Interreg Sudoe

EUROPEAN UNION

TWIST

European Regional Development Fund

Annex 4. Circular economy Action Plan

Annex to the E1.3.1 TWIST Common STrategy for mutual learning and capitalisation of RIS3 results

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Table of contents

1. Introduction 1
2. Circular Economy and the wastewater sector 3
3. Citation List 15

List of figures

Figure 1.1 - TWIST Mission and Strategic Objectives 1
Figure 2.1 - Categories of water reuse 5
Figure 2.2 - Costs and benefits of water reuse for major stakeholders 6
Figure 2.3 - Ladder of increasing value propositions related to wastewater treatment... 8

List of acronyms and abbreviations

EU – European Union

PHA - Polyhydroxyalkanoates

R&D&I – Research, development and innovation

RIS3 - Research and Innovation Smart Specialization Strategies

SME – Small and medium enterprise

TWIST – Transnational Water Innovation Strategy

UE – Unión Europea

WWTP – Wastewater treatment plant

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1. Introduction

The Transnational Water Innovation Strategy (TWIST) has framed the project and its goals within the European strategic and policy context and has set a strategic framework to execute the defined objectives.

The defined vision for the TWIST strategy is:

"A territory that is resilient to market and climate changes, that stimulates economic growth and environmental protection by being anchored in innovation and stakeholders engagement".

In order to accomplish the defined vision, a mission and four strategic objectives have been set as showed on Figure 1.1.

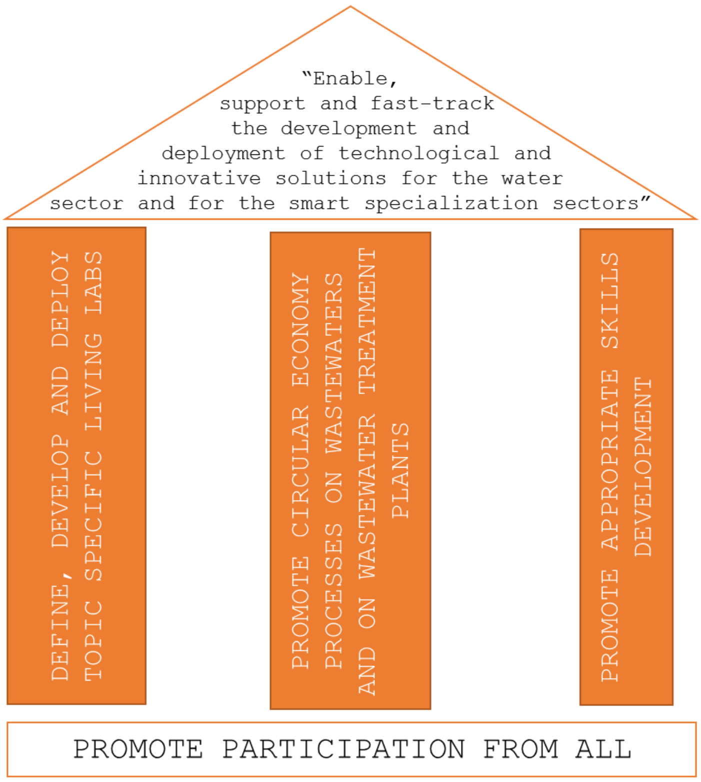

Figure 1.1 - TWIST Mission and Strategic Objectives

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It is therefore aimed for the strategy to become an engine for innovation of the water sector within the TWIST regions using as leverage the Research and Innovation Smart Specialization Strategies (RIS3).

This Action Plan defines steps that assist on the adoption of circular economy processes on wastewaters, on wastewaters treatment plants and through land use management, as foreseen in the Strategic Objective 2 of the TWIST strategy.

2. Circular Economy and the wastewater sector

Over the last centuries production processes and consumption patterns have developed in a linear manner, where the take-make-use-dispose approach prevailed leading to negative impacts on the environment, on businesses and on people.

As consequence the paradigm is shifting towards a circular model that supports the sustainable development goals and is supported by material and resources efficiency principles.

In light of the raising water and energy demands and their associated cost, of the increasingly strict measures of pollution control and prevention imposed by the EU, the water and wastewater sectors have been seeking solutions for a change, adhering to a greener and circular economy guided by sustainable development principles.

Wastewaters are now seen as a potential source of natural resources offering the possibility of recovering energy, water, nutrients and materials.

The recovery of energy, water and raw materials from the treatment process is becoming praxis where treated wastewater is reclaimed and energetic materials, biogens (nitrogen and phosphorus), hydrogen and plastics are recovered.

These materials once seen as residues are not anymore the end of the production chain being further used as raw materials in other industries and processes allowing recovered materials to be kept in the loop throughout the entire supply chain. Thus, the circular economy model requires not only changes in the production and consumption models, but also new business models and systems. Changing the entire production system and closing the production cycles is key to enable sustainable development and resources sustainability.

The circular economy model when compared to the linear model requires less input and more efficient use of natural resources and allows reduction of emissions, of losses and of material residues.

Thanks to the changes at all stages of a product's life cycle, the circular economy is conducive to minimising the negative environmental impacts of manufactured products, improving macroeconomic indicators and the climate.

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Resources recovery and reuse can arise from three main streams:

- The water stream;
- The materials/resources stream, and;
- The energy recovery stream.

The **water stream** relates to recover and reuse treated water for specific purposes other than drinking, it includes *inter alia,* industrial uses, agriculture, toilet flushing or landscape irrigation or aquifer replenishment. Furthermore, nowadays technology allows reclaimed water to be of a quality that can be safely consumed by humans. This can have great relevance in areas such as the TWIST regions, which are consistently under water stress. Thus, reuse treated water can become an important instrument for drought relief and for climate change adaptation.

Innovation and technological advances are of utmost importance on boosting the use of reclaimed water through improvements on the treatment processes, of its efficiency and on the quality of the recycled water. In parallel, engagement with civil society and end-users needs to take place working towards a wider acceptance of reclaimed water in the perspective “the right water for the right use”.

Wastewater reuse has many potential utilisations after being adequately treated. Figure 2.1 shows some of the categories of water reuse[1].

[1]From http://wedocs.unep.org/bitstream/handle/20.500.11822/8390/Water%20and%20Wastewater%20Reuse_%20An%20Environmentally%20Sound%20Approach%20for%20Sustainable%20Urban%20Water%20Management-20043596.pdf?sequence=3&isAllowed=y

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Category of reuse	Examples of applications
• Urban use	
Unrestricted	Landscape irrigation of parks, playgrounds, school yards, golf courses, cemeteries, residential, green belts, snow melting
Restricted	Irrigation of areas with infrequent and controlled access
Other	Fire protection, disaster preparedness, construction
• Agricultural	
Food crops	Irrigation for crops grown for human consumption
Non-food crops and crops consumed after processing	Irrigation for fodder, fibre, flowers, seed crops, pastures, commercial nurseries, sod farms
• Recreational use	
Unrestricted	No limitation on body contact: lakes and ponds used for swimming, snowmaking
Restricted	Fishing, boating, and other non-contact recreational activities
• Environmental enhancement	Artificial wetlands creation, natural wetland enhancement, stream flow
• Groundwater recharge	Groundwater replenishment for potable water, salt water intrusion control, subsidence control
• Industrial reuse	Cooling system water, process water, boiler feed water, toilets, laundry, construction wash-down water, air conditioning
• Residential use	Cleaning, laundry, toilet, air conditioning
• Potable reuse	Blending with municipal water supply, pipe to pipe supply

(Asano and Levine, 1998)

Figure 2.1 - Categories of water reuse

Some of the benefits and costs of water reuse for major stakeholders can be seen on Figure 2.2.

Stakeholder	Benefits	Costs	Key factors
Central government	Avoided cost of major inter-state freshwater projects or other new major infrastructure	Initial capital cost of project; net fiscal cost of transfers and compensation paid to other stakeholders	Delineation of fiscal and financial responsibilities between different layers of administration; water pricing policy; access to external funding; mandatory health and environmental standards (e.g. EU)
State governments, regional water authorities	Revenues from sale of bulk fresh water to cities; fiscal revenues from further development of urban and rural areas due to greater water security	Capital funding of schemes and O&M costs; purchase(*) of effluent from municipal WWTPs; any fiscal transfers entailed	Division of financial and fiscal responsibilities between central, regional and local governments; local environmental and public health regulations
Municipal utilities	Avoided costs of alternative water solutions; savings in effluent treatment costs; Extra revenues * from urban water sales; reduced pollution charges	Capital and operating costs of new facilities and infrastructure; costs of public health measures and restrictions on amenity	Tariff policy for effluent and fresh water; apportionment of costs between users and authorities;** degree of current and future urban shortages
Farmers	Greater reliability of effluent; savings in abstraction and pumping; savings in fertilizer; increase in yields and sales revenue	Cost of produce restrictions; reduced amenity, reflected in price of land	How much of project cost borne by and recovered from farmers; alternatives available, e.g. own groundwater; price charged for effluent, compared to that of fresh water; ability to sell existing water entitlement; severity of produce restrictions

Figure 2.2 - Costs and benefits of water reuse for major stakeholders[2]

The **materials stream** includes reuse and recovery of a wealth of organic and inorganic materials from raw wastewater, semi-treated wastewater streams and sewage sludge.

[2]Andersson et al. (2016)

Treated sludge can be applied as a fertilizer and as a soil conditioner and stabiliser in forestry, in areas suffering from erosion or in land reclamation.

Recovering phosphorus as struvite is also an opportunity that is likely to bring benefits as would allow the recovery of a scarce resource within the European space while also bringing cost-savings on maintenance of wastewater treatment plants as struvite creates a nuisance by clogging pipes and equipment's.

The cement industry can also use sludge as an alternative fuel source in cement kilns as it has calorific value. For this reason, it can also be used to produce energy – thermal or electric depending on the technology available.

Using sludge for energy production has environmental and economic benefits as it assist on reducing greenhouse gases emissions and the reliance on fossil fuels, being therefore an important tool to meet EU's sustainability targets. Even after combustions sludge ash can be of value and used to produce struvite or in the construction sector as a mineral filler, in asphalt paving mixes or in brick manufacturing. This is also an opportunity to engage with other industries promoting the capture and reutilization of wastewater stream nutrients while avoiding the release of eutrophication agents and contaminants to the aquatic biota maximizing this way circular economy opportunities and environmental protection.

Metals such as copper, silver and gold can also be recovered from the ashes that remain after burning sewage sludge. More recently biodegradable plastics from polyhydroxyalkanoates (PHA) are being produced and tested, and attempts are being made to directly generate electricity during the process of removing contaminants from wastewater using Biological Fuel Cells.

The **energy stream** can be of especial relevance as a sustainability lever and as a cost-reduction measure. Energy recovery can be done through biogas production, heat pumps in treatment plant effluents, and energy recovery from various high temperature streams by heat exchanger.

This approach is key on a circular economy and brings environmental and economic gains both for the water sector as a resources provider, and for other industries that rely on those from natural sources which are scarce, finite and at the mercy of global price competition.

The benefits are plenty and they tend to increase in value with more ambitious investment in sustainability terms. Figure 2.3 shows the ladder of increasing value propositions based on increasing investments and cost recovery potential[3].

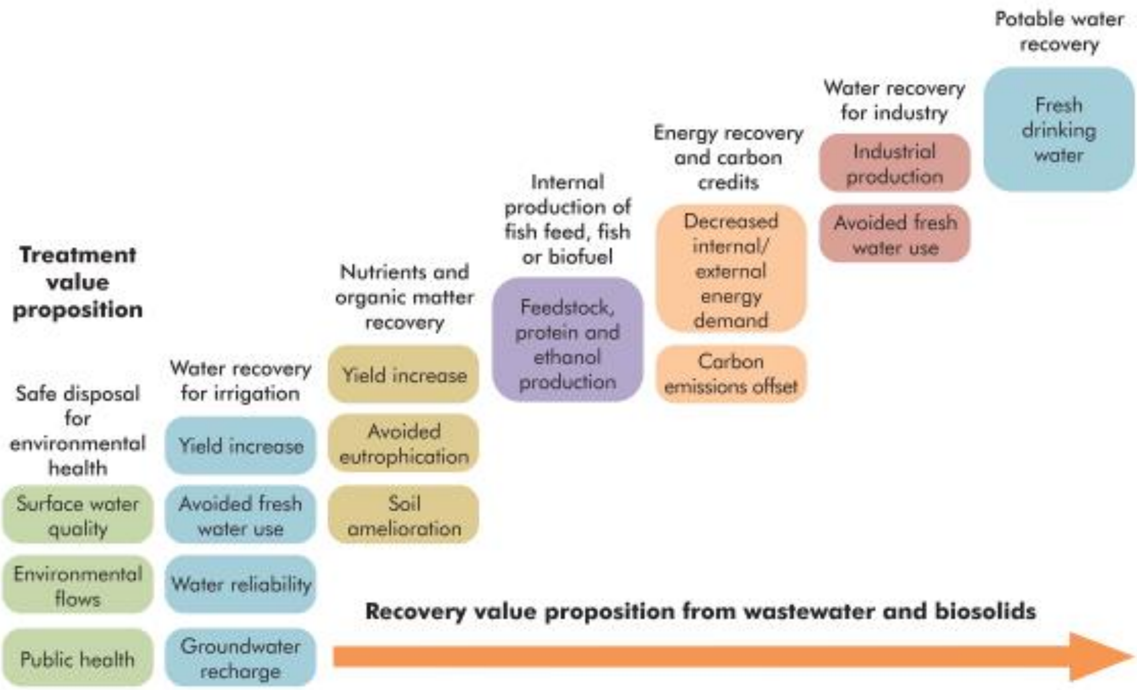

Figure 2.3 - Ladder of increasing value propositions related to wastewater treatment

Resources recovery and reuse allows to "close the loop" for wastewater treatment and bridges the gap with other sectors. Efforts should be made to build consistent communication networks between all agents of the quadruple helix identifying industry's needs and existing (or potential) recovered resources, creating business and technological or organizational innovation opportunities. Promoting structures similar to clusters is likely to be of benefit as it would gather in a network relevant stakeholders promoting this way new opportunities of business.

[3]From http://wedocs.unep.org/bitstream/handle/20.500.11822/8390/Water%20and%20Wastewater%20Reuse_%20An%20Environmentally%20Sound%20Approach%20for%20Sustainable%20Urban%20Water%20Management-20043596.pdf?sequence=3&isAllowed=y

A strong and integrated industrial base is key for economic growth and competitiveness, and the use of recovered resources can be key to develop territorial economies and technology sectors allowing access to recovered raw materials energy. SMEs and research centres can play a major role on boosting these opportunities and on the building up of complete and integrated value chains which are instrumental for productivity gains.

Other options can be explored being creative thinking and innovative solutions vital to make the wastewater sector more efficient, sustainable and cost-effective. As suggested by IWA (2017) solutions of retrofitting, re-thinking and re-imaging should be considered involving issues like novel units being included in conventional processes, flow sheet modifications or creating completely new concepts.

Managing water resources through land use managementby using the natural environment to provide treatment, storage, buffer and recreational solutions can bring multiple benefits and cost savings for WWTP.

According the literature, following resources have the potential to be recovered from wastewaters:

- Cellulose;
- Phosphorus;
- Nitrogen;
- PHA;
- Bioenergy – Biogas; biohydrogen; biodiesel;
- VFA;
- Metals (Fe; Al; Ti; Zn; Cu; Sn; Mn; Cr; Mo; Ag; Ni; U; V);
- Single cell proteins;
- Pharmacs
- Enzymes
- Hormones.

The actions suggested to promote the adoption of the circular economy model are listed below. Some cannot take place if a previous is not carried out, but other can be implemented independently, depending only on decision-making.

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ACTIONS	OBSERVATIONS	WHO	WHEN	HOW	Output
A1 – Identification of the treatment by-products	The by-products and resources with potential to be recovered will depend on the effluent characteristics, thus varying from WWTPs	Utilities responsible for wastewater treatment.			
A2 – Identification of the industrial sectors that use the recovered resources as raw materials					
A3 – Identification of local industries and manufacturers across the entire supply chain that are likely to use the different treatment by-products					
A4 – Liaison with local industries and manufacturers to ascertain their resources needs and openness to use the by-products					

A5 - Work to raise awareness of the industries, farmers and the public regarding the safe use of the recovered products and of its importance	Engage with local and regional authorities to promote Public Awareness events This can also serve as basis to promote near the government the creation of specific regulations				
A6 – Liaise with SMEs, Universities, Research Centres and technology providers to promote R&D&I with regard to possible new commercial applications of the treatment by-products and to the development of new treatment technologies					
A7 – identify needs/potential to improve efficiency in existing facilities					
A8 – Work with the industry to identify energy					

and resource efficiency measures					
A9 – Identify opportunities of co-digestion using other types of biomass, such as food waste.					
A10 – Identify needs/ potential for upgrading facilities					
A11 – Identify needs/ potential of new technologies implementation					

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3. Citation List

Andersson, K., Rosemarin, A., Lamizana, B., Kvarnström, E., McConville, J., Seidu, R., Dickin, S. and Trimmer, C. (2016). Sanitation, Wastewater Management and Sustainability: from Waste Disposal to Resource Recovery. Nairobi and Stockholm: United Nations Environment Programme and Stockholm Environment Institute.

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