ACWUA Energy Efficiency –

Task Force

Tunis, 25 - 26 June 2014

WORKSHOP ON „DEVELOPING AND APPLYING ENERGY PERFORMANCE INDICATORS"

03.07.2014

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Background of the workshop

The Arab Countries Water Utilities Association (ACWUA) is registered as a Non-Governmental & Non-profit association (NGO)**,** founded in 2006 as a result of an initiative by key water sector representatives in the Arab Region. The main objective of the Arab Countries Water Utilities Association (ACWUA**)** is to establish a strong, regional, self-sustainable association of the water supply and sanitation utilities in Arab countries in order to assist the members to improve their performance in the delivery of water supply and sanitation services. In order to achieve the association goals, ACWUA initiated interdisciplinary working groups comprising qualified experts from ACWUA members to deal with specific issues in different priority areas of the water sector.

Since 2014, ACWUA has launched an energy task force, which currently develops “Energy Guidelines for Energy Checks and Energy Analysis”. Part of the Guidelines will be a chapter on Energy Performance Indicators. To discuss possible indicators for the guidelines, a workshop on «Performance indicators and benchmarking» was held in Tunis, Tunisia on June 25nd - 26th, 2014 together with members of the ACWUA energy task force. The workshop was facilitated by aquabench GmbH.

Further to the facilitation of the workshop, aquabench was asked to support the work of the task force in order to

- supplement the proposed energy performance indicators by well known aquabench performance
- indicators
- develop practical guidance for implementing performance indicators inside a utility
- develop a fundamentals for an energy benchmarking system, which may be part of further standardisation work by the energy task force in the mid-term

The main objective of the workshop was to identify the key energy efficiency related performance indicators in water supply and for waste water disposal together with the participants to use them in a methodology termed ‘energy check’.

The documentation of the output from the workshop is subject of this document**.**

Documentation

Opening session

<u>Objective of the session:</u>

To get in touch with each other.

<u>Deliverables:</u>

- Main objectives and agenda of the workshop
- Introduction of aquabench GmbH
- Introduction of participants and their expectations for the workshop

According to the agenda of the workshop, the first session after the opening of the workshop was set-up to develop a mutual understanding about the different scope of the energy check and the energy benchmarking. After this, the next session was planed to select the key energy efficiency indicators for the MENA water supply sub-sector.

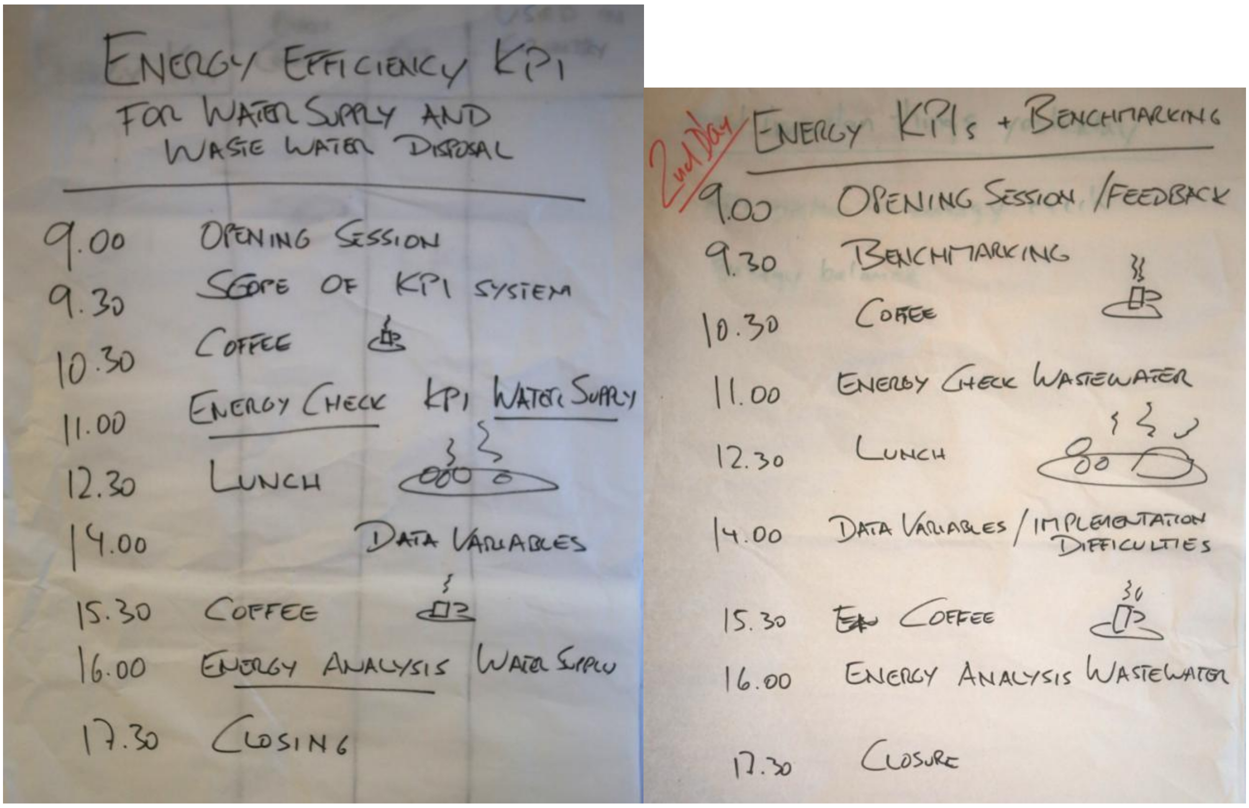


Figure 1: Agenda of the workshop (left side 1st day, right side 2nd day)

The opening sessions of the afternoon in first day was scheduled to discuss implementation difficulties and their possible approaches as well as some definitory related issues regarding the apportionment of energy along different processes within the water supply value added chain. The last session of the afternoon was supposed to deal with the question which main energy consuming components used in MENA water supply sub-sector should be considered for mapping energy consumption in the energy analysis methodology to be introduced with the guidelines.

Due to their greater relevance from the perspective of the participants, the session on benchmarking was re-scheduled to begin the second day of the workshop. The session was designed to discuss the linkage between the energy check methodology introduced with the guidelines and the need for an MENA water sector energy efficiency benchmarking. The second session of the morning was planned to select the key energy efficiency indicators for the MENA wastewater disposal sub-sector.

Following this, the discussed implementation barriers from the first day were to be supplemented from a wastewater perspective in the first session of the afternoon. The last session of the afternoon was finally supposed to deal with the question which main energy consuming components used in MENA wastewater disposal sub-sector should be considered for mapping energy consumption in the energy analysis methodology to be introduced with the guidelines.

The opening session also dealt with the expectations from the participants for the workshop. Most of them were already covered by the agenda of the workshop. The issues below were expected by the participants to be dealt with in the workshop:

- understanding of terms and methodology
- avoiding bias
- develop water and wastewater energy related performance indicators
- develop indicators for the analysis of all processes
- find energy related key performance indicators (KPI)
- find energy related performance indicators for desalination plants
- work on results for the guidelines
- learn about benchmarking
- find indicators for internal controlling of attached utilities
- learn about the relation between different performance indicators
- find energy related KPI for water utilities

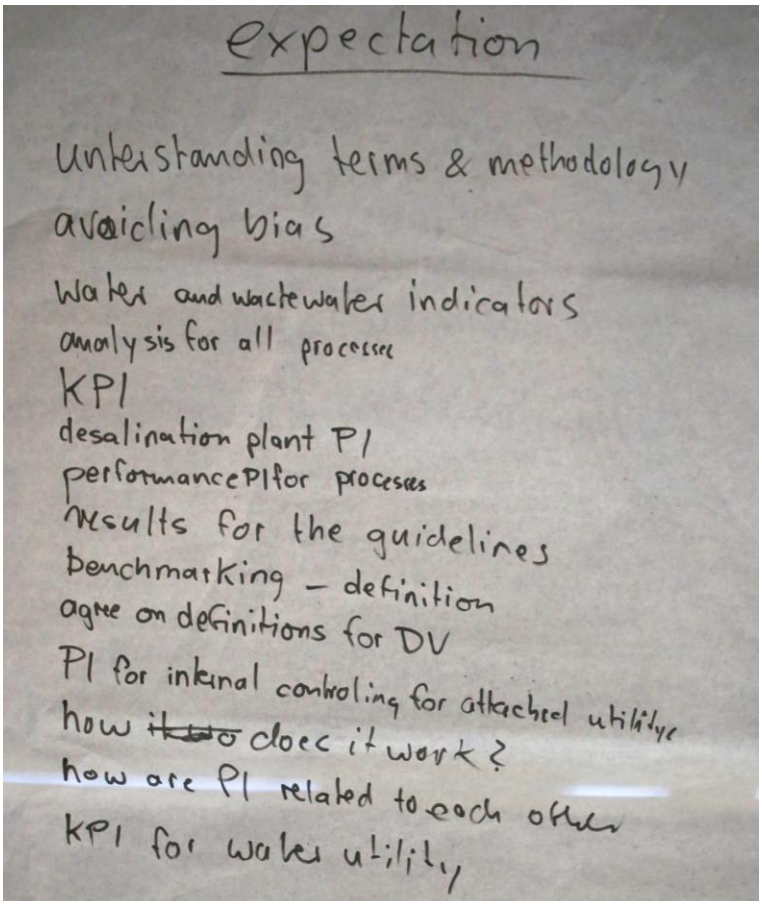


Figure 2: Aims of the workshop participants

Scope of KPI system for energy checks in MENA water sector

Objective of the session: Develop a mutual understanding of the energy check methodology Deliverables: Agreement on both, water supply and waste water disposal methodology regarding • assessment level (plant level and/or utility level) • assessment boundaries beyond energy consumption (energy costs/ energy recovery/energy production/energy reliability/energy procurement/other issues related to energy)

In the beginning of this session the methodological terms 'energy check', 'energy benchmarking' and 'energy analysis' were clarified according to the distinction below which is based on their different objectives.

'energy check'

- rough estimation of the energy efficiency by focusing on the relevant energy consuming aggregates

- identification of deterioration of performance
- internal comparison
- may be assessed from a seasonal to an annual sequence

'energy benchmarking'

- more detailed energy efficiency monitoring by focusing on main business process
- identification of performance gaps to similar utilities
- learning and adapting methods for best-practices from partner utilities (external comparison)
- may be assessed from an annual to a triannual sequence

'energy analysis'

- detailed energy efficiency study by mapping energy consumption and establishing an energy balance
- evaluation of energy performance and subsequent improvement
- may be assessed if 'energy check' indicates deterioration or 'energy benchmarking' detects performance gaps

After this, the aggregation of the input data was addressed. The level of detail that is addressed in the data collection process may be different according to the objectives of the exercise. The assessment may be done on 'utility level', 'process level', 'plant level' or, on the level of different components.

'utility level'

In this level of detail, the utility as a whole is studied. All relevant processes along the value added chain are aggregated to data, which are used in the processing rules of the indicators. This level features the highest level of aggregation.

'process level'

The process level focuses on the main functions that conform the core business of water utilities, e.g. wastewater treatment or sewer operation. If an undertaking operates several plants, the data of each of these plants will be aggregated to one value, which is used in the processing rules of the indicators.

'plant level'

At the plant level, a particular plant is under examination. Still, there may be some aggregation of data involved, e.g. if consumption data of several components are aggregate to a single figure

'component level'

The component level really focuses on either each or the main components of the process/plant under examination. At this level, no aggregation is involved.

As a result of the next sessions, the key performance indicators that were chosen for the energy check are mainly on the component level and the plant level. However, in order to allow for a global appraisal how things are evolving (e.g. to raise awareness at top management level) a few indicators on utility level were added.

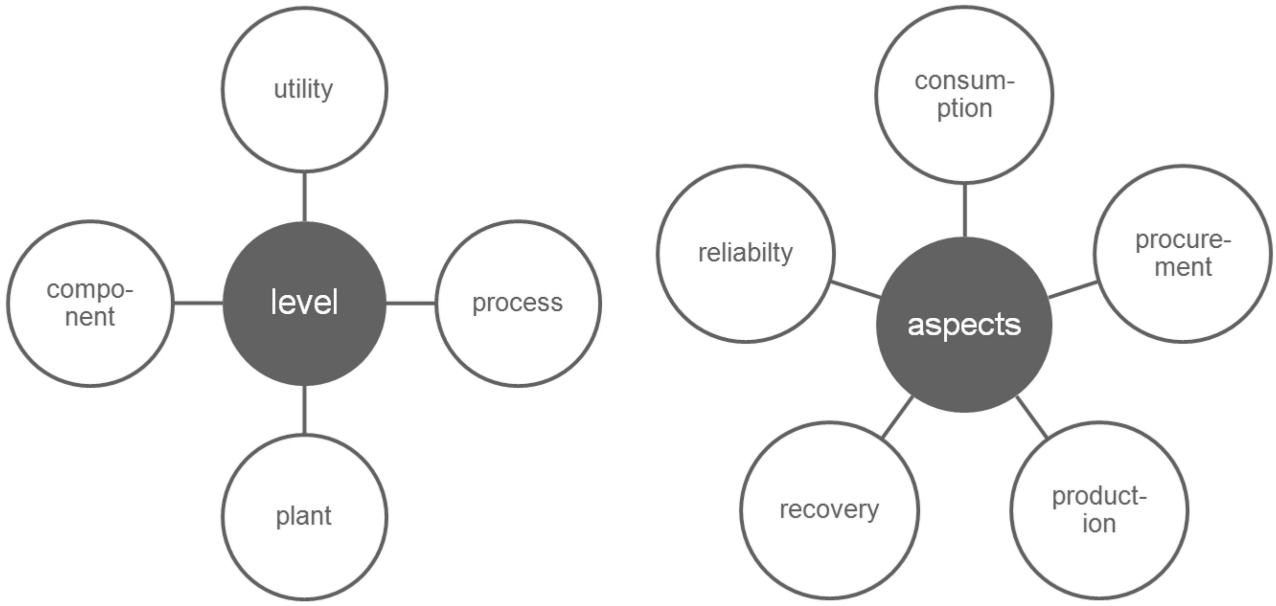


Figure 3: Difference between level and aspects of assessment

Further, different energy related aspects might be covered in any data assessment exercise. For instance, aspects of consumption may be asses to together with aspects of energy recovery (either from generated biogas in the digesters or by utilising potential energy excessive for hydraulic transport needs in the mains), energy production (photovoltaic, wind turbines, hydropower), or aspects of procurement and reliability.

As a result of the next sessions, the key performance indicators that were chosen for the energy check just deal with aspects of energy consumption, energy recovery and energy production. However, for an energy related benchmarking other aspects also may be assessed.

Energy check KPI water supply

Objective of the session: Develop a list of KPI to be included in energy check methodology Deliverables: • Agreed list of KPI to be included in energy check methodology • Determination of energy indicators already used in the MENA water supply sector

In this session, the key energy efficiency performance indicators for the MENA water supply sub-sector were chosen by the participants.

Data variable and performance indicators are arranged in different groups in order to help in identifying its purpose. The nomenclature can be read as below.

data variables

ws - water supply

wsM – monetary data on energy

wsC – data on energy consumption

wsP – data on energy production

wsW – data on water volumes

wsH – data on pump heads

performance indicators

ws – water supply

wsEc – KPI dealing with energy consumption

wsEp – KPI dealing with energy production

wsMc – KPI dealing with monetary costs

An overview of the indicators chosen can be found in the table below. For detailed definitions of the required data variables and information regarding the interpretation of the indicators, it is referred to the annex.

Table 1: Key performance indicators dealing with energy consumption

wsEc1 – energy content per authorised consumption (kWh/m^3)	
total energy consumption for water supply division / authorised consumption	
wsEc2 – proportion of pumping energy (%)	
total pumping energy consumption / total energy consumption for water supply division x 100	
wsEc3 – standardised energy consumption abstraction/intake pumps (kWh/m^3/100m)	
energy consumption well pump, intake pump / abstraction volume / pump head well pump, intake pump x 100	
	wsEc3a – energy consumption abstraction/intake pumps (kWh/m^3)
	energy consumption well pump, intake pump / abstraction volume
wsEc4 – standardised energy consumption raw water booster pumps (kWh/m^3/100m)	
energy consumption raw water booster pumps / pressure boosted raw water volume / pump head raw water booster pumps x 100	
	wsEc4a – energy consumption raw water booster pumps (kWh/m^3)
	energy consumption raw water booster pumps / pressure boosted raw water volume
wsEc5 – overall plant energy consumption per intake volume (kWh/m^3)	
overall waterworks facility energy consumption / treatment input volume	
	wsEc5a – overall plant energy consumption per produced volume (kWh/m^3)
	overall waterworks facility energy consumption / drinking water production volume
wsEc6 – heat demand per volume produced (kWh/m^3)	
energy consumption water treatment / drinking water production volume	
wsEc7 – standardised energy consumption main pumps (kWh/m^3/100 m)	
energy consumption drinking water main pumps / drinking water production volume / pump head drinking water main pumps x 100	
	wsEc7a – energy consumption main pumps (kWh/m^3)
	energy consumption drinking water main pumps / drinking water production volume
wsEc8 – standardised energy consumption booster pumps (kWh/m^3/100 m)	
energy consumption drinking water booster pumps / pressure boosted drinking water volume / pump head drinking water booster pumps x 100	
	wsEc8a – energy consumption booster pumps (kWh/m^3)
	energy consumption drinking water booster pumps / pressure boosted drinking water volume

Table 2: Key performance indicators dealing with energy production

wsEp1 – total energy recovery (%)
total energy recovered / total pumping energy consumption x 100
wsEp2 – total energy production other than recovery (%)
total energy recovered / total energy consumption for water supply division x 100

Table 3: Key performance indicators dealing with energy costs

wsMc1 – electrical energy cost (EUR/kWh)
total energy costs / total energy consumption for water supply division

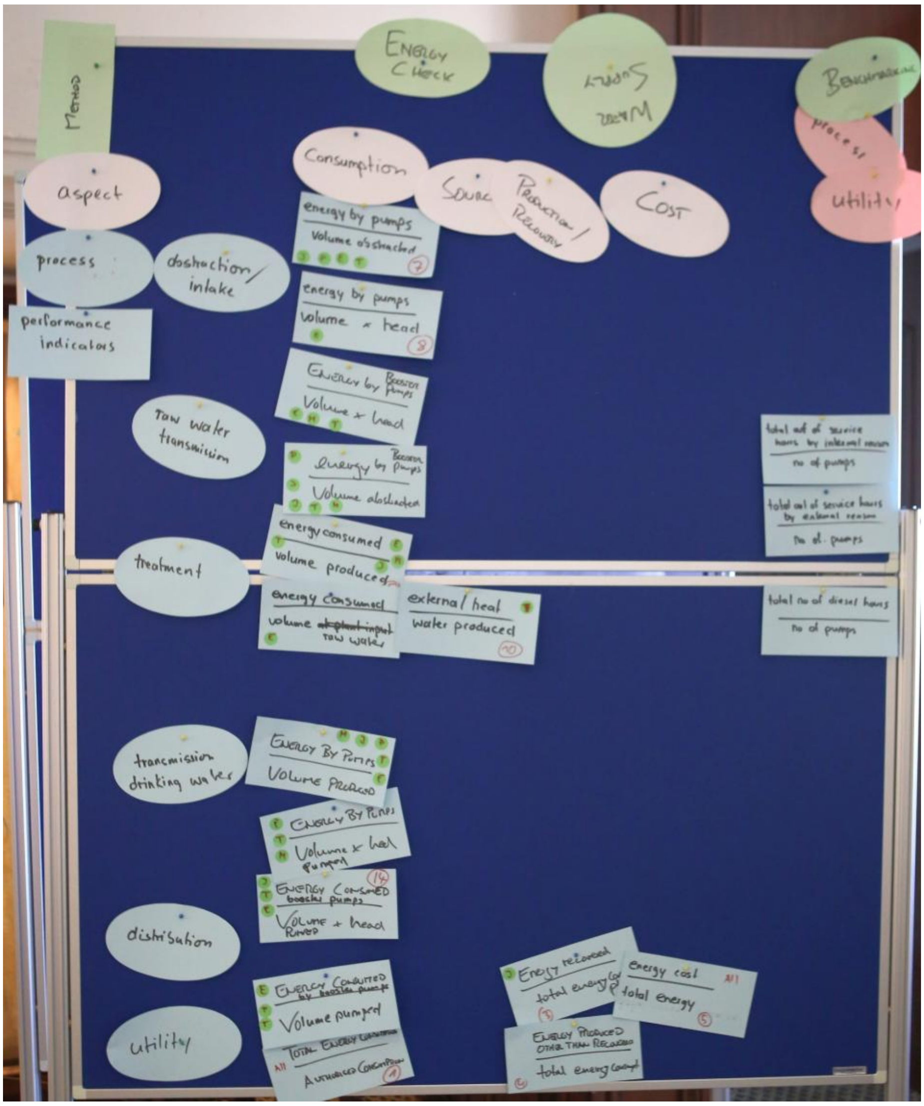


Figure 4: Summary of the chosen KPI from the workshop

Objective of the session:

Determination of the relevant energy consumers/treatment techniques in MENA water supply sector.

Deliverables:

- All relevant energy consuming assets
- Methods used for metering power consumption from energy consuming assets
- Availability and quality of their technical documentation

In this session, the main energy consuming components used in the water supply value added chain of MENA countries were clarified. It was discussed whether to include these components in the energy balance for the guidelines. Table 4 shows final outcome of the discussion.

Table 4: Main energy consuming components in water supply value added chain

Division	Component
Water abstraction	Well pump / intake pump / booster pump
Waterworks – premises	HVAC system
	Air dehumidifier
	Lightning
Waterworks - preliminary treatment	Drum screen
Waterworks – treatment	Stirrer / mixer
	Pulsator
	Scraper/bridge
	Chemical dosing pump / backwash water pump / booster pumps
	High pressure pumps (reverse osmosis desalination plants)
	Evaporators (MSF, MED desalination plants)
	Iron exchanger
	Aeration system
	Ozonisation system
	UV radiators
	Compressors
	Air blowers
Waterworks - sludge treatment	Sludge pumps
	Filter press

	Sludge thickener
	Centrifuge
Pumping stations - pressurisation	Main pumps / booster pumps*
Central buildings, workshops, premises	HVAC system
	Lightning

** The component might be fuel operated in some cases*

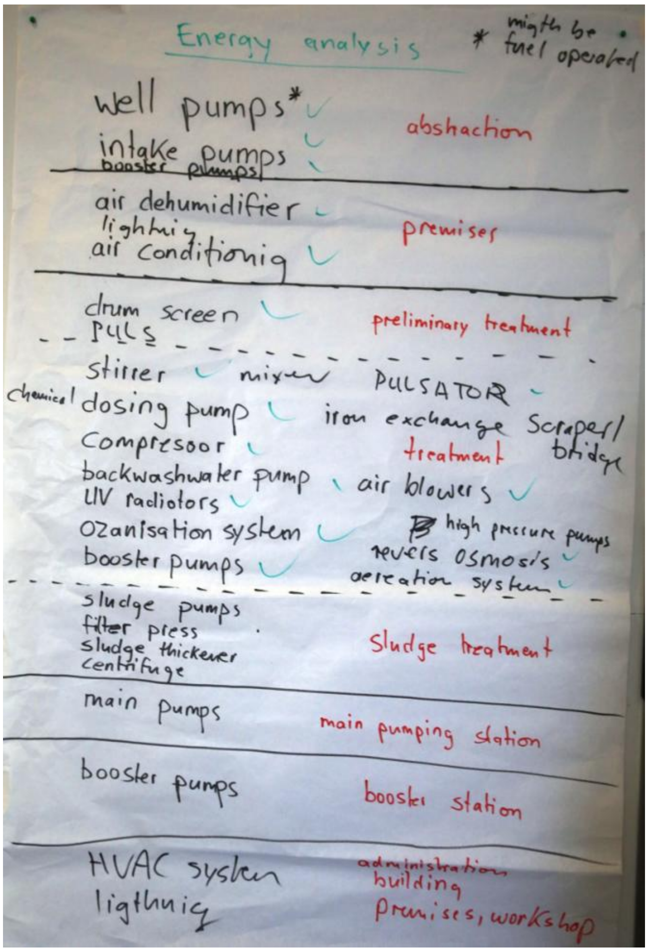


Figure 5: Main energy consuming components as worked out together with workshop participants

<u>Objective of the session:</u>

Develop a list of KPI to be included in energy check methodology

<u>Deliverables:</u>

- Agreed list of KPI to be included in energy check methodology
- Determination of energy indicators already used in the MENA waste water disposal sector

In this session, the key energy efficiency performance indicators for the MENA wastewater disposal sub-sector were chosen by the participants.

Data variable and performance indicators are arranged in different groups in order to help in identifying its purpose. The nomenclature can be read as below.

data variables

wd - wastewater disposal

wdM – monetary data on energy

wdC – data on energy consumption

wdP – data on energy production

wdW – data on water volumes

wdS – data on sludge volumes

wdL – data on pollution loads

wsH – pump heads

performance indicators

wd - wastewater disposal

wdEc – KPI dealing with energy consumption

wdEp – KPI dealing with energy production

wdMc – KPI dealing with monetary costs

An overview of the indicators chosen can be found in the table below. For detailed definitions of the required data variables and information regarding the interpretation of the indicators, it is referred to the annex.

Table 5: Key performance indicators dealing with energy consumption

wdEc1 –energy consumption per population equivalent served (kWh/p.e.)	
total energy consumption for wastewater disposal / total population equivalents	
	wdEc1a – energy consumption per wastewater volume disposed (kWh/m³)
	total energy consumption for wastewater disposal / total volume of wastewater treated
wdEc2– standardised energy consumption lifting pumps in sewer system (kWh/m³/100 m)	
energy consumption lifting pumps in sewer system / lifted volume / pump head lifting pumps x 100	
	wdEc2a – energy consumption lifting pumps in sewer system (kWh/m³)
	energy consumption lifting pumps in sewer system / lifted volume
wdEc3 – overall plant energy consumption per population equivalent served (kWh/p.e.)	
overall wastewater treatment plant energy consumption / population equivalents	
	wdEc3a – overall plant energy consumption per volume of wastewater treated (kWh/m³)
	overall wastewater treatment plant energy consumption / volume of wastewater treated
wdEc4 – standardised energy consumption pumps water treatment (kWh/m³/100 m)	
energy consumption water pumps on wastewater treatment plants / wastewater volume elevated / pump head water pumps x 100	
	wdEc4a –energy consumption pumps water treatment (kWh/m³)
	energy consumption water pumps on wastewater treatment plants / wastewater volume elevated
wdEc5 – energy consumption biological aeration (kWh/p.e.)	
energy consumption aeration component / population equivalents served	
wdEc6 – energy consumption sludge treatment (kWh/ton DS)	
energy consumption sludge treatment / sludge volume handled	
wdEc7 –energy consumption sludge pumping (kWh/m³)	
energy consumption sludge pumps on wastewater treatment plants / sludge volume elevated	
wdEc8 – heat demand per population equivalent served (kWh/p.e.)	
heat demand / population equivalents served	
wdEc9 –energy consumption tertiary treatment (kWh/m³)	
energy consumption tertiary treatment stage / wastewater receiving tertiary treatment	

Table 6: Key performance indicators dealing with energy production

wdEp1 – total energy recovery from biogas (%)
total energy recovered / total pumping energy consumption x 100
wdEp2 – total energy production other than from biogas (%)
total energy produced other than from biogas / total energy consumption for wastewater disposal division x 100
wdEp3 –biogas generation per population equivalent (kWh/p.e.)
volume of biogas production / population equivalents served
wdEp4 – proportion of biogas conversion into energy (%)
electric energy production by cogeneration / energy content of biogas production x 100

Table 7: Key performance indicators dealing with energy costs

wdMc1 – electrical energy cost (EUR/kWh)
total energy costs / total energy consumption for wastewater disposal division

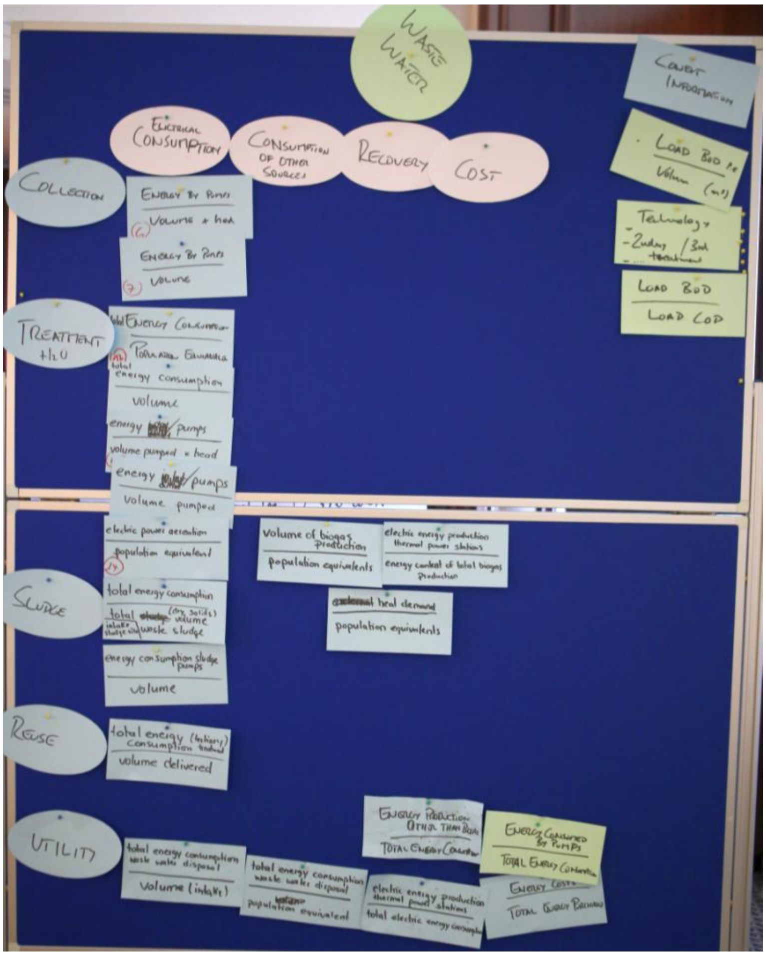


Figure 6: Summary of the chosen KPI from the workshop

Objective of the session:

Determination of the relevant energy consumers in MENA wastewater disposal sector.

Deliverables:

- All relevant energy consuming assets
- Methods used for metering power consumption from energy consuming assets
- Availability and quality of their technical documentation

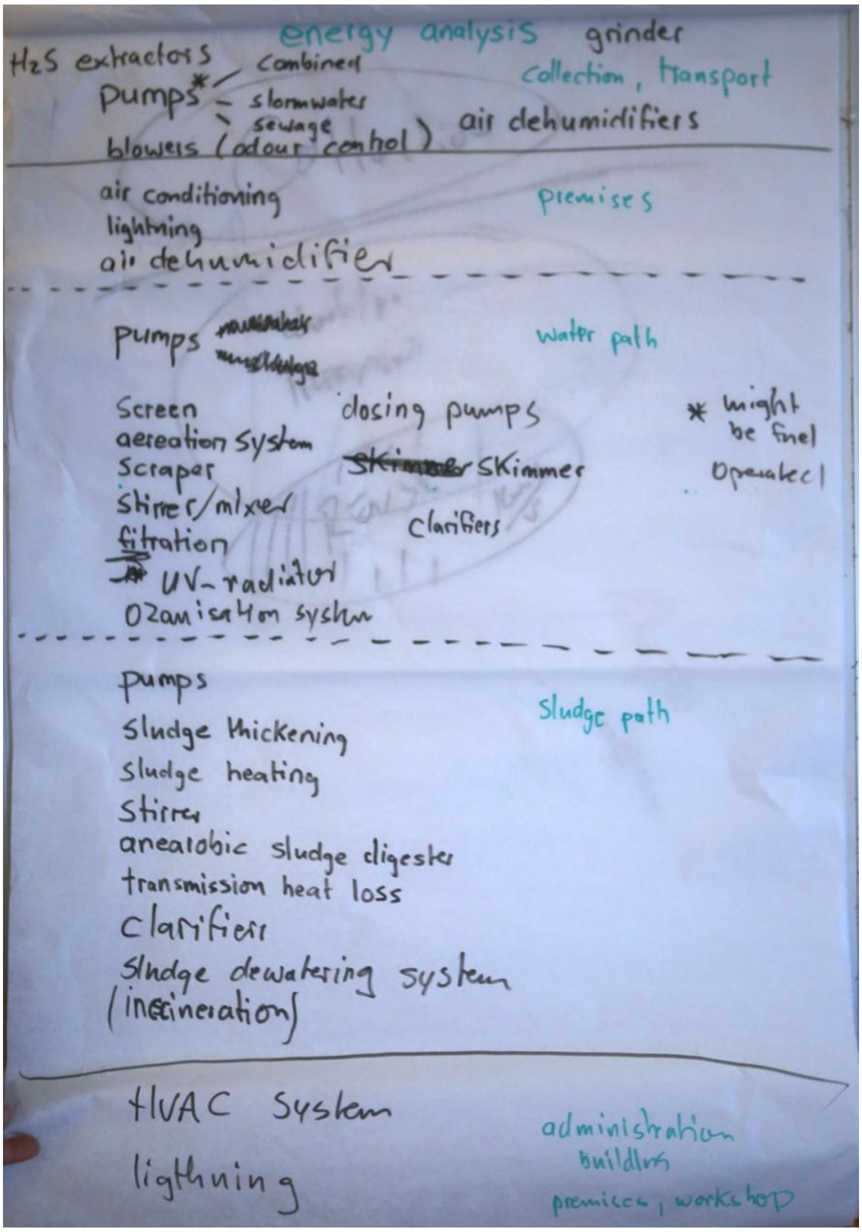
In this session, the main energy consuming components used in the wastewater disposal value added chain of MENA countries were clarified. It was discussed whether to include these components in the energy balance for the guidelines. Table 8 shows final outcome of the discussion.

Table 8: Main energy consuming components in wastewater disposal value added chain

Division	Component
Collection, transport – pumping stations	Combined pumps* / storm water pumps* / sewage pumps*
	H2S extractors, blowers (odour control)
	Air dehumidifiers
Treatment plant - premises	HVAC system
	Air dehumidifier
	Lightning
Treatment plant – water path	Inlet pump / outlet pump
	Aeration system
	Stirrer / mixer
	Scraper/bridge
	Dosing pumps
	Screen
	Clarifiers
	Skimmer
	UV radiator
	Ozonisation system
Treatment plant – sludge path	Sludge pumps
	Sludge thickener
	Centrifuge

	Filter press
	Stirrer
	Clarifiers
	Sludge heating
	Transmission heat losses of digester
Central buildings, workshops, premises	HVAC system
	Lightning

** The component might be fuel operated in some cases*



Data availability and implementation difficulties

<u>Objective of the session:</u>

Discuss instructions as to the further preparation of the energy guidelines

<u>Key question:</u>

- Definitions of needed data variables
- Assessment of data availability
- Data collection guidelines (e.g. energy consumption and process boundaries)

In the beginning of this session, participants were asked to identify difficulties regarding the implementation of energy checks from their perspective. The findings have been then allocated to the six major implementation barriers. Afterwards first ideas and solutions how to address theses issues were discussed. A summary of the outcome can be found in the table below. It was agreed that the guidelines should address common implementation barriers and possible approaches to address these issues.

Table 9: Implementation barriers and possible solutions

Implementation barriers	Approach
Lack of expertise	Capacity building program within utilities (internal training of staff)
	Run a pilot in small scale
Lock of awareness and commitment among the staff	Leadership
	Involvement and back-up by top-management
	Assign clear resources (budget, personnel) to the energy efficiency team
	Nominate energy officer
Different priorities at top management level	
Data availability	Start and improve little by little
	Establish data collection procedures for indicators ranked high priority
Data accuracy and reliability	Start and improve little by little
	Introduction of accuracy bands and reliability bands for indicators
Lack of financial resources	Preparation of cost–benefit analyses
	Prioritisation of measures according to highest return on investment

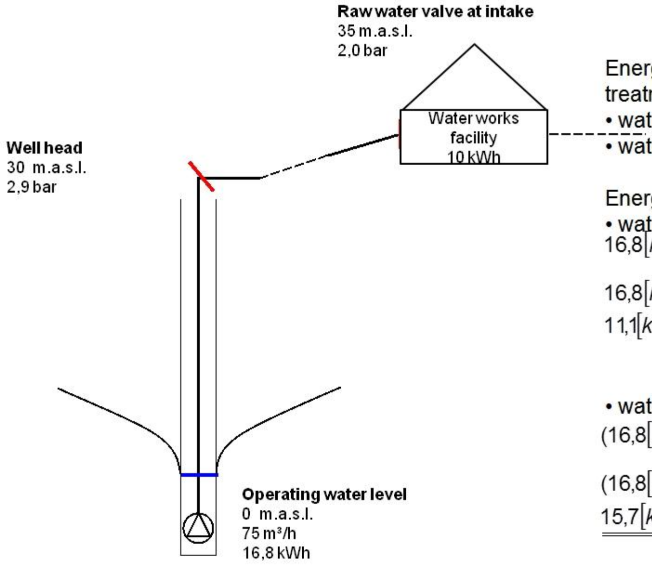
Figure 7: Difficulties regarding further implementation of the monitoring programme and possible solutions

Related to the water supply, some definitory issues regarding the apportionment of energy along different processes within the water supply value added chain were also discussed.

For instance, in some cases electrical energy for water abstraction that is expended in the water catchment is not used for raw water transport but for the water treatment.

If the raw water just requires some classic treatment (e.g. filtration) the energy expended on-site of the waterworks facility would be very low. However due to the use of the energy surplus at the raw water intake, the actual energy consumption for the treatment process itself is higher. If this is not considered, the need for optimising duration and intervals of filter backwashing would be ignored.

Thus it was decided, that the guidelines should give some advice how to deal with energy apportionment. However, the participants agreed that pumping energy consumption usually should the first step of any energy efficiency improvement imitative. If just pumps are considered, there is no need for apportionment.



Energy balance without allocating a proportion of well pumps to treatment:

- water abstraction: 16,8 kWh
- water treatment: 10 kWh

Energy balance with allocation:

- water abstraction

$$16{,}8[kWh]\times\left(1-\frac{2[bar]}{(2{,}9[bar]+(30[m]-0[m])\times 0{,}0980665[bar/m])}\right)$$

$$16{,}8[kWh]\times(1-0{,}34)$$

$$11{,}1[kWh]$$

- water treatment

$$\left(16{,}8[kWh]\times\left(\frac{2[bar]}{(2{,}9[bar]+(30[m]-0[m])\times 0{,}0980665[bar/m])}\right)\right)+10[kWh]$$

$$(16{,}8[kWh]\times(0{,}34))+10[kWh]$$

$$\underline{\underline{15{,}7[kWh]}}$$

Figure 8: Difficulties regarding further implementation of the monitoring programme and possible solutions

Benchmarking

Objective of the session:

Discus possibilities of a water integrity related benchmarking imitative.

Key question:

- Why benchmarking (advantages / disadvantages)?
- How to get started?

Benchmarking in the water industry is a well-known practice. A task force of the International Water Association (IWA) have defined its goals and the main steps. According to those authors, it is defined as follows:

'Benchmarking is a tool for performance improvement through systematic search and adaptation of leading practices.' (Cabrera et al 2011)

It consists of two fundamental components: Performance Assessment and Performance Improvement.

Before reaching performance improvement (the goal of benchmarking), performance assessment is necessary and meaningful. Performance assessment is based on the evaluation of performance indicators as used for the energy check. However, in a benchmarking initiative performance indicators are rather compared to performance indicators of other similar partners than internally to previous values. By doing so, it is possible to find improvement potential and performance gaps.

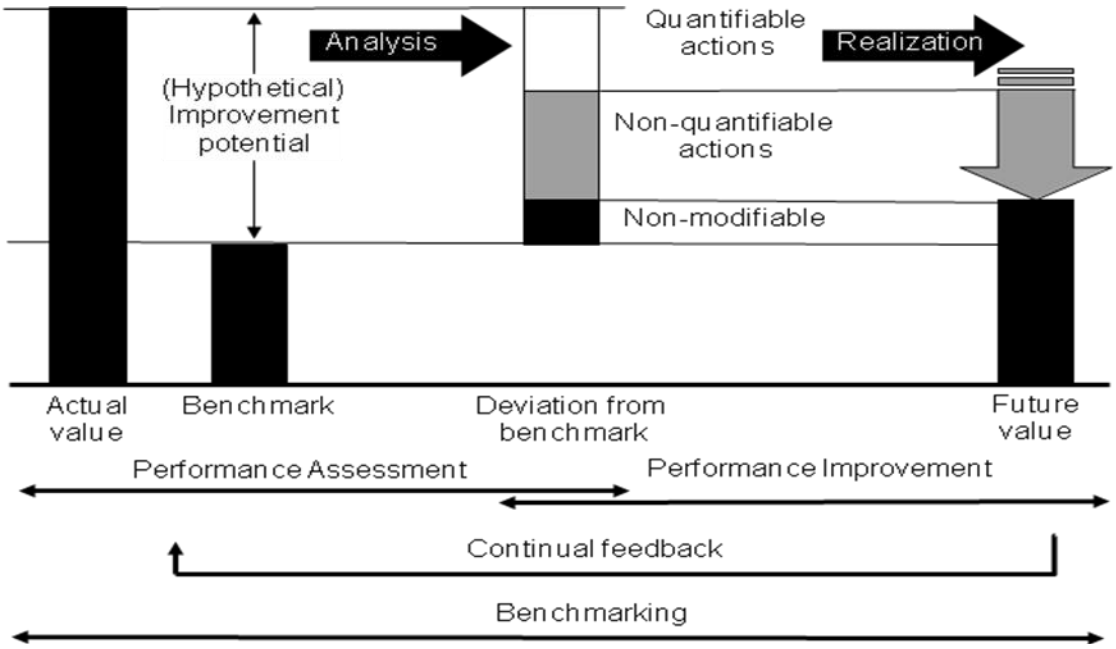


Figure 9: Concept of benchmarking

It might be the case, that others perform already much better than own plants. These plants can be used to establish benchmarks. Those partners might have installed already "good practices" from which the undertaking wants to learn. The idea of an initial assessment followed by an improvement of the performance in the benchmarking process is expressed in the figure above.

Performance assessment helps to understand the own position in the benchmarking initiative. As it is based on performance indicators, it can be expected that through benchmarking a database of energy related reference values will be maintained. These reference values can be used as benchmarks for the energy check. Currently there is no such database for the MENA water sector available.

The other integral part of Benchmarking is performance improvement. This is derived by both an in deep analysis of the own performance with leads to follow-up actions and by discussing good practices with partner utilities.

Benchmarking is no rocket science and it follows logical steps understandable by common sense. IWA manual (Cabrera et al, 2011) describes how to start a benchmarking project and what are success factors.

Closing

Objective of the session:
Discussing unanswered questions.

In the last session of the workshop some unanswered question were discussed together with some good-practices examples from participants. It was agreed to include the examples from the participants below in the guidelines:

- Khaled Zaabar – good practice example on the relevance of the main consumers
- Mr. Al Hamaqta Yasser – good practice example on …………
- Mr. Haji Mustapha – good practice example on …………

The examples need to be send to Eric Gramlich of Tuttahs & Meyer at e.gramlich@tum-aachen.de

Annexes

Water supply data variables (variables ws)

Data variables addressing monetary cost of energy (variables wsM)

wsM1 – total energy costs (EUR)
Costs of electrical energy (including energy for pumping and all other activities related to water supply, e.g. energy for water treatment, premises, offices etc.) during the assessment period.
INPUT DATA Referred to a reference period Referred to utility level
This variable includes not only the costs proportional to energy consumption but also all the other costs associated with energy purchases such as power tariffs and taxes. Data shall be derived from the financial statement of the undertaking. Exchange rates of local currencies should be referred to the end of the assessment period. **Used for indicator(s): wsMc1**

Data variables addressing energy consumption (variables wsC)

wsC1 – total energy consumption for water supply division (kWh)
Electrical energy consumption (including energy for pumping and all other activities related to water supply, e.g. energy for water treatment, premises, offices etc.) during the assessment period.
INPUT DATA Referred to a reference period Referred to utility level
This variable is the total energy consumption of the water supply division or undertaking. Data shall be derived from the bills of the energy supplier. **Used for indicator(s): wsEc1, wsEp2**

wsC2 – total pumping energy consumption (kWh)
Electrical energy consumption for water pumping (customer pumping systems excluded) during the assessment period.
INPUT DATA Referred to a reference period Referred to utility level
This variable is the total energy consumption of every water-pumping component of the water supply division or undertaking. Data shall be derived from energy consumption meters or from the bills of the energy supplier. The consumption of small pumps may be excluded if their influence in terms of global confidence grade of the variable is negligible.
Used for indicator(s): wsEc2, wsEp1

wsC3 – energy consumption well pump, intake pump (kWh)
Electrical energy consumption for each pumping component of the catchment area during the assessment period.
INPUT DATA Referred to a reference period Referred to component level
The data variable shall be assed for each and every pumping component in the catchment area. Data shall be derived from energy consumption meters or from the bills of the energy supplier. If the consumption is not due in a separate bill and no meter is installed it needs to be measured for all relevant operating states of the component on-site. Measured data may be projected for the whole period. When this procedure is to time consuming, for non power controlled pumps it may be reasonable estimated by multiplying pump nominal power with pump working hours during the assessment period
Used for indicator(s): wsEc3, wsEc3a

wsC4– energy consumption raw water booster pumps (kWh)
Electrical energy consumption for each pumping component of the raw water transmission system during the assessment period.
INPUT DATA Referred to a reference period Referred to component level
The data variable shall be assed for each and every pumping component in the raw water transmission system. Data shall be derived from energy consumption meters or from the bills of the energy supplier. If the consumption is not due in a separate bill and no meter is installed it needs to be measured for all relevant operating states of the component on-site. Measured data may be projected for the whole period. When this procedure is to time consuming, for non power controlled pumps it may be reasonable estimated by multiplying pump nominal power with pump working hours during the assessment period **Used for indicator(s): wsEc4, wsEc4a**

wsC5– overall waterworks facility energy consumption (kWh)
Electrical energy consumption of the entire treatment process in the waterworks facility.
INPUT DATA Referred to a reference period Referred to plant level
The data variable shall be assed for each and every waterworks facility of the undertaking. For classic treatment, the variable will corresponds to the energy consumption by the low voltage busbar of the waterworks facility. Data shall be derived from energy consumption meters or from the bills of the energy supplier. **Used for indicator(s): wsEc5, wsEc5a**

wsC6– heat demand (kWh)
Thermal energy demand by evaporators in desalination plants using either multistage flash evaporation (MSF) or multiple effect distillation (MED) process engineering.
INPUT DATA Referred to a reference period Referred to process level
The variable should be assessed for each and every desalination plant of the undertaking. The variable corresponds to the heat energy that has been produced in order to be utilised within the desalination process. **Used for indicator(s): wsEc6**

wsC7– energy consumption drinking water main pumps (kWh)
Electrical energy consumption for each pumping component on-site of the waterworks facility feeding the water transmission system during the assessment period.
INPUT DATA Referred to a reference period Referred to component level
The data variable shall be assed for each and every pumping component feeding the water transmission system on-site of each and every waterworks facility. Data shall be derived from energy consumption meters or from the bills of the energy supplier. If the consumption is not due in a separate bill and no meter is installed it needs to be measured for all relevant operating states of the component on-site. Measured data may be projected for the whole period. When this procedure is to time consuming, for non-power controlled pumps it may be reasonable estimated by multiplying pump nominal power with pump working hours during the assessment period. **Used for indicator(s): wsEc7, wsEc7a**

wsC8– energy consumption drinking water booster pumps (kWh)
Electrical energy consumption for each pumping component in the water transmission and distribution system during the assessment period.
INPUT DATA Referred to a reference period Referred to component level
The data variable shall be assessed for each and every pumping component in the water transmission and distribution system. Data shall be derived from energy consumption meters or from the bills of the energy supplier. If the consumption is not due in a separate bill and no meter is installed it needs to be measured for all relevant operating states of the component on-site. Measured data may be projected for the whole period. When this procedure is to time consuming, for non-power controlled pumps it may be reasonable estimated by multiplying pump nominal power with pump working hours during the assessment period. If in a particular case a fuel driven pump is to be assessed, the amount of diesel needs to be converted to power using its specific heating value. **Used for indicator(s): wsEc8, wsEc8a**

Data variables addressing energy production (variables wsP)

wsP1 – total energy recovered (kWh)
Total electrical energy recovered by the use of turbines or reverse pumps in the entire water supply system that is operated by the undertaking during the assessment period.
INPUT DATA Referred to a reference period Referred to utility level
The data variable shall be assessed for the entire water supply system under operation by the undertaking. Energy recovery relates to the amount of energy produced by the undertaking by utilising potential energy excessive for hydraulic transport needs in order to cover parts of its energy demand for water supply.
Used for indicator(s): wsEp1

wsP2 – total energy produced other than recovered (kWh)
Total electrical energy produced by means of e.g. photovoltaic, wind turbines at the premises of the entire water supply division of the undertaking during the assessment period.
INPUT DATA Referred to a reference period Referred to utility level
The data variable shall be assessed for the entire water supply division of the undertaking. Energy production relates to the amount of energy produced from renewable sources on-site the entire premises of the water supply division/undertaking in order to cover parts of its energy demand for water supply. Energy production by utilising potential energy excessive for hydraulic transport needs must only be included if the volume used for hydropower generation was not prior elevated by pumps operated by the undertaking (e.g. if the water resource is situated at relatively high altitude in an impounding reservoir). In all other cases, hydropower generation is to be assessed using data variable wsP1.
Used for indicator(s): wsEp2

Data variables addressing water volumes (variables wsW)

wsW1 – authorised consumption (m^3)
Total volume of water that is taken by registered customers, other authorised parties (e.g. fire fighters, municipalities for watering, street cleaning etc.) or by the water supplier itself.
INPUT DATA Referred to a reference period Referred to utility level
The data variable shall be assessed for the entire water supply division of the undertaking. Authorised consumption may be metered or unmetered as well as billed or unbilled. It is recommended to use IWA standard water balance to calculate authorised consumption. **Used for indicator(s): wsEc1,**

wsW2 – abstraction volume (m^3)
Volume of water that was abstracted from raw water resources for each pumping component in the catchment area during the assessment period.
INPUT DATA Referred to a reference period Referred to component level
The data variable shall be assed for each and every pumping component in the catchment area. Data can be derived by reading installed flow meters. If there is no flow meter installed or no record available, it needs to be estimated by best means available. **Used for indicator(s): wsEc3, wsEc3a**

wsW3– pressure boosted raw water volume (m^3)
Volume of raw water pressurised by each pumping component in the raw water transmission system during the assessment period.
INPUT DATA Referred to a reference period Referred to component level
The data variable shall be assessed for each and every pumping component in the raw water transmission system. Data can be derived by reading installed flow meters. If there is no flow meter installed or no record available, it needs to be estimated by best means available. **Used for indicator(s): wsEc4, wsEc4a**

wsW4 – treatment input volume (m^3)
Volume of raw water input to each waterworks facility during the assessment period.
INPUT DATA Referred to a reference period Referred to plant level
The data variable shall be assed for each and every waterworks facility of the undertaking. It includes both the volume of raw water abstracted from own resources and imported raw water but less raw water losses due to leakage, inaccuracies associated with metering and raw water taken by the water supplier for own uses and export. The volume should be metered at the inlet valve. If the treatment input volume is unmetered, data variable wsW4 should be used as an alternative.
Used for indicator(s): wsEc5

wsW5– drinking water production volume (m^3)
Volume of water treated for input to the water transmission lines of each waterworks facility during the assessment period.
INPUT DATA Referred to a reference period Referred to plant level
The data variable shall be assed for each and every waterworks facility of the undertaking. The volume should be metered at the outlet valve. It corresponds to the treatment input volume less treatment operational consumption.
Used for indicator(s): wsEc5a, wsEc6, wsEc7, wsEc7a

wsW6– pressure boosted drinking water volume (m^3)
Volume of drinking water pressurised by each pumping component in the water transmission and distribution system during the assessment period.
INPUT DATA Referred to a reference period Referred to component level
The data variable shall be assessed for each and every pumping component in the water transmission and distribution system. Data can be derived by reading installed flow meters. If there is no flow meter installed or no record available, it needs to be estimated by best means available.
Used for indicator(s): wsEc8, wsEc8a

Data variables addressing pump heads (variables wsH)

wsH1 – pump head well pump, intake pump (m)
Pump head for each pumping component in the catchment area during the assessment period.
INPUT DATA Referred to a reference period Referred to component level
The data variable shall be assed for each and every pumping component in the catchment area. For pumps with significant variation of pump head throughout the assessment period, the period should be subdivided into a limited number of time intervals. For instance, if a pump works 1/3 of the time with a flow Q_1 = 10 m³/h and a pump head of h_1 = 50 m, and 2/3 of the time with a flow Q_2 = 12 m³/h and a pump head h_2 = 42 m the resulting pump head will be: $((1/3) \times Q_1 \times h_1 + (2/3) \times Q_2 \times h_2) / ((1/3) \times Q_1 + (2/3) \times Q_2) = 44{,}35$ m **Used for indicator(s): wsEc3**

wsH2 – pump head raw water booster pumps (m)
Pump head for each pumping component in the raw water transmission system during the assessment period.
INPUT DATA Referred to a reference period Referred to component level
The data variable shall be assed for each and every pumping component in the raw water transmission system. For pumps with significant variation of pump head throughout the assessment period, the period should be subdivided into a limited number of time intervals. For instance, if a pump works 1/3 of the time with a flow Q_1 = 10 m³/h and a pump head of h_1 = 50 m, and 2/3 of the time with a flow Q_2 = 12 m³/h and a pump head h_2 = 42 m the resulting pump head will be: $((1/3) \times Q_1 \times h_1 + (2/3) \times Q_2 \times h_2) / ((1/3) \times Q_1 + (2/3) \times Q_2) = 44{,}35$ m **Used for indicator(s): wsEc4**

wsH3 – pump head drinking water main pumps (m)
Pump head for each pumping component on-site of the waterworks facility feeding the water transmission system during the assessment period.
INPUT DATA Referred to a reference period Referred to component level
The data variable shall be assed for each and every pumping component feeding the water transmission system on-site of each and every waterworks facility. For pumps with significant variation of pump head throughout the assessment period, the period should be subdivided into a limited number of time intervals. For instance, if a pump works 1/3 of the time with a flow Q_1 = 10 m³/h and a pump head of h_1 = 50 m, and 2/3 of the time with a flow Q_2 = 12 m³/h and a pump head h_2 = 42 m the resulting pump head will be: ((1/3) x Q_1 x h_1 + (2/3) x Q_2 x h_2) / ((1/3) x Q_1 + (2/3) x Q_2) = 44,35 m **Used for indicator(s): wsEc7**

wsH4 – pump head drinking water booster pumps (m)
Pump head for each pumping component in the water transmission and distribution system during the assessment period.
INPUT DATA Referred to a reference period Referred to component level
The data variable shall be assessed for each and every pumping component in the water transmission and distribution system. For pumps with significant variation of pump head throughout the assessment period, the period should be subdivided into a limited number of time intervals. For instance, if a pump works 1/3 of the time with a flow Q_1 = 10 m³/h and a pump head of h_1 = 50 m, and 2/3 of the time with a flow Q_2 = 12 m³/h and a pump head h_2 = 42 m the resulting pump head will be: ((1/3) x Q_1 x h_1 + (2/3) x Q_2 x h_2) / ((1/3) x Q_1 + (2/3) x Q_2) = 44,35 m **Used for indicator(s): wsEc8**

Water supply energy check key performance indicators

Performance indicators addressing energy consumption (indicators wsEc)

wsEc1 – energy content per authorised consumption (kWh/m³)
total energy consumption for water supply division / authorised consumption
wsEc1 = wsC1 / wsW1
wsC1 – total energy consumption for water supply division (kWh)
wsW1 – authorised consumption (m³)
This indicator provides a measure of the necessary energy utilisation by the undertaking per m³ of authorised potable water during the assessment period and equals to its total electrical energy content. It can be used as a measure how well energy efficiency improvement efforts are globally evolving. Main explanatory factors for external comparison: • Energy conversion efficiency of the pumps • Utilised process engineering for water treatment • Geomorphology of the supply area • Difference between elevation of water resources and maximum, minimum delivery elevation • Energy recovery • Reactive energy consumption Usual values are between 0.2 and 1.2 kWh/m³ provided the undertaking does not operate a desalination plant.

wsEc2 – proportion of pumping energy (%)
total pumping energy consumption / total energy consumption for water supply division x 100
wsEc2 = wsC2 / wsC1 x 100
wsC2 – total pumping energy consumption (kWh)
wsC1 – total energy consumption for water supply division (kWh)
This indicator provides a measure of the proportion of energy used for water pumping. It can be used to monitor whether pumping energy conversion efficiency improvements are eroded by increasing consumption deterioration of other energy consumers. Usually the proportion of pumping energy is above 80% of the total energy consumption. However, the proportion depends largely on the consumption of utilised process engineering for water treatment.

wsEc3 – standardised energy consumption abstraction/intake pumps (kWh/m^3/100m)

energy consumption well pump, intake pump / abstraction volume / pump head well pump, intake pump x 100

wsEc3 = wsC3 / wsW2 / wsH1 x 100

wsC3 – energy consumption well pump, intake pump (kWh)

wsW2 – abstraction volume (m^3)

wsH1 – pump head well pump, intake pump (m)

This indicator provides a measure of the energy conversion efficiency of the well or intake pumps operated by the undertaking. It equals the average amount of energy consumed per m^3 at a pump head of 100 m. It is the inverse of the pumping efficiency. A value of 0.5 kWh/m^3/100m for this indicator corresponds to an average pumping efficiency of 9810 N x 100 m / (3600 J/Wh) / 500 Wh x 100 = 55%. Usual values for well pumps are between 25% and 60%.

wsEc3a – energy consumption abstraction/intake pumps (kWh/m^3)

alternative indicator

energy consumption well pump, intake pump / abstraction volume

wsEc3a = wsC3 / wsW2

wsC3 – energy consumption well pump, intake pump (kWh)

wsW2 – abstraction volume (m^3)

This indicator provides a measure on energy utilisation of the well or intake pumps operated by the undertaking in relation to the volume elevated during the assessment period. As this indicator does not consider pump head, it should be only used if indicator wsEc3 cannot be calculated.

wsEc4 – standardised energy consumption raw water booster pumps (kWh/m^3/100m)

energy consumption raw water booster pumps / pressure boosted raw water volume / pump head raw water booster pumps x 100

wsEc4 = wsC4 / wsW3 / wsH2 x 100

wsC4– energy consumption raw water booster pumps (kWh)

wsW3– pressure boosted raw water volume (m^3)

wsH2 – pump head raw water booster pumps (m)

This indicator provides a measure of the energy conversion efficiency of the raw water booster pumps operated by the undertaking. It equals the average amount of energy consumed per m^3 at a pump head of 100 m. It is the inverse of the pumping efficiency. A value of 0.5 kWh/m^3/100m for this indicator corresponds to an average pumping efficiency of 9810 N x 100 m / (3600 J/Wh) / 500 Wh x 100 = 55%. Usual values for (drinking water) booster pumps are between 50% and 70%.

wsEc4a – energy consumption raw water booster pumps (kWh/m³)	
alternative indicator	**energy consumption raw water booster pumps / pressure boosted raw water volume** **wsEc4a = wsC4 / wsW3** wsC4– energy consumption raw water booster pumps (kWh) wsW3– pressure boosted raw water volume (m^3)
	This indicator provides a measure on energy utilisation of the raw water booster pumps operated by the undertaking in relation to the pressure boosted raw water volume during the assessment period. As this indicator does not consider pump head, it should be only used if indicator wsEc4 cannot be calculated.

wsEc5 – overall plant energy consumption per intake volume (kWh/m³)
overall waterworks facility energy consumption / treatment input volume **wsEc5 = wsC5 / wsW4** wsC5– overall waterworks facility energy consumption (kWh) wsW4 – treatment input volume (m^3)
This indicator provides a measure on energy utilisation by the treatment process in relation to the raw water plant intake volume during the assessment period. In some cases, raw water will have an energy surplus at the plant intake, which will be used for the treatment process. As for practical reason this indicator only uses electrical energy according to the consumption of the low voltage busbar the denominator may not correspond to the entire energy utilised for water treatment. The processing rule of this indicator assumes that no component is used requiring high voltage power supplies. If this is not the case (e.g. reverse osmosis plants and other advanced treatment technologies) the user needs to create a new variable assessing high voltage power consumption utilised for water treatment that needs to be added to the processing rule as denominator. Special care is required in result interpretation when used for external comparisons. The overall energy consumption will vary widely according to the utilised process engineering.

wsEc5a – overall plant energy consumption per produced volume (kWh/m³)	
alternative indicator	**overall waterworks facility energy consumption / drinking water production volume** **wsEc5a = wsC5 / wsW5** wsC5– overall waterworks facility energy consumption (kWh) wsW5– drinking water production volume (m³)
	This indicator provides a measure on energy utilisation by the treatment process in relation to the production volume during the assessment period. As this indicator does not consider treatment operational consumption and losses, it should only be used if indicator wsEc5 cannot be calculated due to the lack of a water meter at the plant raw water intake valve. In some cases, raw water will have an energy surplus at the plant intake, which will be used for the treatment process. As for practical reason this indicator only uses electrical energy according to the consumption of the low voltage busbar the denominator may not correspond to the entire energy utilised for water treatment. The processing rule of this indicator assumes that no component is used requiring high voltage power supplies. If this is not the case (e.g. reverse osmosis plants and other advanced treatment technologies) the user needs to create a new variable assessing high voltage power consumption utilised for water treatment that needs to be added to the processing rule as numerator. Special care is required in result interpretation when used for external comparisons. The overall energy consumption will vary widely according to the utilised process engineering Usual values are around 0.03 kWh/m³ (classic treatment), 0.12 kWh/m³ (activated carbon and ozone), 0.2 kWh/m³ (membrane ultrafiltration), 2 to 5.6 kWh/m³ (multistage flash evaporation and multiple effect distillation) and 4 kWh/m³ for reverse osmosis (but it may reach up to 7 kWh/m³ with a particularly poor raw water resource).

wsEc6 – heat demand per volume produced (kWh/m³)
energy consumption water treatment / drinking water production volume **wsEc6 = wsC6 / wsW5** wsC6– heat demand (kWh) wsW5– drinking water production volume (m³)
This indicator provides a measure on heat energy utilisation by evaporators in relation to the production volume during the assessment period of desalination plants using either multistage flash evaporation (MSF) or multiple effect distillation (MED) process engineering. Usual values are around 64 kWh/m³ for MSF plants and 54 kWh/m³ for MED plants.

wsEc7 – standardised energy consumption main pumps (kWh/m³/100 m)
energy consumption drinking water main pumps / drinking water production volume / pump head drinking water main pumps x 100
wsEc7 = wsC7 / wsW5 / wsH3 x 100
wsC7– energy consumption drinking water main pumps (kWh)
wsW5– drinking water production volume (m³)
wsH3 – pump head drinking water main pumps (m)
This indicator provides a measure of the energy conversion efficiency of the main pumps feeding the transmission lines operated by the undertaking. It equals the average amount of energy consumed per m³ at a pump head of 100 m. It is the inverse of the pumping efficiency. A value of 0.5 kWh/m³/100m for this indicator corresponds to an average pumping efficiency of 9810 N x 100 m / (3600 J/Wh) / 500 Wh x 100 = 55%. Usual values for drinking water main pumps are between 50% and 70%.

wsEc7a – energy consumption main pumps (kWh/m³)	
alternative indicator	**energy consumption drinking water main pumps / drinking water production volume**
	wsEc7a = wsC7 / wsW5
	wsC7– energy consumption drinking water main pumps (kWh)
	wsW5– drinking water production volume (m³)
	This indicator provides a measure of the energy conversion efficiency of the drinking water booster pumps operated by the undertaking. As this indicator does not consider pump head, it should be only used if indicator wsEc7 cannot be calculated.

wsEc8 – standardised energy consumption booster pumps (kWh/m³/100 m)
energy consumption drinking water booster pumps / pressure boosted drinking water volume / pump head drinking water booster pumps x 100
wsEc8 = wsC8 / wsW6 / wsH4 x 100
wsC8– energy consumption drinking water booster pumps (kWh)
wsW6– pressure boosted drinking water volume (m³)
wsH4 – pump head drinking water booster pumps (m)
This indicator provides a measure of the energy conversion efficiency of the drinking water booster pumps operated by the undertaking. It equals the average amount of energy consumed per m³ at a pump head of 100 m. It is the inverse of the pumping efficiency. A value of 0.5 kWh/m³/100m for this indicator corresponds to an average pumping efficiency of 9810 N x 100 m / (3600 J/Wh) / 500 Wh x 100 =

55%.

Usual values for drinking water booster pumps are between 50% and 70%.

wsEc8a – energy consumption booster pumps (kWh/m³)	
alternative indicator	**energy consumption drinking water booster pumps / pressure boosted drinking water volume** **wsEc8a = wsC8 / wsW6** wsC8– energy consumption drinking water booster pumps (kWh) wsW6– pressure boosted drinking water volume (m³)
	This indicator provides a measure on energy utilisation of the drinking water booster pumps operated by the undertaking in relation to the pressure boosted drinking water volume during the assessment period. As this indicator does not consider pump head, it should only be used if indicator wsEc8 cannot be calculated.

Performance indicators addressing energy production (indicators wsEp)

wsEp1 – total energy recovery (%)
total energy recovered / total pumping energy consumption x 100 **wsEp1 = wsP1 / wsC1 x 100** wsP1 – total energy recovered (kWh) wsC2 – total pumping energy consumption (kWh)
This indicator provides a measure on recovery of excessive energy for hydraulic transport needs by use of turbines or reverse pumps during the assessment period. It can be used as a measure how well energy recovery efforts are globally evolving. At favourable geomorphologic conditions, up to 40% of the pumping energy may be recoverable.

wsEp2 – total energy production other than recovery (%)
total energy recovered / total energy consumption for water supply division x 100 **wsEp2 = wsP2 / wsC1 x 100** wsP2 – total energy produced other than recovered (kWh) wsC1 – total energy consumption for water supply division (kWh)
This indicator provides a measure on production of renewable energy on the undertakings premises in order to cover parts of its energy demand for water supply. It can be used as a measure how well energy production efforts are globally evolving.

Performance indicators addressing monetary costs (indicators wsMc)

wsMc1 – electrical energy cost (EUR/kWh)
total energy costs / total energy consumption for water supply division
wsMc1 = wsM1 / wsC1
wsM1 – total energy costs (EUR)
wsC1 – total energy consumption for water supply division (kWh)
This indicator provides a measure on the average cost of energy per unit of procurement. It is largely dependent on both, national energy policy and the context within the undertaking operates (e.g. distribution of nominal power of energy consuming components along the system). Thus, special care is required in result interpretation when used for external comparisons.

Wastewater disposal data variables (variables wd)

Data variables addressing monetary cost of energy (variables wdM)

wdM1 – total energy costs (EUR)
Costs of electrical energy (including energy for wastewater pumping, treatment andall other activities related to wastewater disposal, e.g. energy for premises, offices) during the assessment period.
INPUT DATA Referred to a reference period Referred to utility level
This variable includes not only the component proportional to the energy consumption but all the other costs associated with energy purchases such as power tariffs and taxes. Data shall be derived from the financial statement of the undertaking. Exchange rates of local currencies should be referred to the end of the assessment period. **Used for indicator(s): wdMc1**

Data variables addressing energy consumption (variables wdC)

wdC1 – total energy consumption for wastewater disposal division (kWh)
Electrical energy consumption (including energy for wastewater pumping and treatment as well as all other activities related to wastewater disposal, e.g. energy for premises, offices etc.) during the assessment period.
INPUT DATA Referred to a reference period Referred to utility level
This variable is the total energy consumption of the wastewater disposal division or undertaking. Data shall be derived from the bills of the energy supplier.

Used for indicator(s): wdEc1, wdEc1a, wdMc1

wdC2 – energy consumption lifting pumps in sewer system (kWh)

Electrical energy consumption of each pumping component in the sewer system during the assessment period.

INPUT DATA
Referred to a reference period
Referred to component level

The data variable shall be assessed for each and every pumping component in the sewer system. Data shall be derived from energy consumption meters or from the bills of the energy supplier. If the consumption is not due in a separate bill and no meter is installed it needs to be measured for all relevant operating states of the component on-site. Measured data may be projected for the whole period. When this procedure is to time consuming, for non-power controlled pumps it may be reasonable estimated by multiplying pump nominal power with pump working hours during the assessment period. If in a particular case a fuel driven pump is to be assessed, the amount of diesel needs to be converted to power using its specific heating value.

Used for indicator(s): wdEc2, wdEc2a

wdC3 – overall wastewater treatment plant energy consumption (kWh)

Electrical energy consumption (including wastewater, sludge treatment, premises) during the assessment period.

INPUT DATA
Referred to a reference period
Referred to plant level

The data variable shall be assed for each and every wastewater treatment plant of the undertaking. Data shall be derived from energy consumption meters or from the bills of the energy supplier.

Used for indicator(s): wdEc3, wdEc3a

wdC4– energy consumption water pumps on wastewater treatment plants (kWh)

Energy consumption of each pumping component in the water path of the undertakings wastewater treatment plants during the assessment period.

INPUT DATA
Referred to a reference period
Referred to component level

The data variable shall be assessed for each and every pumping component in the water path of each and every wastewater treatment plant. Data shall be derived from energy consumption meters. If no meter is installed it needs to be measured for all relevant operating states of the component on-site. Measured data may be projected for the whole period. When this procedure is to time consuming, for non-power controlled pumps it may be reasonable estimated by multiplying pump nominal power with pump working hours during the assessment period.

Used for indicator(s): wdEc4, wdEc4a

wdC5 – energy consumption aeration component (kWh)

Energy consumption of the aeration system in the biological treatment stage during the assessment period.

INPUT DATA
Referred to a reference period
Referred to component level

The data variable is to be assed for each and every waste water treatment plant of the undertaking. Data is to be derived from energy consumption meters. If no meter is installed, it needs to be measured for a limited period and then projected for the whole assessment period.

Used for indicator(s): wdEc5

wdC6 – energy consumption sludge treatment (kWh)

Electric energy consumption of the sludege treatment components during the assessment period.

INPUT DATA
Referred to a reference period
Referred to process level

The variable should be assessed for each and every treatment plant of the undertaking. The variable corresponds to the entire electric energy consumption of all relevant sludge treatment components such as sludge pumps, mechanical dewatering units (during and before the final treatment stage used to decrease sludge volume or water amount), mixers, chemical dosing stations, aeration units (for the biological treatment stage), mechanical sludge-drying units (e.g. filter press), drainage pumps and all other relevant components. Data is to be derived from energy consumption meters. If no meter is installed, it needs to be estimated by the best means available.

Used for indicator(s): wdEc6

wdC7 – energy consumption sludge pumps on wastewater treatment plants (kWh)

Energy consumption of each pumping component in the sludge path of the undertakings wastewater treatment plants during the assessment period.

INPUT DATA
Referred to a reference period
Referred to component level

The data variable shall be assessed for each and every pumping component in the sludge lines of each and every wastewater treatment plant. Data shall be derived from energy consumption meters. If no meter is installed it needs to be measured for all relevant operating states of the component on-site. Measured data may be projected for the whole period. When this is to time consuming, for non-power controlled pumps it may be reasonable estimated by multiplying pump nominal power with pump working hours during the assessment period.

Used for indicator(s): wdEc7

wdC8 – heat demand (kWh)

Heat demand of digesters in treatment plants utilising anaerobic sludge digestion during the assessment period.

INPUT DATA

Referred to a reference period

Referred to process level

The variable should be assessed for each and every treatment plant of the undertaking utilising anaerobic sludge digestion. The variable corresponds to the heat energy that has been produced in order to be utilised for heating the digesters.

Used for indicator(s): wdEc8

wdC9 – energy consumption tertiary treatment stage (kWh)

Energy consumption of the components in wastewater treatment plants with a tertiary treatment stage during the assessment period.

INPUT DATA

Referred to a reference period

Referred to process level

The variable should be assessed for each and every treatment plant of the undertaking applying one or more tertiary treatment process as advanced treatment stage such as filtration, lagooning, nutrient removal, phosphor removal, heavy metals removal and disinfection. The variable corresponds to the entire energy consumption of all relevant components of the tertiary treatment stage such as centrifugal pumps feeding of the sand filters, drum filters, chemical dosing pumps, UV radiators, the ozonation system and all other relevant components. Data is to be derived from energy consumption meters. If no meter is installed, it needs to be estimated by the best means available.

Used for indicator(s): wdEc9

Data variables addressing energy production (variables wdP)

wdP1 – total energy recovery from biogas (kWh)
Total energy recovered from biogas at wastewater treatment plants utilising anaerobic sludge digestion during the assessment period.
INPUT DATA Referred to a reference period Referred to utility level
The data variable is to be assessed for the entire waste water disposal division of the undertaking taking all waste water treatment plants into account where energy is recovered from biogas produced in the digesters. Ways of recovering energy from biogas may include production of heat for re-use on-site, simultaneous production of electricity and heat re-used on-site (cogeneration) but also biofuel production as well as conversion of biogas into biomethane for injection into the natural gas network or in electrical form for injection into the electricity network (if there is more on-site energy production than demand). The variable only corresponds to the amount of energy that has been recovered by the undertaking in order to cover parts of its energy demand for waste water treatment processes. **Used for indicator(s): wdEp1**

wdP2 – total energy produced other than biogas from biogas (kWh)
Total energy produced by means of e.g. photovoltaic, wind turbines etc. at the premises of the entire wastewater disposal division of the undertaking during the assessment period.
INPUT DATA Referred to a reference period Referred to utility level
The data variable shall be assessed for the entire wastewater disposal division of the undertaking. Energy production relates to the amount of energy produced from renewable sources on-site the entire premises of the wastewater disposal division/undertaking in order to cover parts of its energy demand for wastewater disposal. **Used for indicator(s): wdEp2**

wdP3 – electric energy production by cogeneration (kWh)
Electric energy produced from biogas by combined heat and power co-generators during the assessment period.
INPUT DATA Referred to a reference period Referred to plant level
The variable should be assessed for each and every treatment plant of the undertaking were combined heat and power co-generators are installed to recover energy from the biogas produced in the digesters.

The variable corresponds to the entire electrical energy production of the plant regardless of its use.

Used for indicator(s): wdEp4

wdP4 – volume of biogas production (m³)
Volume of biogas generated during the assessment period.
INPUT DATA Referred to a reference period Referred to plant level
The variable should be assessed for each and every treatment plant of the undertaking utilising anaerobic sludge digestion. The volume should be declared as standard cubic metre and referred to standard temperature and pressure at 0° C and 1013 bar.
Used for data variable(s): wdP5
Used for indicator(s): wdEp3

wdP5 – energy content of biogas production (kWh)
Energy content of biogas generated during the assessment period.
INPUT DATA Referred to a reference period Referred to plant level
The variable should be assessed for each and every treatment plant of the undertaking utilising anaerobic sludge digestion. The energy content can be derived by multiplying plant specific volume of biogas production (data variable wdP4) with its specific heating value.
Used for indicator(s): wdEp4

Data variables addressing water volumes (variables wdW)

wdW1 – total volume of wastewater treated (m³)
Total volume of wastewater treated by wastewater treatment plants operated by the undertaking during the assessment period.
INPUT DATA Referred to a reference period Referred to utility level
The data variable shall be assessed for the entire wastewater disposal division of the undertaking. It corresponds to the entire wastewater volume that has been treated on all wastewater treatment plants regardless of the required quality of the discharge. Wastewater treated by on-site systems operated by the undertaking is not to be included.
Used for indicator(s): wdEc1a

wdW2 – volume of wastewater treated (m³)
Volume of wastewater treated during the assessment period.
INPUT DATA Referred to a reference period Referred to plant level
The variable should be assessed for each and every treatment plant operated by the undertaking. It corresponds to the volume that has been treated during the assessment period resulting from collected sewage, rainwater and infiltration volumes. It should be derived from the inlet flow measurements. **Used for indicator(s): wdEc3a**

wdW3 – lifted volume (m³)
Volume of wastewater lifted by each pumping component in the sewer system during the assessment period.
INPUT DATA Referred to a reference period Referred to component level
The data variable shall be assessed for each and every pumping component in the sewer system. Data can be derived by reading installed flow meters. If there is no flow meter installed or no record available, it needs to be estimated by best means available. **Used for indicator(s): wdEc2, wdEc2a**

wdW4 – wastewater volume elevated (m³)
Volume of wastewater pumped by each pumping component in the water path of the undertakings wastewater treatment plants during the assessment period.
INPUT DATA Referred to a reference period Referred to component level
The data variable shall be assessed for each and every pumping component in the water path of each and every wastewater treatment plant. Data shall be derived from meter readings. If there is no flow meter installed or no record available, it needs to be estimated by best means available. **Used for indicator(s): wdEc4, wdEc4a**

wdW5 – wastewater receiving tertiary treatment (m³)
Volume of wastewater receiving tertiary treatment during the assessment period.
INPUT DATA Referred to a reference period Referred to process level
The variable should be assessed for each and every treatment plant of the undertaking applying one or more tertiary treatment process such as filtration, lagooning, nutrient removal or disinfection. The variable corresponds to the volume delivered to the application that reuses treated wastewater (e.g. irrigation, watering of golf courses and public gardens). Data shall be either derived from the meter readings or from invoices issued to the re-users.
Used for indicator(s): wdEc9

Data variables addressing sludge volumes (variables wdS)

wdS1 – sludge volume handled (ton DS)
Dry weight of sludge handled during the assessment period.
INPUT DATA Referred to a reference period Referred to process level
All dry weight of sludge handled by the undertaking during the assessment period, including not only the dry weight of sludge produced in the wastewater treatment plants, but also dry weight of sludge inputs from other sources. Sludge handled may also include sludge from on-site systems. If applicable, the value should be obtained before digestion. The variable must be entered as dry solids, e.g. if the handled amount is 20 tons of sludge and the percentage of dry solids is 30%, then dry solids are equal to 20 tons x 0.3 = 6 tons dry solids.
Used for indicator(s): wdEc6

wdS2 – sludge volume elevated (m³)
Volume of sludge pumped by each pumping component in the sludge path of the undertakings wastewater treatment plants during the assessment period.
INPUT DATA Referred to a reference period Referred to component level
The data variable shall be assessed for each and every pumping component in the sludge path of each and every wastewater treatment plant. Data shall be derived from meter readings. If there is no flow meter installed or no record available, it needs to be estimated by best means available.
Used for indicator(s): wdEc7

Data variables addressing pollution loads (variables wdL)

wdL1 – total population equivalents served (p.e.)
Total population equivalents that were connected to wastewater treatment plants operated by the undertaking during the assessment period.
INPUT DATA Referred to a reference period Referred to utility level
The data variable is to be assessed for the entire waste water disposal division of the undertaking. It corresponds to the entire load that was connected to all waste water treatment plants regardless of the required quality of the discharge. On-site systems operated by the undertaking are not to be included. The pollution load should be measured at the intakes of the waste water treatment plants operated by the undertaking. It is recommended to have a minimum set of at least twelve samples (one 24-hour sample for each month) available to assess the data variable. Population equivalents should be calculated using the standard pollution load of sewage generated by one inhabitant (based on BOD_5) corresponding with the national or regional norm. If there is no norm available, a value of 60 g/d should be applied. **Used for indicator(s): wdEc1**

wdL2 – population equivalents served (p.e.)
Connected population equivalents during the assessment period.
INPUT DATA Referred to a reference period Referred to plant level
The variable should be assessed for each and every treatment plant operated by the undertaking. The pollution load should be measured at the inflow of the waste water treatment plant. It is recommended to have a minimum set of at least twelve samples (one 24-hour sample for each month) available to assess the data variable. Population equivalents should be calculated using the standard pollution load of sewage generated by 1 inhabitant (based on BOD_5) corresponding with the national or regional norm. If there is no norm available, a value of 60 g/d may be used. **Used for indicator(s): wdEc3, wdEc5, wdEc8, wdEp3**

Data variables addressing pump heads (variables wdH)

wdH1 – pump head lifting pumps (m)
Pump head for each pumping component in the sewer system during the assessment period. INPUT DATA Referred to a reference period Referred to component level
The data variable shall be assessed for each and every pumping component in the sewer system. For pumps with significant variation of pump head throughout the assessment period, the period should be subdivided into a limited number of time intervals. For instance, if a pump works 1/3 of the time with a flow Q_1 = 10 m³/h and a pump head of h_1 = 50 m, and 2/3 of the time with a flow Q_2 = 12 m³/h and a pump head h_2 = 42 m the resulting pump head will be: ((1/3) x Q_1 x h_1 + (2/3) x Q_2 x h_2) / ((1/3) x Q_1 + (2/3) x Q_2) = 44,35 m **Used for indicator(s): wdEc2**

wdH2 – pump head water pumps (m)
Pump head for each pumping component in the water path of the undertakings wastewater treatment plants during the assessment period. INPUT DATA Referred to a reference period Referred to component level
The data variable shall be assessed for each and every pumping component in the water path of each and every wastewater treatment plant. For pumps with significant variation of pump head throughout the assessment period, the period should be subdivided into a limited number of time intervals. For instance, if a pump works 1/3 of the time with a flow Q_1 = 10 m³/h and a pump head of h_1 = 50 m, and 2/3 of the time with a flow Q_2 = 12 m³/h and a pump head h_2 = 42 m the resulting pump head will be: ((1/3) x Q_1 x h_1 + (2/3) x Q_2 x h_2) / ((1/3) x Q_1 + (2/3) x Q_2) = 44,35 m **Used for indicator(s): wdEc4**

Waste water disposal energy check key performance indicators

Performance indicators addressing energy consumption (indicators wdEc)

wdEc1 –energy consumption per population equivalent served (kWh/p.e.)
total energy consumption for wastewater disposal / total population equivalents
wdEc1 = wdC1 / wdL1
wdC1 – total energy consumption for wastewater disposal division (kWh)
wdL1 – total population equivalents served (p.e.)
This indicator provides a measure of the necessary electrical energy utilisation by the undertaking in relation to the population equivalents served during the assessment period. It can be used as a measure how well energy efficiency improvement efforts are globally evolving. Main explanatory factors for external comparison: • Energy conversion efficiency of the pumps • Utilised process engineering for wastewater and sludge treatment • Geomorphology of the catchment area • Energy recovery from biogas • Reactive energy consumption Usual values are between 30 kWh/p.e. and 80 kWh/p.e.

wdEc1a – energy consumption per wastewater volume disposed (kWh/m³)	
alternative indicator	**total energy consumption for wastewater disposal / total volume of wastewater treated**
	wdEc2 = wdC1 / wdW1
	wdC1 – total energy consumption for wastewater disposal division (kWh)
	wdW1 – total volume of wastewater treated (m³)
	This indicator provides a measure of the necessary electrical energy utilisation by the undertaking in relation to the volume of wastewater disposed during the assessment period. It can be used as a measure how well energy efficiency improvement efforts are globally evolving. As the major part of energy consumption for wastewater disposal usually is related to the pollution load rather than the hydraulic load, the indicator only should be applied if indicator wdEc1 cannot be calculated.

wdEc2– standardised energy consumption lifting pumps in sewer system (kWh/m³/100 m)
energy consumption lifting pumps in sewer system / lifted volume / pump head lifting pumps x 100
wdEc3 = wdC2 / wdW3 / wdH1 x 100
wdC2 – energy consumption lifting pumps in sewer system (kWh)

wdW3 – lifted volume (m³)
wdH1 – pump head lifting pumps (m)
This indicator provides a measure of the energy conversion efficiency of the lifting pumps in the sewer system operated by the undertaking. It equals the average amount of energy consumed per m³ at a pump head of 100 m. It is the inverse of the pumping efficiency. A value of 0.5 kWh/m³/100m for this indicator corresponds to an average pumping efficiency of 9810 N x 100 m / (3600 J/Wh) / 500 Wh x 100 = 55%. For external comparison, it may be specified whether the assessed lifting pump elevates wastewater, storm water or sewage. Usual values for lifting pumps are between 11% and 56%.

wdEc2a – energy consumption lifting pumps in sewer system (kWh/m³)	
alternative indicator	**energy consumption lifting pumps in sewer system / lifted volume**
	wdEc3 = wdC2 / wdW3
	wdC2 – energy consumption lifting pumps in sewer system (kWh)
	wdW3 – lifted volume (m³)
	This indicator provides a measure of the energy consumption of lifting pumps in the sewer system operated by the undertaking in relation to the volume lifted during the assessment period. As this indicator does not consider pump head, it should be only used if indicator wdEc3 cannot be calculated. For external comparison, it may be specified whether the assessed lifting pump elevates wastewater, storm water or sewage.

wdEc3 – overall plant energy consumption per population equivalent served (kWh/p.e.)
overall wastewater treatment plant energy consumption / population equivalents
wdEc3= wdC3 / wdL2
wdC3 – overall wastewater treatment plant energy consumption (kWh)
wdL2 – population equivalents served (p.e.)
This indicator provides a measure on energy utilisation by the treatment process in relation to the population equivalents served during the assessment period. Special care is required in result interpretation when used for external comparisons. The overall energy consumption will vary widely according to its treatment capacity, utilised process engineering for both, water and sludge treatment, the wastewater composition as well as the required quality of the discharge.

wdEc3a – overall plant energy consumption per volume of wastewater treated (kWh/m³)

alternative indicator	**overall wastewater treatment plant energy consumption / volume of wastewater treated** **wdEc3a= wdC3 / wdW2** wdC3 – overall wastewater treatment plant energy consumption (kWh) wdW2 – volume of wastewater treated (m^3)
	This indicator provides a measure on energy utilisation by the treatment process in relation to the volume of wastewater treated during the assessment period. As the major part of energy consumption for wastewater treatment usually is related to the pollution load rather than the hydraulic load, the indicator only should be applied if indicator wdEc3 cannot be calculated. Special care is required in result interpretation when used for external comparisons. The overall energy consumption will vary widely according to its treatment capacity, utilised process engineering for both, water and sludge treatment, the wastewater composition as well as the required quality of the discharge.

wdEc4 – standardised energy consumption pumps water treatment (kWh/m^3/100 m)
energy consumption water pumps on wastewater treatment plants / wastewater volume elevated / pump head water pumps x 100 **wdEc4 = wdC4 / wdW4 / wdH2 x 100** wdC4 – energy consumption water pumps on wastewater treatment plants (kWh) wdW4 – wastewater volume elevated (m^3) wdH2 – pump head water pumps (m)
This indicator provides a measure of the energy conversion efficiency of the water pumps on-site wastewater treatment plants operated by the undertaking. It equals the average amount of energy consumed per m^3 at a pump head of 100 m. It is the inverse of the pumping efficiency. A value of 0.5 kWh/m^3/100m for this indicator corresponds to an average pumping efficiency of 9810 N x 100 m / (3600 J/Wh) / 500 Wh x 100 = 55%. Usual values for water pumps within wastewater treatment are between 45% and 68%.

wdEc4a –energy consumption pumps water treatment (kWh/m^3)	
alternative indicator	**energy consumption water pumps on wastewater treatment plants / wastewater volume elevated** **wdEc4a = wdC4 / wdW4** wdC4 – energy consumption water pumps on wastewater treatment plants (kWh) wdW4 – wastewater volume elevated (m^3)
	This indicator provides a measure of the energy conversion efficiency of the water pumps on-site

	wastewater treatment plants operated by the undertaking in relation to the volume elevated during the assessment period. As this indicator does not consider pump head, it should be only used if indicator wdEc4 cannot be calculated.

wdEc5 – energy consumption biological aeration (kWh/p.e.)
energy consumption aeration component / population equivalents served
wdEc5 = wdC5 / wdW4
wdC5 – energy consumption aeration component (kWh)
wdL2 – population equivalents served (p.e.)
This indicator provides a measure on energy utilisation by the aeration system in relation to the population equivalents served during the assessment period. Special care is required in result interpretation when used for external comparisons. Energy consumption of the for biological aeration will vary according to the design of the aeration tanks to allow efficient mixing, the air production machines utilised, the type of sparger and the system for regulating the biological aeration to meet the exact air requirement of the purifying bacteria. Usually, biological aeration accounts for more than 40% of a plants energy consumption.

wdEc6 – energy consumption sludge treatment (kWh/ton DS)
energy consumption sludge treatment / sludge volume handled
wdEc6 = wdC6 / wdS1
wdC6 – energy consumption sludge treatment (kWh)
wdS1 – sludge volume handled (ton DS)
This indicator provides a measure on energy utilisation by the sludge treatment process in relation to the dry weight of sludge handled during the assessment period. Special care is required in result interpretation when used for external comparisons. Energy consumption for sludge treatment depends on the type of technology used. In general, for sludge from extended aeration, almost all treatment types are more energy-intensive than for mixed sludge.

wdEc7 –energy consumption sludge pumping (kWh/m³)
energy consumption sludge pumps on wastewater treatment plants / sludge volume elevated
wdEc7 = wdC7 / wdS2
wdC7 – energy consumption sludge pumps on wastewater treatment plants (kWh)
wdS2 – sludge volume elevated (m³)
This indicator provides a measure of the energy consumption of the sludge pumps on-site wastewater treatment plants operated by the undertaking in relation to the volume elevated during the assessment

period.

wdEc8 – heat demand per population equivalent served (kWh/p.e.)
heat demand / population equivalents served
wdEc8 = wsC8 / wdL2
wdC8– heat demand (kWh)
wdL2 – population equivalents served (p.e.)
This indicator provides a measure on heat energy utilised for heating the digesters in relation to the population equivalents served during the assessment period. Although thermal energy usually is of minor significance the thermal indicator completes the energy check

wdEc9 –energy consumption tertiary treatment (kWh/m³)
energy consumption tertiary treatment stage / wastewater receiving tertiary treatment
wdEc9= wdC9 / wdW5
wdC9 – energy consumption tertiary treatment stage (kWh)
wdW5 – wastewater receiving tertiary treatment (m³)
This indicator provides a measure of the energy consumption of the tertiary treatment stage operated by the undertaking in relation to the volume of waste water receiving tertiary treatment during the assessment period. Special care is required in interpreting results when used for external comparisons. Energy consumption for tertiary treatment depends on the quality required by the final use of the water that determines both the kind of treatment technologies and their sophistication.

Performance indicators addressing energy production (indicators wdEp)

wdEp1 – total energy recovery from biogas (%)
total energy recovered / total pumping energy consumption x 100
wdEp1 = wdP1 / wdC1 x 100
wdP1 – total energy recovery from biogas (kWh)
wdC1 – total energy consumption for wastewater disposal division (kWh)
This indicator provides a measure on energy recovery from biogas generated during anaerobic sludge digestion. It can be used as a measure how well energy recovery efforts from biogas are globally evolving.

wdEp2 – total energy production other than from biogas (%)
total energy produced other than from biogas / total energy consumption for wastewater disposal division x 100

wdEp2 = wdP2 / wdC1 x 100
wdP2 – total energy produced other than from biogas (kWh)
wdC1 – total energy consumption for wastewater disposal division (kWh)
This indicator provides a measure on production of renewable energy on the undertakings premises in order to cover parts of its energy demand for wastewater disposal. It can be used as a measure how well energy production efforts are globally evolving.

wdEp3 –biogas generation per population equivalent (kWh/p.e.)
volume of biogas production / population equivalents served
wdEp3= wdP4 / wdL2
wdP4 – volume of biogas production (m^3)
wdL2 – population equivalents served (p.e.)
This indicator provides a measure of the biogas generation in relation to the load during the assessment period. Special care is required in result interpretation when used for external comparisons since the reception of co-substrates will have a great influence of the value. As for practical reason this indicator only uses population equivalents as denominator the user might create a new variable assessing organic dry solid matter of the sludge feeding the digesters.

wdEp4 – proportion of biogas conversion into energy (%)
electric energy production by cogeneration / energy content of biogas production x 100
wdEp3= wdP3 / wdP5 x 100
wdP3 – electric energy production by cogeneration (kWh)
wdP5 – energy content of biogas production (kWh)
This indicator provides a measure on the proportion of biogas that was converted to electricity during the assessment period. Ideally, the entire biogas volume should be utilized. However, due to maintenance of the combined heat and power co-generators and thanks to non-uniform gas production in combination with a too small or even non-existing gas storage tanks, losses through flaring will occur.

Performance indicators addressing monetary costs (indicators wdMc)

wdMc1 – electrical energy cost (EUR/kWh)
total energy costs / total energy consumption for wastewater disposal division
wdMc1 = wdM1 / wdC1
wdM1 – total energy costs (EUR)
wdC1 – total energy consumption for wastewater disposal division (kWh)
This indicator provides a measure on the average cost of energy per unit of procurement. It is largely

dependent on both, national energy policy and the context within the undertaking operates (e.g. distribution of nominal power of energy consuming components along the system). Thus, special care is required in result interpretation when used for external comparisons.

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