The WiNE project

and the index of circularity

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BACKGROUND INFORMATION FROM IWA 2017-2019

- Water use efficiency – Only looking at quantitative aspects
- Simplistic approaches to promote water reuse without linking to impacts over water bodies
- Compliance of IED without link to WFD goals

Reduce of freshwater consumption

- Use of less water per unit of produced material
- Energy savings
- Reduction of CO_2 emissions (reduction of pumping)

Water resources

- Reduce the water bodies over-exploitation
- Promote water resources replenishment

Consequences

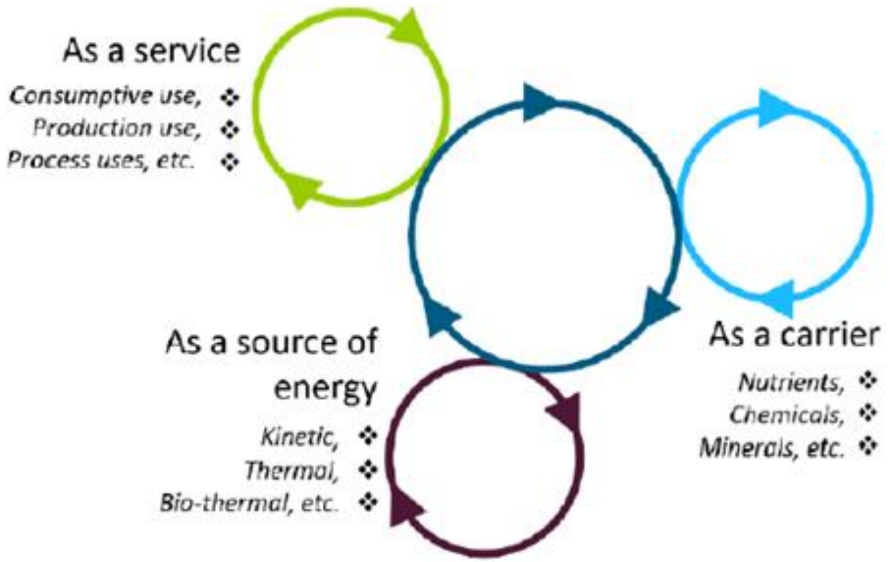
- Concentration of pollutants in wastewaters
- May promote short and long negative impacts on water bodies (acute and chronic effects on ecosystems)

Water resources

- Reduction of natural values (ecosystem lost)
- Increase of CO_2 emissions (oxidation of organic matter/algae blooms)
- Can compromise the water status

- Use an integrated approach to water use under industrial and urban cycle, at local and catchment scale
- Needs to understand the principles of circular economy in the water use cycle

WATER CIRCULARITY



Classic approach:

- **Water use efficiency, namely the quantitative aspects through the reduction of consumptions and losses**
- **Rain waters recovery**
- **Water reuse.**
- **Use of sludge from wastewater treatment plants and manure as a source of organic matter and nutrients and for energy production**

To achieve a real transition, the above factors cannot be seen as individual indicators but instead they should be linked with the several possible processes

Important trade-offs and synergies between societal decisions on health and environment and technological developments may be overlooked due to their usual separate treatment (Hauschild *et al.*, 2022)

Hauschild, M. Z., McKone, T. E., Arnbjerg-Nielsen, K., Hald, T., Nielsen, B. F., Mabit, S. E., & Fantke, P. (2022). Risk and sustainability: trade-offs and synergies for robust decision making. Environmental Sciences Europe, 34(1), 11. doi:10.1186/s12302-021-00587-8

HOW TO DEVELOP THE INDEX?

SMART criteria: Easily accessible and measurable factors (key factors) that take into account the relationships between the water use patterns, the processes and the environmental systems were considered as inputs

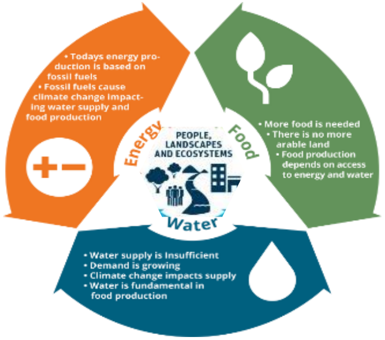
S	**SPECIFIC**	The index accurately describes what is intended to be measured and does not include multiple measurements
M	**MEASURABLE**	Regardless of who uses the index, consistent results can be obtained and tracked under the same conditions
A	**ACHIEVABLE**	Collecting data for the index is simple, straightforward, and cost-effective
R	**RELEVANT**	The index is closely connected with each respective input, output or outcome
T	**TIME-BOUND**	The index includes a specific time frame, i.e., the validity of the environmental/ discharge permit

WASTEWATER IN NATURAL ENVIRONMENT – WINE 2019/20

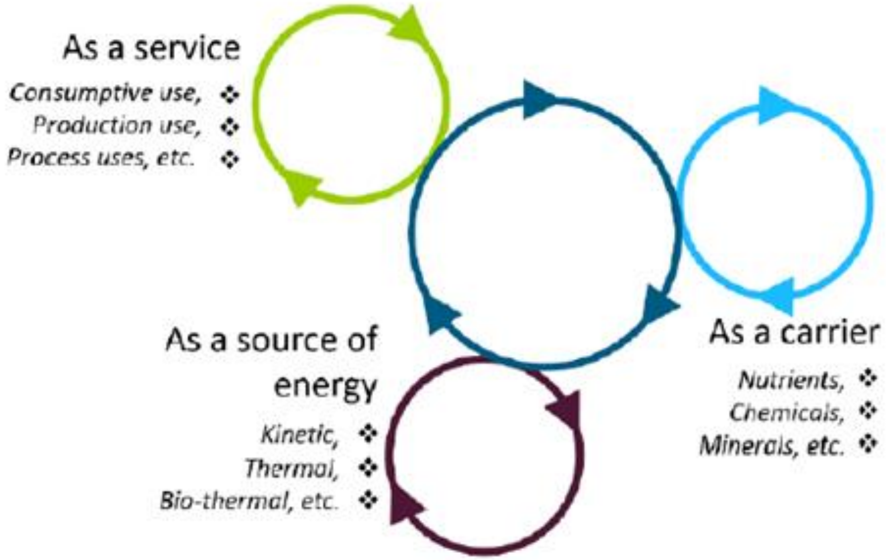
Circularity Index (IC) developed to endorse the transition to the circular economy: Tool to measure the circularity of a certain process or installation

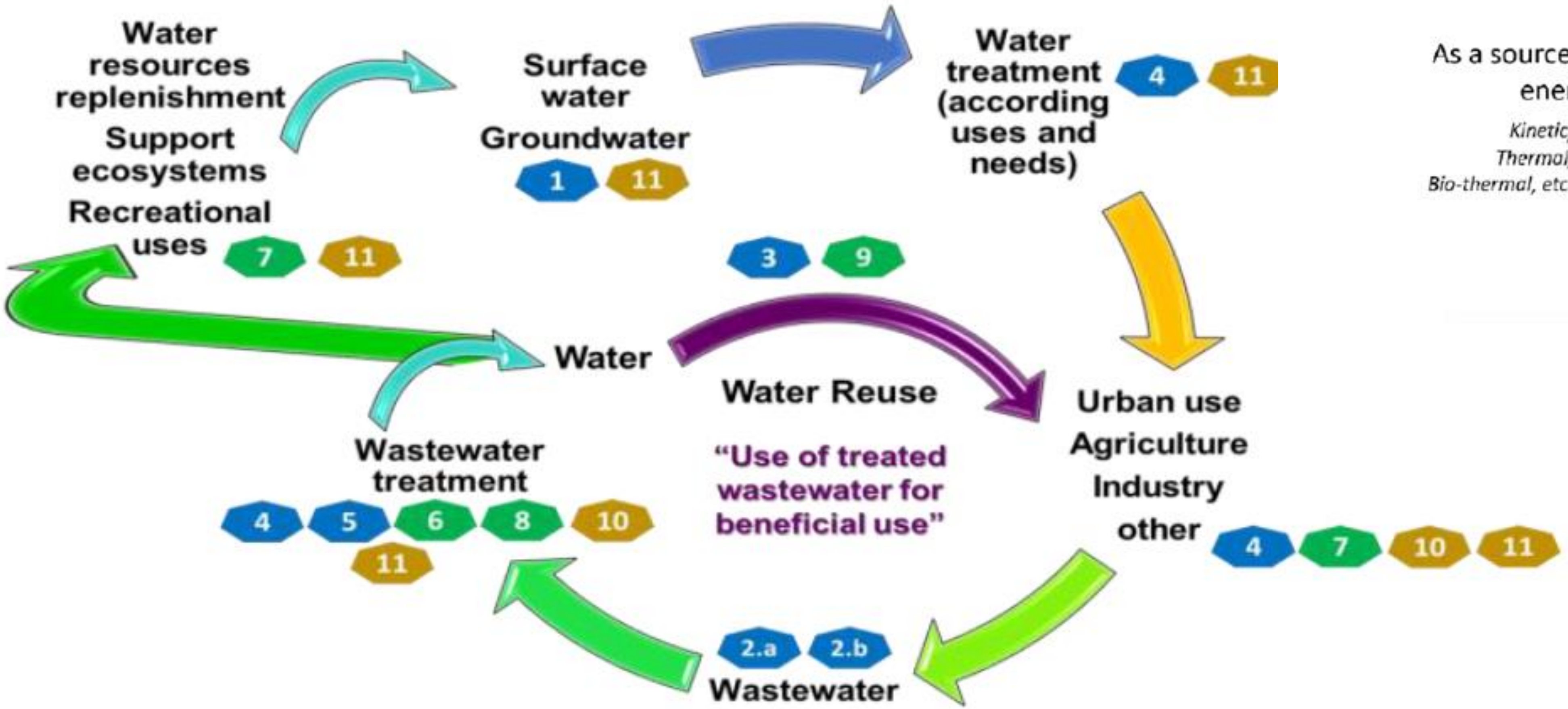
Key-Factors

1. Freshwater consumption
2. Wastewater discharges:
   a. Non-IED installations
   b. IED installations
3. Water reuse
4. Best management practice and technologies
5. Priority substances (PS), priority hazardous substances (PHS) and other pollutants (OP) and specific pollutants (SP)
6. Microplastics and/or compounds of emergent concern
7. Biodiversity
8. Recovery of nutrients
9. Internal industrial symbiosis
10. Sludge
11. Voluntary and incentive instruments



WATER CIRCULARITY





Key Factors: Distributed by 3 levels of Importance

WASTEWATER IN NATURAL ENVIRONMENT – WINE 2019/20

Excel tool 1.0

$$I_c = \frac{\sum (f_{i\ s\text{-}key} \times f_{i\ w})}{N_f}$$

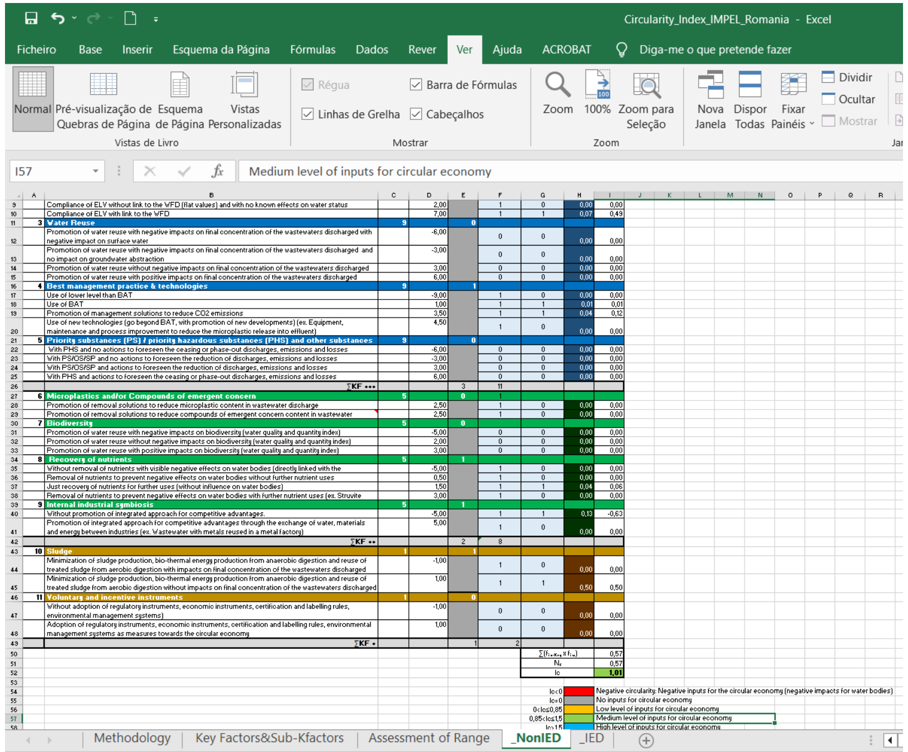
INDEX

$$f_{i\ w} = \frac{\left| f_{i\ s\text{-}key_{+++,++or+}} \right|}{F_{key_{+++,\ ++or+}} \times n_{s\text{-}key\ app_{+++,++or+}}}$$

WEIGHTING FACTOR

$$N_f = \frac{n_{F_{key+++}} \times 9 + n_{F_{key++}} \times 5 + n_{F_{key+}} \times 1}{5 \times 9 + 4 \times 5 + 2 \times 1} = \frac{9 n_{F_{key+++}} + 5 n_{F_{key++}} + n_{F_{key+}}}{67}$$

NORMALIZATION FACTOR



Red	$Ic < 0$	Negative Circularity: Negative inputs for the circular economy (negative impacts for water bodies)
Grey	$Ic = 0$	No inputs for circular economy
Yellow	$0 < Ic \leq 0{,}85$	Low Circularity: Low level of inputs for circular economy
Green	$0{,}85 < Ic \leq 1{,}5$	Medium Circularity: Medium level of inputs for circular economy
Blue	$Ic > 1{,}5$	High Circularity: High level of inputs for circular economy

KEY-FACTORS

Key Factor	Key and sub-key factors	Key factor value (F_{key})	Sub-Key factor value ($f_{i\ s\text{-}key}$)
1	**Freshwater consumption**	**9**	
	Measures to reduce consumption without linking the impacts on the quality of wastewaters and contributing directly to its degradation		-9,00
	Measures to reduce consumption without linking impacts on the quality of wastewaters (with non-significant variation on wastewater quality, e.g., reduction on groundwater abstraction with low impacts on wastewaters)		1,00
	Measures to reduce consumption with measures to reduce possible effects of effluents concentration		4,00
	Reducing abstraction directly from water body (ex. Rainwater collection and reuse) promoting		4,00
2.b	**Wastewater discharges IED installations**	**9**	
	Compliance of BREF-EAV without link to the WFD		-9,00
	Situations where BREF-EAV can be equal to ELV, according check-list		2,00
	Compliance of ELV (ELV defined according WFD principles, where ELV needs to be lower than BREF-EAV, according check-list)		7,00
3	**Water Reuse**	**9**	
	Promotion of water reuse with negative impacts on final concentration of the wastewaters discharged with negative impact on surface water		-6,00
	Promotion of water reuse with negative impacts on final concentration of the wastewaters discharged and no impact on groundwater abstraction		-3,00
	Promotion of water reuse without negative impacts on final concentration of the wastewaters discharged		3,00
	Promotion of water reuse with positive impacts on final concentration of the wastewaters discharged		6,00
4	**Best management practice & Technologies**	**9**	

Positive & Negative Impacts

KEY-FACTORS

Key Factor	Key and sub-key factors	Key factor value (F_{key})	Sub-Key factor value ($f_{i\ s\text{-}key}$)
6	**Microplastics and/or Compounds of emergent concern**	5	
	Promotion of removal solutions to reduce microplastic content in wastewater discharge		2,50
	Promotion of removal solutions to reduce compounds of emergent concern content in wastewater discharge		2,50
7	**Biodiversity**	5	
	Promotion of water reuse with negative impacts on biodiversity (water quality and quantity index)		-5,00
	Promotion of water reuse without negative impacts on biodiversity (water quality and quantity index)		2,00
	Promotion of water reuse with positive impacts on biodiversity (water quality and quantity index)		3,00
8	**Recovery of nutrients**	5	
	Without removal of nutrients with visible negative effects on water bodies (directly linked with the installation)		-5,00
	Removal of nutrients to prevent negative effects on water bodies without further nutrient uses		0,50
	Just recovery of nutrients for further uses (without influence on water bodies)		1,50
	Removal of nutrients to prevent negative effects on water bodies with further nutrient uses (ex. Struvite recovery)		3,00
10	Sludge	1	
	Minimization of sludge production, bio-thermal energy production from anaerobic digestion and reuse of treated sludge from aerobic digestion with impacts on final concentration of the wastewaters discharged		-1,00
	Minimization of sludge production, bio-thermal energy production from anaerobic digestion and reuse of treated sludge from aerobic digestion without impacts on final concentration of the wastewaters discharged		1,00
11	Voluntary and incentive instruments	1	

Positive & Negative Impacts

RESULTS FROM REAL CASES

Case study	IED Installation	NON IED Installation	Description of WWTP	Ic
A 1	X		Pulp mill before permit review	-1,24
A 2	X		Pulp mill after permit review	1,19
A 3		X	Urban WWTP	1,91
B 1	X		Pulp and paper industry	0,35
B 2	X		Biorefinery	2,13
B 3	X		Oil refinery	-1,01
C 1		X	Urban WWTP with industrial connections	3,48
C 2	X		Company cleaning and shredders plastic barrels	1,46
D 1	X		Pulp and paper industry and urban wastewater	1,39
D 2	X		Fertilizer production plant	1,00
D 3	X		Large smelter	2,94
E 1	X		Pulp and paper industry	0,52
E 2	X		Brewery	1,09

WATER CIRCULARITY INDEX AND UWWTP

- **The Index allows to measure some important interlinks such as:**
  - **Compliance of ELV defined according WFD principles or just simple flat values defined on current legislation**
  - **Removal of nutrients to prevent negative effects on water bodies and/or further nutrient uses (with/without influence on water bodies)**
  - **Promotion of water reuse and its relationship with impacts on concentration of discharge TWW and biodiversity**
  - **Removal of PS/PHS, microplastics and compounds of emergent concern (CoC)**

Considering the effects of non removal of microplastics and CoC

Case study	IED Installation	NON IED Installation	Description of WWTP	Ic^1	Ic^2
A 3		X	Urban WWTP	1,91	1,69
C 1		X	Urban WWTP with industrial connections	3,48	2,68
D 1	X		Pulp and paper industry and urban wastewater	1,39	1,08

Without considering effects of non removal of microplastics and CoC

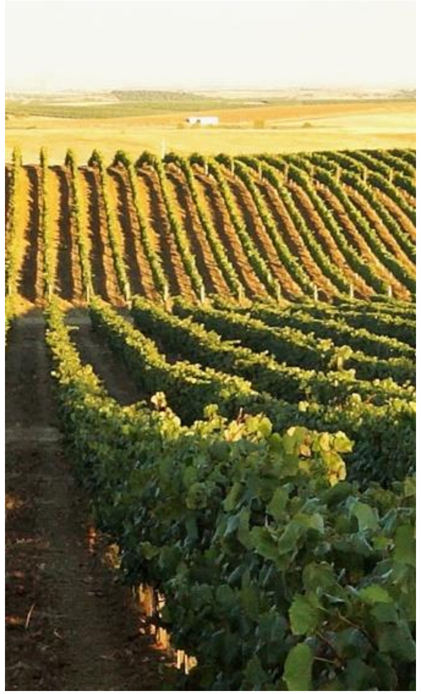
HIGH CIRCULARITY VS NEGATIVE CIRCULARITY

- ELV compliance according WFD criteria
- Use of new technologies
- Consideration of PHS and measures to cease, phase-out emmissions, discharges and losses
- Promotion of Water reuse with positive impacts on biodiversity
- Promotion of an integrated approach for competitive advantages
- Reduction of sludge production with no impact on final effluent concentration
- Adoption of voluntary and incentive instruments

- Measures to reduce water consumption with a negative impact on wastewater quality and which directly contribute to the degradation of the receiving environment
- Compliance of EAV-BAT (IED instalations) with no link to WFD
- Promotion of water reuse with negative impacts on final concentration with negative impacts on surface water
- Without removal of nutrients and with consequent visible negative effects on the water bodies
- Without adoption of voluntary and incentive instruments

WINE: CURRENT FOCUS

Critical activities/facilities with high pressure over water bodies



Regional/local activities with significant impact in terms of water use (e.g., high water consumption, high discharge loads, seasonal activities, etc.)

Food production activities that uses or intended to use treated wastewaters and/or biosolids or sludge

MAIN GOAL & TEAM

This project intends to improve the Water Circularity Index and its application to identify and link best practices in terms of:

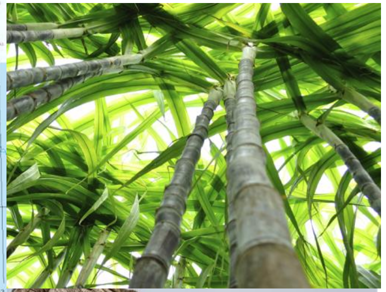
- **Water use within process or activity and reuse (use of treated wastewaters as an alternative water source)**
- **Water quality management**
- **Sludge management**
- **Water resources uses**
- **Energy balance**

2022-2024:

- **3 site visits**
- **Final Conference**

REGIONAL OR LOCAL ACTIVITIES

- **Local and or seasonal activities with significant impact in terms of water use but important for local communities' economy**



Sugarcane Production: Wastes and By-Products

The sugarcane (*Saccharum officinarum*) is one of the most important crops in the History of Madeira Island.

The production of sugarcane in Madeira Island dates back to the 15th century, having contributed inexorably to the economic, social and cultural development of the Region through trade and sugar exports. Currently, sugarcane is mainly used in the production of cane honey and sugarcane rum (agricultural rum).

- **Problems: Bagasse & Vinasse**
  - **Bagasse may be used as substrate for mushroom production, for pellets or for cosmetic industry**
  - **Vinasse requires specific treatment (high pH and organic load) prior discharge into water bodies or to be used as a fertilizer for banana crop production**

Circularity water index: Allows to find the solutions that promotes a higher transition to a circular model and to identify better synergies. Also helps industry understanding the importance of environmental compliance for the “sustainability” of their products

WATER REUSE: CROPS IRRIGATION

Options to use freshwater/reclaimed water depends on the location of farmers and type of crops and the quality of water from the diverse sources…

Are used appropriate efficient water use measures (type of crops, location and growing cycle)?

Are being used condensate/rain water from greenhouses roofs?

Is the water used by farmers affecting other uses?

…

FINAL REMARKS

The index allows the impact of integrated approaches to water use to be assessed. It confirms the promotion of water circularity depending on the management options chosen

Application to IED and non-IED installations and water reuse solutions enables the cumulative impact of efficient water use to be assessed both in terms of quantity and quality

The index can/should be refined to include energy aspects and further integrate impacts on CO_2 emissions

The definition of factors applicable at the final product level could support the adoption of best practices in water use with relevance to regional and/or seasonal products

An indicator that promotes integrated compliance with environmental legislation

Reports available on: https://www.impel.eu/en/projects/wastewater-in-natural-environment-wi-ne

CAN THIS INDEX BECAME A LABEL?

IMPEL

European Union Network for the
Implementation and Enforcement
of Environmental Law

Thank you
for
your attention!