Economic Regulators' Role in Supporting the Ecological Transition of Water and Sanitation Service Operators

Study by

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The Florence School of Regulation would like to thank WAREG for their support to set up interviews with water regulators. Views expressed in this publication reflect the opinion of the individual authors and do not necessarily reflect the views of WAREG or the European University Institute.

Published by

European University Institute (EUI)

Via dei Roccettini 9, I-50014

San Domenico di Fiesole (FI)

Italy

Contents

Introduction

Economic regulators of water and sanitation services (WSS) across Europe were originally established to address harmful consequences arising from the natural monopoly of the sector. This is reflected in their mandates, practices, and regulatory philosophies. While they apply different tariff methodologies, they share commonalities with respect to the overall objective of preventing monopolistic price abuse by WSS operators and protecting consumers' interests, while at the same time ensuring that operators are sustainably funded and incentivised to maintain and improve service quality standards.

At the European level, these regulators operate in a context where the European Water Framework Directive (WFD) introduced in 2000, requires Member States' regulation of WSS to reflect not only the economic cost of providing WSS services, but environmental and resource costs as well. However, the shift to a 'full cost' model has proved difficult, with no Member State achieving full compliance with this goal even two decades later. This situation underlines the key role that WSS regulators have in promoting and improving the adoption full cost reflective tariffs.

Furthermore, in a broader context where climate change exacerbates water risks and increases the need for resilient WSS services, water regulators can also play a crucial role in incentivising and ing WSS operators in making their ecological transition.

This paper identifies the current practices employed by regulators in supporting the ecological transition of WSS operators, including reflecting the full cost of WSS services, promoting the adoption of circular economy (CE) practices, and addressing emerging challenges such as micropollutants. It also provides options for new and better ways to support the ecological transition of WSS operators. Finally, it concludes with recommendations to support water regulators in shifting from a narrow 'regulation of natural monopolies' focus towards a broader role as regulators of externalities.

Section 1: Reflecting Environmental and Resource Costs in Economic Regulation

1. Legal basis for reflecting environmental and resource costs and associated obstacles

The economic regulation of WSS operators is firmly rooted in addressing the negative externalities of the natural monopoly. This is reflected in the legal mandates, regulatory powers, and intervention methodologies of economic regulators of the WSS sector. Specifically, economic regulators seek to mitigate the risks of monopolistic pricing and efficiency-gain disincentives arising from the lack of competition in the natural monopoly. At the same time, they must ensure that operators remain financially sustainable and possess the necessary resources to deliver high-quality services. Parallel to this, they also pursue social-political objectives including protection of consumer interests, promoting access to water (e.g., cross-subsidisation for rural service delivery), and water affordability measures. In this sense, economic regulators are rather adept at ensuring that the economic costs of supplying water/providing sanitation, including operational and capital costs, are well reflected in the tariffs charged to end-users.

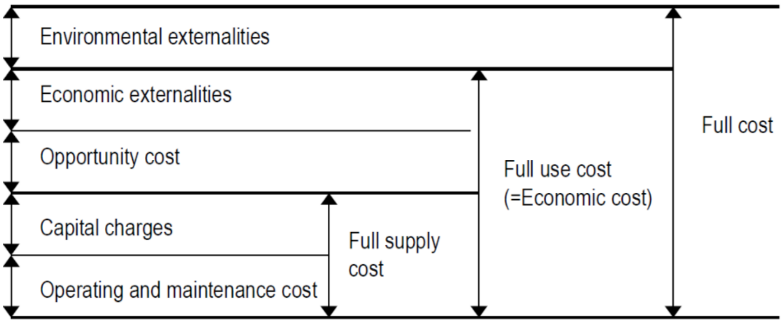
The Water Framework Directive 2000/60/EC, on the other hand, requires that the full costs of WSS are captured, including environmental and resource costs, particularly through applying the polluter pays principle (Box 1). Environmental costs are defined as the costs or damage that water use imposes on the environment and ecosystems and those who use the environment, including non-use values. Resources costs are defined as the costs of foregone opportunities that other uses suffer (today or in the future) due to the depletion of the resource beyond its natural rate of recharge or recovery (CIS Guidance, 2003).

Box 1 Water Framework Directive (EC) 2000/60 of 23 October 2000, Article 9(1)

1. Member States shall take account of the principle of recovery of the costs of water services, including environmental and resource costs, having regard to the economic analysis conducted according to Annex III, and in accordance in particular with the polluter pays principle.
Member States shall ensure by 2010
- that water-pricing policies provide adequate incentives for users to use water resources efficiently, and thereby contribute to the environmental objectives of this Directive,
- an adequate contribution of the different water uses, disaggregated into at least industry, households and agriculture, to the recovery of the costs of water services, based on the economic analysis conducted according to Annex III and taking account of the polluter pays principle.
Member States may in so doing have regard to the social, environmental and economic effects of the recovery as well as the geographic and climatic conditions of the region or regions affected.

Contrary to the robust reflection of economic supply costs in economic regulators' practices, environmental and resource costs are not yet well nor fully captured (Figure 1). Transposing and implementing the EU requirement (i.e., bridging the gap between economic supply costs and the full cost recovery) has proved to be challenging for several reasons.

Figure 1 Full cost definition



First, economic regulators across Europe are limited by the legal mandates granted by their national legislation. While they typically possess comprehensive mandates for reflecting economic supply costs, they commonly lack the legal responsibility and regulatory powers necessary for capturing environmental and resource costs. Where these responsibilities do exist, they often are held by other national or sub-national agencies or authorities. For example, water abstraction charging/licensing often falls under the purview of local governments (Italy) or environmental agencies (Portugal, Ireland, England and Wales, France, Scotland). Therefore, even when economic regulators attempt to reflect environmental and resource costs, they are hamstrung in doing so by their legal competencies and mandates.

The second challenge lies with the difficulty in identifying and measuring environmental and resource costs themselves. Some of these costs are easier to measure than others - for example, where the environment supports economic activity (i.e., fishing, tourism), the value of this activity represents part of the value of environmental costs should it be impeded by WSS provision (CIS Guidance, 2003). However, the non-use value of the environment - or in other words, the intrinsic value of the environment irrespective of actual or potential use value to humans - is notoriously difficult to identify and measure. This is because translating non-economic values into economic costs is an imprecise science based on abstraction and subjective and proxy approaches. It is difficult for economic regulators, whose methodologies and practices are rooted in empirical econometric analysis of known variables, to apply their philosophies and economic tools to the capture of non-economic values.

The third challenge is one of policy. Given that economic and resource costs are currently not being adequately reflected in the prices paid for WSS, it stands to reason that the end-user price of water and sanitation services will invariably need to increase if governments are serious about reflecting the full costs of WSS. As with any policy that will increase households' cost of living and industries' input costs, better reflecting the full costs of WSS will require elected officials to manage the political consequences of implementing necessary but unpopular measures. Further an increase in prices will likely have disproportionate impacts on disadvantaged segments of society and as such will need to be paired with robust social policies to mitigate these impacts. Economic regulators are unlikely to effectively support the ecological transition of the sector by reflecting the full cost of WSS without support from policymakers with a view to set up coherent cross-sectoral policies, and without coordinating with other regulatory bodies.

2. Current Regulatory Practices for Reflecting Environmental Externalities

❖ Inclusion of Environmental Externalities as Price Component in Tariff Methodology

European economic regulators' primary method for reflecting environmental externalities in their regulatory practices is through embedding them as cost components in their tariff setting methodologies – both directly and indirectly. Directly, where environmental taxes and fees form a specific component of the utilities' permissible operational costs (OPEX) which is the case across all WAREG members excluding WICS (Scotland) (WAREG, 2019). ARERA (Italy) is unique among regulators in that it considers environmental costs in their own tariff component distinct from OPEX (Box 2). And indirectly, because the costs of compliance with environmental standards (typically set by environmental regulators) are reflected in general operating costs and capital investment requirements – even if this is not explicitly measured or categorised as such. Additionally, environmental costs may be reflected in tariff methodologies that designate sanctions/penalties/forfeits as allowable components of OPEX[1] (WAREG, 2019), insofar as the penalty amount reflects the actual cost of environmental harm caused (ARERA, 2015).

Box 2 ARERA's (Italy) Environment and Resource Costs (ERC) Tariff Component

ARERA's (Italy) tariff setting methodology is based on a revenue cap formula (VRG) that takes into account CAPEX, cost components related to specific objectives (FoNI), Opex, as well as a component to recover costs from previous year balance (Rc). From 2015, ARERA introduced a specific component referred to as ERC (Environment and Resource Costs) in its tariff-setting methodology that is distinct from OPEX.

$$VRG^a = Capex^a + FoNI^a + Opex^a + ERC^a + Rc^a_{TOT}$$

Its purpose is to disaggregate environmental and resource costs to improve transparency and facilitate opportunities for closer compliance with Article 9 of the WFD (EC) 2000/60. In its first year of implementation, it represented a sum of 346 million euros which would otherwise have been accounted in the components of 'local charges' and 'other operating costs'. Specifically, the ERC included expenditure relating to environmental protection contributions and urban wastewater purification, among others.

Through measuring the ERC component, ARERA was able to surface these otherwise hidden environmental costs; enabling better benchmarking and opening the opportunity for more targeted initiatives to incentivise environmental and resource cost capture in the future. The Environment Ministry can define costs that fall within the ERC component, which provides scope for specific policy interventions. For example, the Environment Ministry may, as a matter of policy,

[1] Albania, Spain, Malta, Flanders, Brussels, Croatia, and Scotland.

directly designate otherwise non-allowable costs as permissible under the ERC component to better achieve full cost recovery.
While the creation of the ERC component does not, on its own accord, capture environmental and resource costs to a greater extent, it does represent an expansion of regulatory capacity through which ARERA can achieve (with ministerial support) closer compliance with the objective of full cost recovery.

Source: ARERA, 2020

There are two key advantages of reflecting environmental costs through tariff methodologies. First, in the context where economic regulators operate under limited legal mandates, it makes sense to reflect externalities as far as possible through their strongest and most comprehensive regulatory tool – the power to set or regulate tariffs. Second, because tariff methodologies are designed to ensure that operators' revenue is sufficient for meeting their financial requirements arising from their capital and operational expenditure, the inclusion of environmental costs in the tariff framework automatically ensures that these costs are internalised by operators to a certain extent and reflected in a manner that is financially sustainable.

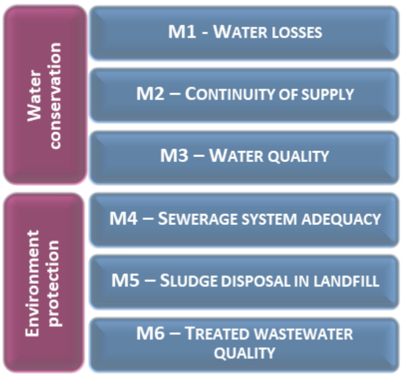
However, the disadvantages and limitations of reflecting environmental costs in tariff methodologies are numerous. Where tariff methodologies reflect the costs associated with complying with environmental standards and laws, whether they meet the objective of full cost recovery is determined solely by the robustness of the underlying standards. In this context, from the perspective of the economic regulator, these standards are a 'black box'. The only variable known to economic regulators is the cost of compliance; the robustness of the underlying standards remains unknown. Economic regulators also lack the means of revising or enforcing these standards. This can be somewhat remedied through intra-agency coordination between economic and environmental regulators – and indeed this does occur to ensure policy alignment – but ultimately, economic regulators cannot operate on the assumption that compliance with standards constitutes full accounting for environmental externalities.

❖ Promoting Environmental Externality Capture through Key Performance Indicators (KPIs)

Ecological KPIs subjectively capture the status of a given aspect of ecosystem and reflect the deviation of its status from undisturbed/reference conditions (Voulvoulis, 2017). This is expanded upon in Annex V of the WFD which describes 'quality elements' and their corresponding status, ranging from 'high' (i.e. undisturbed conditions) to moderate (variation from type-specific conditions). Beyond the ecological indicators described in the WFD, other KPIs can be used to reflect environmental externalities including carbon emissions, water leakage, effluent strength, etc.

Virtually all WSS economic regulators rely on some combination of KPIs, either directly through the imposition of their own KPIs or indirectly through environmental agencies and laws, to capture environmental externalities. This 'capture' is achieved when the cost of meeting these KPI-measure standards is reflected in the allowable tariff charges. KPIs are also used in a carrot-and-stick approach like that employed by CRU (Ireland) which penalises and rewards operators based on their water leakage performance. In Italy, since 2016, ARERA has introduced 6 macro performance indicators with differentiated regulatory targets according to the operator's efficiency (Figure 2).

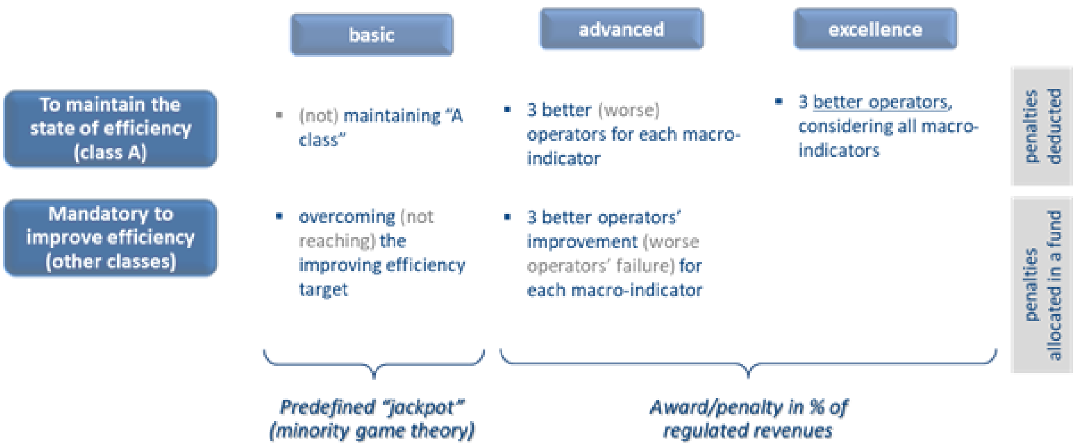
Figure 2 The 6 regulatory macro-indicators



Source: (ARERA, 2021)

Each macro-indicator applies to all operators of water services, including wholesalers and bulk water providers. Five efficiency classes (from class A to class E) are defined according to the indicator value for each operator at the beginning of the regulatory cycle. Since 2020, ARERA introduced financial incentives based on utilities' performance and indicators level. When a utility is ranked at class A for an indicator, it is financially rewarded (penalised) if it is among the 3 best (worst) performing operators of the class A. If the operator is ranked in any other class, it gets a financial reward (penalty) if it is among the 3 best (worst) improving operators for each macro-indicator. As such, KPIs are used as a financial incentive through a reward/penalty mechanism (Figure 3).

Figure 3 Financial incentive schemes based on utilities performance and macro-indicators level



Source: (ARERA, 2021)

As a starting point, regulators could review existing KPIs and categorise those that directly or indirectly allow for externality capture, as ARERA has done through the ERC Where 'pure' environmental KPIs are often already designated as such, others typically categorised as 'efficiency' targeted are also relevant, particularly water loss and energy efficiency. Below is a sample of KPIs used by MEKH (Hungary), ARERA (Italy), and Portugal (ERSAR) which could be leveraged to improve externality capture (Table 1).

Table 1 Existing regulatory KPIs that could be used to improve externality capture

Regulatory key performance indicators in Hungary (MEKH, 2022)		
KPI Reference	KPI	Unit of Measurement
3	pipe bursts (water)	unit/km
4	pipe bursts (wastewater)	unit/km
5	water loss	m3/day
11	consumption	m³/household/year
12	energy efficiency (water)	kWh/ m³
13	energy production (own energy)	%
16	level of treated wastewater discharged to the environment	%
17	sludge utilisation as biogas	%
18	energy efficiency (wastewater)	kWh/ m³
ARERA technical quality macro indicators in Italy (ARERA, 2022)		
KPI Reference	KPI	Unit of Measurement
M1a	linear water losses	m3/km/per day
M1b	water losses	% Water losses
M4a	rate floodings/discharges from sewage	№/100km
M5	disposal of sludge in landfills	%
M6	rate of wastewater samples exceeding regulatory limits	№
ERSAR regulatory performance indicator for water and sanitation services (ERSAR, 2016)		
KPI Reference	KPI	
AA10	mains failures	
AA12	real water losses	
AA13	standardised energy consumption (drinking water)	
AA14	proper sludge disposal (drinking water)	
AR01	service coverage through sewerage networks	
AR03	flooding occurrences	
AR08	sewer collapses	
AR10	standardised energy consumption (wastewater)	
AR11	accessibility to the wastewater treatment	
AR12	control of emergency discharges	
AR13	compliance with discharge permit	
AR14	proper sludge disposal (wastewater)	

Source: MEKH 2022, ARERA 2022, ERSAR 2016

- **Using Innovation Funds to address Negative Environmental Externalities**

Innovation funds are financial tools that provide backing to incentivise innovative projects by lowering the financial risks taken by operators and investors, often because the level of risk exceeds the confident probability of reward. Innovation funds help reduce the risk by sharing the cost across multiple organisations. They are set according to selection criteria to assess whether the project is truly 'innovative' and complies with predefined policy objectives. Some of these selection criteria reflect environmental externalities as they target the restoration and improvement the ecological status of water bodies, or the mitigation and adaptation to climate change.

In some countries, these innovation funds are still incipient as they are currently being deployed. This is the case in Italy, where ARERA, the Italian WWS economic regulator, passed provisions to set up an innovation fund as part of its third Tariff Method (MTI-3). It will be funded by a component of the endogenous operational costs of regulated operators, that will be collected by the Fund for Energy and Environmental Services (*Cassa per I servizi energetici e ambientali* – CSEA). The definition of eligibility criteria for WSS operators to access the fund is still being discussed.

In other countries, like England, Wales or Ireland, these funds are already in place and support innovation projects led by WSS operators.

Innovation Fund Case Study: OFWAT

In 2021, OFWAT launched the first round (2021-2025) of a £200 million Innovation Fund to support WSS operators in funding innovation projects, research, and development. This fund is designed to complement Ofwat's existing PR19 framework and will fund activities not currently incentivised through the price review. The purpose is to drive transformational innovation that companies would not otherwise invest in. Innovation is not limited to the development of new technologies but may also involve establishing new processes. The key features of the fund are (OFWAT, 2020):

- It was co-designed with regulated entities through a consultation process undertaken in 2020, strengthening buy-in and support from the sector
- The £200 million pool is funded through an agreed-upon payment transfer mechanism settled through a centralised payment system managed by a contracted third-party (OFWAT, 2022)
- Risk-sharing is implemented through a 10% co-investment requirement on the part of the applicant WSS operator
- The fund is competitive; meaning companies are incentivised make strong applications to not only potentially win a round of funding, but mitigate the costs of their fund contribution
- Foreground IP created by WSS operators (but not third-party partners) is shared royalty-free with other WSS operators

Furthermore, through the competitions, the Innovation Fund aims to support initiatives that can deliver significant value for customers, society and the environment aligned with one or more of the following themes:

- Responding and adapting to climate change, including how to meet the sector's ambition of net-zero emissions.
- Restoring and improving the ecological status of water environments and protecting current and future customers from the impacts of extreme weather and pollution.
- Understanding long-term operational resilience and infrastructure risks to customers and the environment, and finding solutions to mitigate these in sustainable and efficient ways.
- Testing new ways of conducting core activities to deliver wider public value.

- Exploring the opportunities associated with open data, stimulating innovation and collaboration, for example, encouraging new business models and service offerings that benefit customers, including those in vulnerable circumstances.

Some innovation enablers, which are critical to growing the sector's capacity to innovate, have been identified. Across the competitions, the Fund seeks to support initiatives that demonstrate and strengthen these enablers, including:

- *Collaboration:* building and strengthening collaboration and partnerships across companies, the supply chain and outside the water sector.
- *Openness:* to sharing data, insights and ideas within the water sector and with other sectors.
- *Adaptability:* flexibility and openness to trying out new ways of working.
- *Innovation risk management:* delivering value from all innovation projects, particularly more experimental projects, even if they fail.
- *Scalability and deployability:* improving the ease of scaling up and rolling out of proven innovations within the sector.
- *Long-term view:* taking both a longer-term and broader perspective to better meet the evolving needs of customers, society, and the environment.

Features of note regarding successful winners of the fund's first round of funding include:

- A total of £36 million pounds distributed among 9 winning projects
- Eight (of nine) projects included a university as a partner
- Eight (of nine) projects included two or more WSS operators as project partners; many were cross-sector coalitions
- Eight (of nine) projects targeted an environmental externality (Including water resource management, carbon intensity, energy usage, water quality management, water pollution, etc.)

Innovation Fund Case Study: Water Services Innovation Fund (CRU)

The Commission for Regulation of Utilities (CRU) in its 2014 *Water Charges Plan* exercised its discretionary power to allow for Irish Water to undertake €2M in expenditure over its forthcoming review period through an innovation fund (Commission for Energy Regulation, 2014). The purpose of this fund was to encourage Irish Water to invest in research and innovation projects to:

> *'…explore technological advances and other innovations in areas such as effective customer engagement, energy reduction, treatment processes, infrastructure rehabilitation, increased understanding of customer behaviours, climate change adaptation and environmental compliance, which could ultimately benefit customers.'* (Commission for Energy Regulation, 2015)

Irish Water is required to submit a proposal to CRU, in advance of incurring expenditure, demonstrating that the proposed investment in research or innovation meets the qualifying criteria.

The proposals for innovation fund expenditure must (a) have a reasonable probability of delivering defined and tangible benefits to customers and (b) the expected benefits of the investment must outweigh its costs. Proposals must target at least one of the following objectives:

- provision of safe, secure, and reliable water services
- increased understanding of customer behaviours and their drivers and effective customer engagement
- enhanced energy savings in the provision of water services
- achievement of relevant environmental standards and the objectives of the Water Framework Directive
- mitigation of negative climate change impacts
- provision of water services in an economical and efficient manner
- improved conservation of water resources.

In addition to requiring Irish Water to seek approval for innovation fund expenditures in advance, reporting requirements are also in-place to measure the outcomes of these projects and measure them against expected benefits.

As of November 2021, CRU has approved 10 projects whose expenditure can be counted against the innovation fund component since its introduction at the beginning of the 2015 regulatory review period (Commission for Regulation of Utilities, 2020) (Table 2).

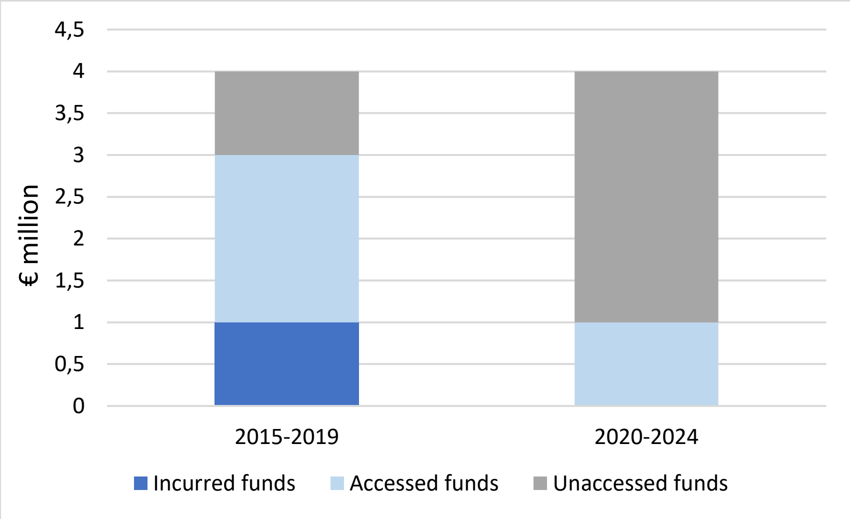
Table 2 CRU Innovation Fund Projects 2015-2020

Project	Approval Date	Status at end 2020
Pilot Technology Trials of Water Metering Systems for Multi-Unit Developments	Sep 2015	Complete
Promoting Sustainable Household Water Consumption	Dec 2015	Complete
Universal Water Meter Display Platform	Dec 2016	Not progressed
Climate Change Adaptation – Identification of Climate Sensitive Catchments	Mar 2017	Complete
Investigating Novel Sensing Techniques for Monitoring Trade Effluent	Jul 2019	Complete
Enhancing Existing Wastewater Treatment Plants Through Aerobic Granular Sludge Addition	Apr 2020	Ongoing
Development of pilot Sludge Treatment Reed Beds for Use in Treating & Dewatering Water Sludge Containing Aluminium Sulphate	Jun 2020	Ongoing
Effecting Transformational Change in Leakage Reduction within the Greater Dublin Area (GDA)	Oct 2020	Approved
Developing the Evidence Base for Treatment Wetlands Targeting Phosphorus Removal and Delivery of Co-Benefit	Oct 2020	Ongoing

Source: (Commission for Regulation of Utilities, 2020)

While the fund was successful to *enable* investment in innovation, research, and capacity-building to address environmental externalities, it did not by itself, directly *promote* investment in innovative research and projects. While the expenditure allowance at the core of the scheme is essential for sustainably financing innovation, its effectiveness is limited in that it is not paired with incentives or requirements to make such investments. According to CRU, Irish Water spent just over €1 million and accessed a further budget of €2 million of the €4 million available for innovation fund investments for the 2015-19 period (Commission for Regulation of Utilities, 2020). Thus 25% of the available funding remained unused, potentially showing an absorption issue. For the period 2020-2024, Irish Water already used €1 million among the €4 million budget available (Figure 4).

Figure 4 CRU Water Services Innovation Fund up-take



Source: (Commission for Regulation of Utilities, 2020)

That is not to say there is no incentivisation for WSS operators to take advantage of such a scheme; the usage of three-quarters of the allowance indicates that there are some incentives at play. For example, Irish Water could have responded to a normative pressure or expectation created by CRU to take advantage of the scheme. However, the more directly attributable reason for WSS operators to take advantage of such a scheme is in circumstances where they anticipate that eligible projects would yield efficiency improvements that would aid them in meeting regulatory targets.

WSS operators under such a scheme are incentivised to invest in projects that yield the maximum potential efficiency optimisations – with modest environmental benefits – over projects with would generate significant positive environmental outcomes. To illustrate this; **Option 2** would be incentivised over **Option 3**, despite it delivering a lower potential environmental benefit (Table 3).

Table 3 Investment Incentivisation under an OPEX-Allowance 'Fund' Model

	Low potential optimisation gains	High potential optimisation gains
Low potential environmental benefit	**1.** Weak Incentive	**2.** Strong Incentive
High potential environmental benefit	**3.** Weak Incentive	**4.** Strong Incentive

Finally, another design feature of CRU's innovation fund that is worth examining is its project eligibility criteria. The requirement that investments must deliver 'tangible benefits to customers' might render proposals ineligible that would otherwise support CRU's enforcement of the WFD's environmental and resource cost recovery requirements (Commission for Energy Regulation, 2015). The requirement that benefits to *customers* must outweigh its costs would limit the range of investment opportunities that target the otherwise permitted objectives including mitigation of climate change impacts and improved conservation of water resources. Take for example a hypothetical project that would result in more accurate measurements of groundwater reserve depletion which by extension could potentially increase abstraction charges and therefore have a detrimental impact on customers who will be charged higher tariffs. Projects which could increase implementation of the WFD by more fully reflecting costs in tariffs would be difficult to justify under the fund's qualifying criteria.

Despite the few critiques mentioned above, the fund is an efficient and useful means for enabling investments in research and innovation that can yield net environmental benefits. The benefits of this approach are that the fund is financially sustainable through guaranteed cost-recovery; does not require significant resources to implement by the economic regulator; the rules are transparent; and the reporting mechanisms are strong. However, its design is such that investments are made in projects in a manner biased in favour of optimisation outcomes over environmental externality capture.

3. Opportunities for Better Reflecting Environmental Externalities

❖ Accounting for Ecosystem Services

While the concept of 'ecosystem services' originated in the 1990s, it was popularised by the Millennium Ecosystem Assessment (MEA) which also supplied the first authoritative definition:

> *Ecosystem services are the benefits people obtain from ecosystems. These include provisioning services such as food and water; regulating services such as flood and disease control; cultural services such as spiritual, recreational, and cultural benefits; and supporting services, such as nutrient cycling, that maintain the conditions for life on Earth.* (Millennium Ecosystem Assessment Program, 2005)

The MEA groups ecosystem services into four categories; provisioning, regulating, cultural, and supporting services. Below is a list of water and water-adjacent ecosystem services categorised accordingly (Box 3).

Box 3 Water and Water-Adjacent Ecosystem Services

Provisioning Services *(products obtained from ecosystems)*
- Drinking water
- Water for agriculture and industrial use
- Fisheries and aquaculture
- Raw biotic materials (e.g., algae as fertilizer)
- Abiotic energy sources (e.g., hydropower generation)

Regulating Services *(benefits obtained from regulation of ecosystem processes)*

- Water purification (e.g., excess nitrogen removal by microorganisms)
- Air quality improvement (e.g., deposition of NOx on vegetal leaves)
- Flood protection
- Pest and disease control (e.g., natural predation of diseases and parasites)
- Local climate regulation (e.g., maintenance of humidity patterns)

Cultural Services *(nonmaterial benefits obtained from ecosystems)*

- Recreation (e.g., swimming, recreational fishing, sightseeing)
- Education and aesthetic value (e.g., matter for research and artistic representations)
- Spiritual and religious
- Cultural heritage and sense of community

Supporting Services *(services necessary to produce all other ecosystem services)*

- Soil formation and composition (e.g., rich soil formation in flood plains)
- Habitat for non-aquatic wildlife

Source: (Millennium Ecosystem Assessment Program, 2005)

Currently, these ecosystem services are largely not reflected in the economic regulation of WSS. This means that where environmental externalities of WSS operators negatively impact these services, the associated environmental cost is not being captured. Likewise, without recognising the value of ecosystem services, opportunities for WSS operators to make investments to protect or enhance them cannot easily be recovered as allowable tariff components (Box 4).

Box 4 Ecosystem Service Intervention Case Study: LIFE Brenta 2030 Project (Italy)

The LIFE Brenta 2030 project was launched in 2019 to address risks associated with high abstraction and recreational use of the Natura 2000 Site in North-Eastern Italy – an important water regional water source. The project included an innovative mechanism whereby a 'Payment for Ecosystem Services' (PES) was established for the protection of diversity and water conservation.

Farmers received funds through a PES mechanism, funded through by internalised environmental and resource costs through water tariffs, to convert agricultural land into Forest Infiltration Areas (FIA). FIAs recharge groundwater aquifers by surface waters during non-irrigation months. The area is covered by local trees or shrubs, and their roots facilitate the infiltration of water into the ground. The system provides several services including:

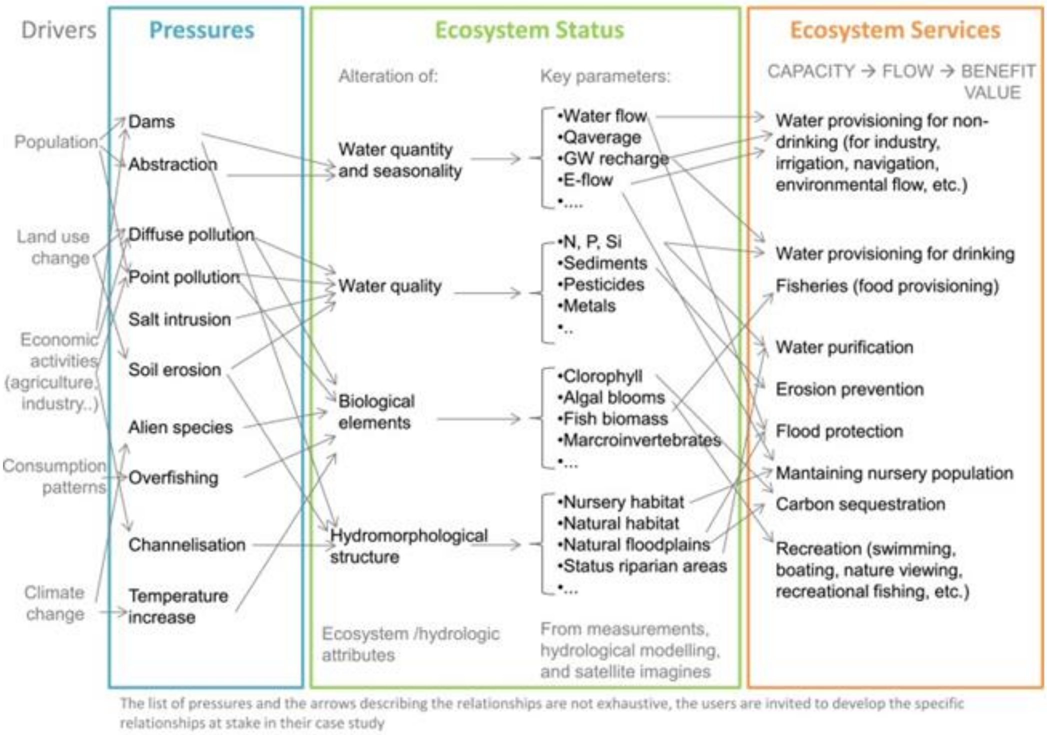
- Aquifer recharge
- Water quality enhancement
- Biodiversity increase
- C02 capture
- Increased recreational value

In identifying the opportunity to support ecosystem services funded by internalised e environmental and resource costs, the project is supporting the capture of environmental externalities associated with WSS.

Source: (Zanetti, 2019)

As a starting point, regulators should consult the integrated assessment framework created by Grizzetti et al. (2016) which links pressures, ecosystem status, and ecosystem services in a way that can be operationalised to capture externalities associated with pressures (Grizzetti, 2016) (Figure 5).

Figure 5 Integrated Assessment Framework



Source: (Grizzetti, 2016)

- **Using Non-Use Value KPIs**

A key feature of the ecosystem services approach is that it is anthropocentric at its core, given that the value of these services is ultimately derived from the utility they provide for humans. The alternative to an anthropocentric approach is one that recognises the environment as having ‘intrinsic value’ (IV) distinct from any value to humans.

The anthropocentric conceptualisation of ecosystem services is useful in that utility for humans is more easily translated into economic and/or monetary valuations which fit neatly within economic regulation. For example, if water-adjacent flora sequesters a volume of carbon, its value as a service can be abstracted by the economic cost that the carbon would otherwise impose via climate change.

IV, on the other hand, is rooted not in economic utility-based analysis but in normative moral/ethical philosophical tradition. Batavia & Nelson (Batavia C., 2017) note that attempts have been made to integrate IV as an ecosystem service itself through 'existence value' – reflecting a *preference* (and therefore utility) that humans desire a feature of the environment to be of a certain level of quality. For example, in the WSS context, this 'existence value' could refer to the increase in welfare to a person who, for ethical reasons, values the conservation of waterbodies. The 'IV' in this formulation is measured by the person's willingness-to-pay for said conservation. While Batavia & Nelson (Batavia C., 2017) are correct in pointing out that value cannot be intrinsic if it's derived from a person's valuation, it nevertheless provides a useful starting point for abstraction. Where WSS economic regulators lack mandates and/or support for purely ethics based IV abstraction, interventions based on 'existence value' are a more palatable and practical alternative.

Therefore, to capture non-use values, or otherwise approximate IV through 'existence value', WSS regulators should seek to identify KPIs which correspond with these values and measure end-users' willingness-to-pay for associated measures. It should, however, be noted that the logic of ecological protection in the WFD is principally framed not in anthropocentric logic but in an implicit recognition of IV. Article 1(a) states that the purpose of the directive is to *'prevent further deterioration and protects and enhances the status of aquatic ecosystems and, with regard to their water needs, terrestrial ecosystems and wetlands directly depending on the aquatic ecosystems'* – the key being 'their' needs and not those of humans.

- **Setting a Precautionary Cost Component**

WSS economic regulators are still working towards the objective of full cost recovery as set forth in the WFD article 9. However, until full compliance is achieved, harmful environmental externalities will continue to be generated and associated costs will not be reflected in tariffs. While the exact value of these costs is unknown, what is known is that the value is greater than zero. In France, environmental costs caused by WSS have been tentatively estimated to €3.7 billion per year. These costs correspond to damages caused by WSS to the environment that have not been yet compensated by an actual expenditure (Office Français de la Biodiversité, 2019). In such circumstances where there is 'known unknown', it is appropriate to include a precautionary cost component in tariffs to partially reflect these costs. The regulatory justification for such a precautionary charge is derived from the WFD itself, as well as Article 191 of the Treaty on the Functioning of the European Union sets forth both the precautionary and polluter-pays principles with respect to environmental protection.

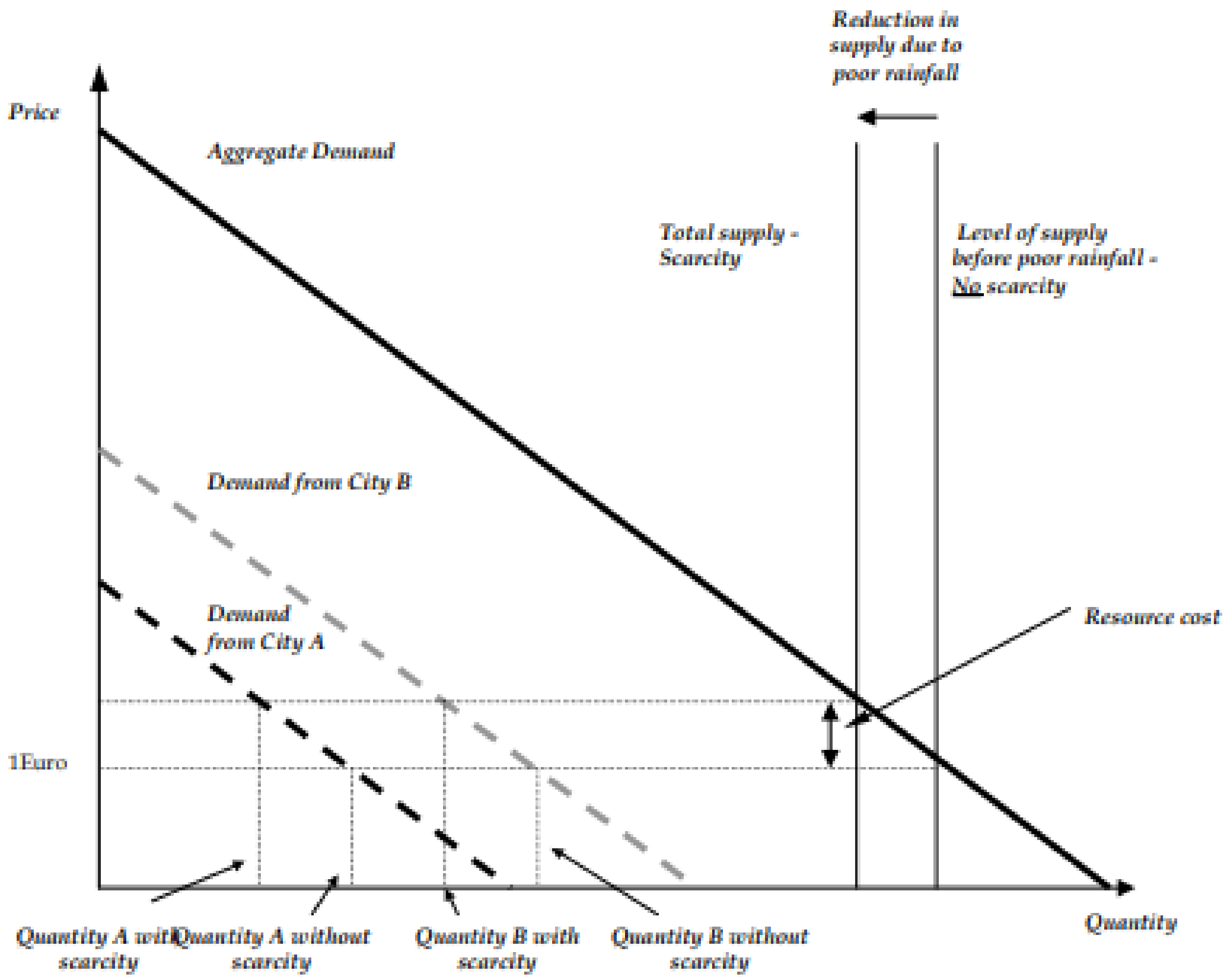
The revenues raised by a tariff component which reflects 'known unknown' environmental and resource costs can be used to fund research into identifying externalities that are not currently measured or reflected. Additionally, the revenue could be held in capital investment funds which can be accessed at later dates to remedy the consequences of uncaptured externalities, e.g., compensation payments, etc. The charge can be justified on the grounds that uncaptured externalities today are creating risks that will need to be addressed in the future, and there is currently no funding mechanism in place to address these consequences. Emerging pollutants are a good example of those uncaptured externalities as their impacts on human health and/or the environment are not yet fully understood. The challenge at the core of addressing emerging pollutants is this knowledge gap and that there are limited resources available for evaluating the risk of a high number of diverse contaminants and their sources (OECD, 2018).

4. Focus on Regulatory Practices for Reflecting Resource Costs

According to the WFD Guidance document, resource costs refer to the cost of forgone opportunities that other users suffer due to the depletion of the resource beyond its natural rate of recharge or recovery; whether they be other users today or in the future (CIS Guidance, 2003). These costs are typically addressed through the issuing of licenses designating the authorised volume of water that can be extracted from a source, accompanying by an abstraction charge which reflects the value of the scarcity of water and its opportunity cost.

According to the WFD guidance, robust resource cost scheme should reflect competing demand for water between various use types (potable, industry, and agriculture) and specific users (municipalities, factories, farms). At the same time, it should also reflect water scarcity, ideally with a means for variability depending on short-medium term water scarcity in specific locations. The guidance acknowledges that there is no well-established method for estimating resource costs but does offer an example of a model (Figure 6) that may be applied which reflects the opportunity cost of competing uses in the context of both scarce and non-scare supply.

Figure 6 Model for estimating water resource costs



Source: (CIS Guidance, 2003)

Supplementing the resource cost model above, authorities can use the OECD framework to reform their water licensing regimes (Table 4). This framework is valuable because it encourages the consideration of each element of the regime in the multi-dimensional context of economic efficiency, environmental sustainability, and social equity.

Table 4 OECD framework for water allocation regimes

Elements of an allocation regime	Economic efficiency	Environmental sustainability	Social equity
		System level elements	
Legal definition of the ownership of water resources	Allows for clear assignment of entitlements of use.	Confers legal authority to secure water for the public good uses.	Allows for clear assignment of entitlements of use.
Appropriate institutional arrangements for allocation	Ensure that a competent public authority can manage system and user level allocations issues, with clear lines of accountability, while minimising transaction costs.	Ensure that a competent public authority can designate and enforce adequate environmental flows.	Ensure equity in process, through adequate mechanisms for stakeholder engagement.
Identification of available water resources	Allows for efficient augmentation of available resources.	Ensures hydrological integrity and allows for managing system connectivity.	May be used to ensure fair access to adequate resources.
Identification of in situ requirements/definition of available ("allocable") resource pool	Balances use and non-use values of *in situ* activities vs. use value of diverted activities.	Ensures adequate environmental flows.	Balances needs of *in situ* users vs. users of diverted flows.
Abstraction limit ("cap")	Balances cost of closing system with risks of unsustainable use.	Allows for "closing" the resource pool to ensure sustainable functioning.	Balances needs of current water users with future water users.
Definition of permitted uses not required to hold an entitlement	Balances transaction costs associated with managing small scale uses with the cost (risk) of possibly undermining system integrity and foregoing abstraction charges.	Ensures hydrological integrity.	Balances customary, small-scale and subsistence uses with need with the need for system level integrity.
Definition of "exceptional circumstances"/sequence of priority uses	Can be used to ensure that the sequence of priority uses reflects to some extent the marginal value of use.	Can be used to avoiding irreversible damage to vulnerable ecosystems and key species and ensure environmental flows are not simply used as an "adjustment factor" in times of scarcity.	Can be used to ensures that human needs are a priority; Equity in process can be ensured through involvement of stakeholders in the definition of "exceptional circumstances" and the sequence of priority uses.
Requirements for new entrants	Ensures that water can be allocated to higher value uses.	May require an environmental impact assessment to support hydrological integrity.	May require an assessment of third party impacts; can be used to encourage fairness in access between existing users and possible new entrants.
Mechanisms for monitoring and enforcement	Balance transaction costs associated with monitoring and enforcement with costs (risks) imposed by unauthorised use.	Ensure hydrological integrity by ensuring adequate environmental flows.	Ensure common pool resources are used equitably and that use entitlements are respected (amounts are not exceeded) and illegal use discouraged.
Appropriate infrastructures	Ensure that water can be stored, treated and transported to water users as needed.	Ensure that water to serve environmental purposes can be stored, treated and transported to water users as needed.	Ensure that water uses have adequate and fair access to water.

Source: (OECD, 2015)

European economic regulators are usually not responsible for issuing water abstraction licenses, nor do they determine abstraction charge levels. This power is instead typically held by national environmental agencies (as is the case in Portugal, Ireland, England, Wales, France, and Scotland) or in sub-national or regional authorities (Italy).

In practice, the abstraction schemes managed by these authorities do not adequately reflect water resource costs considering water scarcity and opportunity cost. Over half of OECD countries, for example, reported that abstraction charges do not reflect water scarcity (OECD, 2021). In Italy, abstraction licenses fall under the jurisdiction of regional governments and do not take into account the changing availability of water resources, nor do they account for changes in demand driven by population growth and economic development, leading one group of researchers to characterise the Italian license scheme as ‘torturous and substandard’ (Santato, 2016).

In some cases, the existing licensing regimes disincentivise efficient resource use. In Hungary, for example, the Water Management Authority (distinct from economic regulator) charges water users for the full volume of water abstraction permissible under their license, irrespective of how much they remove; meaning that users have no incentive to abstract less than their maximum allowance. There are political and social considerations that impact the water resource regime as well; with the OECD (OECD, 2021) noting that the agricultural sector commonly benefits from lower abstraction charges or even exemptions.

Overall, the failure to appropriately reflect resource costs is particularly problematic in the context of increasing global demand for water resources amidst volatile water scarcity patterns arising from climate change (OECD, 2015); making reflecting resource costs an even greater priority today and in the future than it was when the WFD was first introduced in 2000.

As noted above, economic regulators typically do not possess the power to determine the conditions of abstraction licenses or set abstraction charges. Likewise, economic regulators are often not responsible for determining legal water pollution discharge levels and water pollution charges – responsibilities that lie instead with environmental regulators. They do, however, interact with the charges set by national or sub-national authorities as abstraction charges form a component of WSS operator OPEX costs which are accounted-for in tariff methodologies. Tariffs, therefore, indirectly reflect resource costs, though as noted above, they do not reflect the full opportunity cost of water usage given sub-optimal abstraction charge regimes.

The second means through which economic regulators can exert some measure of control on water resource usage, within the restrictive bounds of their legal mandates, is through leveraging specific features of their tariff methodologies. For example, efficient water use is incentivised through excess water charges as well as volumetric block tariffs in some jurisdictions. A more widespread practice however is the implementation of KPIs targeting network water leakage; incentivising operators to undertake repairs and network maintenance to reduce water resource waste and, by extension, reduce abstraction volumes.

Among the 6 macro-indicators introduced by ARERA in 2016, the indicator M1, which focuses on “water losses”, is composed of two components:

- Indicator M1a “linear water losses”, expressed in m^3/km/day, and,
- Indicator M1b “percentage of water losses”, expressed in %.

Macro-indicator M1 applies to all operators of water services, including wholesalers and bulk water providers. The five efficiency classes (from class A to class E) for M1 are defined according to the values of indicators M1a and M1b (Table 5).

Table 5 Class definition for Macro-indicator M1 "Water losses"

		Water losses per km (mc/km/day)				
		M1a <15	15≤ M1a <25	25≤ M1a <40	40≤ M1a <60	M1a ≥60
Leakage rate (%)	M1b <25%	A	B	C	D	E
	25%≤ M1b <35%	B	B	C	D	E
	35%≤ M1b <45%	C	C	C	D	E
	45%≤ M1b <55%	D	D	D	D	E
	M1b ≥55%	E	E	E	E	E

Source: (ARERA, 2021)

The improvement objectives established for the macro-indicator M1 for each class is described in Table 6.

Table 6 Regulatory targets for Macro-indicator M1 according to class

ID	Indicator	Tariff type	ID Class	Targets
M1	M1a – Water losses per km [mc/km/day] M1b – Leakage rate [%]	RES	A	Conservation
			B	-2% M1a yearly
			C	-4% M1a yearly
			D	-5% M1a yearly
			E	-6% M1a yearly

Source: (ARERA, 2021)

As already mentioned in Section 1, since 2020, ARERA introduced financial incentives based on utilities' performance and indicators level. As such, water losses reduction (M1) is being financially incentive through a reward/penalty mechanism.

CRU (Ireland) has gone one step further than implementing water leakage KPIs (supported by a reward and penalty scheme) and excess use charges. It directly supports the implementation of schemes aimed at reducing water leakage; including an innovative 'First Fix Free' scheme whereby Irish Water reimburses domestic users for leakage repair costs for pipes on their private properties (i.e., pipes that are not formally part of the public water network), with plans to roll this out to industrial customers. While measures targeting excess demand and water leakage are invaluable, particularly in water-scarce areas or in areas with extremely high-water leakage rates due to historical underinvestment, economic regulators are still nevertheless hamstrung by their inability to directly set abstraction (and pollution) charges themselves. In these circumstances, it may be advisable for regulators to include in their tariff calculations a supplementary resource charge component, according to the precautionary principle, which is earmarked for investment in aquifer renewal, resource cost research, or other investments to offset at least some of the resource-cost gap that is known to exist.

Section 2: Supporting the transition to the Circular Economy

1. Circular economy definition and model framework

Regulators need a clear definition of the 'circular economy' (CE) to set targets, design incentives, measure outcomes, and evaluate performance of regulatory interventions to support the of operators to CE.

The challenge for regulators is that policymakers and researchers are not operating from a common definition of CE (Ekins, 2019). Two meta-studies of academic and policy papers, surveying sample sizes of 114 (Kirchherr, 2017) and 565 (Merli, 2018) respectively, both found that CE is a vague and inconsistent concept. One went as far as to characterise it as 'circular economy babble' (Kirchherr, 2017). These studies found that most descriptions of CE are not particularly novel. Instead, they are often a simplistic 're-hashing' of longstanding concepts and principles such as the 'Four Rs'[2].

Despite the European Commission launching its first CE framework in 2015, the EU lacked a formal definition of CE prior to the adoption of *Council Regulation (EC) 2020/852* (Lingl, 2019). This recently published definition provides regulators with a legal basis for identifying and qualifying CE practices in a way that is conceptually distinct from more general sustainability principles. CE is defined in Article 2(9) (Box 5), while Article 13(1) lists specific practices consistent with achieving CE objectives (see Annex II: Circular Economy Categories).

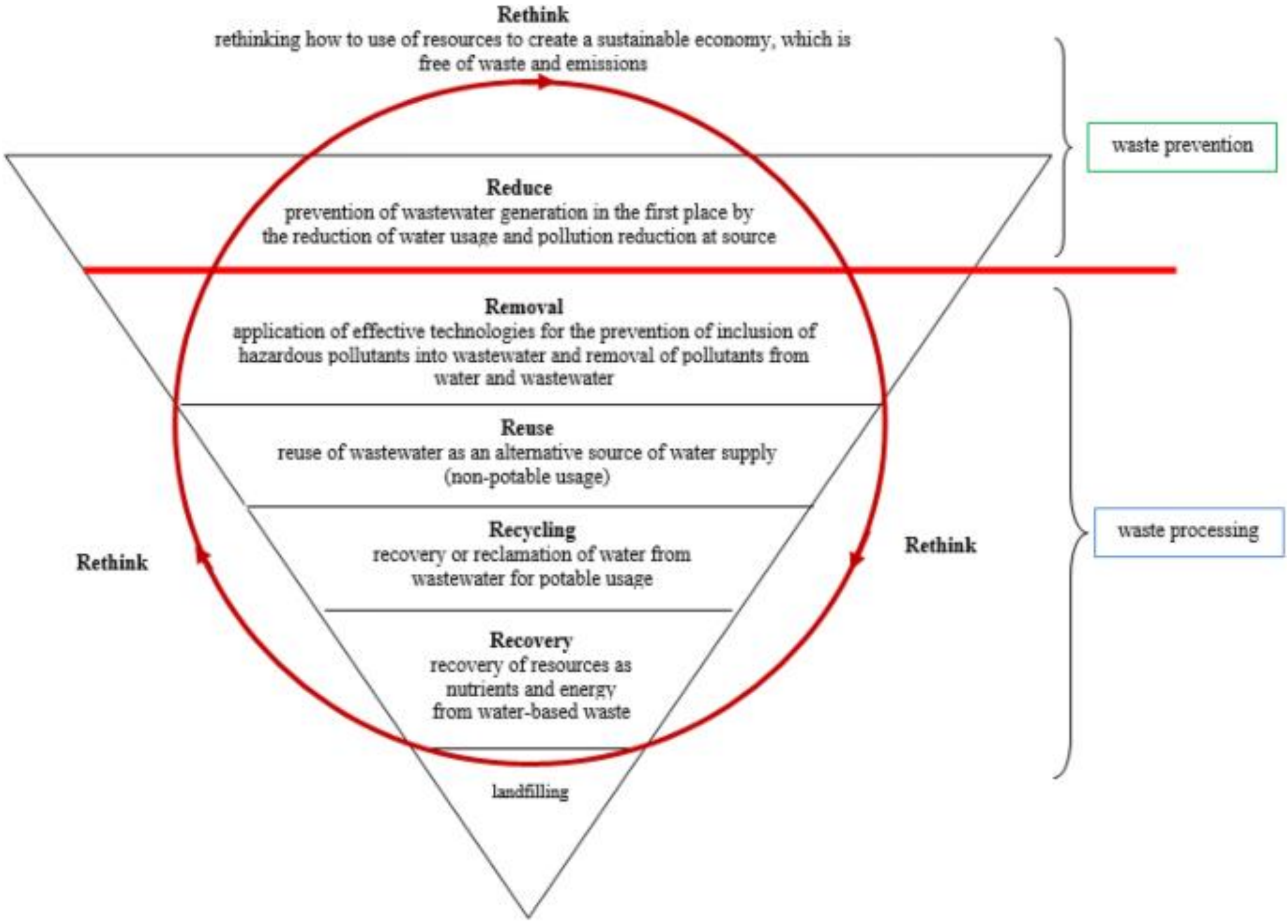
Box 5 Council Regulation (EC) 2020/852 of 18 June 2020, Article 2(9)

9. 'Circular economy' means an economic system whereby the value of products, materials and other resources in the economy is maintained for as long as possible, enhancing their efficient use in production and consumption, thereby reducing the environmental impact of their use, minimising waste and the release of hazardous substances at all stages of their life cycle, including through the application of the waste hierarchy.

Where the WFD targets environmental and resource externality capture, a transition to the CE requires a fundamental shift in the WSS economic model to minimise the use of virgin materials (including water) in both production and consumption and maximise the value of resources at every stage of their life cycle. Smol et al. (Smol, 2020) have attempted to operationalise this with a '6 R' hierarchy model (Figure 7).

[2] 'Reduce, Reuse, Recycle, and Recover'

Figure 7 The CE model framework in the water and wastewater sector



Source: (Smol, 2020)

While a useful starting point, this model does not capture the full scope of CE in WSS. It solely targets water resource use and does not reflect the *actual* resource use of the sector including materials and pollution associated with physical infrastructure, capital, and energy. A comprehensive transition to the CE requires the recognition that resources have a lifespan before and after their use in the WSS sector, and their use in the WSS needs to be optimised to maximise their value accordingly.

2. Current Regulator Practices Supporting the Transition to the Circular Economy

While most European regulators have not yet begun to explicitly promote CE practices through their regulatory frameworks, many *incidentally* support operator practices and investments which meet the EU's CE criteria in Article 13, CE 2020/852. For example, EWRC (Bulgaria) has implemented a KPI for the use of wastewater sludge as agricultural fertiliser which 'increases the use of secondary raw materials and their quality, including by high-quality recycling of waste'. Likewise, measures undertaken by most regulators to reduce water leakage similarly promote the transition to the CE through the reduction of the use of virgin water resource, and as water preservation constitutes an increase in natural resource use efficiency.

There is a distinction, however, between supported practices that are *incidentally* consistent with CE, and practices that are promoted within the context of a broader CE strategy. If regulators explicitly identify practices within a CE framework, operators would be able to take advantage of national and European schemes, grants, and resources to support their implementation. Likewise, given the reliance of CE on policy consistency across sectors, isolated CE practices may be limited in their effectiveness without complementary cross-sectoral policy measures. For example, while EWRC (Bulgaria) supports the conversion of sludge into agricultural fertilizer, uptake of the end-product is limited given consumer and farmers preferences for using chemical fertilisers.

This demonstrates how cross-agency coordination is essential for supporting the CE transition of WSS operators. While EWRC introduced an incentive to *produce* sludge fertiliser which preserves the value of natural resources (and thereby reduces virgin resource use), it lacks the power to ensure that there is *demand* for the output.

This is where engagement with other government agencies to develop coordinated policy is necessary. For example, chemical regulators could impose a levy on chemical fertilisers to disincentivise their use, while agricultural agencies could condition subsidies on sludge fertiliser adoption. Individually, a broad adoption of this CE practice is unlikely. Together, a coordinated approach would synergise to align market incentives and operationalisation of the CE transition across the supply chain.

As such, governments need to align regulatory interventions that follow the life cycle of resources and WSS economic regulators need to coordinate their interventions with government agencies that intervene both upstream and downstream of the WSS sector. Successful CE means the creation of a chain of preserved resource value - not a single link – so WSS economic regulators should seek to avoid siloed policymaking.

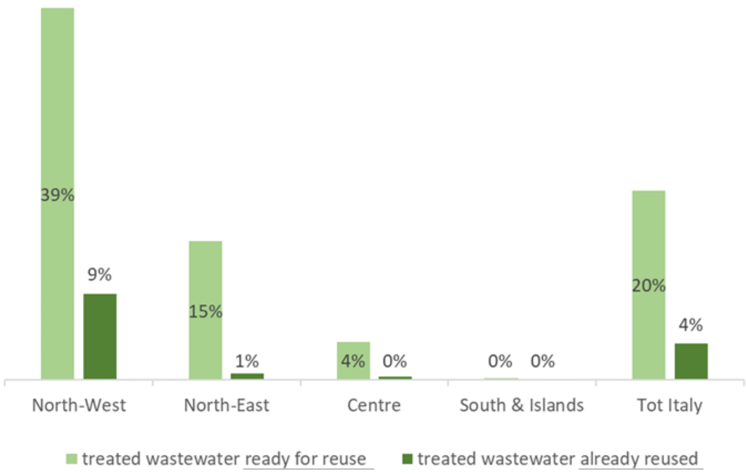
To this end, the authors of one of a highly influential paper found, while examining successful CE transition interventions, that success came from 'the involvement of all actors of the society and their capacity to link and create suitable collaboration and exchange patterns' (Ghisellini, 2016).

Having established the distinction between implicit and explicit CE practices, it is evident that most European regulators have not yet to begun to actively support the uptake of explicit designated CE practices by operators. There are several reasons for this; the 'muddiness' of CE as a concept and lack of a clear EU authoritative definition until 2020 has made it difficult for economic regulators to justify regulatory interventions, particularly where their mandates are limited to tariff-setting. Nevertheless, the nascent adoption of CE is evident in the practices of some economic regulators.

The Italian government has one of the most advanced CE strategies in Europe (Mazur-Wierzbicka, 2021), beginning with its 2017 strategy paper, 'Towards a Model of Circular Economy for Italy – Overview and Strategic Framework'. The strategy identifies the priority of developing a regulatory framework that facilitates, encourages, and introduces economic incentives for the use and reuse of water according to CE principles. It is in this normative context that the Italian economic regulator for water and waste services, ARERA, has begun to identify regulatory practices that constitute CE (Guerrini, 2020) which will enable it to integrate them in a WSS circular economy strategy as well as a broader whole-of-government approach where the synergies that underpin CE can be achieved.

Taking stock of the untapped potential for wastewater reuse (Figure 8), ARERA introduced in the third regulatory cycle (ARERA, 2021) expanding from 2020 to 2023, specific incentive mechanisms to promote innovative and multi- sector measures, including wastewater reuse for agricultural and industrial purposes, or for technical purposes in wastewater treatment plants, so as to ensure efficient water resource use, in particular in contexts characterised by droughts.

Figure 8 Untapped potential for wastewater reuse in Italy



Source: ARERA, 2021

Innovative and multi-sector measures, aimed at energy and environmental sustainability also include energy efficiency, plastic use reduction, energy and raw material recovery. Operators are not compelled to implement such measures as they are not considered by ARERA as being part of mandatory water and sanitation services standards. However, these measures are incentivised through a revenue sharing mechanism affecting a component used to assess Rc^{a}_{tot}. The revenue share amounts to 75% if innovative and multi- sector measures are implemented by the operator, compared to 50% when no measures are implemented.

WICS (Scotland) supports the adoption of CE practices through permitting the public water utility, Scottish Water, to manage and fund a subsidiary (Scottish Water Horizons Ltd) whose responsibilities includes the promotion of CE practices in the WSS sector. This is achieved through Scottish Water Horizons providing direct funding sourced partly from water tariff revenues to innovative schemes and projects designed to achieve CE outcomes. An example of such a project is the biogas heat project in Stirling which recovers energy from anaerobic digestion from wastewater treatment to support the district heating network, with projected savings including 381 tonnes of carbon emissions and a 10% reduction of end-user energy bills (Scottish Water) (Box 6).

Box 6 Stirling Energy Centre (Scotland)

'A system was created to extract natural heat from sewage and convert it into usable low carbon energy to power the [district heating network]. The Energy Centre was designed to use heat from several generation units comprising a combined heat and power (CHP) unit, with electrical output used to power a 'SHARC' sewage heat recovery system. The system also integrates heat from boilers using biogas generated from the existing anaerobic digestion plant. The heat produced from the CHP and the heat recovery units is then distributed to consumers in a low temperature (60/40) district heating network. The large sewer heat pump was the largest installation in the UK, and the first to supply multiple customers via a district heating network.'

Source: https://ramboll.com/partner-for-change/scottish-water-horizons

As noted above, most regulators support practices that constitute CE. However, they do not do so within a broader strategic framework. Those that have made progress towards an integrated CE approach have done so in the context of a broader government-led strategy.

3. Economic Regulator Options for Supporting the Adoption of Circular Economy Practices

- **Introducing a specific CE investment tariff component to incentivise CE practices development**

Tariff-setting is the most ubiquitous and powerful tool available to economic regulators and as such is a strong starting point from which to explore regulatory interventions to support the adoption of CE practices. Operators cannot be expected to make investments into CE if they cannot recover these investments through tariffs. Therefore, regulators need to not only ensure that CE investments are recoverable through tariffs, but also actively communicate this to operators.

Specific guidance could be generated to assist operators in identifying which investments would constitute CE practices, and if possible, create a distinct tariff component which corresponds to these. This would increase financial transparency, surface CE opportunities, and serve as a signal to operators that they can reliably make such investments and have those investments be sustainable even if the profitability of the CE investment may not mature within a single regulatory period. It is essential for economic regulators to recognise that operators are exposed to risk when making financial investments in adopting CE practices and leverage their regulatory power to designate which expenditures are recoverable to mitigate this risk.

The strategic categorisation of CE practices can serve not only as an *enabler* but also as an incentivisation in and of itself. ARERA (Italy) for example categories revenue earned by operators' sale of biogas to third parties in a manner that excludes it from a tariff multiplier which determines the maximum tariff variation for the given year; meaning that the investment in biogas production is automatically incentivised if operating margins are economically viable (Guerrini, 2020).

- **Implementing regulatory sandboxes to promote CE practices development**

Regulation can pose a barrier to the development and adoption of innovative CE practices, when it is unnecessarily burdensome or slow to adapt. Regulators can decide to play an active role in nurturing and supporting the development and adoption of innovative CE practices through the implementation of regulatory sandboxes which are mechanisms aimed at enabling emerging innovations.

Regulatory sandboxes are policy instruments used in the context of adaptive or anticipatory approaches to regulation (Box 7). They are part of a wider policy mix and represent a move toward 'smart regulation' based on "a close interaction between the regulators and the regulated companies" (Blind, 2012), granting proportionate regulation to innovative firms while keeping risks to an appropriate level. They can support innovation by reducing the time and cost of getting innovative ideas to market and providing access to finance while integrating consumer-protection safeguards (FCA, 2017).

In Portugal, the Secretary of State of Digital Regulation launched in 2021 the *Technological Free Zones* (ZLT) scheme through which WSS operators can submit projects to the Portuguese Innovation Agency. The ZLT scheme is a sandbox that allows operators to develop a technology and be disruptive without being hampered by the existing regulation. So far, three water-related applications were received by the Portuguese Innovation Agency, and two are currently being evaluated.

Box 7 Regulatory Sandboxes

Regulatory sandboxes are policy instruments that facilitate small-scale, live testing of innovations in a controlled market-like environment. Sandboxes are typically employed in cases where the emerging technology is potentially disruptive. It allows the testing of innovative technologies and business models that are not fully compliant with current rules and regulations, by providing temporary suspension of certain mandatory provisions or requirements for those who participate in the sandbox. This means that participants are not required to follow all the regulatory requirements that would normally apply outside the sandbox in the regulated market. In return for this dispensation, participants are required to incorporate appropriate safeguards to insulate the market from risk from their innovative business. This gives participants a safe space to experiment without running the risk of being punished for noncompliance while reducing liability concerns among regulators (Dirk A. Zetzsche et al., 2017). Regulatory sandboxes tend to be delivered with the strong presence of a regulator, who also provides monitoring and supervision. Another key aspect of regulatory sandboxes is the establishment of feedback mechanisms that allow regulators to gather evidence of potential needs for change in the existing regulatory framework, to facilitate the creation of more products or business models. As such, regulatory sandboxes entail an "interest in regulatory discovery" (German Federal Ministry of Economic Affairs and Energy, 2019).

Source: (Inter-American Development Bank, 2020)

- **Using KPIs to incentivise CE practices development**

Where mandates permit it, a 'carrot and stick' approach facilitated through KPIs could be used to promote CE practices. CRU (Ireland) already implements such a technique, whereby operators incur a penalty for failing to meet water leakage targets and a reward for high performance (0-79% of target incurs €20 million penalty; 80-99% dead band; 100% earns a €20 million reward).

This is one example of leveraging KPIs and quality targets that can be applied to incentivise the uptake of CE practices. KPIs should be designed in a manner consistent with *Council Regulation (EC) 2020/852 of 18 June 2020, Article 13(1)* to allow WSS operators to take advantage of broader government and EU schemes, incentives, and knowledge-sharing aimed at supporting CE. Below is an example of KPI categories aligned in such a manner. In many cases, these KPIs are already used by regulators; so, it would simply be a case of explicitly aligning them with the EU-designated activity type (Table 7).

Table 7 Examples of CE aligned WSS KPIs

WSS KPI	*Council Regulation (EC) 2020/852 of 18 June 2020, activity corresponding with Article 13(1)*
Water abstraction reduction	(a.) uses natural resources, including sustainably sourced bio-based and other raw materials, in production more efficiently, including by: (ii.) resource and energy efficiency measures;
Water leakage reduction	(a.) uses natural resources, including sustainably sourced bio-based and other raw materials, in production more efficiently, including by: (ii.) resource and energy efficiency measures;
Greywater reuse and recycling	(a.) uses natural resources, including sustainably sourced bio-based and other raw materials, in production more efficiently, including by: (ii.) resource and energy efficiency measures;
Sludge incineration reduction	(j.) minimises the incineration of waste and avoids the disposal of waste, including landfilling, in accordance with the principles of the waste hierarchy;
Biogas production	(a.) uses natural resources, including sustainably sourced bio-based and other raw materials, in production more efficiently, including by: (ii.) resource and energy efficiency measures;
Mineral harvesting from sludge	(f.) increases the use of secondary raw materials and their quality, including by high-quality recycling of waste;
Bio-fertiliser production	(f.) increases the use of secondary raw materials and their quality, including by high-quality recycling of waste;
Energy efficiency improvement	(a.) uses natural resources, including sustainably sourced bio-based and other raw materials, in production more efficiently, including by: (ii.) resource and energy efficiency measures;
Reduction in sludge volume	(j.) minimises the incineration of waste and avoids the disposal of waste, including landfilling, in accordance with the principles of the waste hierarchy;
Heat recapture	(a.) uses natural resources, including sustainably sourced bio-based and other raw materials, in production more efficiently, including by: (ii.) resource and energy efficiency measures;
Hydropower generation	(a.) uses natural resources, including sustainably sourced bio-based and other raw materials, in production more efficiently, including by: (ii.) resource and energy efficiency measures;

Use of secondary-use materials/resources in network infrastructure (i.e., recycled cement aggregate)	(a.) uses natural resources, including sustainably sourced bio-based and other raw materials, in production more efficiently, including by: (i.) reducing the use of primary raw materials or increasing the use of by-products and secondary raw materials
Use of products made from recycled materials in network infrastructure (i.e., pipes)	(e.) prolongs the use of products, including through reuse, design for longevity, repurposing, disassembly, remanufacturing, upgrades and repair, and sharing products;
Use of products that are designed with a high degree of recyclability and repairability	(c.) increases the durability, reparability, upgradability or reusability of products, in particular in designing and manufacturing activities;
Prioritisation of repair of physical network infrastructure over replacement	(e.) prolongs the use of products, including through reuse, design for longevity, repurposing, disassembly, remanufacturing, upgrades and repair, and sharing products;
Sharing of capital/infrastructure (e.g., shared vehicle fleets between utilities)	(e.) prolongs the use of products, including through reuse, design for longevity, repurposing, disassembly, remanufacturing, upgrades and repair, and sharing products;
Reduction of effluent strength	(d.) substantially reduces the content of hazardous substances and substitutes substances of very high concern in materials and products throughout their life cycle, in line with the objectives set out in Union law, including by replacing such substances with safer alternatives and ensuring traceability;

4. Examples of Circular Economy Practices in the Water Sector

Below is a non-exhaustive sample of the types of circular economy practices that could be targeted for incentivisation by regulators using the regulatory tools described above. For a more comprehensive meta-study of CE opportunities in the WSS sector one should refer to that produced by Guerra-Rodríguez et al. (Guerra-Rodríguez, 2020).

- ❖ **Sludge Reprocessing (Biogas, Fertilizer, Resource Harvesting)**

The treatment of sewage sludge is necessary before water can be returned to the hydrosphere after its extraction and use. However, the residual sludge itself is rich in nutrients, organic matter, minerals, and chemicals that can be transformed, harvested, and reused. Aerobic digestion is widely used in WWTPs to stabilise, sanitise, de-odorise, and reduce the volume of wastewater sludge. It achieves this by breaking down organic matter – converting it into methane which can be used to generate power and heat for WWTPS and their surrounding users (Bachmann, 2015). This biogas is considered under *EU Directive 2018/2001* to be a renewable energy source, and as such, is subject to the legal and financial benefits that come with such classification. Further, high value materials including phosphorus, nitrogen, and sulphur can be screened or otherwise extracted from sludge; allowing for their reuse and reducing the demand for virgin resources (Solon, 2019). The biogas and resource extraction processes can be complementary if methane is used as an electron doner for denitrification (Noyola, 2006). The remaining biomass can be incinerated to produce sewage sludge ash (SSA) which, when used as agricultural fertiliser, produces similar comparable yield results to conventional phosphate fertiliser (Franz 2008). SSA also has potential use in the construction industry as a replacement aggregate for use in concrete and mortar (Smol M. K., 2015).

❖ Recycling Water Distribution Pipes

The choice of material for water pipes comes down to a variety of factors including the life-cycle cost (LCC) (covering both upfront purchasing and ongoing maintenance costs), impact on water quality and safety, surrounding environmental factors, durability/longevity, and suitability relative to the volume and chemical characteristics of water being supplied (Eyran). In the context of ecological transition, the life-cycle energy cost (LCEA) (Filion, 2004) and life-cycle carbon footprint (LCF) (Alsadi, 2020) of pipes of varying materials may also be considered.

While a CE perspective of water distribution pipe material choice should take into consideration LCEA and LCF, it should also consider the opportunity to use pipes produced from recycled materials, the recyclability of the pipes themselves following decommission, and the *repairability* of pipes. The length of water pipe segments (i.e., the degree of concatenation across the network) may also play a role in repairability; with shorter individual segment lengths allowing for reduced material waste where a leakage necessitates pipe replacement.

Water distribution pipes are constructed from a range of materials including metals (steel, galvanised iron, cast iron), cements (cement concrete, asbestos cement), and plastics (PVC and HDPE) (Eyran). The recyclability of each material, both in terms of the limits of material transformation as well as the associated environmental and financial costs, varies greatly. Key for CE is the fact that the recycling technique can produce different resource outputs. For example, Ragaert et al (Ragaert, 2017) in their comparison of eight PVC recycling technologies found that chemical recycling could yield a range of valuable outputs including naphtha and precursors in the generation of UP resins, polyurethanes, textile dyes, antibacterial drugs, and epoxy resins.

In addition to secondary resource recycling an extraction, there are opportunities for water distribution pipes to be better integrated into a ‘closed loop’ system. For example, Juan et al. (Juan, 2020) found that while 100% recycled HDPE is not yet utilised in pressure pipes due to structural bearing load requirements, there are compositions of recycled HDPE and virgin materials that can meet the standards. However, this depends on the quality and manufacturing processes used to create the initial HDPE pipes in the first place; meaning that WSOs need to include such considerations in procurement processes. In an efficient and ideal CE system, it would not be inconceivable that fly ash from the thermal conversion of wastewater sludge (Rutkowska, 2021) could be serve as a component in the production of concrete pipes or pipe-bearing buttresses used to transport water.

❖ Heat Recapture

Water consumed for domestic and commercial use is often heated for comfort and utility, thereby consuming energy in the process. Recapturing this heat using heat exchange technologies from light greywater in dwellings and commercial buildings (showers, bathtubs, WC basins) can reduce the financial and environmental costs of water-heating (Piotrowska, 2020). Greywater heat capture was identified in Directive (EU) 2018/2001 as an ambient energy source (Article 2) and measures to preserve the value of heat would reduce natural resources consumed in producing said heat, and thereby constitute a CE practice.

While several variables contribute to thermal loss and overall return on investment, including investment costs, water usage patterns, heating and capture technology (Kordana, 2017); domestic grey water heat recovery systems can achieve recovery rates of up to 50% (Piotrowska, 2020) (Stec, 2015). Regulation may therefore consider incentivising the installation of greywater heat capture technologies; particularly where centralised greywater capture is used in high-capacity institutions (hospitals, prisons, etc) and heated water-intensive commercial structures (dishwashers, laundromats, etc.). More directly, there are opportunities for WSS regulators to incentivise water operators themselves to invest in heat-capture technology to increase energy efficiency. Given that the optimal digester temperature at WWTP is between 35-40 degrees (Spriet, 2018), such heat could be captured and re-used for general infrastructure heating needs. Temperature differentials in incoming greywater and treated effluent discharge may also be captured for internal re-use (Henriques, 2017).

- **Kinetic Capture**

The kinetic energy of water flowing through a network can be captured and harnessed by WSS operators to offset and reduce their energy costs, increasing overall system efficiency and preserving energy value. The concept is referred to as ‘small’, ‘mini’, or ‘micro-hydro’, contrasting with large-scale hydroelectricity projects. It relies on taking advantage of water speed differentials and increases in water flows following weather events are potential renewable energy-source in WWS, both throughout the system as well as at WWTPs. (Gaius-obaseki, 2010). As an energy source, micro-hydro in water networks has several advantages, including the fact that it does not generate emissions and the lack of a need to divert surface water and maintain additional reservoirs as required of mainstream hydrogeneration (Bousquet, 2017).

The key technology for consideration for water operators is pump-as-turbine (PaT) (alternatively referred to as a ‘reverse-running pump)’; and while an almost century-old technology, its use by water operators has been limited compared to other energy generation sources such as biofuel (Gaius-obaseki, 2010). Pérez-Sánchez et al. (Pérez-Sánchez, 2017) list a range of benefits associated with PaT for their application in the WSS network; including their ability to dissipate excess flow energy, high efficiency, existence of strong computational methods for determining viability, low investment costs, and high number of available machines. One WSO in Southern Germany operates six PaTs at its reservoir which generate between 170 and 230kW which is used to meet the WSOs own energy requirements; contributing to total energy cost savings of between 25% and 28% (Budris, 2011).

WWTPs can also benefit from PaT and micro-hydro. Power can be generated from speed differentials in effluent inflows and outflows which can supplement power needed for heating in waste treatment (Henriques, 2017). Additionally, impulse turbines may also produce positive secondary effects which reduce the cost of water treatment by increasing dissolved oxygen concentrations in effluent outflow and reception streams (Zakkour, 2002) (Bousquet, 2017).

❖ Solar Power

An opportunity to reduce the use of chemicals and energy in the water treatment process exists in the form of solar-enhanced 'advanced oxidisation processes' (AOP), whereby WWTPs can harness photocatalysis techniques to oxidise and mineralise chemicals and pathogens in water; reducing the conventional treatment load (Tsydenova, 2015) (Zhang Y. a., 2018).

In contrast to the use of solar-enhanced AOP which is a relatively new technology that has not yet been scaled, solar power as a desalinisation process (both indirect and direct) is currently being practiced. Direct solar desalinisation, whereby solar energy is directed as brackish or sea water to cause evaporation, which is condensed and recaptured, is a more appropriate technology for use in rural or water scarce areas to replace or supplement standard water supply. While such direct solar desalination is not efficient for use in large-scale water supply; indirect desalinisation certainly is in certain circumstances (Zhang Y. a., 2018). In an indirect capacity, solar power is converted into electricity or captured as heat which serves as an input in the conventional reverse osmosis process to replace or supplement regular electricity from a grid. Indirect or solar-supported desalinisation is most applicable in regions where surface freshwater is scarce, and both solar power and saline water are plentiful. For this reason, the government of Saudi Arabia in 2019 completed the construction of the world's largest solar reverse osmosis desalinisation plant, which has 60% of its energy requirements met by photovoltaic capture and produces 60,300m^3 of water per day from the Persian Gulf[3].

[3] 'Solar Saline Water Reverse Osmosis Al-Khafji' available at https://www.savener.es/en/proyectos/solar-saline-water-reverse-osmosis-al-khafji/

Section 3: Addressing Emerging Pollutants

1. Definition of emerging pollutants and examples

Geissen et al. (Geissen, 2015) define emerging pollutants (EPs) as 'synthetic or naturally occurring chemicals that are not commonly monitored in the environment, but which have the potential to enter the environment and cause known or suspected adverse ecological and (or) human health effects'. EPs, also referred to as 'contaminants of emerging concern' or CECs, are distinct from those substances that are already captured in regulatory frameworks governing water safety for human consumption and the environment, such as the EU's drinking water directive (EU) 2020/2184 (DWD). While certain types of contaminants feature heavily in lists of EPs, such as nanoplastics or endocrine disruptors, EPs are more accurately characterised not by any common technical or scientific features but rather the simple fact that their impact on human health and/or the environment is not fully understood.

The challenge at the core of addressing EPs is this knowledge gap and that there are limited resources available for evaluating the risk of a high number of diverse contaminants and their sources (OECD, 2018).

The scope of responsibility for a regulatory response to EPs in water is shared across a wide range of regulators with varying mandates, principal among them is the European Chemicals Agency (ECHA) which administers REACH, the EU's chemical regulation. Further, European economic regulators of WSS may not have a legal mandate to set water quality standards, which may instead lie with environmental and/or health regulators. Therefore, this section will identify regulatory practices within the scope of WSS economic regulation that can support the mitigation of risks of EPs. It will also survey the key EPs that have bearing on WSS, including those from an exogenous source that should be mitigated through water and waste treatment, as well as EPs generated by the WSS sector itself.

Below is a non-exhaustive list of emerging pollutants.

- **Nano/microplastics**

Plastic particles smaller than 5mm are referred to as microplastics, while particles smaller than 100 nanometres (i.e. 1/10,000mm) are categorised as nanoplastics (Allen, 2022). A 2019 report by the World Health Organisation (WHO) concluded that microplastics and nanoplastics 'do not pose widespread risk to humans and the environment' despite citing a 'significant knowledge gap' in understanding the potential harm to human and aquatic health (World Health Organization, 2019). Leslie & Depledge (Leslie, 2020) point out the epistemological problem with determining that a risk does not exist based on the absence of data of said risk. The conclusion of the WHO report does not appear be consistent with the precautionary principle.

Further, a scientific consensus has not yet formed regarding the efficacy of drinking water and wastewater treatment processes in removing microplastics and nanoplastics. Where the WHO considers WSS to be 'highly effective in removing particles with characteristics similar to those of microplastics' (WHO 2019), other research has found that this success varies greatly depending on the technology employed and the size of particles targeted (Zhang, 2020) (Leslie, 2020) (Devi, 2022). Further, there is evidence to suggest that the water treatment process itself can induce fragmentation of microplastics through chemical and mechanical means, releasing 10x the number of nanoparticles (Enfrin, 2020).

There is simply not enough data in the scientific literature to conduct a proper risk assessment of microplastics and nanoplastics (Mitrano, 2021). As such, consistent with the precautionary principle, WSS economic regulators should support the closing of this knowledge gap through developing funding mechanisms for research (i.e., through innovation funds) and monitoring.

❖ Endocrine Disruptors

The presence of endocrine disrupting chemicals (EDCs) such as disinfection by-products, fluorinated substances, bisphenols and phthalates, pesticides and natural and synthetic estrogens is associated with adverse health and reproductive outcomes in humans and animals (Gonsioroski, 2020). EDCS enter the sewage system through a variety of means, including as agricultural runoff, industrial waste, household cleaning and hygiene products, and human waste.

The most straightforward means for preventing the leeching of EDCs into water systems is through banning the use of harmful chemical compounds in products. For example, the ECHA, through its administration of REACH, recently prohibited the four phthalates (plasticisers used for softening or adding flexibility products) on health grounds[4]. However, such regulatory power does not lie with WSS economic regulators. Given their limited mandate, WSS regulators should consult with their health and environmental agency counterparts to identify additional water monitoring or quality measures that should benefit from financial cost recovery. WSS regulators can also support public health officials by sharing information regarding the coverage and efficacy of wastewater and drinking water treatment processes, as the risk profile of EDCs to a given population will vary depending on water treatment capabilities.

❖ Pharmaceuticals

The presence of, and risks associated with, active pharmaceutical ingredients in drinking water and wastewater have been the subject of significant scientific inquiry for the past two decades. These ingredients make their way into the water supply principally through human waste and the disposal of unused pharmaceutical and hygiene products (e.g., disposal in landfill, flushed down a toilet, or rinsed down a household sink).

Governments have sought to prevent the contamination of the environment and water at its source by establishing collection schemes for unused pharmaceuticals. Many of these schemes stem from an obligation introduced by EU Directive 2004/27/EC that Member States create 'specific precautions

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[4] https://echa.europa.eu/-/endocrine-disrupting-properties-to-be-added-for-four-phthalates-in-the-authorisation-list

relating to the disposal of unused medicinal products or waste derived from medicinal products, where appropriate, as well as reference to any appropriate collection system in place'.

Some of these collection schemes are consistent with the polluter-pays principle, such as that, in France, expired or unwanted medications can be returned to pharmacies for disposal – financed by pharmaceutical companies. The OECD in 2022 published a comprehensive report (OECD, 2022) into the management of pharmaceutical household waste. It describes several policies that governments should introduce to prevent the introduction of pharmaceutical contaminants into the environment and waste systems. However, the policy recommendations fall outside the scope of economic WSS regulators.

Typically, the pharmacokinetics[5] of drugs are well documented through the R&D process of medications approved for human use in Europe. As such, WSS regulators should consider engaging their medicine counterparts to identify high-risk compounds that are excreted after being metabolised.

The role of WSS economic regulators in the pharmaceutical contaminant context should be like that for endocrine disruptors, i.e., ensuring that the costs of monitoring and treating pharmaceutical contaminants in water are sustainability recoverable through tariffs. Likewise, WSS economic regulators should consult with their counterparts responsible for administering policies described in the OECD report to ensure that the polluter-pays principle is properly adhered-to.

2. From the precautionary principle to the extended producer responsibility

While economic regulators of WSS typically lack the capability and/or mandate to directly address the knowledge gap associated with EPs, there is scope for regulatory intervention based on the precautionary principle based on Article 191 of the Treaty on the Functioning of the European Union. Given the number and diversity of EPs and the general acknowledgement that an unquantified degree of health or environmental harm is being caused by some of these, it follows that health and environmental *costs* of WSS are not being reflected in water tariffs.

Here, as with the unknown or difficult-to-quantify environmental costs explored in Section 1 of this paper, there is an opportunity for WSS regulators to reflect part of this cost through a precautionary tariff cost component. The revenue raised through this precautionary component can be invested into addressing the knowledge gap of EPs by funding research and enhanced monitoring. Regulators may seek applications for research into high-priority EPs to be funded, and from this derive a tariff cost component for the forthcoming regulatory period. By working backwards from high-value investment in research, regulators will be better-able to justify the quantification of the cost component to their regulated entities.

Existing performance-based schemes can accommodate additional EP-based KPIs; however, coordination may be required with environmental regulators to add these to existing environmental

[5] Pharmacokinetics is the process through which chemical compounds are moved though, and changed by, the human body.

indicator requirements and monitor them accordingly. Measures to address EPs, including improved monitoring capability or the development of technologies that reduce the production of EPs in the WSS process, can also be recognised as eligible projects as part of innovation funds, such as those managed by OFWAT (England & Wales) and CRU (Ireland).

In addition to the precautionary principle, the extended producer responsibility (EPR) could also be applied to the water and sanitation sector.

EPR is a part of the 'polluter pays principle' that holds producers responsible for managing the waste generated by their products put on the market' (OECD, 2014). The scope of responsibility can be broad, ranging from the responsibility to design products with minimal environmental impacts to the mitigation of the environmental cost of their disposal.

EPR schemes for the four mandatory waste streams (which include batteries and accumulators (B&A), electrical and electronic waste (WEEE), end-of-life vehicles (ELV), and packaging) have been set up in all Member States (European Commission, DG ENV, 2014). The level of cost recovery of EPR schemes varies a lot across schemes and across countries. At most, they recover all the net costs related to the management of separately collected waste. These net costs include the costs for collection and treatment, minus the revenues from the sales of recovered materials, and the administrative, reporting and communication costs related to the operation of collective schemes (European Commission, DG ENV, 2014). However, they hardly ever recover all the components of the full cost of the waste stream management which include:

- "Collection, transport and treatment costs for non-separately collected waste (waste covered by EPR but not entering the separate collection channel, e.g., waste collected together with mixed municipal waste);
- Costs for public information and awareness raising (in addition to the Producer Responsibility Organisation's own communication initiatives), to ensure participation of consumers within the scheme (i.e. through separate collection);
- Costs related to waste prevention actions;
- Costs for litter prevention and management;
- Costs related to the enforcement and surveillance of the EPR system (including, auditing, measures against free riders, etc.)" (European Commission, DG ENV, 2014).

In a context of increased recycling rates, the cost-recovery level of EPR schemes will need to be enhanced to ensure a better implementation of the polluter pays principle and to reduce cross-subsidies from users to producers.

In a comprehensive report commissioned by EurEau (Extenso Deloitte, 2019), Extenso Deloitte evaluated EPR implementation options in the context of EU's legislative framework and found that a combination of mandatory control-at source and downstream EPR measures was the most effective means for addressing micropollutants and microplastics. Mandatory control-at-source measures were found to be effective given the diffuse nature of emission pathways into the environment. The addition of downstream EPR (or 'post-marketing') measures expands the policy response to better reflect a full life-cycle approach. These downstream measures included information provision (product labelling, etc), best available manufacturing techniques, awareness campaigns (end-users, consumers), application conditions, monitoring and reporting, and additional end-of-life treatment.

The EPR, which prevailed, for instance, in France when the diffuse water pollution charge was introduced in 2000, could be extended to other industries marketing products that generate significant water pollution. Through EPR, the cost of negative environmental externality is internalized in the economic calculation of the producer. Following this logic, pharmaceutical producers could be held liable for the costs of the pollution their products generate and pay a specific water pollution charge.

Concluding Remarks

Based on the analyses presented in the previous sections and taking into account the ecologic transition challenges that WSS services are faced with, the following recommendations were formulated.

General

1. Governments should review the legal mandate of economic regulators of WSS to identify gaps that prevent them from implementing requirements to better reflect the full cost of WSS services (including environmental externalities and resource costs) in accordance with the EU Water Framework Directive (WFD) and either expand their mandates accordingly or strengthen formal coordination among regulatory authorities and between regulatory and policy-making authorities.
2. Governments should establish and contribute to funds, possibly administered by economic regulators, that provide for investment in innovative technologies, research, and green infrastructure to address environmental externalities and reduce resource costs.

Environmental Externalities & Resource Costs

3. Regulators should, where their mandates permit, re-evaluate their regulatory philosophy to shift away from a narrow ‘regulation of natural monopolies’ focus towards a broader role as regulators of externalities.
4. Governments should review existing water abstraction charging schemes to ensure that they adequately reflect the opportunity cost of water, particularly with respect to water scarcity arising from climate change, population and economic growth. Charges should reflect usage intensity, water source renewal (i.e., groundwater vs. surface water), and competing uses.
5. Regulators should, where the abstraction regime managed by other agencies is insufficient for reflecting true resource costs, introduce a supplementary resource cost tariff component earmarked for investment in mitigating and addressing water scarcity risks (i.e., aquifer renewal, resource cost research, etc).

Circular Economy

6. Regulators should adopt the EU’s formal definition of Circular Economy (CE) practices, designate CE practices accordingly and, if possible, categorise CE investments separately in their tariff methodologies.
7. Regulators should ensure that revenue earned from the provision of services and sale of energy/materials generated through CE practices is reflected in tariff methodologies in a manner that preserves the economic benefit for the WSS operator – thus incentivising the development of CE practices in the WSS sector.
8. Regulators should engage with other government agencies to ensure that there is whole-of-government coordination to promote CE synergies and coherent cross-sectoral CE strategies and policies.

Emerging Pollutants

9. For pharmaceutical micropollutants, extended producer responsibility and polluter pays principle (WFD) should be implemented thus providing funding for micropollutants treatment investment. Such investment in micropollutant treatment will increase water REUSE capacity, thus promoting CE practices in the WSS sector.
10. Regulators should include in their tariff determination methodologies a cost component to reflect a precautionary principle with regard to emerging pollutants and direct the revenue collected to fund further research and monitoring capabilities for these pollutants.

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Annex I: WAREG Members & Observers

WAREG Members

Albania	ERRU - Water Regulatory Authority
Azores Islands (PT)	ESARA - Water and Waste Services Regulation Authority
Armenia	PSRC - Public Services Regulatory Commission
Brussels-Capital Region (BE)	BRUGEL - The Brussels Energy Regulatory Commission
Bulgaria	EWRC - Energy and Water Regulatory Commission
Croatia	VVU - Council for Water Services
Estonia	ECA - Estonian Competition Authority
Flanders (BE)	VMM - Flemish Environment Agency
France	MEDDE - Ministry for Ecological and Solidary Transition
Greece	SSW - General Secretariat for Natural Environment & Water
Georgia	GNERC - Georgian National Energy and Water Supply Regulatory Commission
Hungary	HEA - Hungarian Energy and Public Utility Regulatory Authority
Ireland	CRU - Commission for Regulation of Utilities
Italy	ARERA - Regulatory Authority for Energy, Networks and Environment
Kosovo	WSRA - Water Services Regulatory Authority
Latvia	PUC - Public Utilities Commission
Lithuania	VERT - National Energy Regulatory Council
Malta	REWS - Regulator for Energy and Water Services
Moldova	ANRE - National Agency for Energy Regulation
Montenegro	REA - Energy Regulatory Agency
Northern Ireland (UK)	NIAUR - Authority for Utility Regulation
North Macedonia	ERC - Energy Regulatory Commission of the Republic of Macedonia
Portugal	ERSAR - Water and Waste Services Regulation Authority
Romania	ANRSC - National Romanian Regulator for Public Services
Scotland (UK)	WICS - Water Industry Commission for Scotland

WAREG Observers

Denmark	KFST - Danish Competition and Consumer Authority
England & Wales (UK)	OFWAT – Water Services Regulation Authority
Spain	MITECO - Ministry for Ecological Transition
Turkey	MOFWA - Ministry of Water and Forestry of the Republic of Turkey
Poland	PGWWP - State Water Holding Polish Waters

Annex II: Circular Economy Categories

Council Regulation (EC) 2020/852 of 18 June 2020, Article 13(1)

1. An economic activity shall qualify as contributing substantially to the transition to a circular economy, including waste prevention, re-use and recycling, where that activity:

(a) uses natural resources, including sustainably sourced bio-based and other raw materials, in production more efficiently, including by:
   a. reducing the use of primary raw materials or increasing the use of by-products and secondary raw materials; or
   b. resource and energy efficiency measures;

(b) increases the durability, reparability, upgradability or reusability of products, in particular in designing and manufacturing activities;

(c) increases the recyclability of products, including the recyclability of individual materials contained in those products, inter alia, by substitution or reduced use of products and materials that are not recyclable, in particular in designing and manufacturing activities;

(d) substantially reduces the content of hazardous substances and substitutes substances of very high concern in materials and products throughout their life cycle, in line with the objectives set out in Union law, including by replacing such substances with safer alternatives and ensuring traceability;

(e) prolongs the use of products, including through reuse, design for longevity, repurposing, disassembly, remanufacturing, upgrades and repair, and sharing products;

(f) increases the use of secondary raw materials and their quality, including by high-quality recycling of waste;

(g) prevents or reduces waste generation, including the generation of waste from the extraction of minerals and waste from the construction and demolition of buildings;

(h) increases preparing for the re-use and recycling of waste;

(i) increases the development of the waste management infrastructure needed for prevention, for preparing for re-use and for recycling, while ensuring that the recovered materials are recycled as high-quality secondary raw material input in production, thereby avoiding downcycling;

(j) minimises the incineration of waste and avoids the disposal of waste, including landfilling, in accordance with the principles of the waste hierarchy;

(k) avoids and reduces litter; or

(l) enables any of the activities listed in points (a) to (k) of this paragraph in accordance with Article 16.

Annex III: Survey Questions

Below are the questions administered to select WAREG members during interviews undertaken in November 2021.

Part 1: Environmental Externalities

1.1 - Capabilities

a. How many environmental scientists, economists, or engineers are employed by your organisation? (Number of full-time equivalents)
b. How much money is spent annually on measuring and costing environmental externalities?
c. What portion of this expenditure is incurred through external consulting fees?
d. What are your organisation's future plans for modifying its capabilities to measure/cost environmental externalities? (e.g., hiring plans, budget changes, outsourcing, etc)

1.2 - Governance

a. Who in your organisation directly responsible for measuring and costing environmental externalities?
b. Does your organisation coordinate/collaborate with other government bodies to perform environmental externalities assessments? (e.g., Environment minister, environmental protection regulator, etc)
c. Which officials or agencies hold your organisation accountable with regard to measuring/costing environmental externalities? (e.g., Environment minister, environmental protection regulator, etc)
d. Is there a public consultation mechanism for measuring and costing environmental externalities?

1.3 - Aquatic Externalities

a. Does your organisation impose water abstraction charges?
b. Are there different abstraction rates according to the water stress level of the geographic area?
c. Are there different abstraction rates for groundwater vs. surface water abstraction?
d. Are these abstraction charges disaggregated between non-agricultural industry and households?
e. Does your organisation impose water pollution charges?
f. Are these pollution charges disaggregated between non-agricultural industry and households?
g. Which economic methods are used to assess aquatic environmental externalities?
h. What other economic instruments are used to capture or reduce aquatic environmental externalities? (e.g., payments for ecosystem services, compensation schemes, emission permits, etc.)
i. Does your organisation promote/incentivise investment in research or technologies relating to addressing water resource depletion? (e.g., grants, allocated tariff component, etc)

1.4 - Non-aquatic Externalities

a. Has your organisation implemented any incentivisation practices or requirements directed towards regulated operators targeting the following? If so, what are they? If not, are there any plans to do so?
    i. Energy efficiency

ii. Decarbonisation
iii. Use of recycled products
iv. Waste recycling
v. Waste generation
vi. Soil pollution / degradation
vii. Air pollution
viii. Noise pollution
ix. non-aquatic biodiversity
x. Nature-based solutions
xi. Environmental aesthetics
xii. Any other non-aquatic environmental externality

b. Has your organisation implemented any incentivisation practices or requirements directed towards regulated operators targeting the following? If so, what are they? If not, are there any plans to do so?
c. Does your organisation promote/incentivise investment in research or technologies relating to addressing pollution abatement? (e.g., grants, allocated tariff component, etc)

1.5 – Ecosystem Services

a. Has your organisation captured the value of any of the following ecosystem services? If so, what are they? If not, are there any plans to do so?

i. Fisheries and aquaculture
ii. Raw biotic materials (e.g., algae as fertilizer)
iii. Water purification (e.g., excess nitrogen removal by microorganisms)
iv. Air quality improvement (e.g., deposition of NOx on vegetal leaves)
v. Erosion prevention (e.g., vegetation controlling soil erosion)
vi. Flood protection
vii. Maintaining populations and habitats
viii. Pest and disease control (e.g., natural predation of diseases and parasites)
ix. Soil formation and composition (e.g., rich soil formation in flood plains)
x. Carbon sequestering (e.g., carbon accumulation in sediments)
xi. Local climate regulation (e.g., maintenance of humidity patterns)
xii. Recreation (e.g., swimming, recreational fishing, sightseeing)
xiii. Intellectual and aesthetic value (e.g., matter for research and artistic representations)
xiv. Abiotic energy sources (e.g., hydropower generation)
xv. Any other ecosystem service.

1.6 – Performance Measurement

a. What key performance indicators (KPIs) does your organisation use to measure environmental externalities (i.e., energy efficiency, carbon emissions, contaminant volume, water leakage, pollution incidents, etc.)
b. Are there any plans to introduce new environmental KPIs? If so, what are they?
c. Does your organisation currently have the internal technical capacity to develop environmental KPIs or does it outsource this?

Part 2: Circular Economy

Adoption of circular economy practices

a. Has your organisation formally adopted a specific definition the "circular economy" (distinct from "sustainability" and the "Four R's")?
b. Does your organisation have a framework in place for identifying 'circular economy' practices?
c. Does your organisation coordinate/collaborate with other government bodies and industry to support circular economy practices?
d. Has your organisation implemented any practices or requirements regulated operators' adoption of the following? If so, what are they? If not, are there any plans to do so?
    i. Use of primary raw materials and products made from them
    ii. Use of secondary raw materials and recycled/remanufactured products
    iii. Substitution of products containing hazardous substances
    iv. Procurement of products that are themselves recyclable
    v. Procurement of repairable products and infrastructure
    vi. Sharing of capital, infrastructure, or products
    vii. Designing processes to preserve the economic value of materials
    viii. Waste generation
    ix. Waste recycling
    x. Incineration and landfilling
    xi. Wastewater reuse
    xii. Nutrient recovery
    xiii. Biogas production
    xiv. Any other circular economy measure

Part 3: Resilience

3.1 - Water Scarcity

(a.) Has your organisation implemented any incentivisation practices or requirements directed towards regulated operators and targeting the following? If so, what are they? If not, are there any plans to do so?

i. Urban greywater reuse
ii. Industrial water recycling
iii. Agricultural water reuse
iv. Water recycling
v. Desalination
vi. Abstraction reduction
vii. Water leakage
viii. Water usage efficiency
ix. End-user water consumption
x. Any other water-scarcity measure

(b.) Does your organisation promote/incentivise investment in research or technologies to address water scarcity? (e.g., grants, allocated tariff component, etc)

(c.) Does your organisation coordinate/collaborate with other government bodies and industry to address water scarcity (e.g., land use planning)? If not, does it plan to do so?

3.2 - Emerging Pollutants

a. Does your organisation apply the precautionary principle to emergent pollutants by the following? If not, are there any plans to do so?

i. Compulsory monitoring of emergent pollutant presence in water bodies performed by regulated operators.
ii. Collecting a fee to fund future investment to address emerging pollutants
iii. Collecting a fee to fund the mitigation of potential and unknown externalities
iv. Any other measure to address uncertainties associated with emergent pollutants.

b. Does your organisation promote/incentivise investment in research or technologies to better monitor and address emerging pollutants (e.g., grants, allocated tariff components, etc)? If not, does it plan to do so?

c. Does your organisation coordinate/collaborate with other government bodies and industry to address emerging pollutants (e.g., pharmaceutical and chemical regulators)? If not, does it plan to do so?