POWERSTEP final conference 17-05-2018

What is the current energy situation in a WWTP?

H2020 project ENERWATER

Stefano Longo (stefano.longo@usc.es)

Universidade de Santiago de Compostela

Water-energy nexus

- Water cycle ≅4% electricity consumption worldwide
- 30% for wastewater treatment
- Double this figure by 2040

ENERWATER born to face the challenge of treating wastewater using the minimum amount of energy, becoming a collaborative platform (Coordinated Support Action) for energy efficiency in the field of water treatment.

ENERWATER consortium

44 months (March 2015 – October 2018)

1.7 MM €

Universidade de Santiago de Compostela (ES)

Università degli Studi di Verona (IT)

Università Politecnica delle Marche, Ancona

University of Cranfield (UK)

Technical University of Cologne (DE)

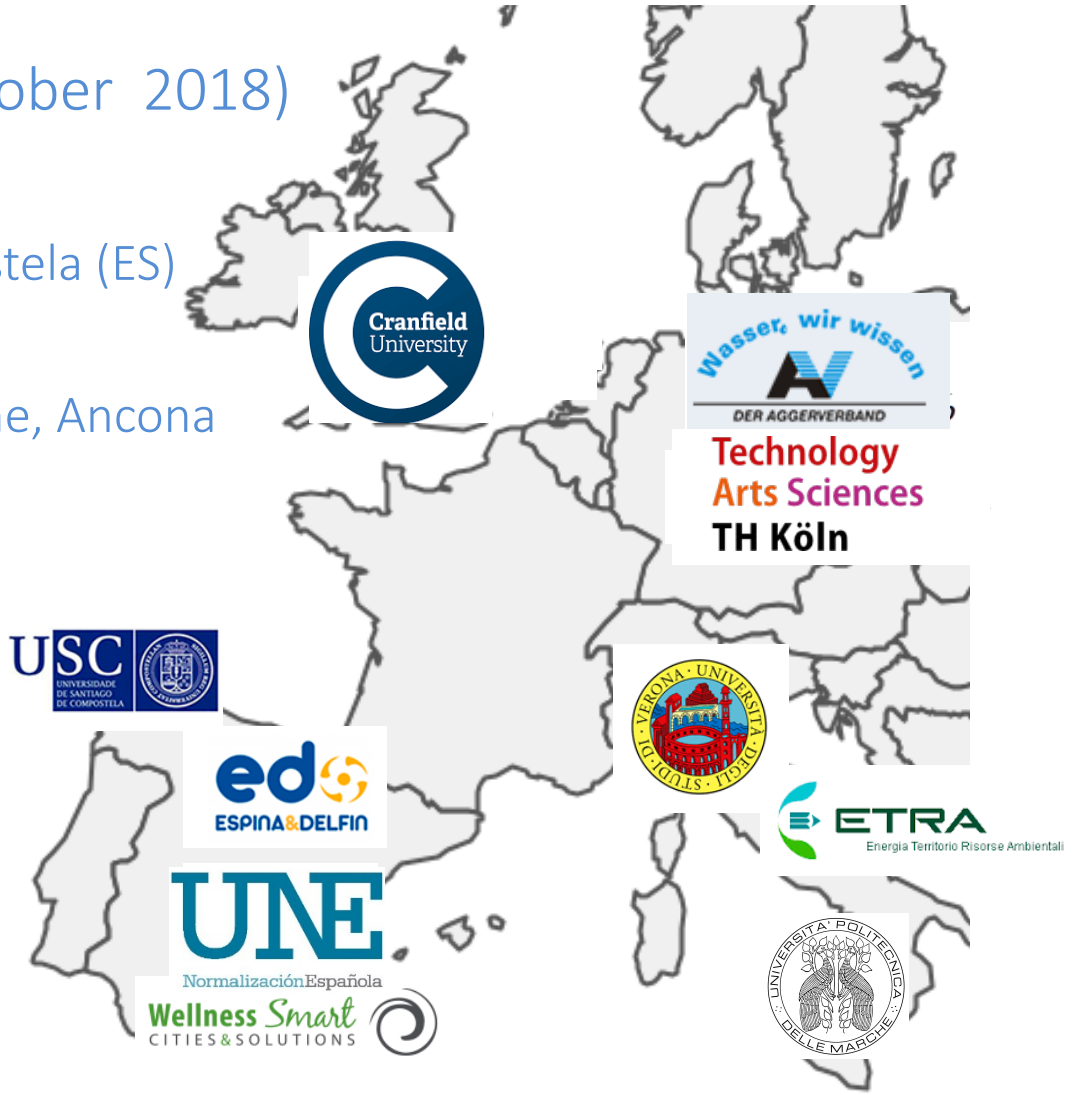
Espina y Delfín (ES)

ETRA (IT)

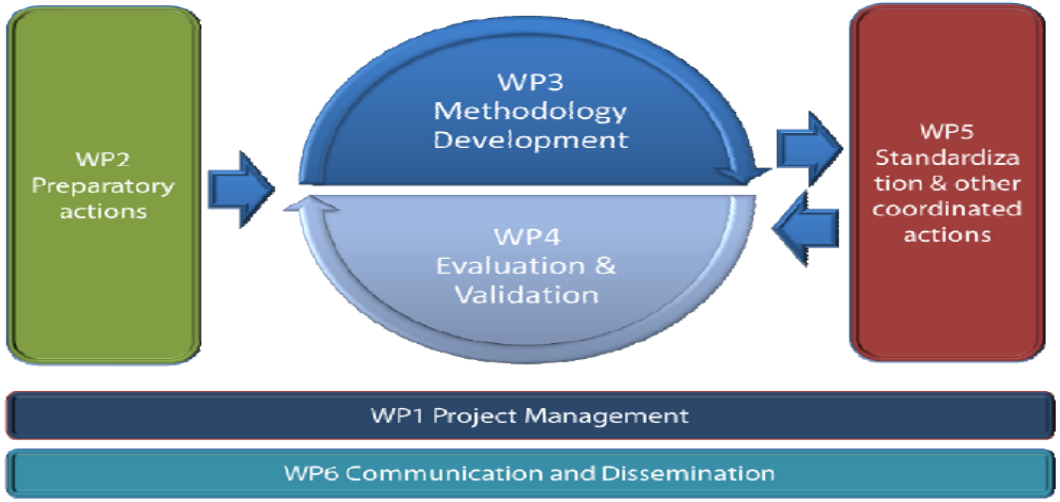
Aggerverband (DE)

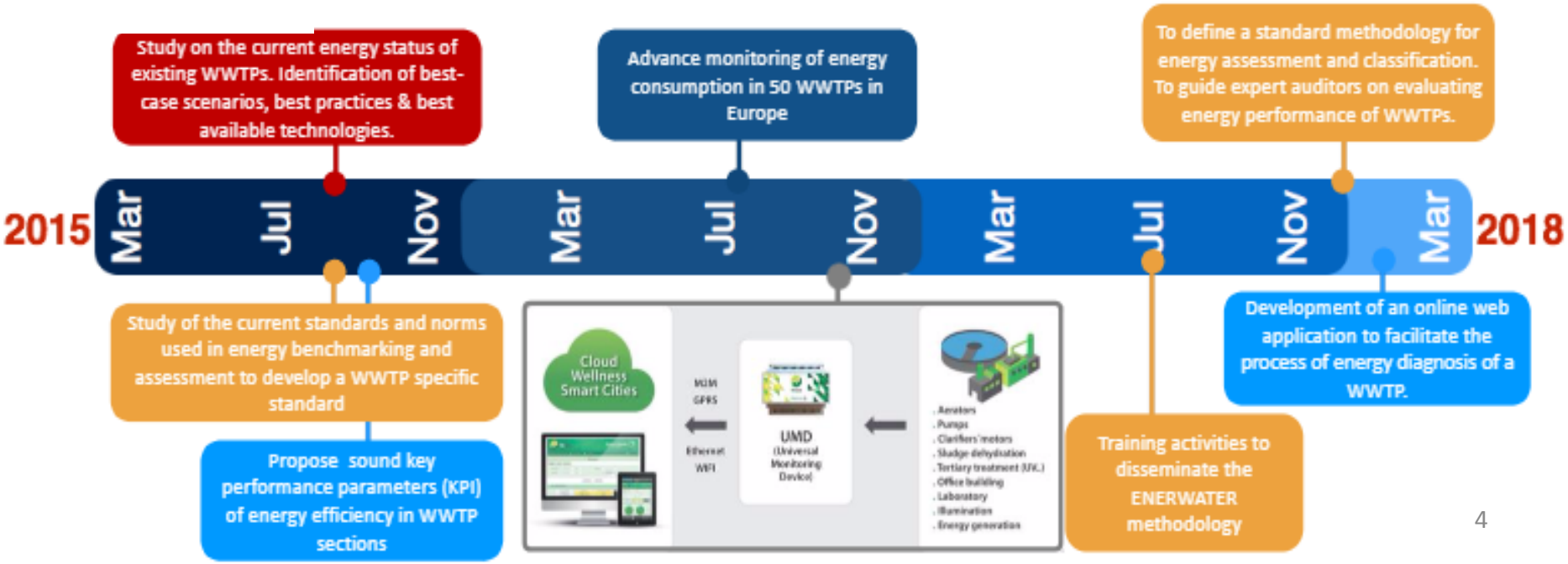
AENOR (ES)

Wellness Smart Cities (ES)



Structure and lifeline of ENERWATER





Learning from the literature

Applied Energy 179 (2016) 1251–1268

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Applied Energy

journal homepage: www.elsevier.com/locate/apenergy

Literature review: What sources of information? What data are reported? How? Why and for what? What kind of methodologies are used in the evaluation of energy efficiency at WWTPs?

601 WWTPs => Final sample= 388
Population eq. = 15.7 MMPE
Electricity consumption= 1.72 GWh/d
- 2.62 MMPE (16.6%) in North America
- 3.22 MMPE (20%) in Asia
- 9.86 MMPE (62.8%) in Europa

Monitoring and diagnosis of energy consumption in wastewater treatment plants. A state of the art and proposals for improvement

Stefano Longo [a], Benedetto Mirko d'Antoni [b], Michael Bongards [c], Antonio Chaparro [d], Andreas Cronrath [c], Francesco Fatone [b], Juan M. Lema [a], Miguel Mauricio-Iglesias [a], Ana Soares [e], Almudena Hospido [a,*]

[a] Department of Chemical Engineering, Institute of Technology, Universidade de Santiago de Compostela, 15782 Santiago de Compostela, Spain
[b] Department of Biotechnology, University of Verona, Strada Le Grazie 15, 37134 Verona, Italy
[c] Cologne University of Applied Sciences, Research group GECO-C, Steinmüllerallee 1, 51643 Gummersbach, Germany
[d] Wellness Smart Cities, Calle Charles Darwin, 41092 Sevilla, Spain
[e] Cranfield Water Science Institute, Cranfield University, Cranfield, Bedfordshire MK43 0AL, UK

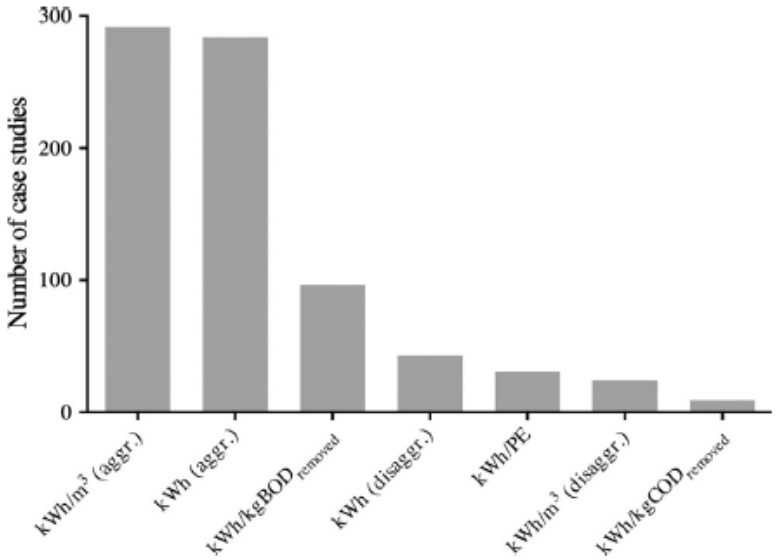


Fig. 2. Statistics frequencies of how energy data are reported in the literature. Aggr. = aggregated data; disaggr. = disaggregated data.

WWTPs energy benchmarking methods applied so far in the wastewater sector (Data Envelopment Analysis or USEPA Energy Star method) can be used for comparison but they fail at prescribing any improvement strategy

How to define energy efficiency at WWTP?

Energy efficiency = relationship between the production of a service, good or energy and the consumption of energy

$$\frac{\text{Input}}{\text{Output}}$$

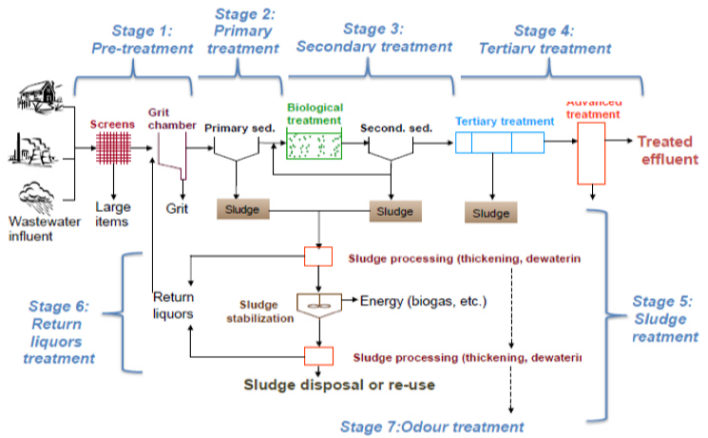
Input → Energy
(electricity, diesel, gas, chemicals)

Output → Energy service
(pumping, TS removal, nutrient removal, pathogen removal, sludge handling etc.)

ENERWATER methodology: Overview

Check the energy consumption and determine the KPIs

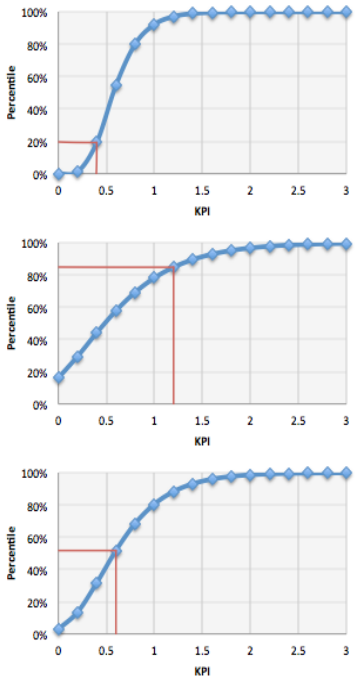
$KPI_1 = \frac{kWh}{m^3 \text{ of water treated}}$ $KPI_2 = \frac{kWh}{kg \text{ solids removed}}$ $KPI_3 = \frac{kWh}{kg \text{ pollutant removed}}$ $KPI_4 = \frac{kWh}{(m^3 \cdot \log \text{ reduction of pathogens})}$



$KPI_6 = \frac{kWh}{kg \text{ nitrogen removed}}$ $KPI_7 = \frac{kWh}{kg \text{ volatile organic compound}}$ $KPI_5 = \frac{kWh}{kg \text{ sludge treated}}$

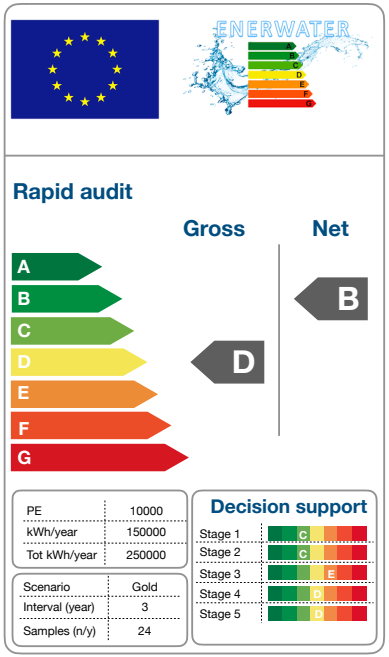
WWTP divided into functions -> a KPI is associated to each function performance

Compare vs other WWTPs



Assign a percentile to each KPI with a 600 WWTPs database

Get the energy label



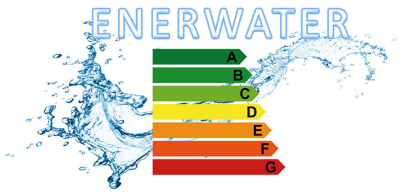
Diagnosis of inefficient processes. Communication through the energy label

ENERWATER methodology: Define

There is a clear need to establish suitable KPIs within the WWTP that allow a comparable, realistic and universal form of reporting the energy data.

STAGE	FUNCTION	KPI
STAGE 1	Pumping	kWh/m^3
STAGE 2	Solid removal	$kWh/kg\ TSS_{removed}$
STAGE 3	Pollutants removal	$kWh/kg\ TPE_{removed}$ *
STAGE 4	Pathogens removal	$kWh/Log_{reduction} * m^3$
STAGE 5	Sludge handling	$kWh/kg\ TS_{processed}$

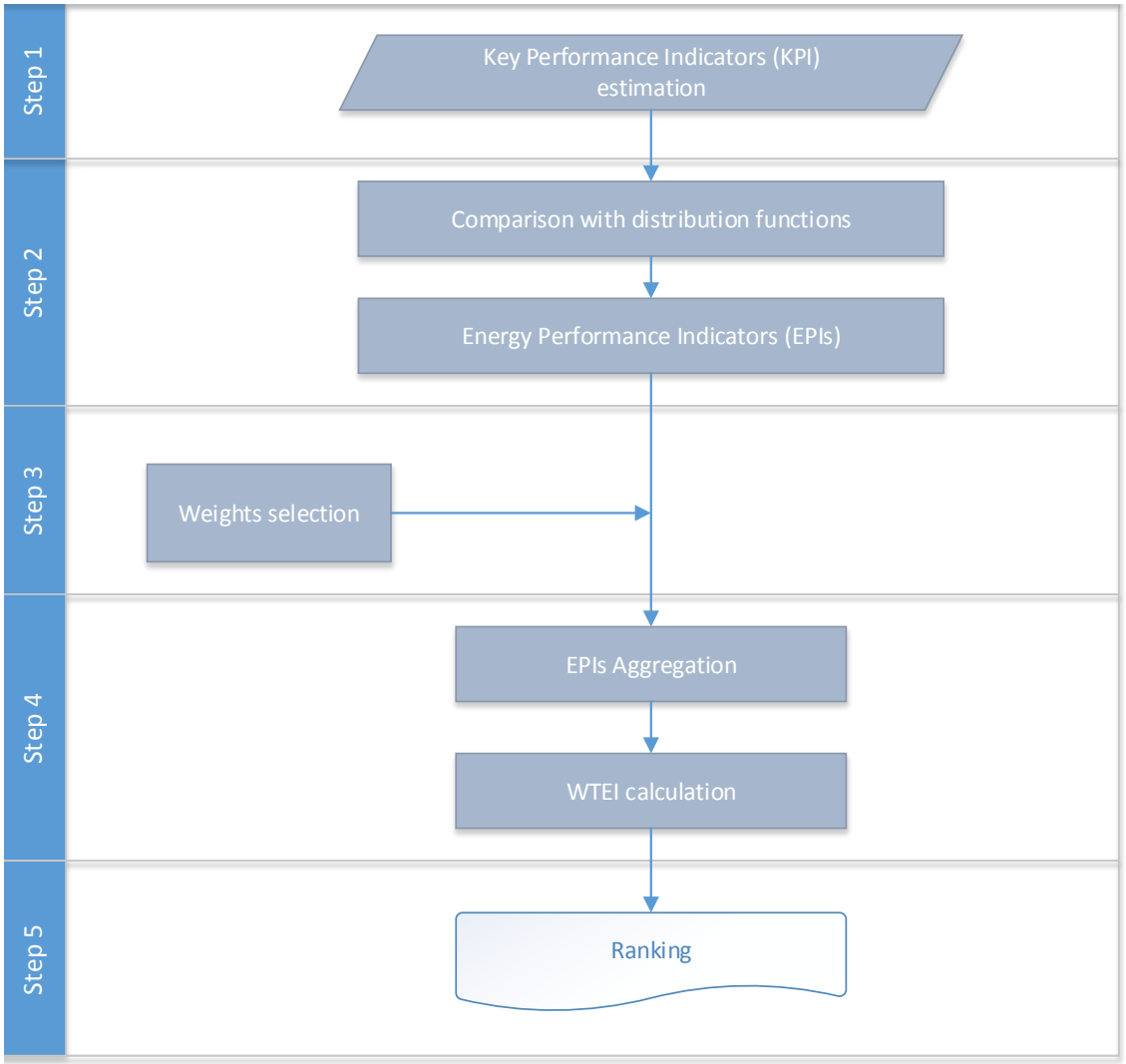
* kgTPE (total pollution equivalent) = kgCOD+20 kgTN+100 kgTP Benedetti et al. 2008



ENERWATER methodology:
Rapid audit vs decision support

	Rapid Audit Methodology	Decision Support Methodology
Energy consumption data	• Aggregated energy consumption from energy bills	• Disaggregated online data from energy meters on site
Plant operation data	• Routine influent/effluent analyses	• Intra-sectional influent/effluent data
Objective	• Energy benchmark • Rapid tool to energy efficiency assessment	• Diagnosis • Understanding • Verification • Training tool

Water Treatment Energy Index (WTEI) calculation



Data collection and KPIs calculation

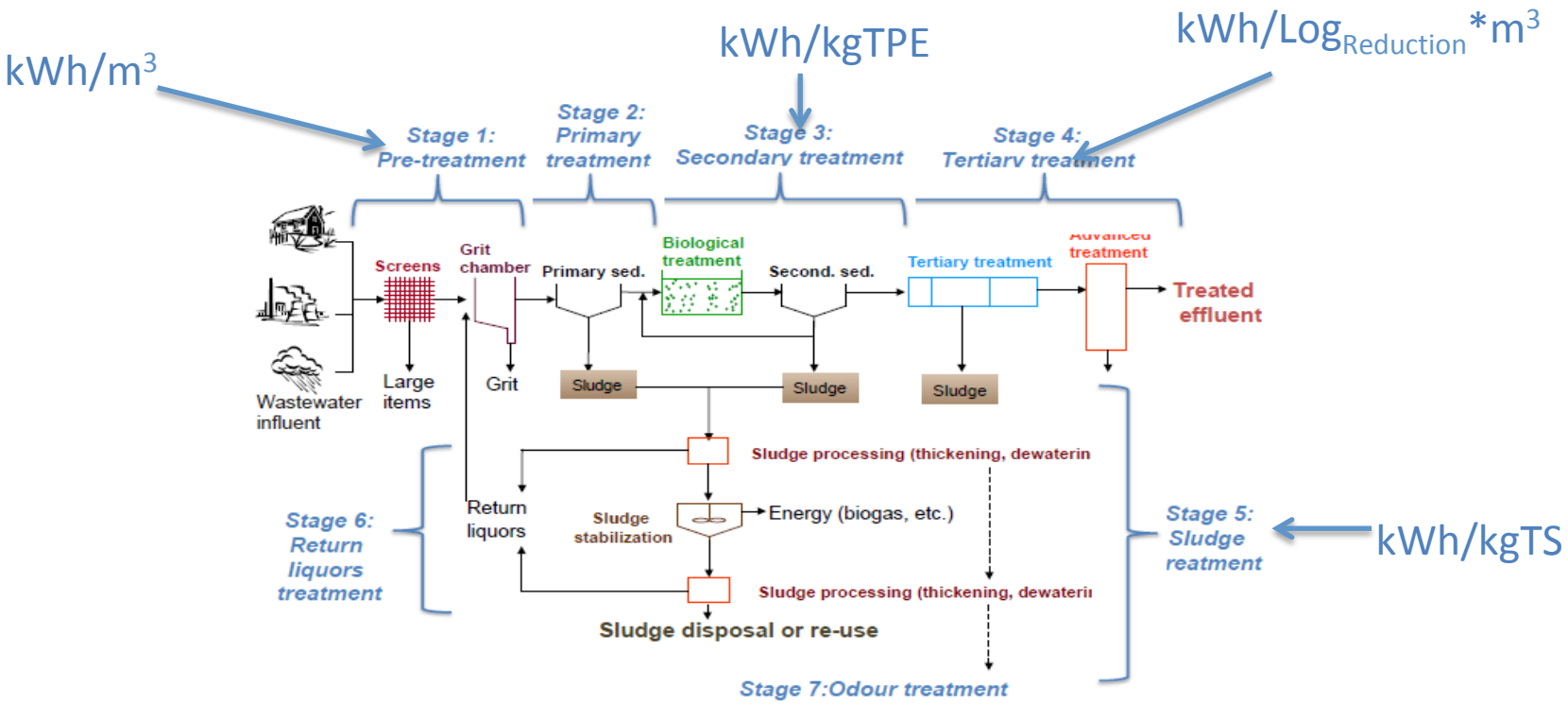
Compare the value of the KPIs with distribution functions and obtain percentile of each KPIs (EPIs)

Choose the weights for the selected KPIs from database of WWTPs energy consumption data

Aggregate the EPIs into a single WTEI through a weighted sum

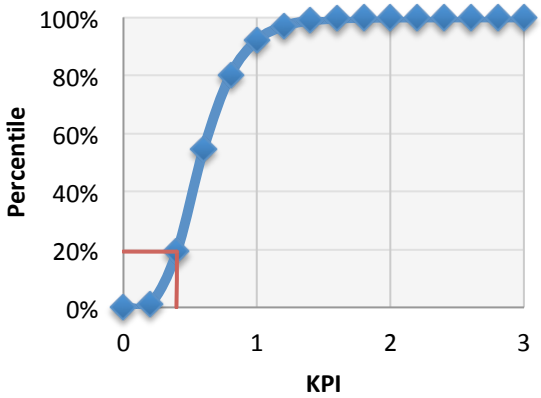
Assign label corresponding to the value of the WTEI

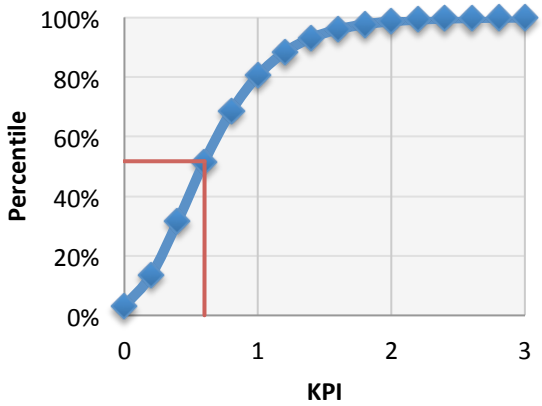
Step 1: KPI determination

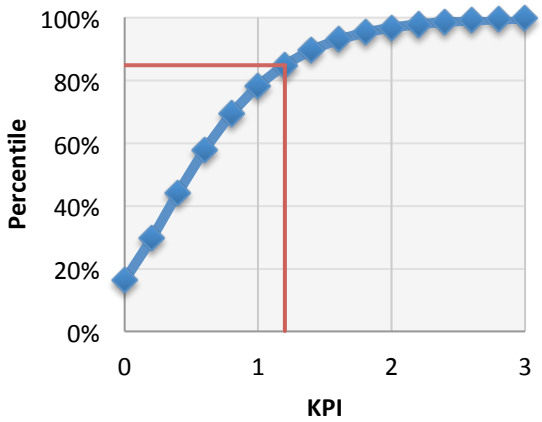


Step 2: KPI normalization

Compare the value of the KPIs with the database distribution function and obtain the percentile for each KPI. The percentile is a normalized manner to express the performance of the plant for a given KPI. Therefore, they are denominated energy performance indicators (EPI)

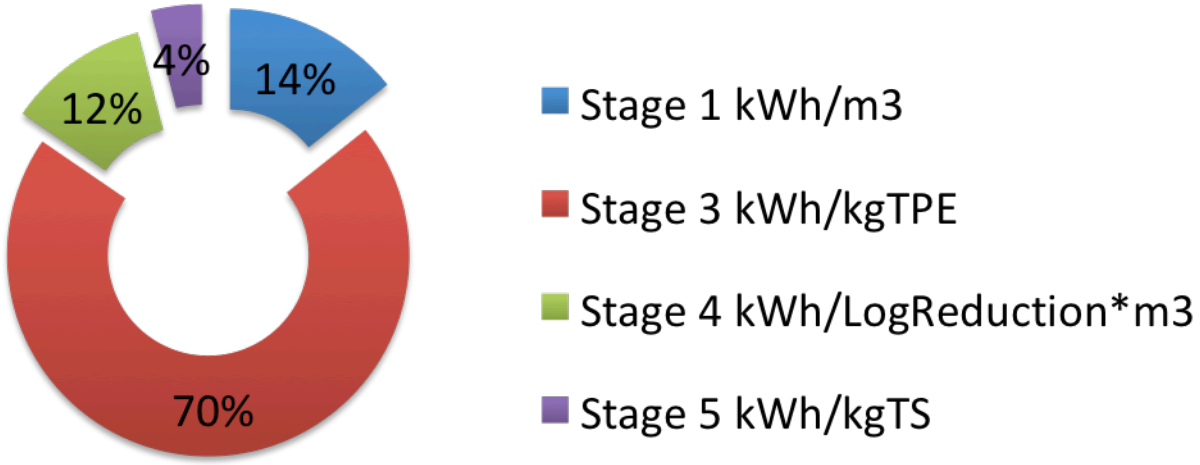






Step 3: Weight selection

These weights have been estimated based on the average contribution of each function of the WWTP to the overall energy consumption, i.e. pumping accounts for approximately 14.25% of the overall energy consumption and the secondary treatment (removal of COD and nutrients) accounts for the 70%.



If the four KPIs are not applicable, normalise the weights to sum unity such as:

$$w_{norm,i} = \frac{w_i}{\sum_1^k w_i}$$ where k is the number of applicable KPIs

Step 4: Aggregation

Aggregate the EPI into a single WTEI through a weighted sum (Equation 7). This method of aggregation is compensatory, i.e. one EPI can compensate to a certain extent the performance in other functions

$$WTEI_c = \sum_{i=1}^{k} w_{norm,i} \times EPI_{i,c}$$

Normalized KPI value

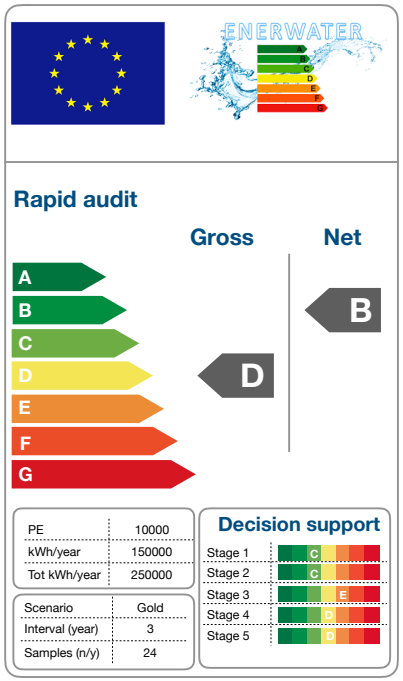
Composite indicator value for plant c

Weight value for KPI k

Step 5: Rank and label assignation

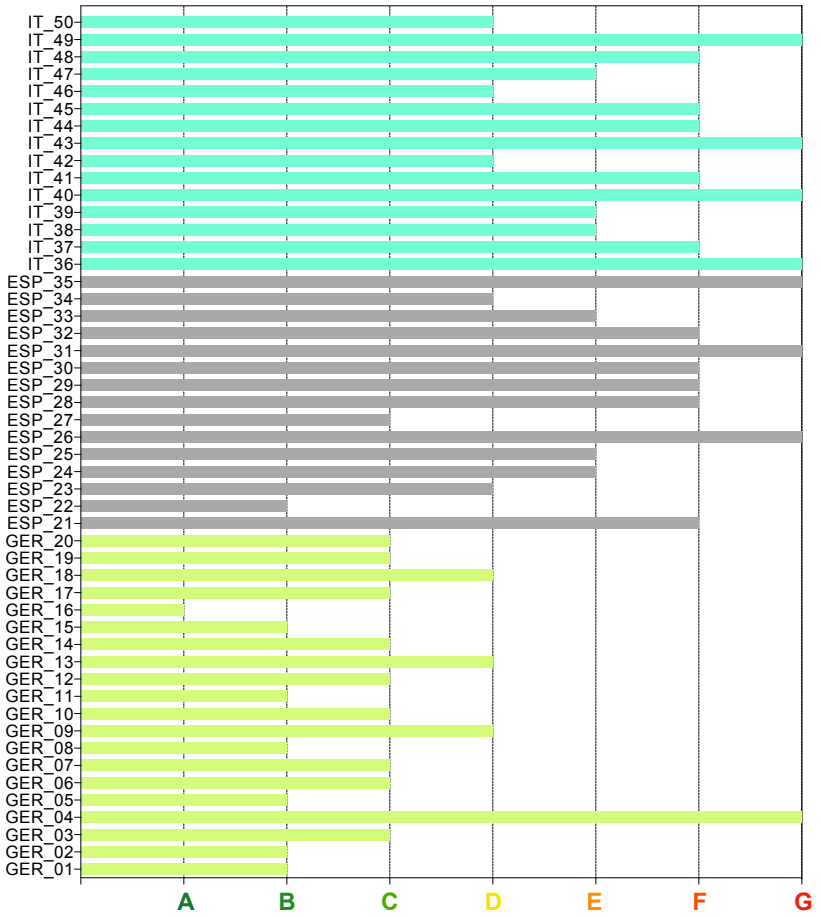
The boundaries between labels have been decided according to the following criterion, common in EU efficiency labelling standards: the median performance index is the upper boundary of class D. This labelling strategy allows good discrimination power at high efficiency, serving as an incentive for innovation.

Label	WTEI
A	<0.11
B	0.11≤WTEI<0.22
C	0.22≤WTEI<0.33
D	0.33≤WTEI<0.44
E	0.44≤WTEI<0.55
F	0.55≤WTEI<0.75
G	<0.75

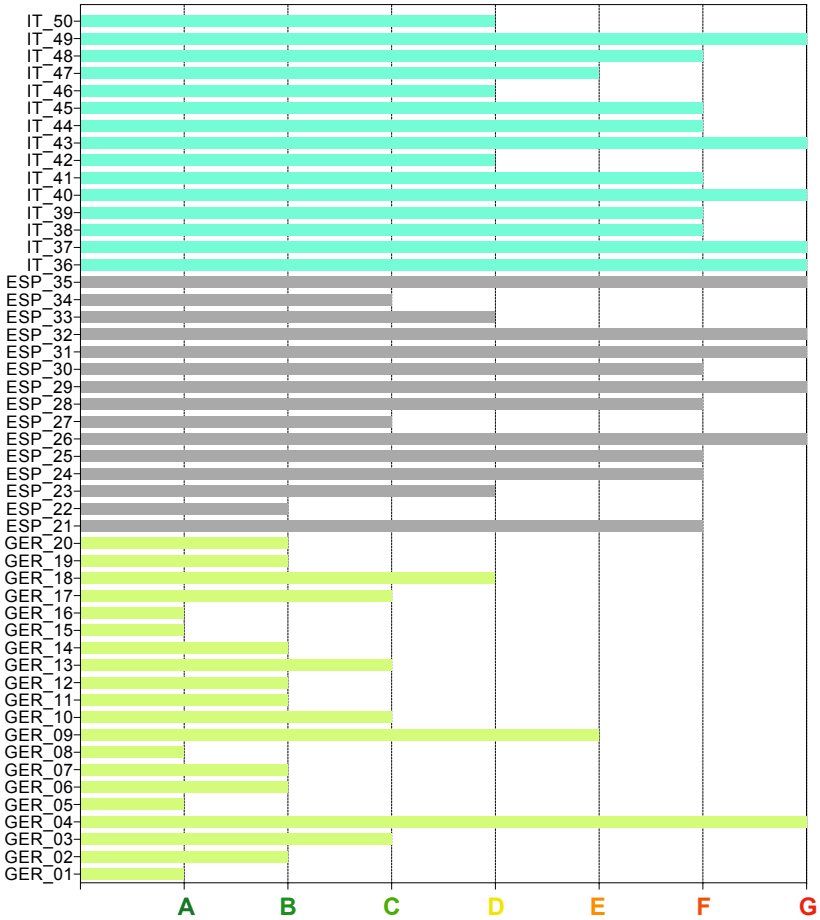


Preliminary results

Rapid audit



Decision support



Conclusions

The application of the ENERWATER Rapid Audit methodology to benchmark and audit municipal WWTPs advanced the current state of the art and allowed:

- the comparison among heterogeneous WWTPs based on the basic functions of a plant
- the disaggregation of the key performance indicators based on these functions
- the definition of single WTEIs and energy labels (classes A to G) that can support the decisions of the water utilities to best target of energy saving actions to less performing WWTPs

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Thank you! Questions?

Stefano Longo (stefano.longo@usc.es)

Universidade de Santiago de Compostela

www.enerwater.eu

ENERWATER Project

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