D.T2.5.1

REGIONAL STRATEGY – CROATIA

Project Title: REEF2W Increased renewable energy and energy efficiency by integrating, combining and empowering urban wastewater and organic waste management systems

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Table of content

1. PURPOSE AND SCOPE

1.1. Purpose (REEF 2W)

Purpose of this deliverable is to develop a Regional Strategy with the aim to enable production of renewable energy at the pilot Zabok by using both wastewater sludge complemented with bio-waste collected in the region. To this end, the Regional Strategy focuses on: introducing anaerobic treatment- co-digestion of sludge and bio-waste at the wastewater treatment plant (WWTP) Zabok, utilization of biogas (CHP and biomethane) and application of digestate as soil improver.

Evidence of the potential of wastewater-to-energy solutions, which is demonstrated in this strategy and other documents deriving from REEF 2W, invites all stakeholders in the waste and wastewater sector to actively participate in process of implementation of REEF 2W solutions.

Regional and local government can enable solid waste and wastewater utilities to implement these solutions. REGEA as their partner is prepared to inspire them and to support them in all ways to effectively make use of the tools and knowledge developed in REEF2W and to be successful in implementing chosen and feasible solutions.

1.2. Problem Statement

Problems regarding climate change, energy security, energy independence, energy transition are present (and must be addressed) both on global and local scale.

Potential of renewable energy in waste and wastewater sector is addressed through REEF 2W and Strategy is one portion of overall efforts to decrease energy consumption, make energy transition and implement more energy efficient solutions that help to make more energy independent WWTPs (and then consequently their communities).

Problems regarding the Croatian case are that the energy component and sludge disposal of the WWTPs are not sufficiently recognized in waste and water management in Croatia.

1.3. Target Group

Target group in this project and strategy comprises local (cities and municipalities) and regional (counties) authorities as well as regional (scope of the project) utilities from waste and wastewater sector.

1.4. Scope

Strategy focuses on pilot Zabok, but in accordance with its results, Strategy can be applicable and usable for other waste and wastewater operators and stakeholders both on regional and national level.

One of the largest projects in the water sector in the operating area of Zagorski vodovod Ltd. (wastewater operator) is currently ongoing with a value of 63,5 million EUR (excluding VAT). The project includes the (extension and) construction of the Zabok and Zlatar drainage system (Zabok system 118 km, Zlatar system 54 km) and the construction of two WTTPs (WWTP Zabok (Oroslavje) with a capacity of 36.940 ES and WWTP Zlatar Bistrica with a capacity of 14.690 ES). The area comprises the towns of Zabok, Oroslavje, Donja Stubica and Zlatar and the municipalities of Veliko Trgovišće, Bedekovčina, Sveti Križ Začretje, Mače, Stubičke Toplice, Gornja Stubica, Marija Bistrica, Zlatar Bistrica, Konjščina and Lobor (all in Krapina-Zagorje County).

The REEF 2W solutions proposed for this (pilot) location (both are considered in the Regional Strategy and in the Feasibility Study) contain the following: introducing anaerobic treatment- co-digestion of sludge and bio-waste to the WWTP Zabok, utilization of biogas (CHP and biomethane) and application of digestate as soil improver.

1.5. Time frame/horizon

The timeframe for implementing this strategy as well as feasible solutions for the pilot is 2021-2027 and it corresponds to the period of the new “Operational Programme Competitiveness and Cohesion” planned for that period. Namely, we stronglybelieve that this fund could and should be a source of co-financing for the pilot, as well as for other projects that would result from the REEF 2W program, solutions and its strategy. This reasoning is also based on the fact that the first phase of the Zagroski vodovod Ltd. project (described under Scope 1.4) was co-financed from the same programme, but for the period 2014-2020.

2. BACKGROUND

2.1. General facts

Waste sector on national level

In Croatia, waste management is currently one of the largest challenges in the environmental sector and certainly one of the most demanding areas in terms of adjustment to the standards of the European Union (EU).

The country is expecting that in 2025 almost the entire population will be included in the organized collection of a municipal waste system. This will lead to a significant increase in the recycling and treatment of waste, thus reducing the disposal of municipal and biodegradable waste. **Croatia still lacks an effective waste management system.** Waste export practices imply high costs for the country, which could be reduced by establishing the correct infrastructure and technology. Croatia moves towards more effective and more efficient waste management systems. It already started to implement efficientwaste management systems whose results will be noticed in the forthcoming years.

Currently municipal waste management in Croatia is **undergoing a radical transformation from decentralized disposal of non-treated waste** on numerous local sub-standard landfills within counties to **centralized waste management and Waste Management Centres (WMC),** serving the needs of one county or, in some cases, of several counties.

Waste sector on Regional level (Krapina-Zagorje County and City of Zagreb)

Krapina-Zagorje County

Area:	**1.229 km^2 (7 cities and 25 municipalities)**
Population:	**132.892**
Number of Utilities:	**6**
Total Amount of Municipal Waste in 2018:	**24.032 t**
Municipal Waste per Capita per Year:	**180 kg**
Share of Mixed Municipal Waste:	**18.549 t (77%)**
Bio-waste Collected in 2018:	**86 t**

There are following goals in Krapina-Zagorje County Plan for waste management to achieve by 2020 in accordance with National Plan for Waste Management:

- Reduce total amount of communal waste by 5%
- In house composting
- Separately collecting 40% weight of produced bio-waste which is integral part of municipal waste
- Building a plant for biological treatment of separately collected municipal waste (2020)

- Establishing a system for management of sewage sludge (2022)

Separate collection of municipal waste will be introduced in all local self-government units in the Krapina-Zagorje County. In 2018 separate collection of communal bio-waste (biodegradable waste from kitchens and canteens, edible oils and fats, biodegradable waste from gardens and parks, waste from markets) was carried out in the cities of Krapina, Zabok and Zlatar, and in 12 surrounding municipalities. In total, 86,3 tonnes of municipal bio-waste were collected by the local self-government units, which represents 0.4% of the total municipal waste collected.

With co-financing from the Environmental Protection and Energy Efficiency Fund, remediation activities are conducted at all 6 municipal waste landfill sites with the ultimate goal of closing them, given that the Krapina-Zagorje County, along with 3 other north-western counties, has opted for a regional waste management centre intended to serve whole north-western Croatia.

Krapina-Zagorje County, Međimurje, Varaždin and Koprivnica-Križevci County, and the municipality of Koprivnički Ivanec founded the company "Piškornica" Ltd. in 2009, because of implementation of the project for the construction of the regional waste management centre of north-western Croatia at the Piškornica site in the municipality of Koprivnički Ivanec.

The Northwest Regional Waste Management Center (RWMC) Croatia has foreseen six transfer stations (TS) for the region of north-western Croatia. At the transfer stations, recycling yards will be established where the waste will be collected for recycling, and waste from TS will be transported by special trucks to the RWMC in Koprivnički Ivanec. One of the six transfer stations is scheduled at the Zabok site.

City of Zagreb

Area:	**641 km^2**
Population:	**802.338**
Number of Utilities:	**1**
Total Amount of Municipal Waste in 2016:	**327.013 t**
Municipal Waste per Capita per Year:	**408 kg**
Share of Mixed Municipal Waste:	**219.184 t (67 %)**
Bio-waste Collected in 2016:	**32.640 t**

For the production of bio-energy at the regional WWTPs, the investigation of aspects related to the utilization of bio-waste plays a key role.

Bio-waste management moving towards recovery through biogas plants (as feedstocks for biogas production) or through composting. Separately collected bio-waste will be taken to material recovery at biological treatment plants (aerobic or anaerobic) to produce compost or digestate and biogas. Waste edible oils and fats can only be processed by anaerobic digesters. To achieve this, equipment and vehicles for separate collection of bio-waste and facilities for biological treatment of separately collected bio-waste should be provided.

The complete analysis of potential bio-waste that can be collected within the agglomerationZagreb, will be presented in an integrated study for the pilot location (deliverable D.T3.3.5.).

Wastewater sector on national level

For water management purposes, Croatia's territory is divided into four water basins and 34 catchment areas. The water basin comprises one or more catchment areas of major river watercourses, or parts thereof, constituting a natural hydrographical entity.

There are four wastewater treatment systems in use in Croatia: mechanical, biological, membrane, plant lagoon. There are two types of Sewage systems: mixed and separate.

The predominant sewage system used is a mixed one (faecal and precipitation waters together). Only a few smaller cities and residential districts of bigger towns have separate or split sewage systems (faecal and precipitation waters are split). Household wastewater disposal falls under the administrative competence of the local government authorities (municipalities). All major Croatian towns have a sewage system for the collection of municipal wastewater in place; WWTPs are present and functioning to varying degrees.

At a local level, there are a relatively large number (143) of municipal companies responsible for public water supply in Croatia. Similarly, public wastewater systems are managed by 130 public utility (municipal) companies, some of which are also responsible for water supply. The owners of these companies are local self-government units.

According to the Waste Management Plan of the Republic of Croatia for the period 2017-2022, adequate management of the sludge from WWTPs disposal is not established in Croatia, which is primarily related to the required infrastructure. The Waste Management Plan sets targets for waste management, which should be achieved by 2022 compared to 2015. It is necessary to improve the management system for special categories of waste and to establish a waste sludge management system from WWTPs. The document on treatment and disposal of waste and sludge generated by the treatment of wastewater on public wastewater systems of towns and municipalities in Croatian counties (Croatian Waters, 2013) has estimated that existing WWTPs produce about 35,000 to 40,000 tons of sludge on dry basis annually.

Wastewater sector on Regional level (City of Zagreb, parts of Krapina-Zagorje and Zagreb County = Zagreb Urban Agglomeration)

Zagreb Urban Agglomeration

Area:	**2.911 km^2**
Population:	**1.086.528**
Number of Utilities:	**7**
Total Number of WWTPs (active or planned):	**32**

Zagreb Urban Agglomeration includes the city of Zagreb as the seat of the agglomeration and parts of the Zagreb and Krapina-Zagorje counties. More specifically, the

agglomeration encompasses a total of 30 local government units - 11 cities and 19 municipalities.

Regarding the area of our pilot project, there is Zagorski vodovod Ltd., utility company, owned by 26 local self-government units that are engaged in public water supply and sewage. The company is responsible for water supplies for 90.000 inhabitants with more than 31.000 terminals. In the public water drainage system of the Zagorski Vodovod Ltd. 4 WWTPs and 5 pumping stations are included. The total drainage network of public sewers is over 250 km. The company is actively interacting with the national REEF 2W partners in Croatia (ZCH and REGEA), giving all the data for the tool, participating in the relevant capacity building activities, dissemination events and trainings to be constantly updated about project outcomes and benefits.

2.2. REEF 2W approach and solutions

In the wake of the energy transition, an increased focus is on the yet unexploited energy-saving potential of the solid waste and wastewater sector. WWTPs are large consumers of energy and make key contributions to the carbon footprint of municipalities and urban governments. Their energy consumption usually accounts for the bulk of operational costs of wastewater utilities, sometimes up to 60 per cent. Despite being a large source of electricity and heat, sewage is generally not included in the calculation. In fact, the amount of energy it contains can be 10 times bigger than what is required to treat it. Lately, an increasing number of utilities have deployed energy-efficiency measures and novel technologies to better harness the energy of sewage. Evaluations of pioneering projects show that utilities are not only capable of becoming energy self-sufficient, but also suppliers of energy thereby diversifying the local mix.

The project's main objective is to drive up energy efficiency and renewable energy production in solid waste and wastewater facilities. It focuses on solutions that integrate organic waste and wastewater streams and the development of new infrastructures. Where beneficial bio-waste will be used to enrich the organic content of sewage sludge, it helps to elevate outputs of heat and electricity in a process called co-digestion.

2.3. External Analysis

In the waste management sector, the main task is the implementation of the main goals of the Regional Strategy set for the period between 2005 and 2025:

- Establishment of an integrated waste management system
- Remediation and closure of the existing landfills
- Remediation of the "black spots"
- Development and establishment of regional and county waste management centres
- Establishment of complete computerization of the waste management

In the wastewater management sector, the development priorities are (among others) systems that will realize the full functionality, from connection, collection, drainage, treatment

to the proper discharge of treated wastewater, taking into account technically sanitary conditions of service provision (water resistance, relief, temporary disposal of sludge, etc.).

In addition to the construction of a public sewerage system—increasing the connection rate of the population to the public sewage infrastructure—significant advances is achieved in improving the sanitary and living conditions of the population and the environment by improving sewage and municipal wastewater treatment.

Therefore, according to the Regional Strategy, the construction of WWTP with a second purification stage is planned, except in coastal areas of less sensitivity where fewer agglomerations are predicted. This will increase the connection rate to the public sewerage system to approximately 60% of the total population (or 2,660,000 inhabitants). The remaining requirements of the Municipal Waste Water Treatment Directive will be implemented in the investment cycle beyond 2023.

Croatia is part of EU since 2013, and is still in process of adjustment to EU laws. It is a complex process that requires a lot of effort, time and financial resources. Major issues and challenges in the waste management in Croatia are, as follows:

- Increased volumes of waste are sent to landfills;
- Limited waste separation at the point of generation, along with low recovery and treatment rates;
- Shortage of municipal waste recovery and treatment plants
- Underdeveloped information and reporting systems

EU legislation requires that the amount of organic material in municipal waste being disposed of at landfills in the Republic of Croatia is reduced by 65% until 2020 compared to 1997 levels. The main objectives defined in the Waste Management Plan (OG No. 3/17) for the period 2017 to 2022 are therefore to increase the fraction of separately collected waste and to reduce the share of biodegradable waste in municipal waste. The Act on Sustainable Waste Management sets out the following objectives to reduce gaseous effluents being emitted from disposed waste with high shares of biodegradable components:

- By 2012 the share of biodegradable municipal waste deposited to landfills must be reduced to 75% of the mass share of biodegradable municipal waste generated in 1997;
- By 2015 it must be reduced to 50 % of the mass share generated in 1997;
- By 2020 it must be reduced to 35 % of the mass share generated in 1997.

The EU Waste Framework Directive and Act on Sustainable Waste Management require that by 2022 50 % of municipal waste is re-treated and recycled, compared to 18 % as of now.

The lack of national support schemes is the main barrier impeding the development of EE and RE measures in WWTPs. Additionally, waste management is another large challenge facing Croatia's environmental sector. To obtain EU standards, for example to name recycling targets, is a challenging task for the government.

Separately collected bio-waste will be taken for material recovery in facilities for biological (aerobic or anaerobic) treatment of separately collected bio-waste (composting plant or anaerobic digestion), in order to produce compost or digestate and biogas.

By the end of 2020, the share of biodegradable municipal waste disposed in landfills must be reduced to 35 % weight of biodegradable municipal waste produced in 1997.

Main barrier relates to disposal of sludge, which is still operated without making use of its resource recovery potential. Various solutions for the treatment and final disposal of sludge have been considered and studied for several decades now.

Croatia currently lacks a nationwide public support scheme that supports RE production in WWTPs.

2.4. Internal Analysis

The above-mentioned project to enhance the water supply infrastructure in the operating area of Zagorski vodovod Ltd. (wastewater operator), is currently ongoing. Project activities include the extension of the Zabok and Zlatar drainage system (Zabok system 118 km, Zlatar system 54 km) and the construction of two WWTPs (WWTP Zabok (Oroslavje), capacity 36.940 ES and WWTP Zlatar Bistrica, capacity 14.690 ES). The construction is expected to be completed by 2020. The Ministry of the Environment and Energy, Hrvatske vode (Croatian waters, national water management body), the Krapina-Zagorje County and all municipalities belonging to this agglomeration are active in this field.

In the meantime REGEA and ZCH will use the outputs of REEF 2W to build capacities and pave the way for a successful implementation of one or more pilot sites in Croatia. In light of the financial model, we believe that an appropriate source for co-financing would be a new "Operational Programme Competitiveness and Cohesion", planned for the period 2021-2027. The project of Zagorski vodovod Ltd. for Zabok & Zlatar agglomeration on which the Regionale Strategy is building, was co-financed from the same programme (67 % of whole price), but for the period 2014-2020. The remaining 33% of the total price will be covered by Zagorski vodovod Ltd., Hrvatske vode (Croatian waters) and the Republic of Croatia. For the REEF 2W pilot, the authors expect approximately the same amount of co-financing and that the co-payment can be covered by Zagorski vodovod Ltd. and regional authorities.

3. METHODOLOGY

3.1. Strategic Framework

The Regional Strategy contains two steps. The first step is to define the vision, goal and objectives. The second step is to formulate strategic areas and strategic actions to be taken.

This strategy is developed in accordance with other strategies and plans, both on national and regional level that are already implemented and that are needed as foundation for this Strategy (see references).

3.2. Data inquiry

Performed data inquiry was based on literature research, interviews with stakeholders, and use and reference to existing knowledge acquired in previous deliverables.

3.3. Stakeholder engagement

Krapina-Zagorje County (where the pilot site is located), as well as Zagreb County and City of Zagreb, all forming regions of the project, are all founders of REGEA. Thus, REGEA maintains direct contact with these stakeholders and can easily communicate and solve problems on a daily basis.

We are in close contact and connection with municipalities, cities and mayors. They are all informed about the project and are constantly updated on its progress.

4. STEP I: VISION, GOAL and OBJECTIVE SETTING – What are we aiming for?

4.1. Vision

The waste and wastewater sector in north-west Croatia is self-sustaining and energy-efficient in 10 years' time (until 2030.), covering its energy demands while also producing additional energy for local communities contributing to make them low-carbon communities.

4.2. Goal

The goal is to influence policy makers, national, regional and local authorities to enable legal and operational framework for implementing REEF 2W solutions

and models in order to implement energy efficiency and renewable energy production in waste and wastewater sector.

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4.3. Objectives

I. Implementing renewable energy production at WWTPs
II. Adding bio-waste in anaerobic digestion WWTPs chain
III. Finding solutions for sludge management

5. STEP II: STRATEGY FORMULATION - How are we implementing our strategy?

5.1. Conclusions from data inquiry

In Croatia, it is necessary to align the management of water flows and sludge flows. The sludge management is part of the overall waste management policy, where utilization of produced sludge is not clear due to the regulations and documents from various state and local government bodies. All this has led to the problem of slowing down the implementation of sustainable waste treatment in practice, even stopping the realization of projects, and thus delaying the realization of plans.

Certain legal regulation in Croatia have to be updated in order to allow easier treatment of bio-waste as well as the usage of sewage sludge.

Priority in Croatia is certainly bio-waste and sewage sludge management. In light of the sewage sludge management, performed analysis confirmed that its utilization is possible in agriculture. In this sense, legal framework must allow WWTPs a manageable utilization of sewage sludge towards the arable areas. In Croatia, there is no solution for the disposal of sewage sludge yet. Feasibility studies must first be carried out to derive appropriate solutions.

In general, within the policy framework, practical experience in adopting legislation on wastewater management at national level in Croatia should be taken more seriously.

5.2. Strategic area with actions

Strategic Area I: Capacity building

Problem statement:

To ensure the sustainability of research results after the project has ended including their further development and application is challenging.

Aim of action:

Capacity building measures strengthen the REEF 2W approach by disseminating project results including skills, knowledge and tools. Furthermore, solid waste and wastewater treatment utilities will be enabled to achieve their energy targets.

Strategic Action I.1: Training

Trainings are offered to qualify experts.

Strategic Action I.2: Register

A register of experts trained within REEF 2W will be published on a web-based platform. These experts will have qualified technical and financial competences that enable them to consult and coach operators of waste or WWTPs.

Strategic Action I.3: Working groups for support on national/regional base

Groups for support on national/regional level will be formed in order to help disseminating and assist in possible implementation of REEF 2W solutions to interested operators of waste and WWTPs.

Strategic Area II: Reaching energy targets

Problem statement:

The clear definition and achievement of energy targets at both local and regional level are challenging.

Aim of action:

Enable local and regional authorities to clearly define their energy targets while advocating and offering REEF 2W solutions to their waste and wastewater utilities.

Strategic Action II.1: Anaerobic digestion that includes bio-waste Implementing REEF 2W solutions on WWTPs (anaerobic digestion with added bio-waste where feasibility and applicability is proven).

Strategic Action II.2: Operational framework

Establishing operational framework that includes both making legal preconditions and suitable finance model(s) that will enable implementing REEF 2W solutions

Strategic Action II.3: Other renewable energy solutions

Introducing other renewable energy solutions (photovoltaics, wind, hydropower, others) on WWTPs where feasibility and applicability is proven.

Strategic Area III: Sludge management

Problem statement:

Sludge management problems—particularly its disposal—are not sufficiently recognised and addressed in the waste and water management sector in Croatia. The application of REEF 2W solutions for renewable energy production will be difficult or even impossible if there is no effective and viable solution for sludge disposal.

Aim of action:

To address this challenge/problem by implementing an adequate sludge management

Strategic Action III.1: Legal framework

Adjusting legal framework for the implementation of an adequate sludge management.

Strategic Action III.2: Sludge management solutions

Research and work on sludge management solutions and their implementations.

Strategic Action III.3: Sludge management base

Forming a sludge management base that involves stakeholders in sludge disposal chain.

6. CONCLUDING WORDS & CHALLENGES

6.1. Challenges

Challenges, public authorities are likely to face when implementing strategic actions, are as follows:

- Adequate support from municipal/regional/national level of the government;
- Sufficient support from local community;
- System of incentives and finance model in general.

6.2. Conclusion

Multi-faceted environmental management covering a wide range of complex and interlinked sectors and activities—water and waste management, air pollution, natural habitat/nature protection, biodiversity, noise, industrial pollution, and chemicals—is crucial for environmental protection.

Sustainable development is therefore integral to Croatia's environmental policy and strategy framework.

The solid waste and wastewater sector plays an important role in the energy transition.

REEF 2W and this Regional Strategy will provoke and start changes both on regional and national level in Croatia. Firstly, in the way of thinking, then in removing barriers and ultimately in implementing measures and projects. As a result, the production of renewable energies are introduced to WWTPs, which thereby become largely or completely self-sufficient or even power plants and thus contribute to the energy transition.

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