, consumption of precipitation chemicals and polymers, waste generation as well as air pollution and generation of odours and noise.. Leakages, overflows and similar irregularities will obviously have particularly critical impacts. There are also, in addition to the construction of infrastructure as such impacts created by vehicles, pumps, measuring instruments and other moveable equipment that are part of the operation.

2.5 The various contract types

The manner of involving the private sector in wastewater infrastructures depends very much on prevailing national practices for outsourcing. In some countries the private sector may be asked to merely construct and repair whereas in others the approach is to include the private sector in operation, occasionally involving actual transfer of ownership of the infrastructure.

These variations in policies are expressed in the different types of contracts used in the water sector. Contracts may concern only design and construction, together or separately. Contracts concerning specifically management and operation might occur and there is finally more comprehensive contracts where design, works and operation may be contracted as a whole and the project as such delegated to the private party to execute. The obligation to maintain and repair infrastructure will often be contractually defined as an integrated part of the operational duties. Occasionally, the project may be extended to include an obligation for the private party to make the necessary investments for the purpose of modernization.

The public private partnerships are typically distinguished according to the extent to which they cover some or all of the above phases, hence the various abbreviations DB (design/build), DBO (design/build/operate) etc. The contracts may also differ as to the consideration that the private party receives. In the case of separate contracts for design, works or management it will be payment of an agreed sum. In the case of a more comprehensive public private partnership contract the private party may instead be given the right to exploit the infrastructure and thus recover costs, including investments, through the tariffs charged to the customers. In these cases, the contractual relationship between the parties will often take the form of a concession.

However, in relation to any environmental obligations none of these distinctions according to contract type or manner of consideration are important. What matters are the activities that the contract covers and the distinction between planning, construction and operation is indeed appropriate for covering all contractual aspects of relevance for GPP. For the purpose of providing useful advice, focus should therefore be put on activities to be included and it is in fact not necessary to complicate matters by introducing further distinctions according to how contracts are habitually categorized and which of these are most frequently used in practice.

Section 4 in the present report provides an outline of the FIDIC standard contracts, which are the commonly used contracts in WWTP projects. These different contracts, more specifically Red Book, Yellow Book and Silver Book contracts combine the three activity phases described above. The three phases and the corresponding different requirements can therefore be combined according to the structure of the FIDIC contracts or in other ways, including separate contracts for design and operation etc.

2.6 EU Public procurement directives

Public procurement

The public procurement directives set requirements for the manner in which certain larger public contracts must be contracted. The essential requirement is the use of a competitive procedure (tendering) involving all interested enterprises and with conditions and selection processes that are non-discriminatory, proportionate, transparent and verifiable and applied in a consistent manner. The directives allow the use of various tender procedures ranging from open procedures without any negotiation, procedures involving all interested bidders and with negotiating phases and finally procedures that may in principle involve only one bidder. The so called negotiated procedures are allowed especially in case of more complex projects, including for example comprehensive public private partnerships.

The scope of the directives is limited to contracts of a certain size. It is assumed to be particularly relevant in the context of economic activities between EU member states and the directives do not apply to concessions defined in the sense mentioned above, under Section 2.3. However, the directives are as a consequence of the hierarchical structure of EU law considered as merely concrete expressions of general principles of transparency and equal treatment that must be taken into consideration for broader areas of public contracting.

This broader application means in practice that not just the design and construction but also the more comprehensive contracting of water infrastructure projects with the inclusion of operation and investment activities even where such projects are not strictly covered by the directives. The environmental requirements will still relate to different activities as described above under Section 2.3. However, transposed to the different phases of a procurement process, the requirements will need to be of a different nature depending on whether they concern technical specifications, contract terms or the criteria for qualification and contract award.

For all procedures the directives set requirements for standards to be used especially in technical specifications, the content of publications as well as qualification and award criteria. The directives explicitly allow environmental requirements to be included[3] and the various options in this respect are further outlined in 2.6 below.

Technical specifications

When it comes to technical specifications, the requirements must be formulated as mandatory requirements. If bidders in these cases deviate from the specifications in their bids the effect might be that the bid must be rejected as non-responsive. To minimize uncertainty in this respect, the instructions to bidders may usefully indicate on which points alternative solutions would be acceptable and which issues are so important that any deviations must necessarily lead to rejection. Typical specifications to safeguard environmental concerns would consist of

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[3] In this connection the directives explicitly refer to the requirements under EU environmental arrangements concerning environmental management and eco-labels. However, to ensure transparency and equal treatment, products that fulfil the requirements under the eco-label without having the label must also be accepted.

specifications regarding the use of certain eco-friendly materials, requirements for the capacities and efficiency of the wastewater infrastructure, requirements regarding the frequency and scope of sampling and other control procedures and requirements regarding the energy-efficiency and waste management levels of the operation in general. In the case of project–oriented procurement involving both design, construction and operation, the technical specifications concerning the construction may be output oriented and thus leaving open for bidder to design his own technical approach. This allows him to choose (and take the risk for) the solutions for fulfilling the output specifications (including environmental ones) that best suit his operation.

Contractual terms

As regards contractual terms, there may be a number of points that are fixed in the draft contract which is part of the tender dossier issued by the procuring entity. This would include classical terms concerning liability, compensation etc. and any alternative proposals or reservations on the part of a bidder will in many cases result in the bid being rejected as non-responsive along the same lines as in the case of technical specifications. Contractual terms of environmental relevance include for example requirements to ensure that eventual tariffs are set in accordance with the polluter-pays principles. This means in concrete terms that the full cost is paid by households and which on the other hand allocates the basic operational risk on operator by limiting the costs that in this way can be passed on. The operator must be insured to cover any environmental liability or obligations for operator to regularly report to the procuring entity to enable fulfilment of information obligations in relation to the public.

Concerning qualification criteria, the requirements are necessarily formulated as minimum levels concerning financial and technical capacity and with indication of documentation that bidders must submit to allow the procuring entity to verify that the criteria are fulfilled. The question of rejection is more straightforward provided that the criteria are sufficiently quantified and verifiable. Qualifications of environmental relevance would for example concern specific environmental management experience and qualifications.

Award criteria

The award criteria provide the basis for evaluating the bids and for identifying the winning bid. This phase of the procurement process involves bids from bidders that have been evaluated as qualified and whose bids are otherwise compliant in respect of technical specifications as well as the contract terms. The award criteria define the themes for competition and the directives allow a choice between either lowest price only or the most economically advantageous tender. It is in the latter case that environmental aspects become relevant.

Moreover, the award criteria must relate to the bid and must not be confused with the above qualification criteria, which concern the evaluation of the bidders' ability to perform the contract in question. Award criteria can on the other hand include issues that might as well have been used as technical specifications or for that matter contract terms.

Thus, award criteria can be formulated as performance requirements where bidders would be allowed to commit to higher levels of (for example) wastewater treatment efficiency or higher degrees of monitoring. Award criteria could also concern terms of the contract allowing bidders to propose terms that go beyond a minimum that the contract prescribes, for example higher levels of investment obligations or higher/stricter targets for pollution control on site, including reduction of minor effects, such as odours.

EU environmental requirements

The nature of these various EU environmental requirements of relevance for water infrastructures are further outlined in Section 2.6 below. The procurement directives make reference to some of these requirements, notably the EMAS (Eco-Management and Audit Scheme) and the Eco-label regulations. Both schemes are voluntary and their inclusion in the directives does not mean that the use of these schemes is made mandatory. The purpose is to ensure transparency and equal treatment and to limit the use of purely national schemes as requirements or criteria.

Use of national eco-label schemes is not actually excluded but in the special case, where a procuring entity wishes to require a certificate for environmental audit, it is obliged to refer to EMAS only. This does not mean that the procuring entity can require bidders to join the EMAS scheme. The procurement directives make quite clear that procuring entities cannot refuse to accept other certificates or for that matter labelling schemes from a bidder, if such alternatives offer similar guarantees as EMAS. This is important for contracting entities to keep in mind when using these regulations as basis for requirements and criteria.

The role of these regulations in the public procurement process differs. The standards developed on the basis of the Eco-label regulation relate to the various categories of products that the regulation covers. These standards can thus be used as basis for development of technical specifications or award criteria. The EMAS Regulation concerns organisation and production processes, all in all environmental management. Capacity for environmental management is not just relevant when formulating qualification requirements. Such capacities are relevant also where technical specifications or contract terms include requirements to production processes. As it is further described in 2.6 below, the environmental management requirements can in certain cases even be used as award criteria.

New proposals for a reform of the public procurement directives were tabled just towards the end of 2011[4]. It is of course too early to say what the directives will look like once this proposal has been through discussions in Council and the European Parliament. However, a notable new element is the explicit mentioning of life-cycle costing. The proposed rules require that the methodology of the cost calculation should be indicated in the tender documents and includes other conditions to ensure that all bids in such cases are evaluated on an equal and transparent basis.

[4] See COM (2011) 896 final of 20 December 2011.

2.7 EU Environmental principles and regulation

The EU environmental regulation of relevance for the establishment and operation of wastewater infrastructures can be roughly divided into general, horizontal requirements applicable for installations in general and more specific requirements related to wastewater infrastructure and processes, water quality and emission restrictions. In addition, there are certain requirements concerning energy efficiency and savings and sewage sludge that are relevant for wastewater infrastructure as well.

The requirements that follow from these rules and any requirement for the purpose of promoting environmental policies must take into consideration the specific principles of EU environmental policies, namely the precautionary principle, the principle of preventive action, the principle of rectification at source and the polluter pays principle[5]. These principles are not mere political declarations. They play an important role as guidance in cases where the detailed rules of the directives do not provide the full answer. The precautionary principle would for example speak in favour of design and construction of infrastructure that can easily be upgraded to progressively higher levels of discharge quality even in cases where the risks of increased environmental damage are not entirely certain and thus might be difficult to justify from the point of normal planning and in the context of a local political context. It is also the precautionary principle that can provide guidance when it comes to choosing between GPP core criteria and GPP comprehensive criteria.

Similarly, rectification at source might in a situation of choice lead a procuring entity to insist on strict emission requirements even when the required quality levels in force in the environment surrounding the infrastructure allows some slack.

2.7.1 Horizontal regulation

Environmental Impact Assessment (EIA)

The Environmental Impact Assessment (EIA) Directive (Dir.2001/42) requires environmental assessment of various planned projects, including waste and water infrastructure projects. The assessment must cover all possible impacts of the planned action and consider whether any alternatives would have lesser impacts. The other important requirement of the directive is the public consultation and information.

A distinction is made between categories of projects where assessment is mandatory and other categories where a significant environmental effect is likely for concrete reasons and where assessment would only be required in such cases. Large waste water treatment plants servicing areas with populations beyond a certain size are covered by the first category whereas other plants are covered by the second category.

[5] The principles are included in Art.191 of the EU Treaty but with the precise definition left to ECJ case law.

The EIA is not made a condition for approval of such projects but an EIA must have taken place before a project can be approved. The practical effect of this is that the question of EIA becomes relevant at the earliest phases of the planning of a project. For non-mandatory projects the competent national authorities must establish procedures for screening of projects to check for likely environmental effects that would require EIA.

It depends on the concrete circumstances of the project to what extent EIA relevant activities are part of the planning and design phase. Such activities should in any case be made subject to separate procurement covering the design phase exclusively. To have EIA activities included as part of a tender for an entire wastewater infrastructure project would lay the procurement process open to criticism due to the obvious conflict of interest that the appointed operator would inevitably find himself in.

Industrial emissions

The directive 2010/75 on industrial emissions (formerly integrated pollution prevention and control) includes requirements for national permit systems for large industrial installations and requires individual emission limits to be set in each permit based on best available technology (BAT). On the basis of the directive a number of BAT reference documents (the so-called BREFs) have been developed for various sectors, including waste treatment in general and certain categories of wastewater treatment. The directive does not apply to WWTPs covered by the urban wastewater directive, see 4.2.3 below, however the relevant BREFs would still be useful for formulation of for example technical specifications for construction.

Eco-management and audit system (EMAS)

The Regulation 1221/2009concerning an eco-management and audit system (EMAS) establishes a voluntary system open for industrial installations as well a number of other entities for whom environmental performance is relevant. The audit concerns sites rather than companies or organisations and requires a comprehensive environmental strategies and action plan to be established for each site covering all environmental aspects and with the purpose of continuous improvement of environmental performance. The activities on the site and supporting management systems in the enterprise concerned must be audited and the enterprise is obliged to issue regular environmental statements that are subject to independent validation. EMAS certification or any other equivalent certification or other documentation for environmental management can be used in connection with qualification requirements and the accomplishment of a level of environmental management for the site in question equivalent to what is required for EMAS or equivalent certification could be used as a contractual performance requirement for operators. EMAS and similar schemes may also play a role in the context of award criteria, even though they are process rather than product oriented. Thus, the above contractual performance requirement can instead be formulated as an award criteria and in that manner be "put to competition" to obtain optimal undertakings from the bidders[6].

Control of major-accident hazards involving dangerous substances

The so called Seveso II directive (Directive 96/82 on the control of major-accident hazards involving dangerous substances) is aimed at preventing major accidents involving large quantities of dangerous substances and to limit the consequences of such accidents. It requires operators of installations where dangerous chemicals are present to take various preventive measures, including risk assessments, emergency plans and it sets forth relatively detailed rules on inspections by competent authorities.

Environmental liability

The Directive 2004/35 on environmental liability is focused on environmental damages and opens up for in principle strict liability for the polluter. The directive allows room for special national rules as regards for example cases where there was no fault or negligence on his part and as to whether insurance should be compulsory. Depending on national solutions, the requirements of the directive could be reflected in contractual terms for operator concerning strict liability for certain environmental damages and/or obligation to take up environmental damage insurance.

EU eco-label scheme

Amongst the horizontal measures should also be mentioned Regulation 66/2010 on the EU eco-label scheme. The regulation introduces a voluntary common EU label for enterprises to use in their marketing of products. The label can be used for nearly all types of products for which eco-label criteria exist. This might very well include some of the equipment and materials to be used during the operation of a waste water infrastructure. The scheme is based on common criteria for each type of product and common assessment/verification procedures. The criteria relate to the important environmental impacts over the life cycle of the product in question and may include for example energy consumption, waste generation and release of hazardous substances. The eco-label criteria could be included as requirements in the technical specifications or award criteria for the equipment and materials that is used by the operator.

2.7.2 Water specific regulation

Water framework directive

The water framework directive (WFD) (Dir. 2000/60) requires member states to embark on a more comprehensive approach to protection of surface waters, groundwater and coastal waters based on river basin districts. The main objectives include a.o. reduction of discharges and a complete phasing-out of discharge of certain hazardous substances. In addition to managerial requirements as regards for example river management plans the directive establishes overall objectives for the various water types.

The importance of the water framework directive is for the purpose of waste water treatment especially important when it comes to the chemical substances.

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[6] See further in chapter 5.2.4 in "Buying Green. A Handbook on Green Public Procurement" published by the Commission of the European Union.

The European Community and individual Member States have over the years taken many initiatives and introduced various legislation and regulatory instruments to protect the aquatic environment against chemical pollution, many of which are now incorporated in the Water Framework Directive.

Whereas Council Directive 91/271/EEC concerning urban wastewater treatment establishes general requirements for the treatment of urban wastewater and sets specific limit values for general wastewater constituents and parameters (e.g. COD, BOD_5, SS, N and P), it does not directly address the issue of chemical substances occurring not only in industrial effluents but also in urban sewage as a result of the ubiquitous use of such substances in modern society.

Instead, a number of other directives have been regulating chemical substances in relation to aquatic pollution, in particular Directive 76/464/EEC "on pollution caused by certain dangerous substances discharged into the aquatic environment of the Community" with daughter directives.

However, the introduction of the Water Framework Directive (WFD) (Directive 2000/60/EC) marks a new approach to the protection of the aquatic environment in the European Community by taking the desired quality of the aquatic environment as the starting point instead of the traditional source/discharge oriented approach applied e.g. in Directives 76/464/EC and 91/271/EEC. This approach implies that in principle any emission limit value should be established locally for the specific discharge by taking into consideration the required environmental quality, the size and conditions of the specific water body (not least the water exchange) and possible releases from other pollution sources. From that information the acceptable substance concentration in the effluent in question is determined.

The WFD also introduced the terms "priority substances" and "priority hazardous substances", which the Member States are obliged to control by "progressively reducing pollution from priority substances and ceasing or phasing out emissions, discharges and losses of priority hazardous substances" (Article 4(a)(iv)).

A main long term environmental objective of the WFD is to achieve "good surface water status" in as many of the Community's surface waters as possible (exemptions possible for "heavily modified water bodies"). With regard to chemical pollutants the basis for achieving this is that the surface water body has a "good surface water chemical status" meaning that the "concentrations of pollutants do not exceed the environmental quality standards established in Annex IX" to the directive.

Environmental Quality Standards

When the WFD was introduced in 2000, Annex IX only comprised quality standards (limit values) for a few substances, which had been adopted from the daughter directives of Directive 76/464/EEC. In 2001, Decision no. 2455/2001/EC established the first list of (33) priority substances and in 2008 a daughter directive under the WFD, Directive 2008/105/EC on "environmental quality standards in the field of water policy…" ("The EQS Directive"), entered into force. This directive confirmed 13 of the 33 "priority substances" as "priority hazardous substances" (Annex II) and establishes environmental quality standards (EQS) in "inland surface waters" and "other surface waters" (Annex I) for all 33 priority substances and for eight "other pollutants" from earlier legislation.

In relation to discharges to the aquatic environment, Directive 2008/105/EC requires that the EQS values are complied with in surface water bodies. Member States may designate mixing zones adjacent to points of discharge. Their extent should be "restricted to the proximity of the point of discharge" and "proportionate" (Article 4, point 3(a) and (b)). Concentrations of one or more of the priority substances or other pollutants may exceed the relevant EQS within such mixing zones if they "do not affect the compliance of the rest of the body of surface water with those standards".

Recently (31.01.2012), a proposal for a revised EQS directive has been put forward by the European Commission (COM(2011) 876 final). Among other things the proposal suggests to add 15 new priority substances to the existing list and revised EQS values for a number of the existing substances. Nine of the new substances are pesticides but the amended list also includes more wastewater relevant substances such as e.g. PFOS (perfluorooctane sulfonic acid and its derivatives) and two substances with estrogenic activity i.e. 14α-ethinylestradiol (synthetic estrogen) and 17β-estradiol (natural estrogen).

For the purpose of procurement processes the capacity to deal with the substances in question must be a part of the technical requirements for design, construction as well as operation. Award criteria could be designed to allow bidders to compete on higher ability to deal with these hazardous substances or with other hazardous substances in addition to the ones presently covered by the directive.

Priority substances under the WFD

The environmental quality standards (EQS) for the 33 priority substances under the WFD and EQS Directive (Annex I) are listed below in Table 6-1 (direct copy of Annex I to the EQS Directive). It is noted that the proposal for a revised EQS directive (see above) also includes changes in EQS values for a number of the existing Annex I substances.

As appears from the table, two types of EQS are developed; and annual average value (AA-EQS) and a maximum allowable concentration (MAC-EQS), the former being relevant for continuous discharges while the latter refers to releases occurring only occasionally and with short duration. For some substances a short term EQS has not been defined.

Further, two sets of EQS, for "inland surface waters" and "other surface waters" (estuaries, coastal and marine waters) respectively, have been established for some substances due to observed or potential higher variation in sensitivity among organisms in the marine environment than among freshwater organisms. I.e. the inland surface waters EQS are either higher or identical with the EQS for other surface waters.

It is also noted that a substantial number (12) of the 33 priority substances and 8 other pollutants are specific pesticides, which are not permitted or at least severely restricted in the EU today and therefore even less relevant to urban wastewater treatment plants than pesticides in general.

Obviously, a list of only 33 plus 8 substances is not exhaustive and the list may also to some extent be historically and/or geographically "biased" as the substances were identified and prioritised some years ago using a procedure, the so-called COMMPS procedure (combined monitoring-based and modelling-based priority-setting), which takes into account the inherent substance properties, information about uses and volumes, **and** available aquatic monitoring data from throughout Europe to identify substances of EU-wide relevance; there may have been more rapid changes in some Member States than others.

Chemical pollutants are also addressed under the "good ecological status" objective of WFD. These pollutants, generally called "river basin specific pollutants" or "Annex VIII" pollutants, are substances identified by EU Member States as being of national or local concern. Member States derive EQS at national level for these substances, and are required to meet them in order to reach good ecological status.

Table 2-1 Environmental Quality standards (EQS) for the 33 priority substances covered by Directive 2008/105/EC (daughter directive of the WFD).

ANNEX I

ENVIRONMENTAL QUALITY STANDARDS FOR PRIORITY SUBSTANCES AND CERTAIN OTHER POLLUTANTS

PART A: ENVIRONMENTAL QUALITY STANDARDS (EQS)

AA: annual average;

MAC: maximum allowable concentration.

Unit: [μg/l]

(1)	(2)	(3)	(4)	(5)	(6)	(7)
No	Name of substance	CAS number (1)	AA-EQS (2) Inland surface waters (3)	AA-EQS (2) Other surface waters	MAC-EQS (4) Inland surface waters (3)	MAC-EQS (4) Other surface waters
(1)	Alachlor	15972-60-8	0,3	0,3	0,7	0,7
(2)	Anthracene	120-12-7	0,1	0,1	0,4	0,4
(3)	Atrazine	1912-24-9	0,6	0,6	2,0	2,0
(4)	Benzene	71-43-2	10	8	50	50
(5)	Brominated diphenylether (5)	32534-81-9	0,0005	0,0002	not applicable	not applicable
(6)	Cadmium and its compounds (depending on water hardness classes) (6)	7440-43-9	≤ 0,08 (Class 1) 0,08 (Class 2) 0,09 (Class 3) 0,15 (Class 4) 0,25 (Class 5)	0,2	≤ 0,45 (Class 1) 0,45 (Class 2) 0,6 (Class 3) 0,9 (Class 4) 1,5 (Class 5)	≤ 0,45 (Class 1) 0,45 (Class 2) 0,6 (Class 3) 0,9 (Class 4) 1,5 (Class 5)
(6a)	Carbon-tetrachloride (7)	56-23-5	12	12	not applicable	not applicable
(7)	C10-13 Chloroalkanes	85535-84-8	0,4	0,4	1,4	1,4
(8)	Chlorfenvinphos	470-90-6	0,1	0,1	0,3	0,3
(9)	Chlorpyrifos (Chlorpyrifos-ethyl)	2921-88-2	0,03	0,03	0,1	0,1
(9a)	Cyclodiene pesticides: Aldrin (7) Dieldrin (7) Endrin (7) Isodrin (7)	 309-00-2 60-57-1 72-20-8 465-73-6	Σ = 0,01	Σ = 0,005	not applicable	not applicable
(9b)	DDT total (7) (8)	not applicable	0,025	0,025	not applicable	not applicable
	para-para-DDT (7)	50-29-3	0,01	0,01	not applicable	not applicable
(10)	1,2-Dichloroethane	107-06-2	10	10	not applicable	not applicable
(11)	Dichloromethane	75-09-2	20	20	not applicable	not applicable
(12)	Di(2-ethylhexyl)-phthalate (DEHP)	117-81-7	1,3	1,3	not applicable	not applicable
(13)	Diuron	330-54-1	0,2	0,2	1,8	1,8
(14)	Endosulfan	115-29-7	0,005	0,0005	0,01	0,004
(15)	Fluoranthene	206-44-0	0,1	0,1	1	1
(16)	Hexachloro-benzene	118-74-1	0,01 (9)	0,01 (9)	0,05	0,05
(17)	Hexachloro-butadiene	87-68-3	0,1 (9)	0,1 (9)	0,6	0,6
(18)	Hexachloro-cyclohexane	608-73-1	0,02	0,002	0,04	0,02

Table 6-1 - *continued.*

(1)	(2)	(3)	(4)	(5)	(6)	(7)
No	Name of substance	CAS number (1)	AA-EQS (2) Inland surface waters (3)	AA-EQS (2) Other surface waters	MAC-EQS (4) Inland surface waters (3)	MAC-EQS (4) Other surface waters
(19)	Isoproturon	34123-59-6	0,3	0,3	1,0	1,0
(20)	Lead and its compounds	7439-92-1	7,2	7,2	not applicable	not applicable
(21)	Mercury and its compounds	7439-97-6	0,05 (9)	0,05 (9)	0,07	0,07
(22)	Naphthalene	91-20-3	2,4	1,2	not applicable	not applicable
(23)	Nickel and its compounds	7440-02-0	20	20	not applicable	not applicable
(24)	Nonylphenol (4-Nonylphenol)	104-40-5	0,3	0,3	2,0	2,0
(25)	Octylphenol ((4-(1,1′,3,3′-tetramethylbutyl)-phenol))	140-66-9	0,1	0,01	not applicable	not applicable
(26)	Pentachloro-benzene	608-93-5	0,007	0,0007	not applicable	not applicable
(27)	Pentachloro-phenol	87-86-5	0,4	0,4	1	1
(28)	Polyaromatic hydrocarbons (PAH) (10)	not applicable	not applicable	not applicable	not applicable	not applicable
	Benzo(a)pyrene	50-32-8	0,05	0,05	0,1	0,1
	Benzo(b)fluor-anthene	205-99-2	Σ = 0,03	Σ = 0,03	not applicable	not applicable
	Benzo(k)fluor-anthene	207-08-9				
	Benzo(g,h,i)-perylene	191-24-2	Σ = 0,002	Σ = 0,002	not applicable	not applicable
	Indeno(1,2,3-cd)-pyrene	193-39-5				
(29)	Simazine	122-34-9	1	1	4	4
(29a)	Tetrachloro-ethylene (7)	127-18-4	10	10	not applicable	not applicable
(29b)	Trichloro-ethylene (7)	79-01-6	10	10	not applicable	not applicable
(30)	Tributyltin compounds (Tributhyltin-cation)	36643-28-4	0,0002	0,0002	0,0015	0,0015
(31)	Trichloro-benzenes	12002-48-1	0,4	0,4	not applicable	not applicable
(32)	Trichloro-methane	67-66-3	2,5	2,5	not applicable	not applicable
(33)	Trifluralin	1582-09-8	0,03	0,03	not applicable	not applicable

(1) CAS: Chemical Abstracts Service.
(2) This parameter is the EQS expressed as an annual average value (AA-EQS). Unless otherwise specified, it applies to the total concentration of all isomers.
(3) Inland surface waters encompass rivers and lakes and related artificial or heavily modified water bodies.
(4) This parameter is the EQS expressed as a maximum allowable concentration (MAC-EQS). Where the MAC-EQS are marked as 'not applicable', the AA-EQS values are considered protective against short-term pollution peaks in continuous discharges since they are significantly lower than the values derived on the basis of acute toxicity.
(5) For the group of priority substances covered by brominated diphenylethers (No 5) listed in Decision No 2455/2001/EC, an EQS is established only for congener numbers 28, 47, 99, 100, 153 and 154.
(6) For cadmium and its compounds (No 6) the EQS values vary depending on the hardness of the water as specified in five class categories (Class 1: < 40 mg $CaCO_3$/l, Class 2: 40 to < 50 mg $CaCO_3$/l, Class 3: 50 to < 100 mg $CaCO_3$/l, Class 4: 100 to < 200 mg $CaCO_3$/l and Class 5: ≥ 200 mg $CaCO_3$/l).
(7) This substance is not a priority substance but one of the other pollutants for which the EQS are identical to those laid down in the legislation that applied prior to 13 January 2009.
(8) DDT total comprises the sum of the isomers 1,1,1-trichloro-2,2 bis (p-chlorophenyl) ethane (CAS number 50-29-3; EU number 200-024-3); 1,1,1-trichloro-2 (o-chlorophenyl)-2-(p-chlorophenyl) ethane (CAS number 789-02-6; EU number 212-332-5); 1,1-dichloro-2,2 bis (p-chlorophenyl) ethylene (CAS number 72-55-9; EU number 200-784-6); and 1,1-dichloro-2,2 bis (p-chlorophenyl) ethane (CAS number 72-54-8; EU number 200-783-0).
(9) If Member States do not apply EQS for biota they shall introduce stricter EQS for water in order to achieve the same level of protection as the EQS for biota set out in Article 3(2) of this Directive. They shall notify the Commission and other Member States, through the Committee referred to in Article 21 of Directive 2000/60/EC, of the reasons and basis for using this approach, the alternative EQS for water established, including the data and the methodology by which the alternative EQS were derived, and the categories of surface water to which they would apply.
(10) For the group of priority substances of polyaromatic hydrocarbons (PAH) (No 28), each individual EQS is applicable, i.e. the EQS for Benzo(a)pyrene, the EQS for the sum of Benzo(b)fluoranthene and Benzo(k)fluoranthene and the EQS for the sum of Benzo(g,h,i)perylene and Indeno(1,2,3-cd)pyrene must be met.

Further special directives

There are further special directives concerning groundwater, drinking water, bathing water as well as a directive concerning nitrates in water[7]. These directives essentially lay down various quality standards as opposed to emission restrictions. Only the nitrates directive includes restrictions in emissions by prohibiting use of certain fertilizers in certain vulnerable zones. For the purpose of procurement procedures, the various quality standards can be seen as minimum requirements to the treatment efficiency that wastewater infrastructures must comply with. The quality standards might therefore be relevant for technical specifications in the design phase. A certain minimum of control procedures for incoming wastewater

[7] See directives 2006/118, 98/83, 2006/7 and 91/676 respectively

as well as for the discharges could also be part of the technical specifications as regards operation.

Urban wastewater directive

Finally, the directive 91/271 on urban wastewater treatment (UWWT) includes a number of functional requirements aimed specifically at wastewater infrastructures.

This directive concerns the collection, treatment and discharge of urban wastewater, and the treatment and discharge of wastewater from certain industrial sectors. Its aim is to protect the environment from any adverse effects due to discharge of such wastewater. The directive adopts the emission limit value approach and thus focuses on the end product of a certain process, i.e. wastewater treatment.

In practical terms it requires establishment of sewage systems within areas with concentrations of population or economic activity above certain levels.

Authorisation is required for both discharge of wastewater into such systems and for the operation of wastewater treatment plants as such. General secondary (biological) treatment must be introduced and more stringent tertiary treatment must be in place for sensitive areas. There is a general ban on discharge of sludge into waters as well as requirements as regards reuse of sludge. In terms of procurement the requirements of the directive can be converted into requirements concerning all aspects of design, construction and operation.

The Member States are required to identify sensitive and less sensitive areas which receive treated wastewater. The level of quality for the effluent, and therefore the treatment to be provided will have to vary according to the sensitivity of the receiving waters. In general, the more sensitive the recipient waters, the costlier the treatment. Sensitive areas are typically lakes or marine bays threatened by eutrophication.

Basic requirements of the directive are given in the tables below.

Table 2-2 Discharge requirements

Parameter	**Concentration**	**Min. % reduction of influent**
BOD5	25 mg/l O2	70-90%, 40%, in mountains > 1,500 m
COD	125 mg/l O2	75 %
Total SS	35 mg/l; for > 10,000 pe 60 mg/l; 2,000-10,000 pe	> 10,000 pe; 90% 2,000-10,000 pe; 70%

Table 2-3 Additional requirements for discharge to sensitive areas

Parameter	Concentration	Min. % reduction of influent
Total phosphorus	2 mg/l; 10,000 - 100,000 pe 1 mg/l; > 100,000 pe	80%
Total nitrogen	Annual means of 15 mg/l; 10,000 - 100,000 pe 10 mg/l; > 100,000 pe Or daily averages of 20 mg/l ;	70-80%

The general rule is that secondary treatment is required for all areas except those defined as sensitive areas. For sensitive areas, more advanced treatment with enhanced removal of nutrients must be applied. In certain coastal and marine areas considered less sensitive, primary treatment may be sufficient.

The directive leaves the choice as regards technologies to be left to decisions at national level.

The UWWT Directive does not contain in itself emission limits for hazardous substances nor for viruses and bacteria. The Directive contains however a provision allowing Member States to identify as sensitive areas where further treatment is prescribed to fulfil other EU legislation. Thus, for instance, disinfections processes may be incorporated to a treatment plant where the quality criteria of the Bathing Water Directive (2006/7/EC) could be affected.

2.7.3 Waste, energy-saving and other areas of relevance

Sewage sludge directive

The Sewage sludge directive 86/278 concerns use of sludge as fertilizer in agriculture. It fixes limits for heavy metal concentrations in sludge as well as for the soil in which it is applied. For procurement purposes, the requirements to sludge can be used as technical specifications or award criteria in connection with obligations on the operator as regards sludge reuse activities.

The directive specifies that sewage sludge may be used in agriculture, provided that the Member State concerned regulates its use. Sludge must be treated before being used in agriculture, but the Member States may authorise the use of untreated sludge if it is injected or worked into the soil.

The approach adopted is based on maximum limit values. The directive lays down limit values for concentrations of heavy metals in the soil and in sludge and for the maximum annual quantities of nutrients and heavy metals which may be introduced into the soil. The use of sewage sludge is prohibited if the concentration of one or more heavy metals in the soil exceeds the limit values.

The use of sludge is also prohibited:

- On grassland or forage crops if the grassland is to be grazed or the forage crops to be harvested before a certain period of time has elapsed;
- On soil in which vegetable and certain fruit crops are growing;
- On ground intended for the cultivation of certain fruit and vegetable crops, for a period of ten months preceding and during the harvest.

Basic requirements of the directive are listed in the table below.

Table 2-4 Basic Sludge Requirements

Dry matter mg/kg	**Metal in soil**	**Metal in sludge**	**Added kg/ha/yr**
Cadmium	1-3	20-40	0.15
Copper	50-140	1,000-1,750	12
Nickel	30-75	300-400	3
Lead	50-300	750-1200	15
Zinc	150-300	2,500-4,000	30
Mercury	1-1.5	16-25	0.1

The directive does not require any specific technical infrastructure to be used, though it does specify that the sludge should undergo treatment before being used in agriculture.

The European Commission is currently assessing whether the current sewerage sludge directive should be reviewed – and if so, the extent of this review. The background is that since the directive was adopted, several Member States have enacted and implemented stricter limit values for heavy metals and set requirements for other contaminants.

Wastewater package plants

A CEN standard for wastewater package plants has been issued on the basis of the Building Material Directive (repealed by the Construction Products Regulation mentioned below). The standard EN 12566, concerns a number of requirements concerning construction and to such plants, some of which are environmentally relevant. However, the standards are only relevant for such plants that are in reality a singular product in the same sense as a septic tank. Such products are of a relatively modest value and impact. They are for these reasons alone not subject to separate procurement procedures and they are therefore not relevant for developing GPP in the present context.

Construction Products Regulation

With the introduction of the Construction Products Regulation (305/2011/EU) the standardisation activities (CE labelling) will need to take into account environmental requirements. This is due to the expansion of the basic safety requirements of the Regulation to cover also sustainable use of natural resources, including recyclability, durability, emissions etc. In this context the relevant technical committee under CEN (TC 350) has been mandated to develop voluntary horizontal standardized methods for the assessment of the sustainability aspects of new and existing construction works and standards for the environmental product declaration of construction products. This work has resulted in EN 15804 concerning the product categories rules and frames for developing EPDs.

Energy performance of buildings

Directive2010/31 on the energy performance of buildings is one of the many directives which together with the Construction Products Regulation have been included as basis for the formulation of GPP criteria for construction works. The Commission is currently developing new criteria for office buildings. These GPP criteria could therefore be relevant for buildings that are part of wastewater infrastructures, such as buildings for offices and staff facilities.

There are in addition other EU directives with various requirements to energy consumption of vehicles and various other equipment that would be relevant for wastewater infrastructures for example PCs, printers or pumps. These requirements are relevant, especially the energy performance for pumps, lighting, ventilations etc.

2.8 GPP relevant criteria for wastewater infrastructure projects

The various considerations under Section 2.3-2.8 above leads to the following categories of requirements on the basis of which the actual GPP criteria can be developed. Some of the requirement may not apply to all waste water treatment project, for example very small projects and the qualification requirements may not for all projects need to be at the same level.

Table 2-5 Categories of requirements that must be covered by GPP criteria for wastewater infrastructure projects

	1. Design	2. Construction/installation	3. Operation and investments
A. Technical specifications/ performance requirements	- The WWTP and sewerage system should be designed so that any existing standard on effluents quality, reuse objectives, and bio solids regulations can be met with reasonable ease and cost. - The WWTP and sewerage system must be designed to allow discharges within the following pollution levels (include emission and quality levels (i) legally defined and (ii) suitable for the agglomeration in question); - The WWTP and sewerage system must be designed to allow treatment consisting of (include the types of treatments depending on the sensitivity of the geographic areas to be served); - The WWTP and sewerage system must be designed to allow sufficient performance under various climatic conditions of relevance for the location, including seasonal variations (include technical standards and solutions that would ensure that the plant and system can deal with normal and extraordinary amounts of wastewater); - The WWTP and sewerage system must be designed to limit (to a certain percentage) pollution of receiving waters from storm water overflows via collecting systems under unusual situations, such as	- Buildings must fulfil the relevant GPP criteria as regards energy consumption and building materials, see the specific GPP criteria already developed; - Sewerage /collection systems and wastewater treatment plants must be constructed without the use of certain hazardous substances (include materials containing certain chemicals, certain paints, varnishes etc.)	Operational routines must be specified and include: - Performance specifications involving continuous processing of water and sludge fulfilling the relevant environmental quality standards(include best practice as to how much deviation from the performance requirements are allowed before contractual sanctions are triggered) ; - Normal working routines that include measures to reduce energy consumption and other environmental impacts; - Procedures (include any best practices /standards or leave to operator – guiding principle is the precautionary principle) for regular check of buildings/installations/equipment and especially the entire collecting system to prevent leakages, overflows etc.; - Procedures (include any best practices /standards or leave to operator - guiding principle is the precautionary principle) for sampling and monitoring WWTP discharge to ensure quality and emission levels according to various water directives [indicate directives] (include concrete levels); - Procedures (include any best practices /standards or leave to operator - guiding principle is the precautionary principle) for sampling and monitoring the wastewater being captured in the collection system before WWTP to ensure quality and emission levels according to various water directives

	heavy rain. - The WWTP and sewerage system must be designed to enable treatment , reuse and safe disposal of sludge (include the normal procedure and the capacities corresponding with the general capacity of the system as a whole; treatment priority is reuse); - Use of LCA tools in the design of WWTP and collection/sewerage system (indicate which specific tools); - The project proposal must include factual information on possible environmental impacts for the purpose of EIA according to directive 85/337, including the impact of alternative designs that have been considered. - The project proposal must include appropriate material concerning the environmental impacts for the purpose of public consultation prior to the approval of the project.		[indicate directives] (include concrete levels) - Procedures for processing, reuse and disposal of sludge according to the specific requirements of the directive and prevailing best practices (include relevant requirements and operational best practices as regards sludge treatment and management). - Procedures for inspections and repairs of the infrastructure in accordance with the precautionary principle; - Tariff policies that comply with the polluter pays principle. - Procedures for keeping any pollution at the sites of the infrastructure below the requirements for the areas in question, including (up front) reduction of any odours stemming from the operation. - Use of low-emission/energy vehicles and other equipment (eco-labels or similar level of standard) - Fulfilment of relevant EMAS or equivalent conditions to obtain positive EMAS audit or similar approval of the site or part thereof[8]- Investment policies determined by precautionary principle. A continuous obligation to update

[8] . Further guidance on the scope of EMAS in the case of WWTP operation can be found in the special EMAS toolkit developed by DGENVI. http://ec.europa.eu/environment/emas/toolkit/toolkit_13_4_2.htm

			infrastructure in tune with best available technology (BAT), including existing BREFs of relevance
B. Qualification criteria	The architects, engineers etc must in addition to appropriate professional qualification demonstrate experience in designing WWTP infrastructures in accordance with environmental building design (includes in addition to construction GPPs any environmental requirements of relevance for sites in question, including, the nature habitat, emissions from materials used, preferably involving capacities and treatment methods required for the concrete area,	- Demonstrated technical capacity to build WWTP infrastructures by means of references from previous assignments (include requirements to the information that must be included on the reference list);	- Possession of required permits (include specific requirements) and demonstrated technical capacity to WWTP infrastructures by means of references from previous assignments (include requirements to the information that must be included on the reference list); - Demonstrated technical capacity to put in place environmental management measures (include EMAS certificates) to meet the following criteria: - Ensure effective protection of fauna and flora in the infrastructure sites and surroundings (where the areas of the sites are sensitive); - Environmental management measures aimed at minimizing waste generation on the sites and respecting noise regulations; - Measures to ensure energy efficiency.
C Award criteria	- The WWTP and other required infrastructures must be designed to have minimum impact on the site where it is to be placed and maximum flexibility to take account of future technological developments and regulations;	- Optimal levels of wastewater and sludge treatment capacity; - Capacity to deal with other hazardous substances in addition to the ones presently covered by the Urban Wastewater Directive like some of the hazardous substances defined under the Water Framework Directive (see Section 6.3)	- Optimal quality of discharged water and/or optimal quality of sludge for reuse; - Minimal energy-use/emission from vehicles to be used; - Eco-labelling or similar standard for all or selected types of equipment or materials used during operation.

		- Capacity for improved discharge quality below the required levels;	- High targets for pollution control on site - Size of investment programme to embrace technological and regulatory development - Accept strict environmental liability
D **Contract terms**	Normal conditions for delivery of services.	Normal environmental conditions for execution of works contracts, including for example waste management on site and use of low-emission and low-energy machinery and transport.	Tariff policies must reflect polluter-pays principle; Performance monitoring of operator to ensure that he fulfils environmental obligations. Operator must in the course of operation be obliged to fulfil various information and reporting obligations that follow from EU directives. Investment obligations to cover needs for reinvestments arising out of new environmental requirements rather than just wear and tear. Environmental liability: Contractual terms requiring compulsory insurance to cover any environmental liability

3 Wastewater Technologies

This chapter gives a short description of the wastewater infrastructure technologies most commonly used within and outside the EU. It does not include all of the technologies, but covers an absolute majority used in most procured wastewater infrastructure projects.

3.1 Sewerage systems

3.1.1 Combined and separate sewer systems

Sewerage systems are normally classified as combined or separate systems. Both systems may comprise of pipe network, retention basins and pumping stations.

Combined systems

Sewerage systems may include storm water runoff. Systems designed for handling of storm water are known as combined systems. Combined sewer systems are usually avoided in new developments because precipitation causes widely varying flows reducing wastewater treatment plant efficiency. Combined sewers require much larger and more expensive treatment facilities than separate sanitary sewers. Heavy storm runoff may overload the treatment system, causing insufficient efficiency or overflow. Sanitary sewers are typically much smaller than combined sewers, and they are not designed to transport storm water.

Separate systems

New and modern developments tend to be provided with separate storm drain systems for storm water. As rainfall travels over roofs and the ground, it may pick up various contaminants including soil particles and other sediment, heavy metals, organic compounds, oil and grease etc. Sensitive water recipients may require storm water to receive some level of treatment before being discharged directly into waterways. Examples of treatment processes used for storm water include retention basins, wetlands, different filtration technologies or other kind of treatment.

3.1.2 Construction methods

Sewer construction techniques

Three construction techniques are typically used to build sewers – trenching, micro-tunnelling and large bore tunnelling.

Trenching

Trenching is the oldest sewer construction method. Most old sewers are constructed according to this technique and it is still used today in new areas when

- the sewer pipe can be placed at a shallow depth. Deeper sewers that are trenched require complicated digging and forms to prevent collapse of the trench
- the pipe diameter is small – larger pipes require very large trenches which can be expensive and get in the way of neighbourhood activities
- there is room above ground for equipment and operations

In short the method requires that the contractor digs a trench, places the pipe in the trench, backfills the trench, and then repaves the street and repairs any other surfaces that were disturbed when digging the trench.

Micro-tunnelling

Micro-tunnelling has become a popular alternative to trenching, especially in high-density neighbourhoods with busy streets and shallow utilities that often conflict with surface digging.

The contractor excavates two pits. A jacking where the microtunnel boring machine (MTBM) is lowered into the ground and creates a tunnel opening while passing excavated earth through the back of the machine. The MTBM is remote controlled and no workers enter the tunnel. The receiving pit is smaller, only large enough to retrieve the MTBM. The excavated soil is temporarily stored until it can be hauled offsite. MTBMs are laser guided for accuracy. Cutting teeth bore through soil until the MTBM reaches the receiving pit. The pipe is then pushed into the tunnel. The tunnel and pits are then backfilled and the surfaced is repaired.

Large bore tunnelling

This method of construction is for very large-diameter pipelines placed under busy urban areas and through challenging geological conditions. Tunnelling gives the ability to align sewers under hills and other areas that would not normally be accessible using trenching or micro-tunnelling techniques.

As in micro-tunnelling, the contractor excavates a shaft and shores up the walls. These shafts are deeper and wider than micro-tunnelled shafts. Workers and the tunnel boring machine (TBM) is lowered to the bottom the shafts. Excavation is similar to micro-tunnelling, but the machine is much larger with digging heads capable of boring large diameter tunnel. A worker rides inside the TBM from where it is controlled. Excavated dirt is conveyed behind the TBM to small, open rail cars that haul the dirt back to the shaft where it is lifted out and hauled away. Concrete liner pipes are used to support the tunnel and prevent collapse. The sewer pipes are then brought into the tunnel and joined together by work crews. The machines are removed, shafts are filled, and ground surfaces are resurfaced.

No-dig technologies repair methods

A brief description of the main no-dig sewer repair technologies are given below:

Cures-in-place liner

Cures-in-place liners are pulled through the old pipe by a winch. The liner is inserted through the main clean- out, so that no digging is required. The liner is then cured which results in a new joint less pipe melded inside the host pipe.

Cures-in-place liners can be made from several materials e.g. polyester, glass fibre and epoxy. The method for curing can be quite different depending on the project and the choice of material for the liner.

The liners are most often cured with hot water, steam or UV.

Pipe bursting

This pipe repair technique requires one pit at each end of the pipe section. The burst head is pulled by a winch and is followed by a polyethylene pipe. As the burst head is pulled through, the old pipe is burst aside into the surrounding soil, and the new pipe replaces it. Pipe bursting can be used to increase the size of the pipe being replaced.

3.2 Wastewater and Sludge Treatment Technologies

The most commonly used wastewater and sludge treatment and disposal technologies used in the EU member states includes:

Wastewater treatment technologies

- Trickling filters
- Activated sludge plant with primary clarifiers
- Extended aeration activated sludge plant
- Sequencing batch reactors
- Expanded bed bio film or fluidised reactor
- Membrane bioreactor
- Stabilisation ponds

Sludge treatment technologies

- Gravity thickeners
- Mechanical thickeners
- Sludge stabilisation by extended aeration
- Aerobic sludge stabilisation
- Anaerobic sludge stabilisation
- Sludge dewatering
- Sludge drying beds
- Drying
- Incineration

This section does not give a complete list and description of all wastewater and sludge treatment technologies, but gives short description of the ones most commonly used within the EU member states.

3.2.1 Typical wastewater treatment plant configuration

A typical major wastewater treatment plant includes the following treatment units:

- Coarse screens
- Inlet pumping station
- Fine screens
- Grit and grease chambers
- Primary clarifiers
- Activated sludge tanks
- Secondary clarifiers
- Gravity sludge thickener (primary sludge)
- Mechanical sludge thickener (biological sludge)
- Anaerobic digester or aerobic digester
- Gas utilisation facilities
- Sludge buffer tank
- Sludge dewatering facilities

Below the different technologies are shortly described.

Coarse screen

Coarse screens

In order to protect the inlet pumps from large pieces of solids automatic operated coarse screens shall be provided upstream the pumps. The coarse screens shall be automatic due to the expected high content of solids in the wastewater. Screenings shall be deposited in a container at ground level.

Inlet pumping station

Inlet pumping station

An inlet pumping station will lift the wastewater up to the primary treatment facilities.

Primary Treatment

Primary treatment typically involves screening, grit and grease removal and sedimentation, and is the process by which about 30 to 50 percent of the suspended solid materials in raw wastewater are removed. Typically technologies are:

- Fine screens, including automatic screening compacting in closed systems
- Aerated grit and grease chambers, including sand washing and dewatering
- Primary clarifiers, including raw sludge pumping station

Screens

The raw wastewater is pumped to fine screens, where larger elements such as paper and plastic are retained. The screenings are automatically removed and dumped into a screenings press where compaction takes place before the final disposal in a container. Possible by-pass of the fine screen through a manually raked coarse screen is proposed.

Grit and grease chambers

From the screens the wastewater flows to combine aerated grit and grease chambers. Grit is removed in order to reduce wear and tear of the mechanical installations in the subsequent treatment units and grease is removed to avoid anaesthetic conditions caused by malodorous floating sludge. Settled grit is dewatered and transported to a container by means of a grit separator. Retained grease is scraped off to a grease collector.

Primary clarifiers

In the primary clarifiers a major part of the suspended solids and organic matter is removed. Clarified wastewater is drawn from overflow weirs at the surface and the settled primary sludge is concentrated at the bottom hopper before withdrawal.

The following removal rates are expected in the primary clarifiers:

- BOD_5 20-30%
- Suspended solids 30-60%
- Nitrogen and phosphorus 5-10%

Secondary treatment

The organic matter, nitrogen and phosphorous remaining after primary treatment is treated by biological-chemical secondary treatment processes to meet effluent standards. Secondary treatment commonly is carried out using activated-sludge processes, but other technologies are also used as described in the following sections.

Activated sludge tanks

Primary clarified wastewater is led to the activated sludge tank where biological decomposition of organic matter, nitrification, denitrification and biological phosphorous removal takes place by means of micro- organisms (activated sludge) suspended in the wastewater.

The biological processes for decomposition of the organic matter and nitrification require supply of considerable amounts of oxygen and it is important that the activated sludge is fully suspended during the processing period. Oxygen is provided in the form of compressed air or by surface aerators. Start and stop of the blowers or aerators are normally automatically controlled by on line metering of the actual oxygen concentration in the process tanks. During the denitrification process, which takes places under anoxic conditions, nitrate is transformed into nitrogen gas consuming organic matter. The suspension of activated sludge is provided by mixers.

Most wastewater treatment plants, with the requirement of removing phosphorus, are designed with chemical precipitation. The chemicals may be added to primary, secondary or tertiary processes or to a combination of these. The most common used chemicals for phosphorus precipitation include ferric chloride, ferrous sulphate or aluminium sulphate.

Apart from phosphorus removal by chemical precipitation, the other main method applied is enhanced biological excess phosphorus removal (or bio-P removal), which is a wastewater treatment configuration applied to activated sludge systems for the removal of phosphate. The common element in bio-P removal implementations is the presence of an anaerobic tank (nitrate and oxygen are absent) prior to the aeration tank. Under these conditions a group of bacteria are selectively enriched in the bacterial community within the activated sludge. These bacteria accumulate large quantities of polyphosphate within their cells and the removal of phosphorus is said to be enhanced.

The biological-chemical processes create continuously new sludge. An equivalent amount of sludge shall be removed from the process tank as surplus sludge.

Secondary clarifier

The activated sludge from the process tank is discharged into the secondary clarifiers. In the clarifier suspended sludge and treated wastewater are separated by sedimentation.

Treated wastewater is drawn from the surface via overflow weirs and settled sludge is concentrated in the bottom hoppers. Floating sludge formed in the clarifier is retained in the clarifier and scraped off to a collector for floating sludge.

The concentrated sludge is returned to the process tanks in order to secure a sufficient amount of activated sludge in the process tanks. The return sludge pumping is controlled in correspondence with the influent flow.

Tertiary treatment

Tertiary wastewater treatment is additional treatment that follows primary and secondary treatment processes. It is employed when primary and secondary treatment cannot accomplish all that is required.

The purpose of tertiary treatment is typically to have additional nitrogen or phosphorus removal, removal of pathogens or removal of some specific hazardous substances.

Tertiary treatment technologies can for instance include the following facilities:

- Sand filtration
- Polishing lagoons
- Disinfection systems, like UV radiation or chlorination
- Membrane filtration and separation
- Activated carbon adsorption

Sludge treatment

Sludge thickening

For thickening of primary sludge traditional gravity thickener is often used, which can increase the dry solids content of the primary sludge up to approx. 5-6% DS, which is ideal for the design and operation of the following sludge digester.

For thickening of surplus biological sludge mechanical sludge thickeners can be used, which can increase the sludge content to approx. 5-6 % DS (compared to traditional thickeners, which gives approx. 3-4 % DS for surplus activated sludge). This is a benefit in relation to the design and operation of the sludge digesters. Mechanical thickeners required a consumption of polymer in an amount of approx. 2-3 kg/tonnes dry solids.

Sludge digestion

Thickened primary and surplus activated sludge are pumped to the digesters for anaerobic stabilisation. In the anaerobic digestion process, the organic material in mixtures of primary settled and biological sludge is converted biologically to a variety of end products including methane and carbon dioxide.

The most common anaerobic process used for the treatment of sludge is a mesophilic fully mixed digester where the sludge is heated to approx. 35 °C. The main parameter for anaerobic sludge digestion is the hydraulic retention time; typical design figures are 20-25 days.

As an optional solution for sludge stabilisation aerobic digestion could be considered.

Gas utilisation system

The gas produced in the digesters can be utilised in a combined heat and power plant. The gas drives a gas-engine that runs a power generator. Cooling water from the gas-engine is used for heating and maintains the mesophilic temperatures of the sludge in the digesters.

The produced electricity from the generator covers some 30-50 % of the total electric power demand of the wastewater treatment plants total power consumption.

The complete combined heat and power plant includes an emergency cooler system and a co-heating boiler. The emergency cooler is required in case there is no demand for heat from the digesters or other heat consumers. A co-heating plant is required for the situation that the gas produced is insufficient to heat the digester satisfactory, to start up the digester and optional also for district heating of selected buildings on the WWTP. The co-heat boiler can be based on either natural gas or light fuel oil.

Sludge dewatering

For mechanical sludge dewatering three different methods are the most commonly used: centrifuges, belt filter press and plate filter press.

The sludge will be dewatered to a dry solids content of approx. 20-35 %DS.

Polymer consumption for the dewatering of the sludge in belt filter press is approximately 5-8 kg active polymer per tonnes dry solids.

Control and automation system

Control and automation system

In order to operate the WWTP in a consistent and energy-efficient way a control and automation system incl. Supervisory Control and Data Acquisition (SCADA) for the WWTP is used.

The SCADA system provides facilities for monitoring of actual and historic process values and status, alarms and operation hours of a selected number of equipment. Moreover the SCADA system offers possibility to control selected processes from a central place.

Most equipment is to be locally controlled from a control-panel adjacent to the equipment to be controlled but monitored by the SCADA system. Other facilities such as e.g. the aeration system and return sludge pumps could be centrally controlled via the SCADA system due importance to the treatment process and the relatively high energy consumption.

3.2.2 Extended aerated activated sludge plant

Instead of having primary sedimentation of the raw wastewater in primary clarifiers with the corresponding removal of inlet suspended solids and organic matter, full biological treatment and nitrogen removal can take place in activated sludge tanks and secondary clarifiers. This is typically the situation for small or medium sized treatment plants.

The construction of the process tanks and secondary clarifiers are similar as described in Section 3.2.1. However the process tanks, aeration equipment, mechanical mixers, blower station etc. needs to be increased in sizes and capacities.

The main benefits for this treatment option compared with a configuration with primary sedimentation are:

- More simple operation and less treatment units
- Not necessary to handle primary sludge and therefore reduced risk of odour problems
- Activated sludge can be stabilised in the process tanks

The main disadvantages are:

- Higher operation costs as there is no recovery of energy from gas production in the digesters

3.2.3 Submerged Biological Filter

Biofilters are characterised by bacteria being attached to a solid surface in form of a biofilm. The basic biological processes that take place in a biofilter are identical to the processes in an activated sludge plant.

The main advantages for biofilter technology compared to activated sludge are:

- Less footprint
- Biological purification and retention of SS at the same time
- Often fairly quick recovery after a toxic shock

The main disadvantages compared to activated sludge include:

- Higher construction cost
- More difficult to operate and control
- Risk of clogging (can be avoided by primary sedimentation or precipitation)

Submerged filters are filters where the filter medium is located under the surface of the water. Among many different characteristic designs of filters, the most important characteristic is a stationary or movable filter.

Stationary filter medium

For filters based on stationary filter medium the thickness of the biofilm and the supply of oxygen to the water are especially important.

In respect of thickness of the biofilm and problems with clogging two different approaches can be taken:

1. Specious filter media with sufficient space and hydraulic conditions, which prevent excessive thicknesses of the film, can be used. With such filter media it is not possible to obtain a large specific surface area, and these plants take up correspondingly more space.

2. The alternative is to backwash the filter. This is done by applying a high flow of water. In filters containing an immobilised filter medium, the washing effect is reached through the flow of water eroding the biofilm off the material.

In filters for the removal of organic matter to which oxygen must be supplied, the oxygen can be blown in at the bottom of the filter. When the bubbles rise, the water in the filter is oxidised.

Movable filter medium

Plants based on movable filter medium can in principle be divided into three different principles:

- <u>Expanded filter.</u> A filter with an up flow through a loose filter medium, typically sand, will have a stationary filter medium as long as the filter medium is not lifted off the pressure gradient from bottom to top. If the pressure in the bottom of the filter equals the weight corresponding to the weight of the filter above, a lifting of the filter medium will occur.

- <u>Fluidised filter.</u> If the up flow in the filter is increased beyond the point where a lifting occurs, the filter medium will expand and for a given rate through the filter a balance between the up flow rate and the settling velocity of the particles will occur which depends on the density of the particles. The individual particles of the filter medium will be separated from each other and whirled around in the turbulent up flow. Fluidised filters are the most volumetric efficient biological reactor available. The reactor is, however, not simple to operate.

- <u>Suspended biofilm reactor.</u> In the fluidised filter, the filter medium is kept in suspension in the up flow turbulence. This turbulence can, of course, be established without up flow and instead by a mechanical mixing. Hence we have the suspended biofilm reactor. Consequently the connection to the activated sludge plant has been established. The difference is just that for the aeration tank, an inert carrier is intentionally added to which the bacteria adhere.

3.2.4 Sequencing Batch Reactor

As an alternative to the traditional activated sludge plant with separate process tanks and secondary clarifiers a plant based on the SBR-process could be considered.

The SBR process (Sequencing Batch Reactors) is a fill-and-draw, variable reactor volume technology, developed as one of the first treatment plant types based on the activated sludge concept. Shortly after the initial studies, the emphasis switched to continuous flow "conventional" activated sludge. Further developments with SBR technology were not pursued because of limitations of equipment and engineering experience.

Recent innovations in aeration systems, monitoring and control systems, level meters etc. have revitalised interest in SBR technology, which has led to construction of several wastewater treatment plants based on this technology. The plants have mainly been built in the U.S.A, whereas the number of plants in Europe is moderate. In Great Britain and Ireland SBR tanks are relatively often used.

The SBR consists of a self-contained treatment system incorporating equalisation, aeration, anoxic reaction (if necessary), and clarification within one basin.

The SBR process has some advantages compared to continuous flow systems. For instance the SBR process is more tolerant to peak flows as the wastewater is always led to an equalisation tank. Furthermore return sludge or recycling systems are unnecessary and total quiescence during clarification occurs.

On the other hand the SBR process is somewhat more sophisticated and difficult to operate and control due to the intermitting operation. Furthermore aeration equipment must be larger since process air must be supplied over a shorter period.

3.2.5 Membrane bioreactor (MBR)

Membrane bioreactor (MBR) technology combines biological-activated sludge process and membrane filtration. MBR has become more popular and accepted in recent years for the treatment of many types of wastewaters including municipal wastewater. Although MBR capital and operational costs exceed the costs of conventional process, it seems that the upgrade of conventional process occurs even in cases when conventional treatment works well.

Membrane separation is carried out either by pressure-driven filtration in side-stream MBRs or with vacuum-driven membranes immersed directly into the bioreactor, which operates in dead-end mode in submerged MBRs. The most common MBR configuration for wastewater treatment is the latter one, with immersed membranes, although a side-stream configuration is also possible, with wastewater pumped through the membrane module and then returned to the bioreactor.

3.2.6 Sludge Digestion

In the anaerobic digestion process, the organic material in mixtures of primary settled and biological sludge is converted biologically to a variety of end products including methane and carbon dioxide. The process is carried out in an airtight reactor. Sludge, introduced continuously or intermittently, is retained in the reactor for varying periods of time. The stabilised sludge, withdrawn from the reactor, is reduced in organic and pathogen content.

The most common anaerobic process used for the treatment of sludge is a mesophilic fully mixed digester where the sludge is heated to approx. 35 °C. The main parameter for anaerobic sludge digestion is the hydraulic retention time; typical design figures are 20-25 days.

Trends in sludge stabilisation technologies

Sludge has traditionally been stabilised with the main objective of minimising the risk of odours. In addition a substantial reduction in sludge solids is achieved during the stabilisation process.

In order to accelerate the solids reduction during stabilisation, the use of modified and new stabilisation methods is increasing:

Termophilic anaerobic digestion where the stabilisation takes place at about 55 ^{o}C (normal mesophilic stabilisation operates at about 30 ^{o}C) increases the decomposition of sludge and increases gas production.

Thermal hydrolysis in combination with anaerobic digestion further accelerates the decomposition of organic matter in the sludge to more easily degradable substances, thereby increasing gas production and reducing solids content in the subsequent digestion step. The thermal hydrolysis process is operated in a pressure vessel at about 50 bar pressure and a temperature of 200 ^{o}C.

3.2.7 Sludge dewatering

For mechanical sludge dewatering three different methods are the most commonly used: centrifuges, belt filter press and plate filter press.

In the table below obtainable dry solids contents for stabilised combined primary and surplus activated sludge from the different methods are presented. Furthermore the main advantages and disadvantages are listed.

Table 3-1 Comparison of different sludge dewatering methods

Dewatering Method	**DS content with polymer addition**	**Advantages**	**Disadvantages**
Centrifuges	20 - 25%	Clean appearance, minimal odour problems, fast start up and shut down capabilities Easy to install Relatively low capital cost to capacity ratio Low floor area required for equipment	Scroll wear potentially a high maintenance problem Skilled maintenance personnel required Moderately high suspended solids in filtrate Relatively high energy requirements
Belt filter press	20 - 25%	Low energy requirements Relatively low capital and operating costs Less complex mechanically and easier to maintain	Sensitive to incoming sludge feed characteristics Automatic operation generally not advised
Plate filter press	30 - 35%	Highest cake solids concentration Low suspended solids in filtrate	Batch operation High capital costs Labour-intensive Large floor area required for equipment Skilled maintenance personnel required

3.2.8 Sludge Drying

During drying of dewatered sludge (20-30% DS) up to 90-95% DS, the sludge undergoes different phases. First the free water then the capillary water and finally the bound water is evaporated.

Sewage sludge dryers can be classified as direct or indirect dryers with open or closed loop. Further, they can be characterised as convective - or as contact dryers.

Direct dryers

The most simple and efficient dryer is a direct dryer with an open loop. In this system the drying medium, typically flue gas, is mixed with the sludge. After the dryer the gas and sludge is separated, and the gas is, after a cleaning stage, emitted to the atmosphere.

Typical examples of direct dryers are rotary-drum dryers and belt dryers.

A main problem in relation to direct dryers is to avoid odour nuisances.

Indirect dryers

In the indirect dryer the sludge will not come into contact with the heating medium, but will only be in contact with a "hot wall" heated by the heating medium (contact dryer), or a drying gas in a closed loop which also is heated via a heat exchanger (convective dryer). Indirect dryers are much easier to make odourless, as only a very small amount of gasses has to be treated before emission to the atmosphere.

The indirect contact dryer is often used for pre-drying the sludge up to 35-40% DS in connection with incineration of sludge. Typical examples are disc/paddle dryers and thin film dryers. Steam, hot water or thermal oil are the most used heating media.

Energy demand for drying

Before starting drying, the dewatering process should be optimised. Removing water mechanically is still cheaper than using thermal energy. A typical energy demand (as fuel) for drying 1 kg DS from 20% DS to 90% DS is approximately 13 MJ, when a boiler produces the heat.

If digesters are installed at the wastewater treatment plant it will be obvious to utilise energy from the gas production for the drying process. In other cases a fossil fuel (oil or natural gas) can be burned in a boiler. However, other sources can also come into question, such as surplus energy from industrial process or the waste heat from a gas engine.

3.2.9 Sludge incineration

With sludge incineration the water content in the sludge is evaporated and all organic compounds are destroyed leaving only the ash for further utilisation/disposal. In the incineration process the energy content in the sludge will be utilised.

In the EU member states, incineration is mainly used where local conditions and/or the sludge quality with respect to heavy metals or other harmful substances hamper agricultural use.

Sludge incineration can be carried out either separately (mono-incineration) or in a combination with other types of waste and/or fuels (co-incineration). In many cases other type of waste produced at the wastewater treatment plant like screenings, grit and grease can be co-incinerated.

The dewatered sludge is normally pre-dried before entering the furnace in order to enable auto combustion.

The most common type of furnace nowadays is a fluidised bed type. Formerly multiple hearth furnaces or rotary ovens were used. However, fluidised bed ovens are generally considered superior both regarding combustion efficiency and environmentally.

A flue gas cleaning must be included in the process. The cleaning will typically be carried out in two or three stages:

› Dust separation

› Main cleaning including residual dust separation and absorption of acidic components

› Polishing stage mainly for adsorption of mercury and dioxins.

The flue gas cleaning can be designed as dry, semidry or wet cleaning. Typically sodium hydroxide, sodium hydrogen carbonate or lime are used.

After the incineration process the inorganics from the sludge will be left in the ash. Further, a minor residue from the flue gas cleaning will be created. In most cases the ash and the residue from the flue gas cleaning are land filled.

4 Procurement methods

4.1 Alternative Implementation Contracts

4.1.1 Type of contract

The type of contract that are most frequently used within the EU member states for the implementation of wastewater infrastructure projects is the FIDIC type developed by Federation Internationale des Ingenieurs-Conseils or similar national contract types.

The three relevant types of FIDIC contract are presented below. They are developed for different purposes; however, they may in principle all be applied for implementation of wastewater infrastructure projects.

Type of contract	**Title**	**Year**
"Red book"	Conditions of Contract for Construction	1999
"Yellow book"	Conditions of Contract for Plant and Design-Build	1999
"Silver book"	Conditions of Contract for EPC/Turnkey Projects	1999

The **Red Book** is applied for building or engineering works designed by the Employer, here the purchasing authority. The Contractor constructs the works in accordance with a detailed design provided by the Employer. However, the works may include elements of contractor-designed civil, mechanical, electrical and/or construction works. Sewer collecting systems are most commonly tendered as Red Book.

In a Red Book contract the Employer/Consultant will consider the GPP criteria. In the tender the Contractor will price the detailed design, and not provide its own approach and plant layout.

In this way the Employer has full control of the type of wastewater treatment units and equipment that will be applied. For sewer system projects a Red Book approach is often used.

The **Yellow Book** is applied for establishing electrical and/or mechanical plants, and for the design and execution of building or engineering works designed by the Contractor in accordance with the Employer's requirements and GPP criteria.

The tendering is typically based on a conceptual design prepared by the Employer, where the main wastewater treatment technologies and design parameters are defined by the Employer. In the tender the Contractor will propose a preliminary design based on the conceptual design provided or an alternative approach which fulfils the requirements of the Employer. Before execution of the contract the Contractor will make a detailed design for approval of the Employer.

This procurement process provides the Employer with a high degree although not full control and influence on the selection of appropriate treatment technologies, which will be applied and plant layout.

The **Silver Book** is applied for establishing, on a turnkey basis, process plants or infrastructure projects, where (i) a higher degree of certainty of final price and time is required, and (ii) the Contractor assumes total responsibility for the design including choice of technology and execution of the project, with little involvement and influence of the Employer.

The tendering is typically based on performance and quality requirements for the treatment plant - the "end result". The Contractor will propose its own type of plant in the tender, which will fulfil the effluent criteria and other performance requirements established by the Employer including the GPP criteria.

The Contractor will prepare the design and construct the plant, which eventually will fulfil the Employer's requirements, fully operational at "the turn of the key". In this process the Employer has little influence on the actual design of the plant.

4.1.2 Selection of contract type

Selection of contract type

Typical criteria for selection of the most appropriate type of contract for the actual wastewater infrastructure project are illustrated below. The different types of contract offer different approaches to such important issues as:

1 Responsibility for design of the treatment process and collecting system,

2 Responsibility for the plant layout and the design of structures, mechanical and electrical equipment,

3 Responsibility for cost overrun during implementation,

4 Control of correct interim payments of the contractor's work,

5 Distribution of responsibility between Employer and Contractor during construction,

6 Responsibility of the treatment performance and efficiency,

7 Employer's influence and control of the construction process.

The compliance with these requirements is assessed for each type of contract in the table below.

Requirement	**Red Book**	**Yellow Book**	**Silver Book**
Responsibility for treatment process/collecting system	Employer	Contractor	Contractor
Responsibility for design of plant and structures	Employer	Contractor	Contractor
Responsibility for cost overrun	Employer / Contractor	Contractor	Contractor
Control of interim payments	High	Moderate	Low
Distribution of responsibility during construction	May be difficult	Clear	Clear
Employer's control of construction process	High	High	Low

4.2 Design Stages

The design process of a wastewater infrastructure project is often complex and time consuming.

The design process brings together various requirements of the client (employer), the many stakeholders, the consultant and/or the contractor as to the best way to construct the project in reality. The design process can be viewed as acting over a number of logical stages as described below.

4.2.1 General outline design

General outline design is the level at which solutions might be presented in a Master Plan, generally in discussion with local authorities and operators, knowing the problems and conditions, although not themselves being designers. These are ideas and exchange of mutual experience for solving technical problems, improving level of services from experience of similar solutions and local knowledge.

4.2.2 Feasibility Study

At the feasibility study stage the general outline design idea is further developed to see if it is feasible. It also examines options to solve the basic problems and makes recommendations to the most optimal solution on technical applications, costs, environmental and not least practical grounds. The feasibility study will be assessed on the details of planning concerning the practical implementation, the site selected, constraints, foreseen difficulties and a number of key success criteria like:

- What are the estimated costs for the project at this stage, to build and operate it?
- The assumptions made for the cash flow and cost benefit analyses?
- Will the project have financial commitment to issue for tender?
- Will the project work, subject to further and detailed development?
- What are the risks attached to the current “idea”?
- Are there any factors, which will rule out the “idea” completely?
- Any changes compared to the early fact finding and recommendations for project selection, ownership, topographical and engineering surveys, geo-technical and ground surveys, environmental analyses etc?
- What else needs to be done to assure the client, that it will work and that the risks are manageable?

4.2.3 Conceptual Design/Clients Requirement

The conceptual design covers further work to assure the client, that risks are reduced, the costs are more accurate and to provide design-build contractors with sufficient information to understand the proposal and to develop the preliminary design upon which their tender is based.

The information includes overruling information such as legal requirements needed for the construction to commence, land ownership, access to site, existing utilities, public hearing, authorities' approval etc.

The conceptual design takes a first view on employers (clients) requirements and the contractor designs the project and builds it to his design based on a book of client’s requirement.

The employer's requirement will include a set of specifications, bills of quantities to be completed by the contractor and a number of conceptual drawings.

The employer's requirement will include a.o.:

- The functional requirements, technology, capacity, size, quality to the works comprehensive enough to ensure that each of the tenderers, if compliant, meets the requirement of the employer
- Requirements to the contractors design and design criteria to be used
- Present physical conditions on site or specifications to tenderers, as to which investigations they should do as part of their tender and existing permissions. This could include borders of land, site available, access roads, topographic, soil and ground conditions, utilities etc.
- Eventual environmental constraints during construction and EIA obtained
- Specification of selected GPP criteria
- Permissions required to be obtained by employer or contractor

4.2.4 Preliminary Design

The preliminary design by the contractor is in this context the design of the design-build contractor at the tender stage. It assesses all the risks, so that these can be priced and covers a number of eventualities. It provides sufficient information to allow the client to assess and evaluate the tender.

4.2.5 Detailed Design (Red Book – Employers Design)

The detailed design by the employer/consultant includes in this context the complete detailed design, engineering, drawings and itemized bill of quantity for pricing by the contractor

4.2.6 Working Design (Yellow or Silver Book – Contractors Design)

The working design by the contractor enables the project to be built and provides all the details necessary combining structural, process, hydraulic, mechanical, electrical plant, foundation, flotation, dynamic, static loads and earthquake and other eventual constraints.

4.2.7 Summary

The design criteria must be decided on the basis of a realistic project implementation process for the actual projects and satisfy the clients need according to EU Environmental Directives. The GPP criteria are defined based upon the type of tender.

The experience or lack of experience from the end-user must "weigh heavily on the scale of judging" contracting methods, implementation, selected contractors and physical project quality, placing of responsibility, project hand-over and future management.

This means projects using the latest technology of contractor and manufacturer know-how, quality engineering and contracting in all respects of civil, mechanical and electrical supply and installation. Fulfillment of EU environmental directives and contracting procedures, which will secure price/quality in a competitive world, i.e. projects which could be contracted in any EU member states.

5 Definition of scenarios

5.1 Criteria for selection of scenarios

For demonstration of GPP criteria within wastewater infrastructure projects, a number of typical wastewater infrastructure project scenarios have been defined.

The scenarios have been selected to cover typical wastewater infrastructure projects and commonly used wastewater technologies for sewer systems and wastewater treatment. The design of wastewater treatment plants depends on the local conditions, especially characteristics of receiving waters and the size of the agglomeration which is served by the plant. Therefore, scenarios have according to the Terms of Reference been defined to cover at least the following items:

Agglomerations of:

1. Less than 2000 p.e.: Agglomerations covered by article 7 of the Urban Wastewater Directive, subject to "appropriate treatment" whenever their wastewaters are collected
2. Between 2000 p.e. and 10.000 p.e: Agglomerations subject to secondary or even lower treatment level based on their discharge into fresh or coastal waters respectively
3. Between 10.000 p.e. and 100.000 p.e: agglomerations subject to secondary treatment when discharging into "normal areas", or to more stringent treatment when discharging into sensitive areas, and in this case to certain nitrogen and phosphorus removal requirements, when applicable
4. Above 100.000 p.e.: agglomerations subject to secondary treatment when discharging into "normal areas", or to more stringent treatment when discharging into sensitive areas, and in this case to certain nitrogen and phosphorus removal requirements, when applicable

When defining the process to establish the level of treatment all the regulations involved and especially the requirements established by:

- The Water Framework Directive

- The Directive 91/271/EEC concerning urban waste-water treatment
- The Directive 2006/7/EC concerning the management of bathing water quality

For each of the above mentioned four categories different technologies have been defined and the different items units calculated and described.

5.2 Description of scenarios

The following 16 scenarios have been defined and briefly described in Table 5-1 below.

In Annex A a more precise description of the different scenarios are given including typical type of contract, level of treatment (assumed effluent standards) and a precise description of the different units and technologies that are included in the scenarios.

Table 5-1 Wastewater infrastructure scenarios

Scenario no.	No. of persons	Type of contract	Type of treatment	UWWTD/ Effluent standards	Short description
1.	10.000	Works contract based on detailed design FIDIC Red Book	None	NA	Minor sewer network extension and rehabilitation
2.	120.000	Works contract based on detailed design FIDIC Red Book	None	NA	Major sewer network extension and rehabilitation project
3.	1.500	Design-Build contract FIDIC Yellow Book	Basic secondary treatment	According to UWWD: COD < 75 mg/l; BOD < 25 mg/l	New minor wastewater treatment plant (activated sludge)
4.	1.500	Design-Build contract FIDIC Yellow Book	Basic secondary treatment	According to UWWD: COD < 75 mg/l; BOD < 25 mg/l	New minor wastewater treatment plant (low tech - ponds)
5.	8.000	Design-Build contract FIDIC Yellow Book	Basic secondary treatment	According to UWWD: COD < 75 mg/l; BOD < 25 mg/l	New collector and small WWTP, secondary treatment and aerobic sludge stabilisation
6.	50.000	Design-Build contract FIDIC Yellow Book	Nitrogen and phosphorus removal	According to UWWD: COD < 75 mg/l; BOD < 25 mg/l Total N < 10 mg/l; Total P < 1.5 mg/l	New major WWTP (extended aeration)
7.	50.000	Design-Build contract FIDIC Yellow Book	Nitrogen and phosphorus removal	According to UWWD: COD < 75 mg/l; BOD < 25 mg/l Total N < 10 mg/l; Total P < 1.5 mg/l	New major WWTP (primary clarifiers, digesters and gas utilisation)
8.	50.000	Design-Build contract FIDIC Yellow Book	Nitrogen and phosphorus removal	According to UWWD: COD < 75 mg/l; BOD < 25 mg/l Total N < 10 mg/l; Total P < 1.5 mg/l	New major WWTP (MBR technology)
9.	150.000	Design-Build contract FIDIC Yellow Book	Nitrogen and phosphorus removal Removal of pathogens	According to UWWD + disinfection: COD < 75 mg/l; BOD < 25 mg/l Total N < 10 mg/l; Total P < 1.0 mg/l Total e-coli < 1000 nos /100 ml	New major WWTP (incl. demands for disinfection)
10.	150.000	Design-Build contract FIDIC Yellow Book	Nitrogen and phosphorus removal Removal of pathogens	According to UWWD + disinfection: COD < 75 mg/l; BOD < 25 mg/l Total N < 10 mg/l; Total P < 1.0 mg/l Total e-coli < 1000 nos /100 ml	New major WWTP (incl. sea outfall)

11.	300.000	Design-Build-Operate contract (20 years operation) FIDIC Yellow Book	Nitrogen and phosphorus removal	According to UWWD: COD < 75 mg/l; BOD < 25 mg/l Total N < 10 mg/l; Total P < 1.0 mg/l	New large WWTP
12.	80.000	Works contract based on detailed design FIDIC Red Book	Nitrogen and phosphorus removal	According to UWWD: COD < 75 mg/l; BOD < 25 mg/l Total N < 10 mg/l; Total P < 1.5 mg/l	Extension and renovation of existing wastewater treatment plant
13.	300.000	Design-Build-Operate contract (20 years operation) FIDIC Yellow Book	Sludge stabilisation	NA	Sludge digester and gas utilisation plant
14.	300.000	Design-Build-Operate contract (20 years operation) FIDIC Yellow Book	Sludge drying and incineration	NA	Sludge drying and incineration plant
15.	10.000	Works contract based on detailed design / functional demands FIDIC Red and Yellow Book	Basic secondary treatment	According to UWWD: COD < 75 mg/l; BOD < 25 mg/l	Sewer and wastewater treatment project (minor town)
16.	80.000	Works contract based on detailed design / functional demands FIDIC Red and Yellow Book	Nitrogen and phosphorus removal	According to UWWD: COD < 75 mg/l; BOD < 25 mg/l Total N < 10 mg/l; Total P < 1.5 mg/l	Sewer and wastewater treatment project (major town)

6 Key environmental impacts

The key role of wastewater infrastructure is to reduce the environmental impacts from other activities in society. Legislation ensures that the extend of wastewater and sludge treatment is increased and that minimum treatment levels are obtained. Wastewater and sludge treatment contributes positively by reducing the overall impact from human activities in the receiving water.

When focus is directed to the wastewater treatment plants, life cycle assessments indicate that the most important potential environmental impacts derive from the emission of wastewater to receiving water bodies. The most affected environmental categories seem to be toxicity and eutrophication. Based on this knowledge emphasis is put on hazardous substances and nutrients in the following sections.

To maintain adherence and recognisability to other technical background reports on public green procurement, energy, natural resources and waste are also described in the following sections.

6.1 Energy

Energy is very often used as a measuring parameter for environmental and economical achievement. This is especially reasonable when the system is dominated by an operation phase with high energy consumption compared to the other environmental impacts during the full lifecycle.

As the energy consumption during the operation phase are continuously reduced due to energy efficient ventilation, machines, pumps etc., the energy consumption during production of materials etc. gains increased importance.

Thus focus must be put on the embedded energy and the energy during the operation phase to incorporate the two most significant energy consuming phases of wastewater infrastructure projects. Presently there are models and databases available to perform these assessments e.g. by using LCA on construction materials.

6.2 Natural resources and waste

Increasing focus is directed on the use of non renewable resources as it is recognised that intervention is needed.

It is recognised that the current use of resources are not an option. */Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. Roadmap to a resource efficient Europe. 2009/.*

Resource scarcity is increasing and is also denominated as the "the ticking bomb". As many scarce materials are used for construction of wastewater infrastructure and fossil fuels for the operation phase, resource scarcity is a significant subject to consider.

6.3 Harmful substances/priority substances

Urban wastewater is known to contain a wide range and considerable number of organic and inorganic chemical substances in varying concentrations depending on the number and types of possible specific pollution sources in the catchment to a wastewater treatment plant. Many of these substances are known or suspected to be harmful to the (aquatic) environment. One could consider using the wastewater treatment plant to remove or minimised these substances before e.g. sewage effluent is discharged to surface water bodies.

In addition construction and operation of sewers and WWTP's are the cause of use and emission of harmful substances which affects humans and the environment. Examples are the use of substances to disinfect the effluents or the use of building materials containing heavy metals, flame retardants etc. These emissions can occur during extraction of raw materials, production and use. For some of the construction materials the substances are embedded in the materials and are only emitted after the use - thus in disposal of the materials.

The concerns about chemical contamination of the aquatic environment in the European Community are addressed through the Water Framework Directive (Directive 2000/60/EC) and more specifically through Directive 2008/105/EC "on environmental quality standards in the field of water policy…". The latter directive establishes at present standards for 33 priority (hazardous) substances in the surface waters of the Community, which must be complied with at the border of a mixing zone of limited size (depending on the specific local conditions). Another 15 substances have recently been proposed for inclusion in the directive (COM(2011) 876 final). More details about the legislation and the current quality standards are given in Section 2.7.2.

6.4 Water

Water use is a central area in the sustainable construction and operation of wastewater infrastructure. However, the importance of water use and reuse is varies significantly in the Member States.

During the construction phase water is primarily used for cleaning and as an additive to construction parts e.g. concrete. The total water consumption during this phase is considered to be minor compared to the water use during the operation of the waste water infrastructure.

Water use during the operation is significant in the life cycle of wastewater infrastructure. This water use is determined by several decisions:

- Choice of water saving installations
- Possibility for reuse of treated wastewater
- The use of grey wastewater
- The behavioural knowledge of the employees
- The need for flushing of the sewers
- Chance of water harvesting
- Reduction in the risk for leakages
- Etc.

6.5 Transport

Transport is used in all phases of wastewater infrastructure projects. Due to the use of fuel for transport, emissions occur which leads to numerous environmental impacts.

In the construction phase materials are transported to the construction site. Just as the previous section the operation phase is the most significant.

In the operation phase there are transport of process chemicals and other materials used at the WWTP, trucks for flushing the sewers, if necessary transport of sludge etc. Particularly the latter has a significant impact on the total transport need and thus also the environmental impact from transport.

7 Life-cycle costing considerations and methodology

This section describes lifecycle costing considerations and presents our suggested approach for applying LCC in relation to wastewater infrastructure projects.

7.1 What is LCC?

The concept of Life cycle costs origins from the construction industry where large investments with long life span has created a need for considering the implication of alternative decision in the construction phase that impact on the cost in the operating phase of the assets lifetime.

As such is can be seen as tool for the financial planning of investments in long lived assets such as buildings, transport, infrastructure etc.

Gradually, more and more cost elements have been considered making the LCC more complete in taking into account all factors that impacts on costs.

A different venue of methodology development is coming from the Life Cycle Assessment (LCA) which is a tool for considering environmental impacts of products over their life time. LCA is about the environmental impacts, but there have been methodological developments to include monetary valuation of the environmental impacts. One example is from the Danish Environmental Protection Agency, who financed a number of development projects in the mid 1990'ies where valuation of the external effects was added to an LCA and thereby becoming what was called a Life Cycle Cost approach.

The more recent studies aimed to give guidance on LCC departs from the original LCC in the construction industry but add also environmental and other external effects.

7.1.1 Definitions and concepts

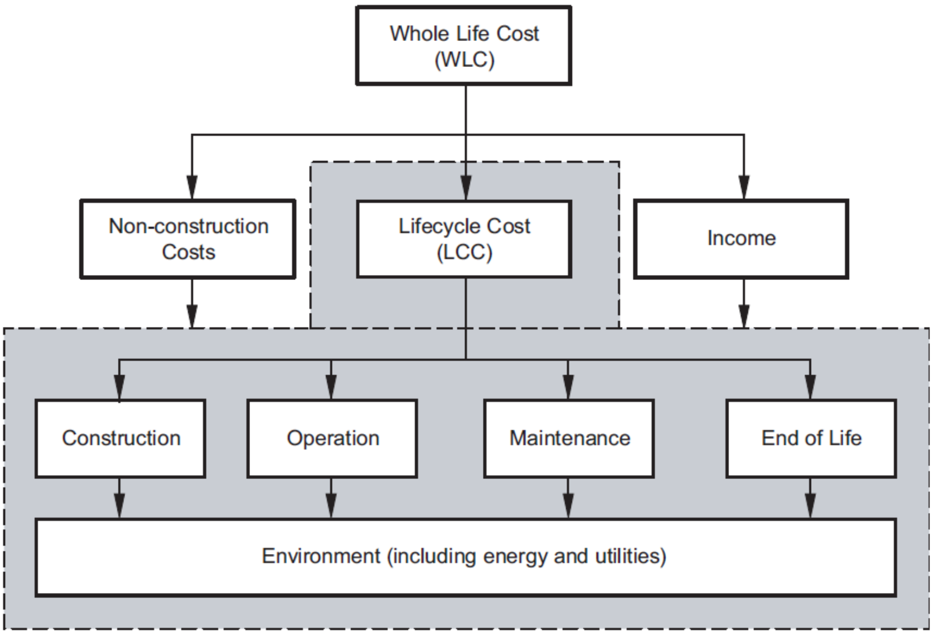
LCC can roughly be defined as a methodology where costs of a given asset is considered over the assets life time.

Though the basic principle is straightforward the specific definition can vary. The crucial part of the definition is which costs elements are considered and included in the LCC.

The ISO/DIS 15686-5 standard includes "definitions" of LCC in terms of the cost elements included and the link to other concepts.

The ISO standard presents Whole Life Costs (WLC) as the more comprehensive concept and LCC is part of WLC.

Figure 7-1 ISO definition of whole life costs and lifecycle costs



Source: ISO/DIS 15686-5.2 Part 5: Life cycle costing

The above WLC and LCC concepts could be compared to the economic notion of a cost-benefit analysis. A standard cost-benefit analysis (CBA) should include the costs and benefits over the lifetime of the investment. WLC, LCC and CBA are therefore similar in many respects. Below the key concepts for monetary assessments of infrastructure projects are compared.

Table 7-1 Comparison of assessment concepts

	Financial assessment	Economic assessment	All life cycle phases included	Both costs and income included
WLC	√	(√)	√	√
LCC	√	(√)	√	
CBA		√	(√)	√
Financial assessment (feasibility study)	√		(√)	√

Source: Consultant's assessment

The meaning of the terms financial and economic assessments is set out below. From the perspective of wastewater company (whether owned by a municipality or privately owned), the financial analysis is the one that describe the expenditure and income that the unit will face. At the planning stage the economic assessment that takes the overall effects on the society into account will be relevant.

- The **financial analysis** consists in comparing revenue and expenses (investment, maintenance and operation costs) recorded by the concerned economic agents in each project alternative (if relevant) and in working out the corresponding financial return ratios;

- The **economic analysis** aims at identifying and comparing economic and social benefits accruing to the economy as a whole, setting aside for example monetary transfers between economic agents.

As the table shows, the LCC as a concept is similar to other financial and economic assessment tools.

In the application of the LCC as part of this study, we will define it as including:

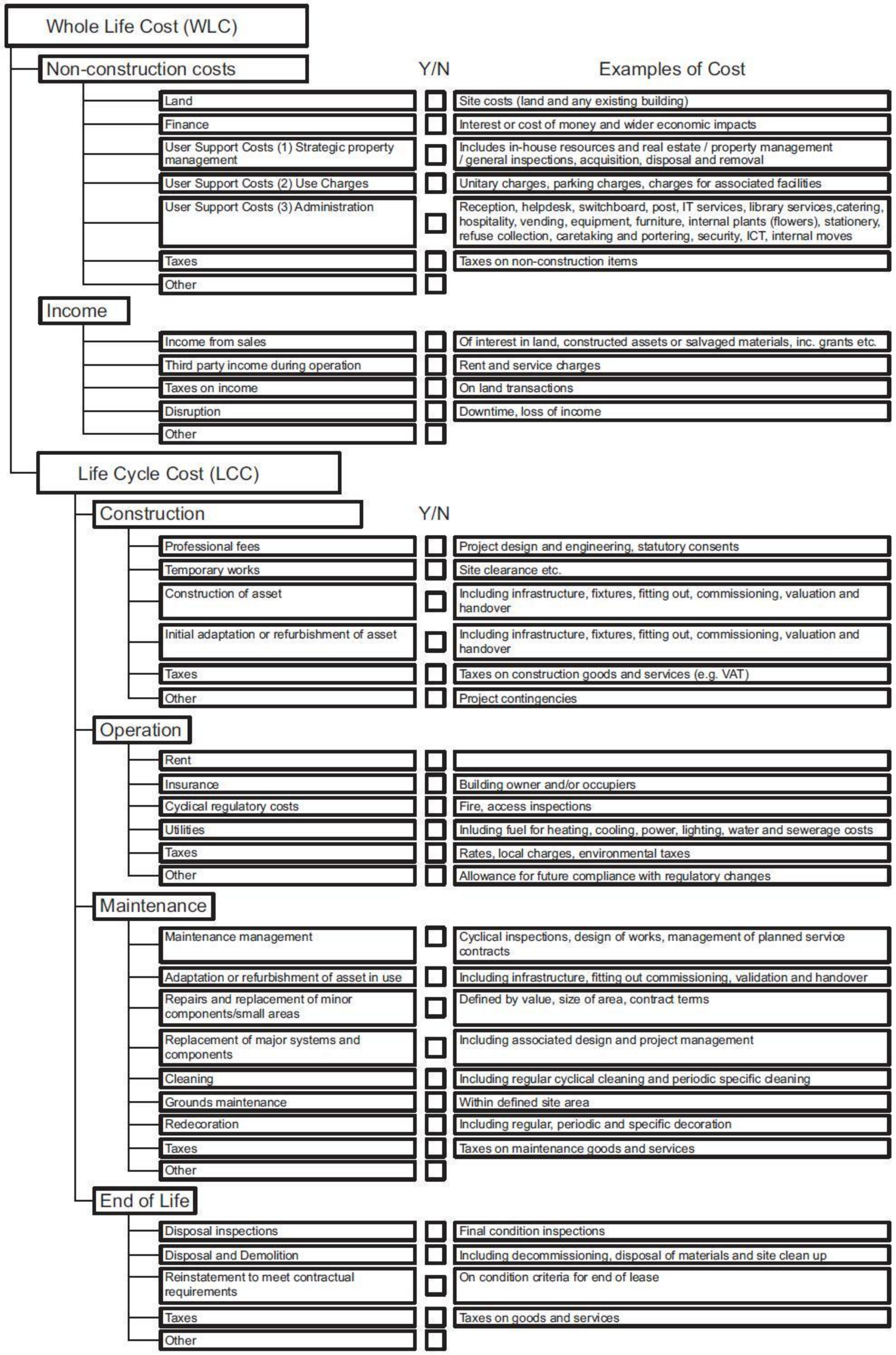
- Financial and economic assessment of all lifecycle phases (insofar as possible)

- The income will be generally not be included, though for some scenarios there could be income elements that should be included.

After having applied the LCC to the scenarios the specific LCC definitions that is to be included in the proposal for the GPP can be completed.

The ISO LCC definition is related to the use of LCC in planning and decision making around construction assets such as buildings etc. It is therefore also relevant to consider in relation to the wastewater infrastructure.

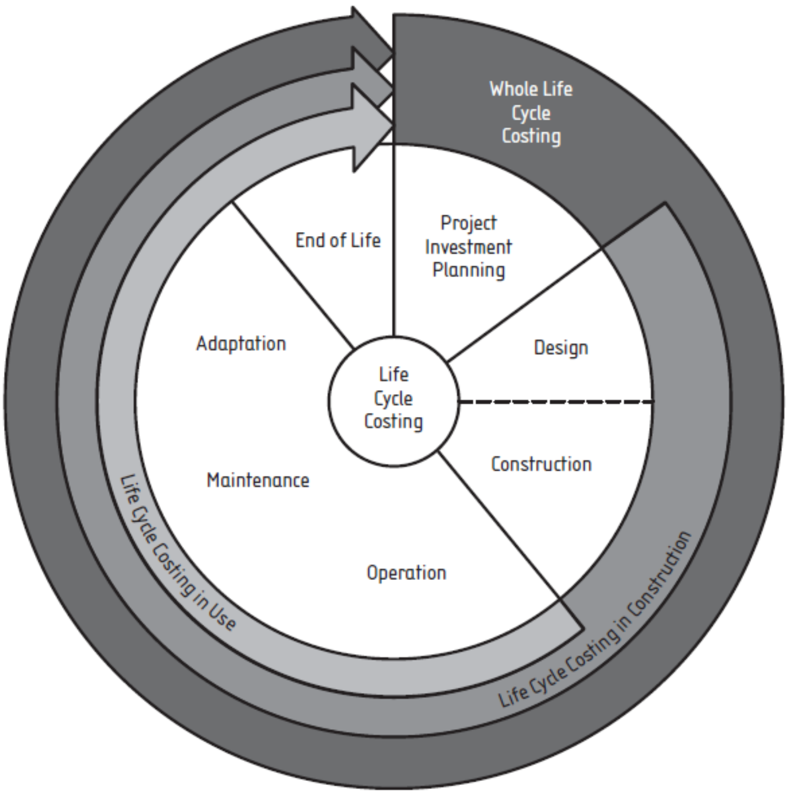
Figure 7-2 Lifecycle cost elements



Source: ISO/DIS 15686-5.2 Part 5: Life cycle costing

In terms of using the LCC, it should be considered where in the project cycle phases the LCC could be most relevant to apply. As illustrated below, LCC can in principle be used in all phases.

Figure 7-3 Lifecycle costing and project planning stages



Source: ISO/DIS 15686-5.2 Part 5: Life cycle costing

Typical decisions informed by LCC analysis include:

- Evaluation of different investment scenarios (e.g. to adapt and redevelop an existing facility, or to provide a totally new facility); - *at the investment planning stage*
- Choices between alternative designs for the whole, or part, of a constructed asset, - *at the feasibility study stage*
- Detailed element level LCC analysis; - *during design and construction stage,*
- Choices b*etween alternative components,* all of which have acceptable performance *(component level LCC analysis); - during the construction or in operation stages*

A discussion of where in the project cycle for wastewater infrastructure projects it is most relevant to use LCC is included in the next section.

7.1.2 How it has been applied so far

Most applications have so far been in the construction industry. Focus has been on the trade off between high initial investment costs and lower operation and maintenance cost at the operation phase and low initial costs followed by higher costs in the later lifecycles.

The recent work by DG Enterprise[9] on the use of LCC in the EU illustrates that the so far limited use of LCC in public procurement has mainly been in relation to the investment decision and option appraisal phase, i.e. at the investment planning stage or at the feasibility study stage.

Before the investment decision is made a WLC assessment where also the benefits of the investment is included can lead to better investment decisions.

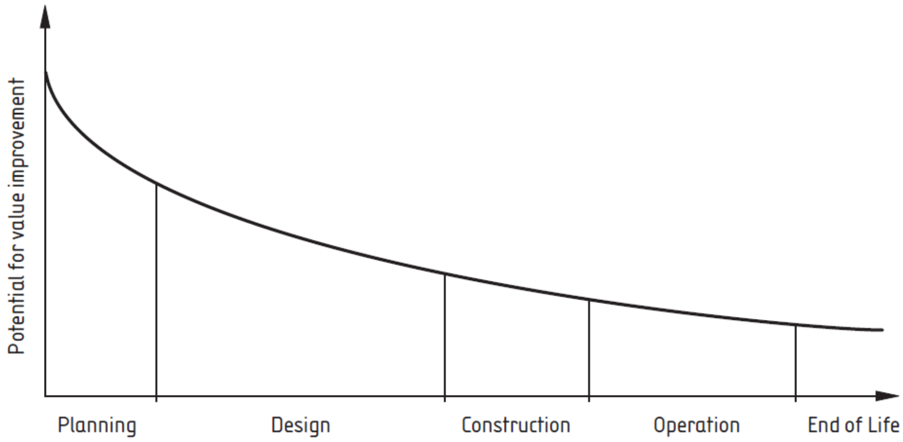
Whether it is called WLC or LCC, the examples from a number Member States illustrates that the concept is introduced to improve decision making around public procurement.

The value of undertaking LCC at different stages of the project cycle is shown below. The figure shows at the investment planning stage where more options are available, there is potential for a large value improvement. Further down the project cycle, there is less freedom to chose and hence less improvement potential from LCC calculations.

The fact the potential benefit is largest in the initial stages does not mean that the use of LCC should restricted to those stages. The LCC can typically be more simple and easy to apply in the later stages so the costs of undertaking the LCC also decreases from the planning stage to operation stage.

[9] Davis Langdon (2007) Towards a common European methodology for Life Cycle Costing (LCC) – Literature Review

Figure 7-4 Value improvement potential from LCC at different project cycle stages



Source: ISO/DIS 15686-5.2 Part 5: Life cycle costing

7.1.3 Examples in relation to GPP

Two examples are presented in this section: A very complex example where all lifecycle stages and all types of costs were considered to a much simpler example where only the financial costs of purchase and operation are included.

The Thames tideway project is an example where LCC was applied in the option analysis phase- before the procurement process. The Thames tideway project is the construction a collection system for storm water in London preventing overflow of untreated sewage into Themes in case of heavy rainfall.

As part of the comprehensive assessment of options for solving the problem a full LCC was undertaken. The project considered alternative routing of large collector along the river and connections to existing wastewater treatment facilities.

The LCC assessment included all costs elements in the construction and operation phase of the project. Possible later decommission was not included. Most of the investment was in the construction of the collection network which would have very long lifetime.

Key results from the assessment are illustrated in the following table taken from a report by the Cost-benefit Working Group[10]. It shows the financial cost - investment and operational costs - as well as financial benefits and non-market costs. The non-market costs are economic costs, see further below for what was included.

---

[10] Thames Tideway Tunnel and Treatment - Option Development: Cost Benefit Working Group Report (2006)

Table 7-2 Key results from the assessment of the Thames tideway project

Option	Financial Costs: Capex (£m)	Financial Costs: Opex (£m)	Financial Benefits (£m)	Non-Market Costs (£m)
1a	2364	366	41	108
1b	2262	347	40	99
1c	2453	356	41	108
1c phased	2460	363	42	109
2a	1816	310	30	61
2b	1878	361	30	65
2c	1907	314	30	57

All figures in 2006 prices totalled over 60 years

Given the nature of this specific wastewater infrastructure project, the main cost element is the investment costs. The operational costs comprise only an around 15% over a 60 years lifetime. The non-market costs comprise less than 5% of the investment costs.

All the elements that were actually quantified included:

- Cost of energy embodied in materials
- Recreation effects (during construction)
- Energy used for tunnel boring
- Delays to traffic
- Transport construction waste
- Disposal of construction waste
- Use of Thames bubblers
- Flood risk
- Recreation (operational phase)
- Energy for operation
- Energy for treatment
- Sludge handling
  - Energy from sludge
  - Transport of ash
  - Disposal ash

The Thames Tideway project is an example of a very comprehensive assessment undertaken as part of the investment planning stage. The LCC, which using the ISO terminology from above, in fact was a full Whole Life Cost analysis was to inform the decision about the project. It was a full cost-benefit analysis including the benefits of the alternative options. In relation to this study it is interesting as it shows that LCC has been applied and that it can be useful in the investment planning stage where all relevant options are appraised.

It should be noted that it required significant resources at investment planning stage to do the full LCC and even though these costs are limited compared to the investment costs, the body responsible for the decision about the infrastructure and the procurement process should be able to commit such funds in case it wants to undertake a full LCC.

The Thames example illustrates a relatively complicated use of LCC where all elements are covered. There are examples where more simple LCC approaches have been used.

A Swedish wastewater company has used LCC to procure pumps where the energy cost during operation was taken into account.

They defined the following award criteria[11]:

> ***Award criteria:*** *Most economically advantageous tender on the basis of purchase price plus the cost of energy consumption by the pumps over a ten-year period, calculated according to the following formula:*
>
> *Energy consumption of pump at specified capacities * Hours per year operating at that capacity * Cost of energy (= 1 SEK per kWh)* 10*

This is an example where the requirements regarding pump capacities and operational hours was given and the contractor should provide the specific energy consumption of the offered pumps as part of the financial offer.

This is an example that using LCC can be very simple and easy and that it can be included in any stage. The purchase of a pump could be in the construction phase as well as in the operation phase when replacement would be required.

7.2 Methodological considerations

In order to make recommendations for the use of LCC as part of the procurement of wastewater infrastructure, the application of the suggested LCC approach to the scenarios defined in the Section 5 will allow testing and revision of the approach.

Based on the definition of the concepts, the specific application to wastewater infrastructure is discussed in the following sections in order to identify the elements of the LCC approach is particularly relevant to assess and test in relation to wastewater infrastructure.

There are some overall issues that should be investigated when applying LCC to the scenarios. These issues include:

› Where in the project cycle should LCC be recommended for use?

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[11] Ryaverket waste water treatment plant, Sweden - GPP criteria example

- How should it be applied in the planning stage?

These questions relate what is illustrated at Figure 7-4. At the planning stage where alternative options to deliver the necessary service or compliance the relevant legislation is assessed and compared, the potential improvement in the overall value of the project (i.e. less costs) are higher than in the later stages.

The assessment of the scenarios will provide insight into the potential improvements in different life cycle stages and thereby inform the recommendations on where and how to apply LCC.

The issues of how to consider the external costs are described and discussed as part of each project life cycle.

7.2.1 Issues in relation to the construction phase

The main issue to consider is what cost elements should be included specifically in relation to wastewater infrastructure.

What should be included?

- Land acquisition
- Capital investment costs
- Embodied energy in key construction materials
  - Concrete
  - Steel
  - Plastic
- Disruptions caused by the construction (most relevant for sewage systems)
- Expected life time of the components

The costs of land might be relevant to consider as different technical solutions might require different amounts of land. The capital investment costs are core of the project costs and should obviously be included in any LCC. In relation to the capital costs, the expected life time of each component should be considered. One would expect the lifetime to be a very important parameter for the overall LCC. It is also one that could be difficult to quantify and validate as part of the procurement process. Hence, this one of the issues to be further considered and to investigate as part of the scenario calculations.

One of the important externalities associated with the construction of the infrastructure includes the energy embodied in the used material. Ideally, the estimation should be based on a full accounting of the environmental impacts which is the same as applying an LCA and monetised all the environmental effects. As the material might be produced under different technologies and at different locations, it will be difficult to estimate all the impacts and there will also not be monetary values to allow for the cost estimation. Estimation of the carbon emissions associated with the embodied energy has been done with regard to large infrastructure projects and was also included in the Thames Tideway example presented above. Hence, this seems feasible to include the embodied energy.

These elements will be further considered in the application of LCC on the scenarios as a basis for making the final recommendation on what should be included in the GPP guideline.

7.2.2 Issues in relation to the operation phase

The elements that should be considered include:

- All operational costs (e.g. manpower, energy, chemicals, transport)
- Maintenance costs (manpower, spare parts etc)
- External costs related to treatment level (e.g. costs of the nitrogen and phosphorous emissions)
- External costs related to the discharge of heavy metals and other priority hazardous substances
- External costs associated with energy use (carbon and air pollution)

Inclusion in the LCC of the operational costs as well as the maintenance costs is relatively straightforward.

The external cost related to the treatment level is more complicated to include. The question is how to determine the value of additional removal of for examples BOD, N or P.

The environmental damage from the discharge of BOD, N or P will depend on the local or regional condition in the receiving water body. Hence, general monetary values for the environmental effect of these discharges can not be established.

If a River Basin Management Plan (RBMP) has been established according the requirements of the Water Framework Directive (WFD), it might allow an assessment of the benefits of increasing the treatment for a wastewater treatment plant within catchment area of a water body. Ideally, the RBMP should be made in a way that minimises the costs of achieving the WFD objectives. The WFD includes a requirement to undertake a cost-effectiveness analysis to determine that the right options have been selected. If an optimal RBMP has been made and the treatment requirements for each wastewater treatment plant have been set accordingly, then there is no benefit of providing better treatment and this element should therefore not be included in the LCC.

The use of energy causes carbon emission and air pollution dependent of the type of source of energy used to operate the wastewater infrastructure. In most cases it will be electricity and national emission values would be available. The carbon emission can be valued through either a national carbon price or by using an appropriate EU value.

The removing of priority harmful substances can be estimated - the quantities discharged when applying different technical options. The monetisation of these discharges is more uncertain, but there are unit costs for example heavy metals and therefore, the cost impacts of the emission/discharge of such substances will be considered.

7.2.3 Issues in relation to decommissioning

The decommissioning of wastewater infrastructure is very similar to for example the decommissioning of buildings.

Whether costs of separating parts and materials that be reused or recycled can be affected by the design is a difficult question to answer. There is probably not sufficient data available on the costs of decommission to allow such an assessment.

The LCC can include the costs of the decommissioning and the value of recycling of materials and costs of the disposal of materials that can not be recycled. The assessment of the scenarios will illustrate how important the decommissioning phase is in the overall LCC and thereby inform the recommendations regarding how this stage should dealt with in the LCC.

7.3 Suggested approach

The approach to be used for the LCC calculation of the scenarios is described in this section.

The LCC is defined as:

LCC = Investment costs + operational costs + decommissioning costs + external costs.

The purpose of the assessment of the LCC for the scenarios is to estimate the importance of the various elements and of the life cycle stages. The assumptions regarding the estimation of each component is described.

It should be noted that purpose of the assessment of the scenarios, see Section 5, is to understand the order of magnitude of each life cycle and the key elements such as the external costs. The assessment of the scenarios will enable the further development of the GPP criteria and the suggestions for how to use LCC.

7.3.1 Cost functions for construction and use costs

The main parts of the LCC are likely to be the investment and operational costs. The estimate of these costs could be done either as detailed bottom-up approach or through a more top-down approach using cost functions.

The way costs are estimated during feasibility and design stages is through detailed bottom-up calculations. For the purpose of estimating the LCC for the scenarios, an approach based on costs functions is suggested. The applied cost functions[12] have been developed as part of comprehensive cost model[13]. Using an already established cost function approach has many advantages:

- It is a tested and documented approach.
- The cost functions will give "average" level of costs for typical treatment and collection systems and will allow this study to focus on including external costs and the decommission phase.
- Using cost functions means that the estimation of compliance costs are made transparent manner as all assumption can be reviewed.

The cost functions covers:

- Collection systems;
- Treatment level (primary, secondary and tertiary treatment).

These cost functions will provide the basis for the estimation of the investment and operational costs of the scenarios. The scenarios include technologies that are not directly included in the cost function database. For these scenarios, we will based on our experience either add or subtract from the base estimate depending on which components are additionally included or not included.

The cost functions for the collection system and for treatment are presented below.

Collection

The generic cost function for the collection system has been developed based on the following:

- Function of the total length of pipes with number of p.e. as driver;
- Distribution of pipe length on pipe diameters; and
- Cost for each diameter size.

The resulting cost function displaying the unit costs per p.e. as a function of agglomeration size in p.e. is illustrated below (Figure 7-5). The graph includes both the point cost estimates and the fitted curve which has been used to derive the costs used here.

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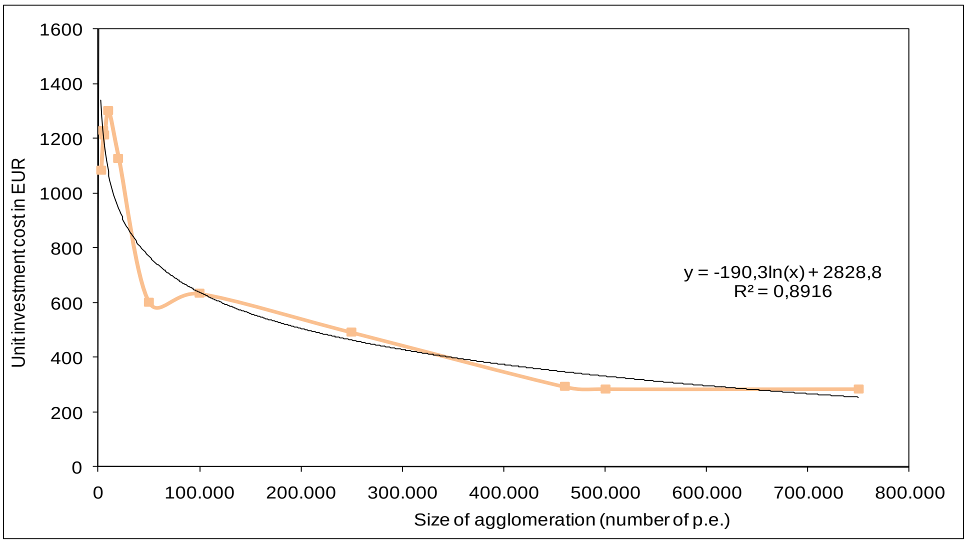
[12] COWI (2004) The FEASIBLE Model Version 2 The report and cost function documentation can be found at OECDs website: FEASIBLE Model documentation website
[13] The basis for the suggested costing approach is the one we have developed and used in preparing sector strategies in the water sector in a number of countries since 1998. The approach called FEASIBLE (Financing for Environmental, Affordable and Strategic Investments that Bring on Large-scale Expenditure) allows for costing of water sector infrastructure[13].

Figure 7-5 Replacement value function for wastewater collection networks



Source: Consultant's estimate

The total replacement value function illustrated above is a result of combining the assumptions on the function concerning total pipe length based on connected population, with the default distribution on pipe diameters as a function of population size and, finally, the unit price of pipes of different diameters. It reflects the unit replacement value of the collection system as a function of population.

The investment cost function show the costs of a single pipe separate system excludes storm water run-off, i.e. it is designed for separate sanitary wastewater only.

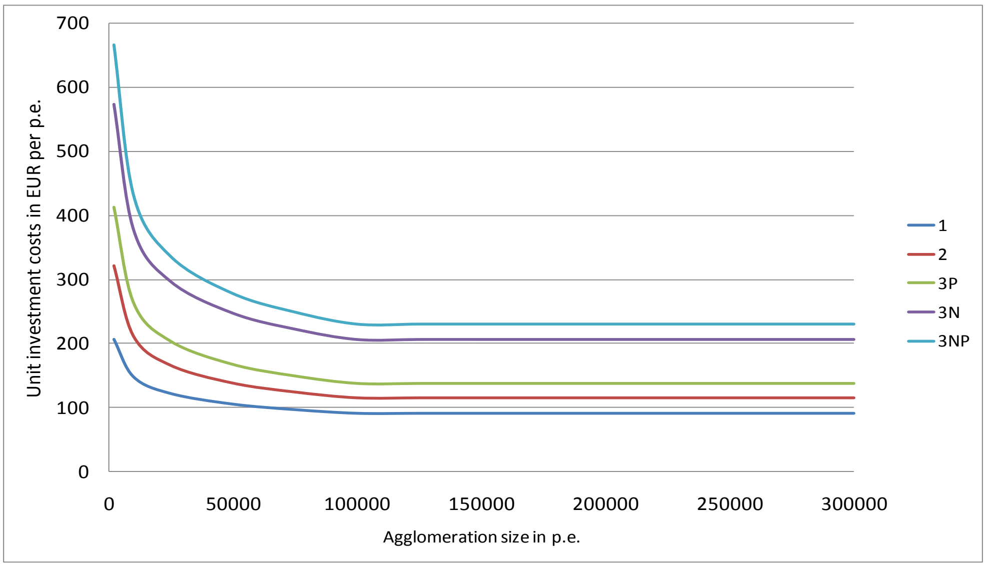
Treatment

As part of developing the FEASIBLE model, cost functions for wastewater treatment were developed[14]. The cost functions are illustrated in Figure 7-6.

The cost functions indicate costs categories for different levels of treatment. Specific technologies will have specific costs that diviates from these cost categories. In the examples of LCC for selected scenarios, the effects of the specific technologies are illustrated see Section 7.4.

[14] DEPA: Calculation system for investment costs for wastewater treatment (in Danish), COWI and Lønholt&Jans I-S, 1990. These cost functions is also used in a text book on civil engineering in the wastewater sector: Winther, L et al, "Spildevandsteknik", 2009 Polyteknisk Forlag. (in Danish).

Figure 7-6 Investment expenditure functions for wastewater treatment



Source: Consultant's estimate

The operation costs for wastewater services are estimated using a percentage of the investment expenditure. This covers all operational expenditure except electricity, which will be specified separately.

Other operation costs: 3% of the total investment expenditure for wastewater treatment. The operational cost functions by technology are presented in Table below[15].

Table 7-3 Cost functions for operational costs

		Cost functions EUR per p.e. 2008 DK price level	
	Technology	O&M excl energy	kWh/p.e.
1	Primary (Mechanical)	= 5 % of investment	15
2	Secondary (mechanical biological)	= 5 % of investment	25
3P	Advanced with P-removal	= 5 % of investment	40
3N	Advanced with N-removal	= 5 % of investment	40
3NP	Advanced with N and P removal	= 5 % of investment	40

Example

As an example of the use of the cost functions, scenario 9 which is a new WTTP for 150.000 p.e. with disinfection. The base investment costs would be estimated as

[15] Given the assumed electricity consumption and current electricity prices the total operational costs including energy amount to about 6% of the investment costs.

the number of p.e. times the unit costs as indicated at Figure 7-6. Based on experience data we will estimate the unit costs of disinfection. The results would:

Investment costs = 150000 p.e * (230 EUR per p.e + unit cost of disinfection)

A similar estimation will be made for the other scenarios.

7.3.2 Assumptions for decommissioning costs

We have experience from a number of decommissioning projects and the costs from the examples will be applied as a basis for estimating the dismantling of the infrastructure. Most of the materials can be recycled. The value of the recycled material will to some extent depends on the local conditions. Scrap metal can be valued by the current prices on scrap metal, while the concrete will have local specific price.

7.3.3 Assumptions for valuation of externalities

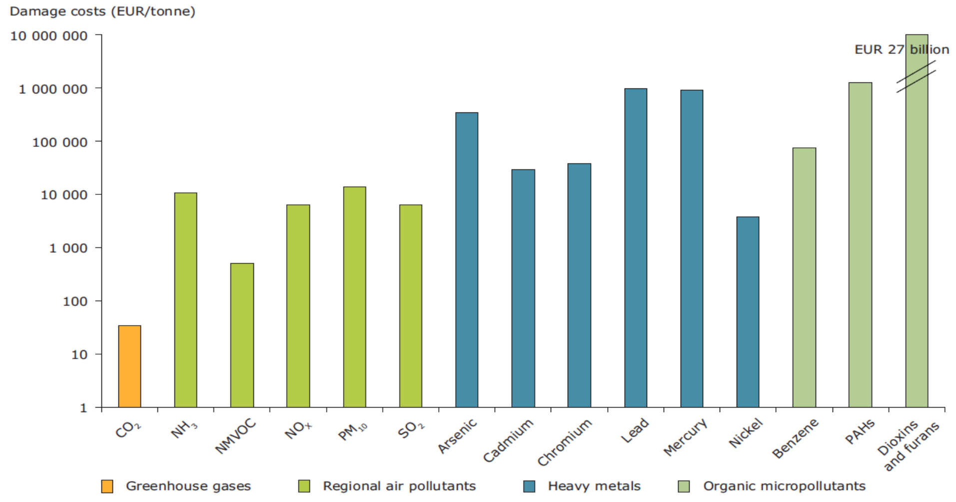
The externalities that can be valued in the LCC estimations for the scenarios include:

- CO_2 (from embodied energy and energy in operational phase) and
- Heavy metals (discharged from the WTTPs)

The CO_2 unit cost - often called the social cost of carbon (SCC) can be based on different approaches and sources. The IPCC has estimated a damage cost between 3 - 70 EUR per tons. In some EU Member States, there are recommended social cost of carbon values. We will use a range of values to test the sensitivity.

The unit costs for heavy metals will be based on a resent study on the costs of air pollution. The costs are based on two intake routes - inhalation and indigestion - so the values for emissions to the water environment have to be adjusted as there is only one uptake route.

Figure 7-7 *Unit costs for air pollutants*



Source: EEA (2011); *Revealing the costs of air pollution from industrial facilities in Europe*; EEA Technical report No 15/2011

7.4 LCC scenario calculations

Based on the suggested approach and using the assumptions presented above, this section includes examples of LCC calculations based on the scenarios described in Section 5.

The estimation of the LCC is divided into financial and external costs. Hence the LCC costs included the categories are the following:

Total LCC	**Financial costs**	**External costs**
Construction	Investment costs	Cost of carbon in materials
Operation	Net present value over life time of O&M costs	Net present value of emissions over life time.
Decommissioning	NPV of decommissioning at end of life time	Saved carbon costs from recovered materials

The next sections describe firstly the financial costs and secondly, the estimation of the external costs.

7.4.1 Financial LLC costs for wastewater treatment plants

Here the LCC estimations for Scenario 6, 7 and 8 are presented. These scenarios all cover the construction of the new wastewater treatment plant for an agglomeration of 50,000 PE.

Construction and operational costs

The assumptions regarding the investment and O&M costs are illustrated in the next table. The data give order of magnitude estimates for the relevant unit costs. It is important to note that the unit costs are estimates of an average EU27 cost level and that local costs could deviate with more than 50% due to both general differences in price and cost levels across EU and as result of specific local (technical) conditions.

Table 7-4 Construction and operation cost assumptions

PE	**50,000**	**Construction**	**O&M**	**Energy (excl sludge)**	**Sludge handling**
		Unit cost in EUR/PE	in % of investment cost	kWh/PE	% of investment cost
Scenario 6	Extended aeration	210	4.0%	45	2%
Scenario 7	Gas utilisation etc	230	5.0%	30	2%
Scenario 8	MBR	240	6.5%	40	2%

The construction costs are based on the cost functions presented in Figure 7-6 and Table 7-above and adjusted based on experience data. We have done a number of feasibility studies where we can draw information about the relative costs of alternative technologies and this information has been used to estimate the unit costs.

Using the cost functions shown in Figure 7-6, the unit cost per PE for a treatment plant that remove N and P is about 275 EUR for at plant with a capacity of 50,000 PE. This cost is in a Danish price level of 2008. Adjusting the price level to EU27 average and inflating the cost to a 2011 price level, the resulting unit cost is 210 EUR per PE. This cost is assumed for the Scenario 6 wastewater treatment plant. The other two technologies have slightly higher investment and operation and maintenance costs. Only Scenario 7 technology has lower energy costs.

The characteristics of the three technologies are described below.

- Extended aeration: Low investment costs, high energy costs
- Gas utilisation: Medium investment costs, low energy costs
- MBR: High investment costs, high operational costs, higher treatment efficiencies, less area required for the site (around 30% less).

Using the above unit costs and the assumptions regarding the O&M costs, the following set of unit costs can be applied.

Table 7-5 Construction and operation cost assumptions

PE	50,000	Construction	O&M	Energy	Sludge	Total
		Unit cost in EUR/PE	EUR/PE	EUR/PE	EUR/PE	EUR/PE
Scenario 6	Extended aeration	210	8.4	4.5	4.2	17.1
Scenario 7	Gas utilisation etc	230	11.5	3.0	4.6	19.1
Scenario 8	MBR	240	15.6	4.0	4.8	24.4

The investment costs should be included in any LCC assessment and they are key part of any standard procurement process.

The challenge is how to include the operational costs. Unless the contract is a design-build-operate, the contractor will not have detailed information that allows the estimation of the operational costs. The wastewater company would therefore have to specify some of the elements and calculation formulas. Through the planning stage where feasibility studies are prepared, the necessary information regarding the operational phase would be developed.

The operational costs could be categorised and the calculation methods defined for each category.

Table 7-6 Calculation of operational costs for LCC

	Vary with technology - costs defined by formula for each technology	Vary with individual design - contractor should estimate costs
Chemicals	Yes	Yes
Materials (spare parts etc)	Yes	Yes
Staff	Yes	No
Energy	Yes	Yes

The elements that are specified by a formula means that the bidder will only affect this element by selecting to propose a specific technology, while for the elements that could vary within each technology, the bidder will have to estimate the specific costs.

The product sheets will include more specific suggestions for how to apply the LCC approach.

Decommissioning costs

The decommissioning is assumed to cost about 25 EUR/PE derived as an expert estimate. This unit cost is assumed to be the same for all three technologies. This is the costs of the demolishing of the site and treatment/disposal of the waste. The value of the material that can be recycled should be included as an income. It is assumed that only the metals have a value. For the calculations, the value of the scrap metal is assumed as 200 EUR per tonne.

As the amounts of metals used in construction vary across the three technologies, the resulting decommissioning costs also vary slightly. The estimates costs vary between 356,000 EUR to 365,000 EUR for the 50,000 PE plants.

Financial LCC

Based on the above assumptions, the LCC for the three technologies can be estimated. The lifetime of the plants are assumed to be 30 years as average for all components. The LCC values are net present values over the 30 year period discounted with a rate of 4%.

Table 7-7 Financial LCC estimates for scenario 6-8 - NPV in million EUR (2011 price level)

	Scenario 6	Scenario 7	Scenario 8
Construction	10.5	11.5	12.0
Operation	14.8	16.5	20.1
Decommissioning	0.4	0.4	0.4
Total LCC	25.6	28.4	32.4

The operation phase accounts for the majority of the financial LCC - around 60% of the LCC is due to the operation of the treatment plants.

7.4.2 External LCC costs

External costs in the construction phase

The main external cost element in the construction phase is related to the energy content of the construction materials. The indicator for the external costs is the GHG emissions associated with the each material.

The amounts of materials used in each of the technologies have been estimated. These are rough indications of the likely amounts for each technology and divided into material fractions.

Table 7-8 Material content in the wastewater treatment plant kg per PE

	Scenario 6	Scenario 7	Scenario 8
Concrete	140.400	126.360	98.280
Steel in concrete	9.600	8.640	6.720
Carbon steel and cast iron	1.803	2.163	1.262
Stainless steel	0.410	0.492	0.492
Plastics	0.450	0.450	0.540
Aluminium	0.013	0.013	0.013
Cobber	0.038	0.038	0.038

The external cost is estimated using an average amount of CO_2 equivalents per kg of material. This is a rough estimation as the energy used to produce the material varies dependent on where the material has been manufactured and the technologies applied.

The external cost related to the emissions of GHS by material is estimated using a value of 40 EUR per CO_2 equivalent. As described in Section 7.3.3, the IPCC has estimated the damage costs as a range between 3 to 70 EUR per tonne of CO_2 equivalent so 40 EUR is midrange estimate.

Table 7-9 Climate change costs related to embedded energy in materials for scenario 6

	CO_2 per kg	Total CO_2 costs per PE	Total external costs in EUR
Concrete	0.67	3.76	188,000
Steel in concrete	1.5	0.58	28,800
Carbon steel and cast iron	0.7	0.05	2,50
Stainless steel	3.5	0.06	2,870
Plastics	1.8	0.03	1,620
Aluminium	11	0.01	270
Cobber	3	0.00	225
Total		4.49	224,00

Note: Numbers are rounded.

The resulting estimates of the carbon costs of construction materials for the three technologies are presented in the below table.

Table 7-10 Climate change costs related to embedded energy in materials in EUR

	Scenario 6	Scenario 7	Scenario 8
Concrete	188,136	169,322	131,695
Steel in concrete	28,800	25,920	20,160
Carbon steel and cast iron	2,524	3,028	1,766
Stainless steel	2,870	3,444	3,444
Plastics	1,620	1,620	1,944
Aluminium	273	275	275
Cobber	225	225	225
Total	224,447	203,835	159,510

The external costs associated with the energy content of the construction materials are not very high when values through the social costs of the carbon emissions.

External costs in the operation phase

The external costs of the operation phase are estimated through three elements:

- Costs of the remaining N and P discharges;
- The costs of the carbon emissions from the used energy; and
- The discharge of heavy metals.

All three technologies comply with the UWWTD requirements. With respect to N and P removal this means that the outlet concentrations will be below 10 mg N per litre and below 1.5 mg P per litre. For the estimations the following outlet concentrations of N and P are assumed.

Table 7-11 Outlet concentrations in mg/l of N and P by scenario

	Scenario 6	Scenario 7	Scenario 8
Total Nitrogen	7	7	6
Total Phosphorous	1	1	0.3

The total amount of N and P is estimated based on 200 l/PE/day.

The value of the N and P discharges will depend on the local conditions. The assessment illustrated here only suggests possible order of magnitude results. The requirement for removal of nutrients should follow from the River Basin Management Plan that already has been developed for each RB with EU as required by the Water Framework Directive.

The monetisation of the damage from N and P pollution is based on a Swedish study. The study that has developed monetary estimates of the damage costs of N and P[16]. They are based on willingness to pay studies for improvement of coastal waters and the Baltic Sea. The damage costs are 8 EUR per tonnes of N and 75 EUR per tonnes of P. The study also includes a comparison with other valuation studies suggesting that the specific N and P damage costs are in line with the results of other valuation studies.

Applying these values to the three scenarios, the annual external costs of nutrients pollution can be derived.

[16] Ahlroth 2009. *Developing a weighting set based on monetary damage estimates. Method and case studies;* Royal Institute of Technology Stockholm, Sweden

Table 7-12 External costs of discharge of N and P in EUR per year

	Scenario 6	Scenario 7	Scenario 8
N	168,000	168,000	167,000
P	177,000	177,000	83,000
Total	345,000	345,000	250,000

The external costs of the electricity used for the treatment is assessed with regard to the GHG emissions. It could be argued that the electricity price already include this effect. All electricity producers are included in the EU Emission Trading System (EU ETS) and hence, the market price of electricity includes a in principle a price of CO_2 emissions. So far the carbon price has been relatively low due to high allocation of ETS allowances.

To illustrate the possible order of magnitude of this effect, an estimation using the average EU GHG emissions for electricity and the damage cost of 40 EUR per tonne of CO_2 has been done.

Table 7-13 External costs of electricity consumption during use - costs of GHG emissions in EUR per year

	Scenario 6	Scenario 7	Scenario 8
Energy consumption in kWh per PE	45	30	40
CO_2 equivalents in g per kWh	300	300	300
Total in EUR per year	27,000	18,000	24,000

The last external cost element that has been assessed is the discharge of heavy metals. The assumptions regarding the inlet concentrations and the assumed treatment levels are presented in the below table.

Table 7-14 Discharge of heavy metals

	Inlet concentration	Estimated treatment efficiency		
	µg/l	Scenario 6	Scenario 7	Scenario 8
Cadmium	0.56	82%	82%	95%
Mercury	0.40	78%	78%	95%
Lead	8.39	70%	70%	95%
Nickel	11.00	42%	42%	95%
Chrome	10.10	41%	41%	95%
Zink	213.00	58%	58%	95%
Copper	79.00	92%	92%	95%
Arsenic	3.20	59%	59%	95%

The valuation of the damage is based on the unit costs presented in Figure 7-7 above. These values are related to air pollution and they are therefore higher that what would be the case for discharges into water. The estimation gives still an order of magnitude assessment that can be used to determine how to account for these types of impacts.

Table 7-15 Discharge of heavy metals

	Damage cost	Estimated damage costs		
	EUR per kg	Scenario 6	Scenario 7	Scenario 8
Cadmium	50	18	18	5
Mercury	1000	16	16	4
Lead	1000	465	465	77
Nickel	5	1,168	1,168	100
Chrome	50	1,090	1,090	92
Zink	0.5	16,151	16,151	1,944
Copper	0.5	1,223	1,223	721
Arsenic	500	237	237	29
Total costs	-	20,369	20,369	2,972

The assessment indicates that the order of magnitude is lower than the external costs associated with the discharges of N and P. It should be noted that the damage costs are uncertain and therefore, it might not be relevant to include this type of effect in an LCC.

Total external costs

The total external costs for the three scenarios are illustrated below.

Table 7-16 External LCC estimates for scenario 6-8 - NPV in MEUR (2011 price level)

	Scenario 6	Scenario 7	Scenario 8
Construction	0.2	0.2	0.2
Operation	6.8	6.6	4.8
Decommissioning	-0.01	-0.01	-0.01
Total LCC	7.0	6.8	4.9

The external costs during operation are discounted over a 30 years life time and with a discount rate of 4%.

7.4.3 Total LCC for the selected scenarios

For Scenario 6, the resulting LCC is illustrated below. The example shows the distribution on each of the included LCC elements.

Table 7-17 LCC example - Scenario 6

Total LCC in MEUR	Financial costs	External costs	Total
Construction	10.5	0.2	10.7
Operation	14.8	6.8	21.6
Decommissioning	0.4	-0.01	0.3
Total LCC	25.6	7.0	32.6

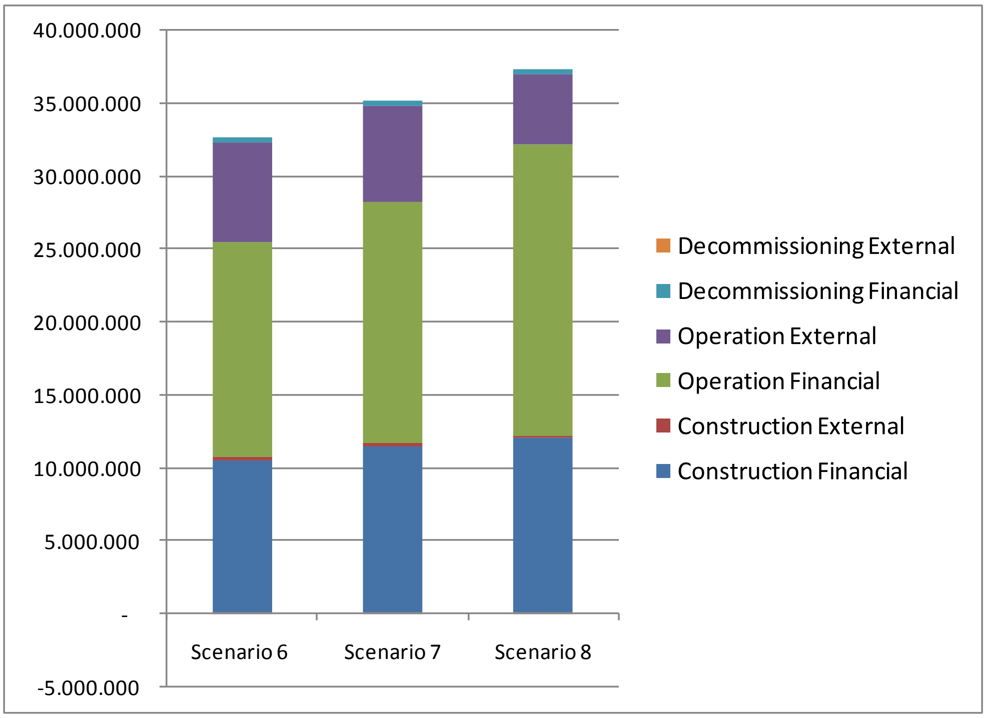
The example for the Scenario 6 technology illustrates that the financial costs are the main cost element and similarly that the operation phase accounts for the majority of the LCC costs both with respect to the financial and the external costs.

The results are similar regarding the other two technologies. All three scenarios are compared with respect to the LCC in the below table.

Table 7-18 LCC estimations for Scenario 6, 7 and 8

		Scenario 6	Scenario 7	Scenario 8
Construction	Financial	10.5	11.5	12.0
	External	0.2	0.2	0.2
Operation	Financial	14.8	16.5	20.1
	External	6.8	6.6	4.8
Decommissioning	Financial	0.4	0.4	0.4
	External	-0.0	-0.0	-0.0
Total LCC	Financial	25.6	28.4	32.4
	External	7.0	6.8	4.9
	Total	32.6	35.2	37.4

The LCC values are illustrated graphically below.



The main findings are:

- The operational phase accounts for the majority of the LCC around two-thirds
- The financial costs accounts for around 80% of the LCC
- The majority of the external costs are associated with the operation - about 97% - though this is sensitive to the specific values for the damage of N and P discharges
- The MBR technology has higher LCC but it also achieves higher removal of pollutants and hence the external costs are lower - additional benefits of the technology is removal of bacteriological pollutants (not monetised) and the area of the plant site is only about 70% of the other two technologies.

The result of the LCC estimations suggests the following regarding the elements to include in an LCC for wastewater treatment plant procurement:

- All the financial cost elements should be included;
- Only the external costs during the operational phase should be included.

This will be further elaborated in the LCC recommendations to be part of the product sheets.

8 Introduction to environmental criteria for wastewater infrastructure projects

In this section an introduction to environmental criteria for wastewater infrastructure projects is given.

Wastewater infrastructure projects are much diversified. Thus it is decided to split wastewater infrastructure into three categories: sewers (pipes, pumping stations etc.), wastewater treatment plants (in- or excluding pipes) and sludge drying and incineration (see chapter 3).

The core and comprehensive criteria in the accompanying Product Sheets for the three categories of wastewater infrastructure projects addresses the most common and largest environmental issues in all of the Member States. It can be favourable for the single Member State to omit some criteria due to lack of the specific problem. An example of this is water consumption which is pertinent in some countries and extraneous in other countries.

8.1 Process of defining criteria

As the GPP criteria are developed to assist all Member States in EU it is vital to develop the criteria to hold the many aspects which can be individual for each Member State and region in EU.

The following process has been used during development of the criteria:

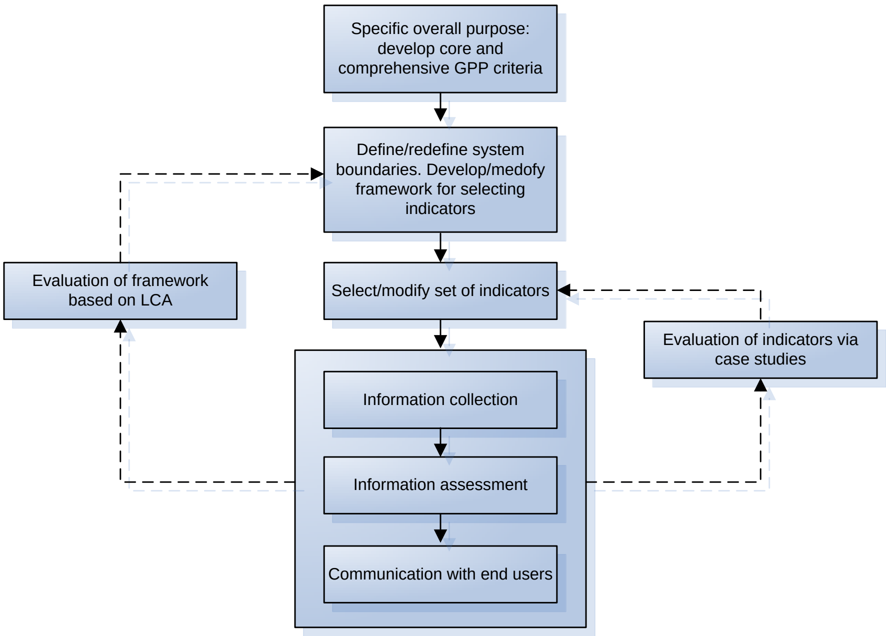


Figure 8-1: Process for developing GPP criteria for wastewater infrastructure

This process has resulted in a number of core and comprehensive criteria which has been accessible and open for commenting by all stakeholders.

In the rest of this chapter the main areas for significant differences in the national and local context are described.

8.2 Key environmental aspects

In this section selected environmental aspects are discussed.

The reason for pointing out some environmental aspects is that the severities differ greatly in the Member States.

Therefore the section can be used for the Member States or Public Authorities as a basis for discussion of weather the environmental aspects must be included as criteria in the Public Procurement stage of a project.

The approach to tackle these environmental aspects is described in chapter 9 and the Product Sheet for wastewater infrastructure.

8.2.1 Different national calculation methods and standards for energy

Construction of wastewater treatment plants and sludge treatment facilities often also includes construction of buildings for offices, etc.

Thus the aspects concerning buildings described in the Technical Background Report ad Product Sheet for Construction are also relevant for the GPP criteria for wastewater infrastructure.

On 18 May 2010 the European Union adopted a recast of the directive on energy performance of buildings (2001/91/EC). Under this frame the Member States applies energy performance requirements for new and existing buildings.

Currently there are no European minimum performance requirements.

Due to the harmonised regulation of process equipment via Directive 2006/42/EC on machinery and the implemented declarations in each Member State, the specifications for process equipment and machines can be applied throughout all Member States in EU.

8.2.2 Climate zones

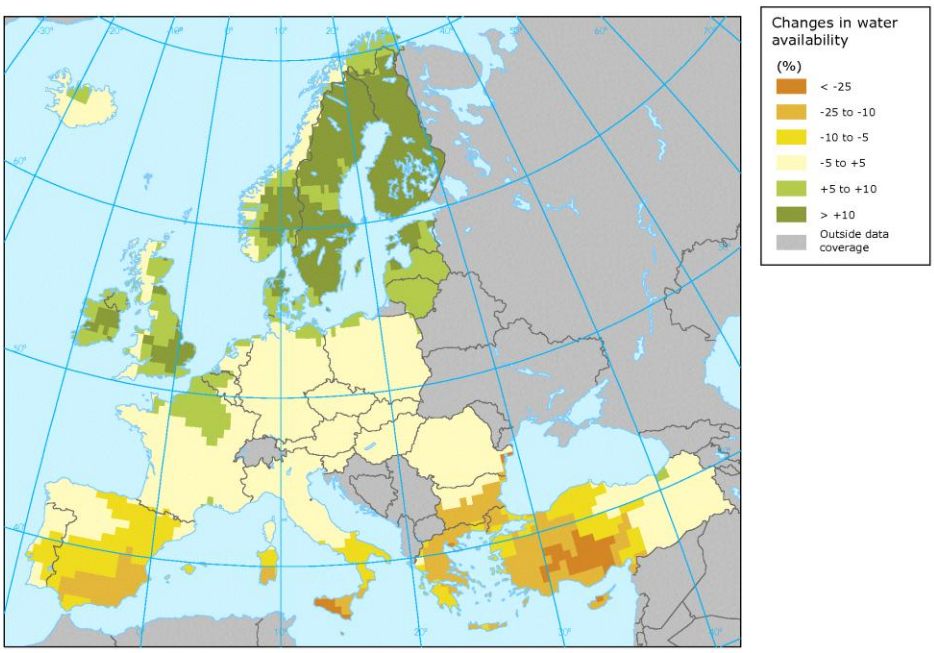
The large differences in temperature in the Member States have great influence on the energy consumption and the treatment efficiency.

Furthermore, the climate zones influence the possibility of using bio fuels for energy requiring operations.

Due to these variations in climate zones, no general requirements for energy demand and treatment efficiency can be applied in the public green procurement criteria for wastewater treatment infrastructure. Thus the Public Authorities must insert national or local values to reflect the specific conditions according to the Product Sheet.

8.2.3 Water scarcity

As described previously the access to water is very limited in some countries which can be seen in the following figure:



/ EEA Report No 4/2005 ISBN: 92-9167-769-8. EEA (European Environment Agency).

OPOCE (Office for Official Publications of the European Communities) Published: Sep 11, 2005/

These countries with water scarcity can have an interest in incorporating criteria on water usage during construction and the use phase, while other countries without water scarcity can neglect this issue. These differences in the need for incorporating environmental considerations will be handled in the Product Sheet where the Public Authorities must address specific aspects targeted to the actual project and site.

It is expected that this water stress will increase during the next years and can be severe for several billions of people. The problem is expected to increase partly due to the increased climate change.

8.2.4 Local/national differences in availability and sustainability of materials used

When a wastewater treatment plant, sludge treatment facilities or sewage pipes are constructed many materials are used. Some of these materials are CE labelled.

According to the new Construction Product Regulation (CPR) all CE labelled products must have an Environmental Product Declaration (EPD), which enables the user to compare products based on potential environmental impacts.

The implementation level of the CPR must be determined by contacting the relevant national body in the Member State responsible for implementation of CPR.

The EPD enables the Public Authorities to set limits for the emission of e.g. greenhouse gasses from construction materials. Restrictions or benchmark are often used for the construction materials which have the largest potential environmental impacts.

As described previously there are also national schemes for sustainable building and ecolabels which can be used for the construction materials by the specific Public Authority.

8.2.5 Local sensitiveness of water bodies

Many studies conclude that the largest potential environmental impact from wastewater treatment plants derive from discharging treated wastewater. For instance */http://www.euneptune.org/Publications%20and%20Presentations/D4-3__NEPTUNE.pdf/*. These studies include general water bodies which differ greatly locally and nationally. Several studies also conclude that toxicity of effluent to saltwater bodies is generally more sensitive than fresh water bodies.

In some Member States permission to discharge treated wastewater from wastewater treatment plants are indispensible for operation of the wastewater treatment plant. This requirement can account for wastewater treatment plants - but also for the industries, hospitals etc. which are discharging to the wastewater treatment plant. Naturally, these permits can restrict and control the emission of contaminants to the receiving water bodies.

Some Member States also require environmental permits for sludge incineration plants and sludge digesters containing limit emission values for handling polluted wastewater, discharge of flue gas etc.

This regulation and thus restriction in the emission of nutrients, pathogens, heavy metals and organic priority substances differs greatly. The reason for differences can be the tradition in the single Member States for detailed regulation of specific pollutants, the sensitiveness of the receiving water bodies etc. To some extend these demands are harmonised via the Water Framework Directive. Still, the level, method and content of regulation are a national and even local matter.

These national and local differences are depicted in the setup of the criteria. Traditionally there are restrictions in the discharge of nutrients which are reflected in the core criteria.

As the demands for discharge of other contaminants often differ nationally and locally, the criteria for all these contaminant must be included in the comprehensive criteria if they are included in national permit levels.

There can also be hazardous substances which are not comprised by the national permit levels, which can be included in the comprehensive criteria. The specific compounds are described in Section 9.3.5 and the Product Sheet for wastewater infrastructure.

9 Recommended criteria options

In this chapter, the proposed criteria for wastewater infrastructure are described and commented briefly.

The criteria are listed and described in details in the wastewater infrastructure product sheet **(link must be inserted)**. Thus the exact criteria and measures to evaluate the bidders' environmental performance are not listed in this Technical Background Report but the overall subjects to be included in the core and comprehensive criteria are discussed in this report.

Furthermore, the process and methodology for implementing the criteria will be described.

The proposed GPP criteria are designed to reflect the key environmental impacts. The approach is summarised in Table 9-1. The order of the environmental impacts does not necessarily translate to the order of their importance.

Key Environmental Impacts	GPP Approach
› Energy consumption especially in the operation phase	› Purchase equipment with low energy consumption/high energy efficiency
› Emission of nutrients with the treated wastewater	› Promote the use of environmentally sound and sustainable materials
› Emission of substances etc. with the treated wastewater (metals, pathogens, pharmaceuticals and organic priority substances)	› Promote the use of materials without or low levels of hazardous substances
	› Favour the treatment efficiency of wastewater treatment plants
› Emissions from sludge incineration	
› Indirect environmental impacts from raw materials production and use	› Increase the energy efficiency of electricity and heat producing units
	› Promote the incentives for reducing the water consumption

Table 9-1: Approach for developing the GPP criteria for wastewater infrastructure

9.1 Process and methodology for GPP criteria

The core and comprehensive criteria are developed for use in all phases of development and implementation of a wastewater infrastructure project. Nevertheless the single steps in the procurement process needs to be addressed with specific criteria for the actual needs and possibilities for incorporating environmental issues.

This process description is prepared as guidance for the Public Authorities when the need for procuring wastewater infrastructure is needed. The steps and application are described in the following.

9.1.1 Initial stages

The initial stages include general outline (Section 4.2.1), feasibility study (Section 4.2.2) and to some extend conceptual design (Section 4.2.3). Common for these stages is that several solutions to the actual problem are discussed. Furthermore the initial decision to handle the problem and fixation of the economic frame are made by politicians based on recommendations from municipal officers and consultants.

The decisions made during the initial stages have great impact on the sustainability and environmental performance of the project. Thus it is very important to incorporate sustainability and environmental considerations very early in the process by developing a strategy. An example is to decide on the treatment focus and level for the wastewater treatment plant e.g. should the effluent standards be more strict than demanded in the UWWTD by demanding for instance bathing water quality in the receiving water bodies. This results in specific requirements for the treatment efficiency of the wastewater treatment plant to remove pathogens.

This strategy can very well contain lines of direction for specific focus areas as well as methodology for weighting the environmental impacts in proportion to economic consequences of the project.

When the process develops the conceptual design phase must further investigate on the overall principles e.g. type, demands and efficiency of primary, secondary and perhaps tertiary treatment facilities, type of sludge treatment etc.

In this initial phase it is also relevant with environmental criteria as for instance construction materials and energy consumption giving rise to environmental impacts which can be addressed and thus limited by GPP criteria.

9.1.2 Preparatory stage

The preparatory stage is also called the preliminary design in Section 4.2.4.

The site of the wastewater treatment plant, sludge incinerator, sewage pipes etc. has been decided in the previous stages. Furthermore, the function of the wastewater infrastructure facilities has been decided e.g. to incinerate sludge, treat wastewater to specific effluent demands etc.

In the preparatory stages the frames has been decided upon but the specific solutions to the problem has not been decided. So the remaining questions can be: is it best to have chemical precipitation contrary to biological removal of phosphorous? Which aeration system is the most optimal in an activated sludge wastewater treatment plant? Should the sludge be treated on site or at an external sludge treatment plant?

The answers to these questions can be supported via the selection criteria applied for the specific project.

In this stage for instance energy demands can be used for assessment of parts of the wastewater treatment plant, the entire wastewater treatment plan, sludge incinerator or sewage system. In this way the single contractor must suggest a technical solution to the problem and also estimate the environmental impacts from energy consumption, construction materials, water consumption etc.

These analyses enable the Public Authority to make the best overall choices for the most sustainable solutions to technical problems.

9.1.3 Detailed design stage

In the detailed design (see description in Section 4.2.5) the full design is developed. This means that the construction materials have been selected and most decisions have been made.

Remaining is the supplier's information of process equipment and construction materials.

There can be relatively big differences in the potential environmental impacts from one supplier of a construction material to another. An example is concrete where the emission of green house gasses can differ with as much as 60% from different suppliers providing a number of cement types. This fact makes it important to set requirements for the most dominating construction materials in this phase.

Furthermore it is important to set energy requirements during the operation phase of the process equipment in the detailed design. This will have a great influence of the total energy consumption during the entire life cycle.

9.1.4 Operation phase

During the operation phase there a few environmental aspects left to consider.

It must be ensured that the specifications guarantied by the contractor are fulfilled. E.g. when the contractors guarantee a certain treatment efficiency it must be verified during operation of the wastewater treatment plant or sludge incinerator. If the promised treatment efficiencies are not fulfilled it can have a significant impact on the total environmental impact.

During the operation phase there must also be focus on the energy consumption, water consumption and consumption of chemicals. Often this is done via the yearly reports where the consumption is indexed in relation to m^3 treated wastewater (for wastewater treatment plants), ton sludge (sludge incineration) or m^3 transported wastewater (for sewage networks).

The Public Authority can use the GPP criteria for wastewater infrastructure to verify the intended and promised performances (see the text about verification in the Product Sheet for Wastewater Infrastructure).

During the operation phase there will also be focus on the consumption of chemicals during operation. The applicable approach here can be alike the comprehensive criteria for construction materials where the chemicals chosen for the operation must be purchased after an evaluation of the sustainability of these chemicals. This fact makes the GPP criteria applicable in the operation phase.

9.1.5 End of life

During the tender phase where the contractors have provided information about the construction materials, information about the construction materials' faith after use, i.e. at decommissioning, has also been given. Thus, this information must have been incorporated during the detailed design or working design where the materials have been chosen. So, for end of life, the GPP criteria are also effective but are typically not applied actively during the end of life for wastewater infrastructure.

9.2 Core environmental GPP criteria

The core GPP criteria are designed to tackle the key environmental impacts to be used by any European contracting authority. They are designed to be used with minimum additional verification effort or cost increases.

Thus, the core criteria ensure that the quick wins are obtained without any expert consultation.

It must be mentioned that not all of the large contributors to potential environmental impacts from emission of treated wastewater are incorporated in the core criteria. The reason is that data on treatment efficiencies of heavy metals, pathogens, pharmaceuticals and organic priority substances can be time consuming and demand the involvement of experts. Nevertheless, the Public Authorities must be encouraged to include these aspects as they contribute significantly to the total potential environmental impact from wastewater treatment plants. This can be done by incorporating the comprehensive criteria.

In the following sections the themes of the environmental impacts are described briefly.

9.2.1 Subject matter and selection criteria

In this section the subject matter and selection criteria will be defined.

Subject matter

The subject matter is defined to be:

› Construction of wastewater treatment plants, sewage systems and sludge treatment technologies minimising energy consumption and using friendly construction materials and products during the entire life cycle; or

› Renovation of wastewater treatment plants, sewage systems and sludge treatment technologies minimising energy consumption and using friendly construction materials and products during the entire life cycle.

Selection criteria

The engineers, planners and architects are important players when public authorities decided to build wastewater infrastructure. The reason is that they typically set the frame for the plant and buildings and thus also decides on many of the construction materials.

Demands for the technical capacity of the contractor are equally important for the project and particularly the operation phase where energy is consumed and treated wastewater is discharged to the receiving water bodies. Therefore, the contractor must have experience in complying with environmental criteria etc.

The engineers/planners/architects and contractors must comply with the specific exclusion criteria. The purpose for these criteria is to ensure that the companies have not violated environmental law and convicted of grave and professional misconduct (Articles 53 and 54 of Directive 2004/17/EC and Article 45 of Directive 2004/18/EC).The Public Authority can use these core criteria to:

- Identify the experience of the engineers, planners and architects in environmental design and construction

- Identify the technical capacity of contractors to take the necessary environmental management measures in order to ensure that the construction works are executed in an environmentally friendly way

The above mentioned experience and technical capacity must be documented by a list of previous relevant projects.

The knowledge gained can be used to exclude certain engineers, planners and architects and/or contractors.

9.2.2 Specifications and award criteria - energy

The energy consumption for wastewater infrastructure is dominated by the energy consumption during operation. Thus it is recommended to focus on energy performance in this phase.

Process equipment

The ideal approach for setting energy requirements and reducing potential environmental impacts from energy consumption is to establish minimum standards which the contractor must comply with. This can be done for the entire plant or for specific installations and process equipment like:

- Aeration systems/blowers
- Pumps for transporting wastewater
- Pumps for transporting sludge
- Mixers
- Sludge dewatering equipment
- Sludge dryers
- Gas utilisation equipment (boilers and generators)
- Sludge incinerators
- Lightning etc. in buildings
- Etc.

The aeration systems/blowers typically consume the majority of the total energy consumption at a wastewater treatment plant. Pumps (wastewater and sludge) are typically the second largest consumers of electricity. The rest of the above mentioned process equipment are only relevant for specific scenarios and will thus not be described in detail.

In sludge digesters gas is produced. The gas is used to produce either heat or electricity and heat. So the energy performance of the sludge digester is the ability to transform energy in the sludge to gas. The energy efficiency of the equipment after the sludge digester is measured by the efficiency of producing either heat or electricity.

Sludge dewatering efficiencies can be evaluated by measuring the energy consumption per dewatered ton of sludge. In this way it is possible to compare several technologies from an energy perspective.

Sludge dryers can be compared by evaluating the heat consumption per kg dried sludge and the percentage of total energy which are withdrawn from the sludge. These can be the key parameters for comparing sludge dryers.

In the Product Sheet energy efficiencies are listed for the main energy consuming process equipment which is mentioned in the above-mentioned list.

Information sources

In some EU Member States there are national minimum standards and requirements for wastewater infrastructure which the contractor must comply with. For process equipment there are often no national requirements.

Due to lack of national energy requirements it is recommended that demands for wastewater infrastructure are developed based on:

- National requirements for operation of buildings
- National legislation and guidance concerning energy consumption for new and renovated buildings
- Relevant CEN standards for assessing the energy performance of buildings
- The Environmental Product Declaration of construction materials and process equipment
- Best Available Technique
- Specification and verification from the producers of pumps, blowers, mixers, sludge dewatering equipment, sludge dryers etc. regarding efficiency
- Expert knowledge and experience from other wastewater infrastructure projects.

The specific criteria can be read in the Product Sheet for Wastewater Infrastructure.

Tests after installation of process equipment can verify the energy efficiency. Therefore it is recommended to insert requirements for tests for the contractor into the technical specifications before handing over of the final work.

Cures-in-place liner

Regarding the renovation of sewer pipes there can be great differences in the energy consumption for installation of cures-in-place pipe liner. Furthermore the material for the pipe liner can vary significantly. Due to the many variations in installation method and material no clear recommendations and criteria for cures-in-place pipe liner can be put up.

Nevertheless a benchmark for energy consumption can be used in those situations where the material for the cures-in-place pipe liner has been decided upon. Another option is to use available environmental product declarations together with information about the energy consumption during installation to assess the total energy consumption for several contractors offer to renovate sewer pipes.

Monitoring

As the operations phase is very important for the total energy consumption during the life cycle of wastewater infrastructure it is recommended to specify requirements for monitoring.

Specifications

The exact specification for energy consumption can be seen in the Product Sheet.

An example is the overall total energy demand for operation of the wastewater treatment plant is [x%] lower than [x kWh/year].

In this case the Public Authority must insert the typical or estimated energy consumption for the planned wastewater treatment plant. Typically there are no national legislation defining the energy consumption for operation of wastewater treatment plants, sludge treatment technologies and sewage systems.

Other examples could be specification of energy consumption per kg oxygen transferred to the aeration tanks, efficiency of pumps, efficiency of gas boilers and gas generators etc.

Finally it could include specification of energy efficient training of the personnel operating the wastewater treatment plants, sludge treatment technologies and sewage systems.

Award criteria

The award criteria must ensure that the extra efforts to reduce the energy consumption even further that depicted in the core criteria will be rewarded with additional points.

An example of this can be done by granting extra points for reduced energy consumption for the single energy consuming units (e.g. the aeration system, pumps etc.). The points could be given linearly e.g. 0 points for providing equipment with the typical/experienced energy consumption. Maximum points can then be given to equipment using the lowest energy consumption for the single unit available on the market. Thus the points are awarded on the basis of a sliding scale between best and worst bids.

9.2.3 Specifications and award criteria - Construction materials and products

The largest potential environmental impacts from construction materials are the primary energy content (deriving from extraction, processing, transportation and disposal) and the use of hazardous substances and non renewable resources.

The choice of construction materials depend on many parameters such as price, aesthetics, social aspects, technical performance, working environmental aspects, exposure, maintenance, operational aspects etc. This means that the criteria for environmental performance are just a part of numerous considerations.

Specifications

It is possible to restrict the use of certain hazardous substances from an environmental and working environmental point of view. The national legislation regarding working environmental can include information about the substances that are restricted or banned for use.

Thus, the specifications for construction materials criteria contains restrictions on the use of certain substances e.g. sulphurhexaflouride.

Another example is the use of wood from sustainable and legal sources.

Regarding the full specifications attention is referred to Product Sheet for Construction and Wastewater Infrastructure.

Award criteria

As only a few of the construction materials are of fundamental importance to the construction phase, the most important materials can be selected for further investigation.

Environmental product declarations (EPD) include external and working environmental considerations. Thus this documentation can be a good source of information to evaluate these parameters.

When EPD's are not available the selected possible suppliers can be asked to provide information about the emission of greenhouse gasses (most important for materials with high consumption of primary energy), content of hazardous substances etc.

Designated databases (ESUCO, Ökobau, PE International, Ecoinvent etc.) also contain information about the environmental performance of many construction materials.

The award criteria are listed in the Product Sheet for Construction and Wastewater Infrastructure containing possibilities for the Public Authorities to grant extra point for the contractors who:

- Use construction materials which causes reduces environmental impacts through the full life cycle
- Use of sustainable forestry sources
- Etc.

9.2.4 Specifications and award criteria - Water consumption

Several water saving technologies have been initiated and commenced in all areas reducing the water consumption significantly.

Specifications

Examples of water saving technologies at wastewater treatment plants which are demanded via the core criteria are toilet flush with water saving equipment and dual flush. Furthermore taps must be equipped with water saving technology.

Other aspects at wastewater treatment plants are high use of treated/cleaned wastewater for cleaning of screens, membranes, grids, sludge dewatering equipment etc. Information about the consumption of fresh water per m^3 cleaned wastewater is required so that the Public Authority can assess the measures taken by the contractors to reduce the use of fresh water.

Also the equipment for cleaning can be equipped with water saving technology.

The water consumption for sewage pipes can be difficult to assess and compare. Furthermore, this water consumption is often of minor importance during installation. During the operation phase water is used for cleaning pipes. But due to numerous conditions which determine the need for cleaning, no key parameters are used to assess the water consumption during the operation phase.

The use of water for cleaning pipes after installation can differ greatly in the Member States and among contractors. Often the water consumption can be minimised by reducing the number of flushing after installation or/and the amount of water per m cleaned pipe.

The use of water for renovation has typically relatively low impact compared to the impacts from the materials used. Nevertheless due to water scarcity in some Member States it can be relevant to use water reduction measures in the construction phase.

Water is also used for cleaning the flue gas after incineration of sludge. As grey water or treated/cleaned wastewater can be used for this operation the consumption of fresh water can be reduced. After cleaning the flue gas this wastewater is returned to the wastewater treatment plant as it contains significant concentrations of hazardous substances.

Another measure to reduce the consumption of fresh water at a wastewater treatment plant is by using treated/cleaned wastewater for mixing of polymers.

Award criteria

The award criteria will be based on:

› The use of rainwater and grey water

- Periodically measures to control and assess the water consumption pr. m^3 sewage or sludge

These are examples of awarding contractors with additional points for reducing water consumption. The full award criteria can be read in the Product Sheet for Wastewater Infrastructure.

9.2.5 Specifications and award criteria - Wastewater treatment efficiencies

Discharge of treated wastewater is the largest potential environmental impact from wastewater treatment plants. Furthermore studies have shown that the largest potential environmental impact from sludge incineration is discharge of water from the scrubber.
/http://www.euneptune.org/Publications%20and%20Presentations/D4-3__NEPTUNE.pdf/

Water treatment efficiencies are an important issue as treating/cleaning the wastewater is the exact purpose of the wastewater treatment plant.

Specifications

The focus on treatment efficiency is often varied depending on tradition, legislation and demands in the discharge permits in the single Member States. Another important parameter is the state and characteristics of the receiving water body.

In the Water Frame Directive there is focus on nutrients (nitrogen and phosphorous) which can cause eutrophication in the water bodies. Wastewater does always contain nutrients contrary to other pollutant which presence is determined by the contributors to the wastewater treatment plant e.g. hospitals, industries etc.

Thus the treatment efficiencies of nutrients are included in the core criteria. As many wastewater treatment plants use chemicals/precipitation agents for the removal of phosphorous, the treatment efficiency of phosphorous are depended on the consumption of precipitation agents. This is the reason for also including a core criteria concerning information about the consumption of precipitation agents.

Pathogens are also present in wastewater. In most cases the receiving water bodies are not sensitive to pathogens. Furthermore the outlets are often constructed and placed so that the discharge of wastewater with pathogens does not cause any problems.

The specific criteria can be seen in the Product Sheet for Wastewater Infrastructure.

As the industry, hospitals, households etc. use and discharge numerous substances there are many considerations to take into account when a wastewater treatment plant is designed. These substances and their incorporation into criteria are described in Section 9.3.5.

The sludge dryer also used water for the scrubber which cleans the flue gas. The water contains hazardous substances including heavy metals. As the water is polluted it is often recycled to the wastewater treatment plant for cleaning. Thus the potential environmental impact from scrubber is included in the aspects about treatment efficiency of the wastewater treatment plant. The emission via flue gas is described in Section 9.2.6 and 9.3.6.

Award criteria

As the substances remaining in the wastewater after treatment are very important to the total environmental impact focus is put here.

The contractors can be rewarded with extra points for guaranteeing the lowest emission of the selected substances in the wastewater. These are listed in the Product Sheet for Wastewater Infrastructure. For the core award criteria focus is on nutrients and thus the treatment efficiency of phosphorous and nitrogen.

9.2.6 Specifications and award criteria - Treatment efficiency of flue gas filter

The incineration of sludge causes emissions to air and water. The emission to air is handled by recirculation of the wastewater for cleaning in the wastewater treatment plant.

The emission to air is controlled by a flue gas filter. The efficiency of this filter is therefore determining the magnitude of the environmental impact from the sludge incinerator.

Specifications

The facilities to incinerate sludge must comply with the Directive on incineration of waste (2000/76/EC) and the BREF document for Waste Incineration from August 2006.

This entails that the emissions from the flue gas filter must not be higher than:

Table 9-2: Emission levels ranges

Substance(s)	½ hour average		24 hour average	
Total dust	1	20	1	5
Hydrogen chloride (HCl)	1	50	1	8
Hydrogen fluoride (HFl)	<2		<1	
Sulphur dioxide (SO_2)	1	150	1	40
Nitrogen monoxide (NO) and nitrogen dioxide (NO_2), expressed as nitrogen dioxide for installations using SCR	40	300	40	100

Nitrogen monoxide (NO) and nitrogen dioxide (NO_2), expressed as nitrogen dioxide for installations not using SCR	30	350	120	180
Gaseous and vaporous organic substances, expressed as TOC	1	20	1	10
Carbon monoxide (CO)	5	100	5	30

/Integrated Pollution Prevention and Control. Reference document and the Best Available Techniques for Waste Incineration. August 2006/

Award criteria

Award criteria are given for the improved performance.

Additional points are given for reducing the emission of the substances listed in Table 9.2 below limit values.

The points are awarded on the basis of a sliding scale between best and worst bids.

The specific award criteria can be read in the Product Sheet for Wastewater Infrastructure.

9.2.7 Contract performance clauses

Contract performance clauses aim to reduce the environmental impacts during the performance stage.

There are several aspects which can vary from one project to another.

The core criteria for contract performance focus on transport of materials, functional tests, energy consumption and waste management.

9.3 Comprehensive environmental GPP criteria

The comprehensive criteria are intended for those public authorities who wish to choose the best option/project based on environmental considerations.

Fulfilment of the comprehensive criteria will require an extra effort for the contractors. Managing and handling the information from the contractors will also require additional administrative effort and minor costs for the public authority.

Some of the comprehensive criteria are quite complex and do require detailed expertise in environmental aspects. Some public authorities can have a demand for sourced expert advice.

This is especially important for the wastewater treatment efficiency as discharge of treated/cleaned wastewater is the largest potential environmental impact from wastewater treatment plants.

Furthermore, the weighting of impacts from hazardous substances, pathogens, pharmaceuticals and nutrients has very great influence on the results. This indicates the large need for detailed and extensive knowledge about these mechanisms to interpret the results and thus award the contractors depending on their performance. An example is the recurring issue regarding heavy metals - is copper damaging the environment more than cadmium? These issues can be dealt with by using weighting.

The comprehensive criteria can be seen in the Product Sheet. It must be stressed that public authorities are not obliged to implement all of the criteria. The criteria must be evaluated by the public authorities to point out the relevant criteria for the actual project in question. An example is the comprehensive criteria for pathogens which are intended for use when it has been decided that the public authorities wants to establish a wastewater treatment plant with demands for bathing water quality in the receiving stream, lake, sea etc.

9.3.1 Subject matter and selection criteria

The comprehensive criteria regarding subject matter focus on the experience of the engineers, planners and architects just like the core criteria. The comprehensive criteria are more detailed about the experience which must be documented by a list of previous relevant projects.

In this section the subject matter and selection criteria will be defined.

Subject matter

The subject matter is defined to be:

- Construction of wastewater treatment plants, sewage systems and sludge treatment technologies using sustainable construction materials and products, reducing energy and water consumption, optimising treatment efficiencies and flue gas treatment during the entire life cycle or

- Renovation of wastewater treatment plants, sewage systems and sludge treatment technologies using sustainable construction materials and products, reducing energy and water consumption, optimising treatment efficiencies and flue gas treatment during the entire life cycle

Selection criteria

It is important that the engineers, planners and architects can demonstrate knowledge within:

- Process equipment

- The construction of wastewater treatment plants, sludge incinerators, sludge digesters, sewers etc. with focus on reducing environmental impacts.
- Water efficiency
- Reduction of water consumption
- Use of local raw materials if possible
- Use of LCC and LCA in design and selection of materials
- High efficiency co-generation
- Etc.

The full list of required areas of knowledge is shown in the Product Sheet for Wastewater Infrastructure.

The above mentioned experience and technical capacity must be documented by a list of previous relevant projects.

The knowledge gained can be used to exclude certain engineers, planners and architects and/or contractors.

9.3.2 Specifications and award criteria - energy

The comprehensive criteria focus on almost the same areas as the core criteria - just in more detail.

In addition to the core criteria, the comprehensive criteria require that the Public authority set up benchmarks or levels for best available technique to measure the degree of energy savings and efficiencies which the contractors offers.

Regarding energy for buildings at the wastewater treatment plant or sludge incineration plant criteria in the Product Sheet for Construction can be applied.

As the most of the energy consumption derives from aeration systems, pumps, mixers etc. the focus on energy efficiency of the buildings are relatively low from an environmental point of view.

Award criteria

Award criteria are given for the improved performance.

Additional points are given for reducing the energy consumption for the most energy consuming technical installations below the experience values.

The points are awarded on the basis of a sliding scale between best and worst bids.

Another initiative to reduce the energy consumption is to create technologies or measures to activate the users by making energy savings visible during the use phase. These initiatives can ensure continuous attention to energy savings during the life time of the wastewater treatment plant, sludge incinerator etc.

Award points are given according to the number of employees who have attended a course in energy efficient behaviour.

9.3.3 Specifications and award criteria - Construction materials and products

Overall criteria for construction materials are described in Section 9.2.3. The comprehensive criteria elaborate and expand on the core criteria.

It is especially for these criteria that the need for experts emerges as environmental assessment of products are quite specialised.

Specifications

Specifications for comprehensive criteria are described in the Product Sheet for Construction.

Award criteria

Additional points are awarded for choosing sustainable materials. Aspects to consider are:

- Environmental aspects in a life cycle perspective
- Life Cycle Costs
- Social aspects[17]
- Aesthetics
- Technical requirements

There are several models and tools available to make this overall and initial assessment. Based on this the most important construction materials can be selected.

The most important materials e.g. concrete and steel must then be assessed in greater detail to choose the most optimal material for the specific use.

A recognised method for quantifying and evaluating the potential environmental impacts is Life Cycle Assessment (LCA). There are several databases available which enables the specialist to make recommendations for materials use. The new Construction Product Directive demands the existence of an environmental product

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[17] According to "Guidelines for Social Life Cycle Assessment of Products" from UNEP social aspects considered can be "*Social impacts32 are consequences of positive or negative pressures on social endpoints (i.e. well-being of stakeholders). Social impacts are understood by these Guidelines to be consequences of social relations (interactions) weaved in the context of an activity (production, consumption or disposal) and/or engendered by it and/or by preventive or reinforcing actions taken by stakeholders (ex. enforcing safety measures in a facility)*".
http://www.unep.fr/shared/publications/pdf/DTIx1164xPA-guidelines_sLCA.pdf

declaration for all CE labelled products and can therefore also be a reliable and good source of information about construction materials' environmental performance.

The LCA data include information about the use of renewable resources and is thus incorporated in the assessment of materials.

At this stage the life time/durability of materials must also be included as it has a significant impact on the result and recommendations.

When the material type has been decided upon, LCA can also be used to create the basis for choosing between several suppliers of materials with the same specifications.

Regarding social issues a Social LCA can be performed for the most dominating materials. There are several other methods for assessment of social aspects in the full life cycle. The ambition level and request for data from the contractor must be decided by the Public Authority.

The contractor is also obliged to present technical data sheets, safety data sheets and declarations of content where possible for the selected materials.

The contractor must then account for the choice of sustainable materials and suppliers based on the 5 aspects mentioned above.

9.3.4 Specifications and award criteria - Water consumption

The comprehensive criteria regarding water consumption is relevant for some parts of Europe with water scarcity.

For these regions it can be necessary to restrict the water consumption which can be done by incorporating the comprehensive criteria.

For all other scenarios than wastewater treatment plants there are no comprehensive criteria.

Specifications

For wastewater treatment plants the consumption of water can be important in areas with water scarcity. To reduce the consumption of fresh water it is important that treated/cleaned wastewater is used for cleaning grids, equipment, membranes etc.

Another way to reduce the consumption of fresh water is by using treated/cleaned wastewater for mixing polymers.

There are numerous other options to reduce the use of fresh water as the specific project has specific needs. The bidder must describe and document the total consumption of fresh water, grey water and treated/cleaned wastewater to enable the Public Authority to compare the offers from the bidders.

The specifications can be seen in the Product Sheet for Wastewater Infrastructure.

Award criteria

- The use of rainwater and grey water
- Periodically measures to control and assess the water consumption pr. m^3 sewage or sludge

These are examples of awarding contractors with additional points for reducing water consumption. The full award criteria can be read in the Product Sheet for Wastewater Infrastructure.

9.3.5 Specifications and award criteria - Wastewater treatment efficiencies

The comprehensive criteria for wastewater treatment efficiencies include the most important and largest potential environmental impacts from wastewater treatment plants.

Thus it is strongly recommended to include these criteria in the final evaluation of the bidder's proposals.

The comprehensive criteria concerns treatment efficiencies of heavy metals, pharmaceuticals, priority substances and pathogens.

In principle, all the current 33 and the proposed 15 new priority substances in WFD can occur in urban wastewater. However, in reality many of them will rarely be detectable or least only be present at very low levels because of their origin or their properties and, hence, for such substances it will not be very relevant to establish requirements to performance of WWTPs in relation to lowering their concentrations in the effluent.

In consideration of the context and objectives of this study, it is proposed to select from the list of relevant hazardous substances to a few indicator substances for which documentation of WWTP performance could be required. It is suggested to omit volatile substances, which will typically be removed from the water phase by stripping during the treatment processes or shortly after discharge, and also leave out substances posing special analytical challenges (e.g. brominated flame retardants).

Relevant indicator substances include the metals (and their compounds):

- **Cadmium and its compounds**
- Lead and its compounds
- **Mercury and its compounds**
- Nickel and its compounds.

and the following selected among the organic priority substances:

- Di(2-ethylhexyl)phthalate (DEHP)
- Naphthalene
- **Nonylphenols and octylphenols**
- **Benzo(a)pyrene (to represent the Polycyclic Aromatic hydrocarbons (PAHs)**

The substances in **bold** are the priority hazardous substances for which an obligation to cease discharges into surface waters exist. It may therefore be relevant to focus particularly on these substances.

It should, however, be mentioned that the proposal for revision of the EQS directive (COM(2011) 876 final) sets a lower EQS for nickel, which probably will lead to more compliance problems than today as the background concentration of nickel in freshwater bodies is sometimes quite high.

Further, a significantly lower EQS for benzo(a)pyrene is proposed, which may make this substance less suitable as an indicator due to technical complications in ensuring a sufficiently low quantification limit in typical analytical methods. Possibly, anthracene or fluoranthene could be used as alternative indicators of PAHs.

The current EQS directive does not include natural or synthetic estrogens but the natural estrogen 17β-estradiol and the synthetic estrogen 17α-ethinylestradiol are included in the proposal for a revised directive. Should these substances be included in the revised directive, it could be considered to include one of them among the "indicator substances" as they are highly relevant in relation to aquatic ecology and quality of surface waters.

Specifications

The European public authority must specify or indicate the typical content of substances in the incoming wastewater if possible. Based on this knowledge it is possible to point out the substances or groups of substances which are important and thus also the relevant comprehensive criteria.

If the wastewater treatment plant must have a discharge permit, it is highly relevant to initiate a dialogue with the supervisory authority about the future discharge limits for the wastewater plant.

In some cases the supervisory authority or political system can also decide to put up demands for the discharge of pathogens on the grounds of bathing water requests for the receiving water body. In this case it is relevant to use the comprehensive criteria about pathogens.

Award criteria

An example of comprehensive award criteria is: The wastewater treatment plant's treatment efficiency of cadmium must de [x] % lower than the maximum defined in the discharge permit for the wastewater treatment plant or the EQS for cadmium.

The full core and comprehensive criteria can be read in the Product Sheet for Wastewater Infrastructure.

9.3.6 Specifications and award criteria - Treatment efficiency of flue gas filter

The comprehensive criteria for the treatment efficiency of the flue gas filter are - in addition to the core criteria - treatment efficiencies for more substances e.g. mercury etc.

The facilities to incinerate sludge must comply with the Directive on incineration of waste (2000/76/EC) and the BREF document for Waste Incineration from August 2006.

Specifications

An example of the comprehensive criteria for the flue gas filter in a sludge incineration plant is:

The concentration of mercury and its compounds (as Hg) must not be higher than 0,05 mg/Nm^3 measured by a non-continuous sample.

The specification for the treatment efficiency of the flue gas filter must incorporate the following compounds:

- Mercury
- PAHs
- Total cadmium and thallium (and their components expressed as the metals)
- Zinc
- The sum of other metals

Award criteria

Award criteria are given for the improved performance.

Additional points are given for reducing the emission below limit values of the substances listed in the above mentioned specification included for the comprehensive criteria.

The points are awarded on the basis of a sliding scale between best and worst bids.

The specific award criteria can be read in the Product Sheet for Wastewater Infrastructure.

9.3.7 Contract performance clauses

The comprehensive contract performance clauses do include environmental considerations at the performance stage. There are several aspects to take into consideration and most of the environmental impacts are project specific.

Just like the core criteria the comprehensive criteria focuses on transport of materials, functional tests, energy consumption and waste management.

ANNEX A - Scenarios

In this section the 16 defined wastewater infrastructure project scenarios are given with detailed specification of the different wastewater components and technologies that are assumed for each scenario.

ANNEX B - Information sources

European legislation

Public Procurement regulation

Directive 2004/17/EC of the European Parliament and of the Council of 31 March 2004 coordinating the procurement procedures of entities operating in the water, energy, transport and postal services sectors

Directive 2004/18/EC of the European Parliament and of the Council of 31 March 2004 on the coordination of procedures for the award of public works contracts, public supply contracts and public service contracts

Horizontal Environmental regulation

Directive 2001/42/EC of the European Parliament and of the Council of 27 June 2001 on the assessment of the effects of certain plans and programmes on the environment (EIA)

Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control)

Regulation (EC) No 1221/2009 of the European Parliament and of the Council of 25 November 2009 on the voluntary participation by organisations in a Community eco-management and audit scheme (EMAS

Council Directive 96/82/EC of 9 December 1996 on the control of major-accident hazards involving dangerous substances (Seveso II -directive)

Directive 2004/35/CE of the European Parliament and of the Council of 21 April 2004 on environmental liability with regard to the prevention and remedying of environmental damage

Regulation (EC) No 66/2010 of the European Parliament and of the Council of 25 November 2009 on the EU Eco label

Water specific regulation

Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy (WFM directive)

Directive 2008/105/EC of the European Parliament and of the Council of 16 December 2008 on environmental quality standards in the field of water policy (EQS-directive)

Directive 2006/118/EC of the European Parliament and of the Council of 12 December 2006 on the protection of groundwater against pollution and deterioration

Council Directive 98/83/EC of 3 November 1998 on the quality of water intended for human consumption

Directive 2006/7/EC of the European Parliament and of the Council of 15 February 2006 concerning the management of bathing water quality

Council Directive 91/676/EEC of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources

Council Directive 91/271/EEC of 21 May 1991 concerning urban waste-water treatment (UWWT directive)

Waste, energy-saving regulation and other regulation of relevance

Council Directive of 12 June 1986 on the protection of the environment, and in particular of the soil, when sewage sludge is used in agriculture

Regulation (EC) No 106/2008 of the European Parliament and of the Council of 15 January 2008 on a Community energy-efficiency labelling programme for office equipment

Directive 2009/33/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of clean and energy-efficient road transport vehicles

Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings

Regulation (EU) No 305/2011 of the European Parliament and of the Council of 9 March 2011 laying down harmonised conditions for the marketing of construction products.

Other sources

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