D2.4.1: 5 REPORTS ON THE LEGISLATIVE/ADMINISTRATIVE FRAMEWORKS IN THE INVOLVED REGION – STRUCTURE AND QUESTIONNAIRE

CROATIA

10/5/2018

Table of content

1. Introduction

Innovation in the water sector is stifled by multiple barriers, keeping innovation outcomes lower than in other sectors. Factors commonly include risk aversion of water and wastewater utilities, lack of public or commercial funding and too stringent and conflicting regulations (Kiparksy et al., 2013, Ajami et a. 2014, Speight, 2015). A growing body of studies is investigating the barriers that particularly apply to nascent wastewater-to-energy systems. Dierich et al. (2017) for example mentions an unsuitable legal framework, low political priorisation of inter-sectoral action, and insufficient experience in utilities as main barriers. In another study (WERF, 2012), the authors find that "inadequate payback/economies" feature as the most dominant among 10 barriers impeding the implementation of biogas usage in the US wastewater treatment plants (WTPs). Financial hurdles also rank high up in a global study focusing on energy efficiency in US water and wastewater utilities, alongside governance issues and knowledge gaps (ESAMAP, 2012).

These studies indicate that the dissemination of wastewater-to-energy systems is generally confined by a wide range of different barriers, rather than a few single ones. Some of the barriers are applicable to all water-related innovations. Others are unique to wastewater-to-energy systems, their specific type of technological or managerial solution, and the local or regional context the utility is situated in. This becomes obvious in studies that examine specific aspects of wastewater-to-energy systems, for example the "flexibilisation" of energy production and consumption in waste water treatments plants (WWTPs) for optimized energy supply (Dierich et al., 2017). Barriers concern cultural or behavioural aspects within the utility itself (e.g. low commitment of top management) as much as external conditions, for example low regulatory pressure to reduce energy consumption (ESAMAP, 2012). Identifying these barriers is a critical step in order to form measures for setting up framework conditions conducive to the uptake of innovative wastewater-to-energy systems.

As with any other environmental reform, improving the energy performance of wastewater utilities (WWUs) requires strong backing through legislation and policy at various political levels. In this report, we understand legislation and policy and the framework they form to include all laws, policies, regulations, strategies, rules and other instruments used to improve energy outcomes of WWUs. These affect a large host of disciplinary fields, like economics, spatial planning, finance, or utility governance and management relevant to wastewater-to-energy systems. implementing the framework, national and sub-national governments play a key role. They need to grant high-level political support for establishing national legislation and policies, take up the role of the regulator and financier, and initiate other important steps, such as creating a well-engaged and connected agency that provides leadership and coordinates efforts nation-wide (e.g. to produce necessary information like energy maps) (Vogt et al., 2010).

In overcoming key barriers, there are different types of legal and policy measures. With respect to heat generation in WWTPs, Kretschmer (2017) distinguishes between regulatory, incentive-oriented and actor-supportive measures. Necessary regulations, for example, require utilities to reduce CO2 emissions, to track and improve energy performance through energy audits, or to prescribe phasing out energy-inefficient

technologies. Incentives, in contrast, may link government funding or tariff reforms to the utility's energy performance. Or they remove subsidies for electricity that discourage utilities from taking steps towards more energy-efficient operations. Typical actor-supportive measures help utilities to gain access to information about new innovations, their costs, benefits, and available funding opportunities, or offer educational programs for and advice to utility staff. Governments can further establish policies to shore up financing, such as specific financial vehicles for investments in energy efficiency and renewable production in WWTPs or by facilitating access to cross-sector financing programs (e.g. climate funds).

2. Scope of the Study

The objective of deliverable 2.4.1 is to

I) examine the **legal and policy situation** with respect to energy efficiency (EE) and renewable energy (RE) production outcomes of WTPs in the five countries participating in the project REEF2Water;
II) identify the main **legal and policy barriers;**
III) and discern **drivers and existing approaches** to overcome them.

The analysis is based on **desktop research**, information compiled in D1.1.1 on the legal situation and experience of the authors themselves.

The aim of deliverable D2.4.1 is to contribute **to improving the legal and policy framework conditions** that are central for the uptake of wastewater-to-energy systems in each of the five countries. The resultant outcomes form the basis for D2.4.2, in which concrete recommendations for improving laws and regulations are provided. These will subsequently be shared and discussed with policy makers from the participating countries. Furthermore, D2.4.1 will form the basis of a position paper (D5.2.3), which identifies local legislation and regulatory barriers hindering REEF2Water regional implementation strategies, as well as measures to dismantle them.

The nature of the Reef2Water solutions implies that their implementation is affected by a **complex legal and policy framework**. Given that the solutions are part of the wastewater, energy, and solid waste system, a **cross-sectorial perspective** that relates to legal and policy aspects of each of these three systems was taken. This ensures that necessary **sector linking** is achieved in practice.

The analysis considers the **different ways to exploit energy** from wastewater, including energy from biogas production, on-site renewable generation and operational energy efficiency. Here, it is being distinguished between **thermal and electrical energy.** Given the project's particular ambition to enrich sludge through **organic substrates** in the treatment process, the analysis considers applicable legislation and policies of the solid waste system. Furthermore, as the project aims at exploring the potential for WWTPs to become local providers of energy, legislation and policies regulating **temporary energy storage** (such as power-to-gas solutions) and **feed-in into the grid** (including relevant

market-based mechanisms) are considered. All of these aspects are examined for **different political-administrative levels**, at which policy and legislation are given effect at (international/EU, national, federal, and municipal). This helps to locate barriers more precisely, as well as to find scale-sensitive measures to overcome them.

3. The EU-Legal and Policy Framework

3.1. Environmental policy and law making in the EU

This chapter summarizes the most relevant EU Directives affecting the implementation of measures to increase EE and RE production in WWTPs. It then analyses a range of legal and policy barriers that are central in doing so.

Directives form the most common regulation in the EU legislative framework. They set the standard conditions and rules. According to the Subsidiarity Principle, member states have to transpose these into national legislative systems, following a clearly defined timetable and a way that best suits national circumstances (LeBlanc et al. 2008).

While member states are aiming at the same goals, the means they use to achieve them can be quite distinct, the heterogeneous development of EU energy markets serving as a very good example.

3.2. Key drivers of wastewater-to-energy solutions and resulting trends across EU member states

The share of renewables in the EU energy mix reached 17 % in 2016. It increased twofold since 2004, being mainly driven by legally binding energy saving and decarbonisation targets (Edwards et al., 2016).

- Renewable energy markets have distinctly developed across member states in what regards their scale and composition of different renewable energy forms. For example, biogas is predominantly used to produce electricity while much of the heat potential remains unexploited (Kampman et al., 2016). Also, only some frontrunners such as Sweden actively pursue producing biomethane for the transport sector.

- Only a few countries, such as Spain, use sewage sludge as a main feedstock for biogas production, making it the feedstock being used the least overall (Scarlat et al., 2018). In most member states, such as Germany and Italy, crops dominate as a feedstock while the potential to use sewage remains largely untapped (Figure 1.).

- The EU has began to embrace a circular economy approach. Its stringent regulatory regime is changing waste streams and disposal options. Importantly, while bio-waste and sludge production increase (Zsirai, 2011), limits are put on landfilling, and particularly of biodegradable material. Applying sludge as a fertiliser and soil conditioner is still the preferred options in most member states, more stringent rules confine this end-use form (Spinosa 2010). Together these developments have driven wastewater-to-energy solutions.

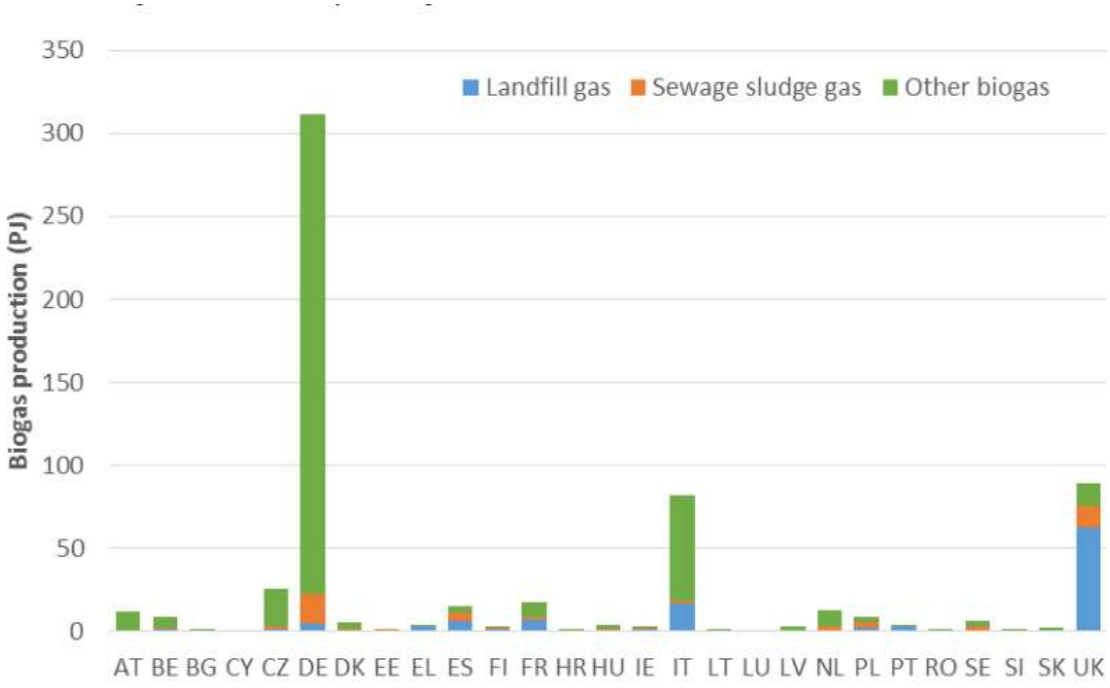

Figure 1: Biogas production per Member State in 2014, differentiated by source (Kampman et al., 2016)

3.3. Overview of key EU legislation and policies

3.3.1. Water & Wastewater

The Water Framework Directive (2000/60/EC)

This directive (here referred to as the WFD) requires that rivers, lakes, transitional waters, coastal waters, and groundwater obtain "good status" by 2027. To achieve this goal, the EU has determined a clear timeline and three six-year management cycles for the member states. One of its main elements is the introduction of River Basin Districts, which form the management units for managing water resources. Importantly, the WFD pertains to services of both water and waste water.

The Urban Waste Water Treatment Directive (91/271/EEC)

The main objective of the Urban Waste Water Treatment Directive (UWWTD) is to protect the environment from negative effects of urban wastewater discharges. It comprises the collection, treatment, and discharge of domestic wastewater, mixture of wastewater, and wastewater from certain industrial sectors. It stipulates the level of treatment and the removal of nutrients and basic sanitary parameters, as well as conditions for sludge disposal and reuse.

The Sewage Sludge Directive (86/278/ EEC)

The Sewage Sludge Directive (SSD) is concerned with the management of sewage sludge. It particularly seeks to encourage the use of sewage sludge as a soil conditioner and fertiliser in agriculture. It bans applying untreated sludge on agricultural land. Also, it sets all the requirements and provisions to prevent potential harmful effects on humans, animals, soil and vegetation as well as surface and groundwater. The Directive lays down the basic limits for potentially toxic elements (PTEs, which are HMs) in SS and soil.

3.3.2. Climate change mitigation

2020 Climate and energy package ("20-20-20 targets")

This package was established in 2007. Its goal is to ensure that the EU meets its climate and energy targets. In consequence, the legislation encompassed three main targets for the year 2020:

- 20% increase in energy produced from renewables
- 20% enhancement in energy efficiency
- 20% cut in greenhouse gas emissions (compared to 1990 level)

Emissions Trading System (ETS)

The ETS is a central element in the EU's policy to tackle climate change and a key tool for reducing greenhouse gas emissions in a cost-effective manner. It is based on a "cap and trade" system. The cab limits the amount of greenhouse gas emissions a certain user or industry is allowed to emit. As the cap is gradually lowered over time, emissions are expected to fall. Within the cap, companies receive or buy emission allowances that cover their emissions. These can be traded.

Effort sharing agreement for the non-ETS sectors

The Effort Sharing Decision establishes binding annual greenhouse gas emission targets for Member States for the period 2013–2020. These targets concern emissions from most sectors not included in the EU Emissions Trading System (EU ETS), such as transport, buildings, agriculture and also waste. The regulation aims to ensure that the non-ETS sectors emissions reduction target of 30% by 2030 compared to 2005 levels.

3.3.3. Renewable energy production and energy efficiency

Renewable Energy Directive (2009/28/EC)

The Renewable Energy Directive (RED),which is currently being revised, establishes a policy framework for producing and encouraging renewable energy in the EU, including biogas. The directive requires that 20 % of the EU's energy mix in 2020 must be renewable. It translates this general goal into individual targets for each of the member states. In a recent proposal to revise the directive the Commission elevated that goal to 27 % by 2030. The RED also defines sustainability criteria for biofuels and bioliquids in the transport sector.

Directive to reduce indirect land use change for biofuels and bioliquids ((EU/2015/1513)

The ILUC was established as response to sustainability challenges concerning bio-energy made out of food-based crops, most importantly indirect land-use change. It amends current legislation on biofuels, including the Renewable Energy Directive (2009/28/EC) and Fuel Quality Directive (2009/30/EC). For example, it limits the share of biofuels produced from crops in the transport sector (7% in overall fuel mix). It also requires that biofuels produced in new installations emit at least 60% fewer greenhouse gases than fossil fuels.

Energy Efficiency Directive (2012/27/EC)

The Energy Efficiency Directive (EED) mandates energy efficiency improvements. It establishes a common framework for the promotion of EE within the EU to meet its EE headline target of 20% by 2020, in all stages and sectors of the supply chain. EU member states have to prepare a National Energy Efficiency Action Plan every three years and report on their progress in the different sectors (i.e. industry, residential, services, public, transportation, electricity and heat generation).

Directive for combined heat and power generation (2004/8/EC)

This directive promotes the use of combined heat and power (CHP) units to improve the efficiency of electricity and heat production. It sets rules on guarantees of origin, efficiency criteria, administrative procedures, and other issues. Member states are encouraged to provide support schemes for CHP units to enable their widespread implementation (including specific support for WTTPs).

3.3.4. Natural Gas

Directive on services in the internal gas market (2009/73/EC)

This 'Gas Directive' establishes common rules for the transmission, distribution, supply and storage of natural gas. It stipulates rules relating to the organisation and functioning of the natural gas sector, access to the market, the criteria and procedures applicable to the granting of authorisations for transmission, distribution, supply and storage of natural gas and the operation of systems. The rules also apply in a non-discriminatory way to biogas and gas from biomass, i.e. sewage gas from WWTPs.

Directive for internal electricity market (2009/72/EC)

This directive establishes common rules for the generation, transmission, distribution and supply of electricity, together with consumer protection provisions, with a view to improving and integrating competitive electricity markets in the EC. It lays down the rules relating to the organisation and functioning of the electricity sector, open access to the market, the criteria and procedures applicable to calls for tenders and the granting of authorisations and the operation of systems such as transmission or distribution systems, including the request for unbundling of electricity production.

Directive for taxation of electricity and other energy products 2003/96/EC (EU 2003a) sets a framework for taxation of electricity and other energy products, e.g. gas or other fuels. It defines the energy products to be taxed and the minimum

amount. The project “Full scale demonstration of energy positive sewage treatment plant concepts towards market penetration” (POWERSTEP) has received funding under the European Union HORIZON 2020 –

3.4. Solid waste management

The Waste ´Framework Directive (2008/98/EC)

This directive defines basic concepts such as the “waste hierarchy” (a priority order set among waste prevention and management options), and stipulates requirements for waste management, such as to up a separate collection of waste, waste management plans, and waste prevention programmes. It also establishes legally binding targets such as for household waste streams including biodegradable materials).

The Landfill Directive (1999/31/EC)

This directive aims at preventing or reducing adverse environmental impacts from landfilling of waste through stringent technical requirements for waste and landfills. It obliges Member States to reduce the amount of biodegradable municipal waste that they landfill to 35% of 1995 levels by 2016 (for some countries by 2020) while current legislative of the proposal of it consider a complete ban of landfilling.

3.5. Legal drivers and barriers

Paucity of energy aspects and targets in water legislation

Energy-related issues remain vastly absent from the EU’s legal and policy framework of the water sector. The key water-related directives, the WFD and the UWWTD, make no provisions that specifically focus on targets, measures or incentives to improve EE or renewable production measures in WWTPs, whether motivated by ambitions of cost-efficiency or decarbonisation. Also, more recent water policy documents such as the “Blueprint to Safeguard Europe's Water Resources” (2012) poorly make that linkage. A legislative proposal of the Drinking Water Directive adopted this year comprises one of the first attempts to embrace the water energy-water nexus by encouraging member states to increase energy efficiency.

Lack of overall cross-sectoral and coherent legal framework

The absence of a cross-sectoral approach spanning across various relevant EU energy, waste, water, agricultural and other concerned directives stifles legal backing needed to more systematically support wastewater-to-energy solutions. Energy-related issues are missing in EU water sector policy and law, which predominantly focus on water quality and quantity goals. The RED, on the other side, fails to articulate specific provisions on how, for example, the waste water sector can contribute to achieving targets concerning carbon reduction and renewable production. Incoherence of the overall legal and policy framework has been ranked as the top barrier for biogas production (Kampmann et al., 2016).

Inadequate priorisation of second generation bio-energy

Member states have been free to opt through which form of renewable energy they accomplish these targets. This flexibility has given rise to divergent developments of the biogas market across the member states (Torrijos, 2016), with in part undesirable outcomes. A prominent example applies to the rise of crop-based biogas, which ranks as the EU's main type of bio-energy and dominant renewable energy form (Kampman et al., 2016). As a feedstock, however, crops have proven adverse environmental impacts (e.g. land use change). The environmental footprint of biogas produced from waste streams, in contrast, is significantly better, but their share in the biogas market lag behind that of crop-based biomass (see. Figure 1). This is because the EU legal and policy does not systematically support renewable energies according to their sustainability performance. Sustainability criteria, which form one central pre-condition towards doing so, exist only for the transport sector while they lack cross-national harmonisation (Kampman et al., 2016).

An improving yet unreliable base of bio-waste feedstock

The EU's stringent regulatory regime for waste functions as a strong driver for wastewater-to-energy systems. The Landfill Directive is viewed as the most important factor propelling the growth of anaerobic digestion (AD) (including on-farm applications) in treating biowaste and industrial feedstock (Edwards et al., 2015). This is because the ban on landfilling and tightening quota for reducing landfilled biodegradable organics increase the need to find solutions for disposing growing amounts of bio-waste (Torrijos, 2016). However, many member states do not have a reliable bio-waste feedstock base (Edwards et al., 2016). Only 25 % of the total bio-waste in the EU is recycled while recycling rates are considerably lower in many member states (Mateescu et al., 2008). In some countries like the UK, access to adequate organic feedstock is already a barrier (Kampman et al., 2016). Additionally, current regulations do not promote AD as a preferable disposal option for biowaste. Legal loopholes still allow member states incinerate or landfill biowaste (Iacovidou et al., 2012). The European Biogas Association (2016) remarks that incineration may become the main disposal option for biowaste as the as the landfilling ban takes effect.

Under-development of heat usage due to weak incentives

Whether WWTPs achieve high potential of energy and carbon emissions savings depends on exploiting both heat and electricity generated during the combustion of biogas. Biogas markets have expanded in several EU member states. However, despite some positive development, often only the electricity generated from biogas is used while the heat potential remains untapped. Currently, only 25 % of the heat is used in Europe's WWTPs (Scarlat et al., 2018). While plant operators face pressure to improve the economics of biogas plants (ibid), weak incentives at the EU-level comprise one key factor responsible for the slow development of heat usage from biogas (Kampman et al., 2016).

Lacking revenue streams for sewage-based co-digestate

Using co-digestate of sewage sludge and bio-waste as soil conditioner or fertiliser (for example in agriculture) can spur the uptake of wastewater-to-energy solutions (Edwards et al., 2015). Such "end-use" applications guarantee that sewage sludge,

whose production in Europe will rise over the next years (Werle, 2015), will be harnessed in the spirit of a circular economy. Currently, however, sludge-based co-digestates are subject to an incoherent and partially conflicting legal and regulatory regime (Iacavidou et al., 2012), which compounds the dissemination of AD technologies. One main barrier is that co-digestate containing sewage sludge is currently classified as waste and not a valuable product. This legal definition only allows WWTP operators to market the biogas, but not its by-products, undermining additional revenue streams (Kampmann et al., 2016).

Ambiguous financial mechanisms for wastewater-to-energy solutions

Access to inexpensive renewable energy will become increasingly important because the cost of sewage sludge treatment is bound to rise due to higher treatment standards and rising energy costs, among others (Zsirai, 2011). Cost pressures, which the imposed by the cost-recovery principle in the WFD, theoretically attractive for WWUs to deploy RE production. However, new technologies such as AD are capital-intensive, generally requiring subsidisation (Edwards et al., 2015). National support schemes (e.g. feed-in tariffs) form the key financial mechanism to drive renewable energy developments in the EU. However, these are still ineffective in many member states, for example due to low or reduced subsidies (Kampman et al., 2016). At the same time, the EU legislation and policies upon which the support schems are based are yet not sufficiently linked to sustainability criteria, as argued above. Furthermore, Green Public Procurement (GPP) for WWTPs currently apply only to EE, but not to producing RE (Loderer and Hananel, 2018).

Grid injection of bio-energy

If not used for self-supply in on-site CHP plants, WWUs have several options to bring bioenergy to the market: As biogas or biomethane via the gas network; as heat via the district heating network; or as electric power via the electric grid. Arguably, a range of barriers apply to each of these options. Generally, decentralized energy forms – such as wastewater-to-energy solutions – lack a common EU framework that explicitly supports them. Across member states + small market entrants providing distributed energy (DE) still face various challenges, including a lack of explicit incentives in planning and operations of networks, high connection charges, or high trading fees (Ropenus and Skytte, 2005). Another specific example concerns cross-border trade of biomethane, which is hindered substantially by national quality standards, which lack harmonisation (Kampan et al., 2016).

4. Overview on legal and policy situation in Croatia

4.1. National Level:

Waste management in the Republic of Croatia is stipulated by the Act on Sustainable Waste Management (OG No. 94/13 and 73/17). This Act defines measures for prevention and reduction of adverse impacts on human health and the environment

resulting from waste management and operations. These aim at reducing the overall quantity of produced waste, as well as recovering resources from waste.

The governing legislation for the waste management in Croatia is the following:

- The Environmental Protection Act (OG No. 80/13, 153/13, 78/15)
- Act on Sustainable Waste Management (OG No. 94/13, 73/17)
- Waste Management Strategy of the Republic of Croatia (130/05)
- Waste Management Plan in the Republic of Croatia for the period 2017-2022 (OG No. 3/17)
- Ordinance on Municipal Waste Management (OG No. 50/17)

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 mandatory obligation to implement separate collection intends to use therewith increased bio-waste yields in composting, anaerobic digestion and incineration with energy recovery. The law also defines the priority order of waste management. Prevention of waste comes first in this order. The implementation of the measures stipulated by bio-waste-related legal provisions is likely to increase the cost of waste disposal, which, from an economic point of view, justifies to avoid producing waste in the first place.

Measured by their authority and thematic mandates, the following institutions are the most important actors in the waste management sector in the Republic of Croatia:

- The Croatian Parliament and the Government of the Republic of Croatia are State Authority Bodies. The key role of the Parliament is to adopt waste-related legislation and national strategies such as the Waste Management Strategy of the Republic of Croatia. The Government adopts the Waste Management Plan and its implementing legislation (such as decisions to be made or annual reports), but also proposes relevant legislation and strategies to the Parliament. Another key mandate of the Government is to ensure framework conditions for and prescribe measures to manage hazardous waste, including incineration.
- The Ministry of Environment and Nature Protection is a State Administration Body and is mainly responsible for preparing new legislation and standards (e.g. the National Waste Management Strategy and National Waste

Management Implementation Plan), implementation of measures (especially for hazardous waste management), supervision and enforcement of secondary legislation, monitoring the Croatian Environment Agency and Environmental Protection and Energy Efficiency Fund, etc.

- The Environmental Protection and Energy Efficiency Fund is an extra-budgetary institution owned by the Republic of Croatia, its purpose being to finance environmental protection programs and projects. The fund also functions as a regulatory institution, among others imposing fines in the context of pollution offenses related to hazardous and non-hazardous industrial waste.
- The Croatian Environment Agency (CEA) is a public institution established by the Government, primarily collecting processes and providing data required for the efficient implementation of the environmental protection policy.
- The Counties and the City of Zagreb are regional self-governing bodies which are responsible for managing all types of waste in their respective jurisdiction. They also develop and provide waste management plans. Furthermore, they gather and submit data on waste. The counties' state administration offices issue permits for non-hazardous waste management.
- At local level, towns and municipalities are self-governing bodies responsible for managing municipal waste, preparing waste management plans and determining locations for waste disposal or recycling yards in spatial plans for their respective areas. Municipal waste is managed by the public utility services.

Other actors involved in waste management are private companies that are registered and entitled to carry out the collection and transport, recovery and/or disposal of waste, as well as consulting firms or other professional and non-governmental organisations.

4.2. Federal Level and Municipal Level:

Counties and cities in Croatia implement laws and can decide how they interoperate the adapted legislation. Regarding the waste management in Croatia, separate collection of waste and charging of waste collection services by amount have become mandatory in Croatia when the Decree on the Management of Municipal Waste came into force on November 1, 2017.
Subsequently, every local self-government in Croatia had to decide on how to provide public services for the collection of mixed and biodegradable municipal waste while complying with the above mentioned Ordinance. Non-compliance with this regulation implies fines pursuant to the Law on Sustainable Development. This also concerns the Croatian Government if it breaches EU waste directives.

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.
In January 2018 the government of Zagreb adopted a legislative amendment concerning the public service to collect mixed municipal waste and biodegradable municipal waste in Zagreb. According to it, the waste management company (ZCH) is

responsible to implement source-separation of bio-waste, which ZCH is expected to begin in 2018.

5. Main legal and policy barriers in Croatia

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 recycling targets, is a demanding task for the government. An analysis carried out in the context of the National Waste Management Plan estimates that the organic share in household waste is 37 %. According to the Waste Management Plan, the municipal waste management system will focus on introducing separate collection of municipal waste, which implies to build the necessary infrastructure: at the origin waste creation, via recycling yards, on public surfaces and through implementing the regulations for special categories of waste (packaging waste, waste tires, etc.).

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.

Beside the Sustainable Waste Management Act, the Waste Management Plan of the Republic of Croatia for the period 2017 – 2022 (OG 3/17) also defines the quantitative targets and deadlines for increasing the amount of separately collected and recycled waste but also the quantitative targets related to the reduction of biodegradable municipal waste disposed to landfills are established. By the end of 2020, the share of biodegradable municipal waste disposed of in landfills must be reduced to 35% compared with 1997 levels.

Strategic guidance for solid waste management

Poor management of waste is among the main challenges the City of Zagreb confronts. Currently, the main portion of municipal waste is disposed of at the landfill site Jakuševec. In the last couple of years systematic actions have been undertaken to increase the quantity of separately collected waste. However, the absence of strategic documents providing waste management concepts or practical guidance for separate waste collection constitutes a serious barrier. To produce bio-energy at the Zagreb WWTP, exploring aspects around the utilization of bio-waste plays a key role. Therefore improving the separate waste collection system is one of the first and necessary steps to be taken for the City of Zagreb.

Low financial Support for bio-energy production

The key driver for encouraging the application of biogas for electricity generation, as well as for co-fermentation technologies, is incentives. In Croatia, these mainly come as feed-in tariffs, which depend on the type of feedstock, plant size and capacity for electricity generation. The WWTP in Zagreb is currently receiving feed-in tariff for RE production. However, the FIT system was suspended in 2015. Hence there is currently no

support scheme promoting RE production in Croatia. The wholesale prices of electricity in Croatia have been moving around 36-40 EUR/MWh in the past few years, according to the Croatian Energy Regulatory Agency (HERA) Annual Report from 2016. The regulated buy-off price at which the suppliers purchase electricity according to the Tariff system for the generation of electricity from RE sources was continuously higher (around 70 EUR/MWh). This made grid injection more attractive than self-supply from economic point of view. However, this is only relevant for RE producers who applied prior to 2015 for subsidies by the FIT system.

Unsustainable sludge management

Another main barrier faced by the WWTP in Zagreb relates to disposal of sludge, which is still done without making use of its resource recovery potential. Various solutions for the treatment and final disposal of sludge at the WWTP in Zagreb have been considered and studied for several decades now. However, the city of Zagreb has not finally decided on and issued legal provisions for disposing sludge in a sustainable way. This is why sludge is still mostly landfilled in the vicinity of the WWTP at present. Restrictions such as prohibitions to apply sludge in agriculture during certain times or health concerns have led to a ban of sludge application in agriculture in Croatia. Plans for an incinerator in the city's area of Resnik were abandoned by the Zagreb's authorities due to public opposition.

Discrimination of small energy providers

Small energy providers, such as WWTPs, which are willing to gain grid access and sell energy must pay high connection costs because WWTPs in Croatia are mostly build outside the urban area. These WTTPs do often not have access to the existing electricity network. To gain access, additional infrastructures are required, the costs of which operators have to bring up themselves. These additional costs lower the ability to feed surplus energy into the market in a way that is financially sustainable.

6. Drivers and existing approaches to overcome barriers in Croatia

Croatia currently lacks a nationwide public support scheme which supports RE production in WWTPs. The fixed feed-in tariffs, which were in place, acted as the most important driver. Stipulated in the Croatian Electricity Act, they guaranteed WWTP operators a fixed price, which had to be above that of the market. Every producer, who held the status of "qualified producer" and has signed a formal agreement with the Croatian Energy market Operator (HROTE) had the right to receive this incentive depending on the type of RES technology and power output of his RES-E plant, as is defined in the Tariff System (OG No.100/15).

Feed-in tariffs were paid depending on the size of the installation and its efficiency. Defined quotas for guaranteed purchase of electricity until 2020 are 70MW for biogas (including waste gas and gas from wastewater treatment plants). New law introduced

feed-in premiums (FIP) but has still not been implemented due to numerous undefined by laws.

In January 2018 City of Zagreb adopted the Decision on the manner of performing the public service of collecting mixed municipal waste and biodegradable municipal waste and services related to public service in City of Zagreb which should be a good start for further utilization of biowaste within the WWTP in Zagreb. City of Zagreb is currently in phase of preparing of the local Waste management plan which is pre-requisite for introducing a source separated bio-waste system. As already mentioned, the plan should be finalized in the next period.

7. Appendix I: Questionnaire for Legal and Policy Barrier Analysis

This questionnaire is intended for gathering primary and secondary data needed to accomplish D2.4.1. There is no obligation to use it, but you may find it useful drawing on all or several of the proposed guiding questions.

- Conduct 5-10 interviews with experts such as utility staff or policy makers and other experts, separately or in focus groups;
- Adjust questions according to the type of interviewed respondent, characteristics of the treatment facility and utility and country context.

Legal and Policy Barriers in Country X

1. How conducive is the legal and policy framework in supporting the implementation of EE and RE measures in the WWTP(s) of your country?

2. Can you outline and describe in detail the most significant legal and policy barriers, differentiating between the main ways for exploiting energy from wastewater where relevant (such as improving operational energy efficiency or generating electricity and heat from biogas)?

3. Can you identify the political level(s) at which legal and policy barriers may be most severe (EU/International, national, federal and local)?

4. Does the legal and policy situation support or impair interventions for exploiting waste heat more than electricity or vice versa? If so, what barriers apply?

5. Which legal and policy barriers constrain WWUs from using surplus heat and electricity for self-supply?

6. What legal and policy barriers impede supplying waste heat or electricity to the market in your country? For example, regulations may prohibit WWUs from

entering business other than managing wastewater while low subsidies for RE might constrain them to gain financial sustainability.

7. What legal and policy barriers particularly apply for integrating systems of solid waste and wastewater to use organic substrates for enrichment of sludge in the co-fermentation process?

Policy and legal drivers and approaches to overcome barriers in Country X

8. Can you outline and describe the most significant legal and policy drivers, differentiating between the main ways for exploiting energy from wastewater where relevant?
9. What governmental or private sector actors do you consider most critical for improving the legal and policy framework for wastewater-to-energy systems?
10. What actor-based instruments (such as a central agency to coordinate interventions with respect to energy-related matters or specific funding or educational programmes) have been established to promote wastewater-to-energy systems?
11. Are you aware of legal and policy interventions that are currently being planned or already under way to overcome the main barriers you mentioned above (e.g a revision of the sludge ordinance or law with respect to CHP?)

Literature

Ajami, N.K., Thompson Jr, B.H. and Victor, D.G., (2014) The path to water innovation. The Brookings Institution.

Dierich, A, Hüesker, F, Ansmann, T. and Gretzschel, O (2017) Rahmenbedingungen für die Sektorkopplung von Abwasserreinigung und Klärschlammbehandlung mit der Energiewirtschaft: Hemmnisse, Treiber und Chancen. *Korrespondenz Abwasser, Abfall* (64)8, 697-706.

Draft of the Waste Management Plan for the City of Zagreb for period 2018-2023

European Biogas Association (2016) Position on the revision of the Waste Framework Directive (Position Paper). Retrieved from: http://european-biogas.eu/wp-content/uploads/2016/04/EBA-position-on-WFD-revision_April-2016.pdf

Edwards, J., Othman, M., Burn, S., (2015) A review of policy drivers and barriers for the

use of anaerobic digestion in Europe, the United States and Australia. *Renew. Sustain.Energy Rev.* 52, 815–828.

HERA (Croatian Energy Regulatory Agency). Annual Report 2016.

HROTE (Croatian Energy Market Operator Ltd.): http://www.hrote.hr/renewables-and-cogeneration

HEP-ODS (Distribution System Operator): http://www.hep.hr/ods/

Christodoulou, A., & Stamatelatou, K. (2016). Overview of legislation on sewage sludge management in developed countries worldwide. *Water Science and Technology*, 73(3), 453-462.

Iacovidou, E., Ohandja, D. G., & Voulvoulis, N. (2012). Food waste co-digestion with sewage sludge–realising its potential in the UK. *Journal of environmental management*, 112, 267-274.

European Council, 1999. Directive 1999/31/EC on the landfill of waste. Official Journal of the European Communities L182, 1e19.

Kampman, B., Leguijt, C., Scholten, T., Tallat-Kelpsaite, J., Brückmann, R., Maroulis, G., ... & Elbersen, B. (2017). Optimal use of biogas from waste streams: an assessment of the potential of biogas from digestion in the EU beyond 2020. European Commission.

Kilinc-Ata, N. (2016). The evaluation of renewable energy policies across EU countries and US states: An econometric approach. Energy for Sustainable Development, 31, 83-90.

Kiparsky, M., Sedlak, D.L., Thompson Jr, B.H. and Truffer, B., 2013. The innovation deficit in urban water: the need for an integrated perspective on institutions, organizations, and technology. *Environmental engineering science*, 30(8), pp.395-408.

Kretschmer, F (2017) Abwasser als erneuerbare Energiequelle – Potenziale, Chancen und Barrieren im österreichischen Kontext. Wiener Mitteilungen. Volume 246 of Wiener Mitteilungen

Loderer and Hananel (2018) The potential of the wastewater sector in the energy transition (Policy Brief). Retrieved from http://powerstep.eu/system/files/generated/files/resource/policy-brief.pdf

Mateescu, C., Băran, G., & Băbuţanu, C. A. (2008). Opportunities and barriers for development of biogas technologies in Romania. *Environmental engineering and Management Journal*, 7(5), 603-607.

Mininni, G., Blanch, A. R., Lucena, F., & Berselli, S. (2015). EU policy on sewage sludge utilization and perspectives on new approaches of sludge management. Environmental Science and Pollution Research, 22(10), 7361-7374.

ROPENUS, Stephanie; SKYTTE, Klaus. Regulatory review and barriers for the electricity supply system for distributed generation in EU-15. In: Future Power Systems, 2005 International Conference on. IEEE, 2005. S. 6 pp.-6.

Scarlat, N., Dallemand, J. F., & Fahl, F. (2018). Biogas: developments and perspectives in Europe. Renewable Energy.

Speight, V.L., (2015) Innovation in the water industry: barriers and opportunities for US and UK utilities. *Wiley Interdisciplinary Reviews: Water,* 2(4), pp.301-313.

Spinosa, L. Sustainability in sludge management: A combined approach to meet future needs. *Water21*, 31–33.

Torrijos, M. (2016). State of development of biogas production in Europe. *Procedia Environmental Sciences*, 35, 881-889.

Tedeschi, S., Malus D., Vouk D. (2012) Final treatment of wastewater sludge in the City of Zagreb. Građevinar

Vogt, R., Frisch, S. and Pehnt, M. (2010) Klimaschutz- und Energieeffizienz potenziale im Bereich Abfall und Abwasserwirtschaft. Institut für Energie- und Umweltforschung Heidelberg (IFEU).

Werle, S. (2015). Sewage sludge-to-energy management in eastern Europe: a Polish perspective. Ecological Chemistry and Engineering S, 22(3), 459-469.

Willis, J., Stone, L., Durden, K., Beecher, N., Hemenway, C. and Greenwood, R. (2012) Barriers to biogas use for renewable energy. Water Environment Research Foundation (WERF).

Zsirai, I. (2011). Sewage sludge as renewable energy. Journal of Residuals Science & Technology, 8(4).

Yousuf, A., Khan, M.R., Pirozzi, D., Ab Wahid, Z., 2016. Financial sustainability of biogas

technology: barriers, opportunities, and solutions. Energy Sour. Part B Econ. Plann.

Pol. 11, 841–848.

D2.4.1: 5 REPORTS ON THE LEGISLATIVE/ADMINISTRATIVE FRAMEWORKS IN THE INVOLVED REGION – STRUCTURE AND QUESTIONNAIRE

CZECH REPUBLIC

11/06/2018

Table of content

1. Introduction

Innovation in the water sector is stifled by multiple barriers, keeping innovation outcomes lower than in other sectors. Factors commonly include risk aversion of water and wastewater utilities, lack of public or commercial funding and too stringent and conflicting regulations (Kiparksy et al., 2013, Ajami et a. 2014, Speight, 2015). A growing body of studies is investigating the barriers that particularly apply to nascent wastewater-to-energy systems. Dierich et al. (2017) for example mentions an unsuitable legal framework, low political priorisation of inter-sectoral action, and insufficient experience in utilities as main barriers. In another study (WERF, 2012), the authors find that "inadequate payback/economies" feature as the most dominant among 10 barriers impeding the implementation of biogas usage in the US wastewater treatment plants (WTPs). Financial hurdles also rank high up in a global study focusing on energy efficiency in US water and wastewater utilities, alongside governance issues and knowledge gaps (ESAMAP, 2012).

These studies indicate that the dissemination of wastewater-to-energy systems is generally confined by a wide range of different barriers, rather than a few single ones. Some of the barriers are applicable to all water-related innovations. Others are unique to wastewater-to-energy systems, their specific type of technological or managerial solution, and the local or regional context the utility is situated in. This becomes obvious in studies that examine specific aspects of wastewater-to-energy systems, for example the "flexibilisation" of energy production and consumption in waste water treatments plants (WWTPs) for optimized energy supply (Dierich et al., 2017). Barriers concern cultural or behavioural aspects within the utility itself (e.g. low commitment of top management) as much as external conditions, for example low regulatory pressure to reduce energy consumption (ESAMAP, 2012). Identifying these barriers is a critical step in order to form measures for setting up framework conditions conducive to the uptake of innovative wastewater-to-energy systems.

As with any other environmental reform, improving the energy performance of wastewater utilities (WWUs) requires strong backing through legislation and policy at various political levels. In this report, we understand legislation and policy and the framework they form to include all laws, policies, regulations, strategies, rules and other instruments used to improve energy outcomes of WWUs. These affect a large host of disciplinary fields, like economics, spatial planning, finance, or utility governance and management relevant to wasterwater-to-energy systems. implementing the framework, national and sub-national governments play a key role. They need to grant high-level political support for establishing national legislation and policies, take up the role of the regulator and financier, and initiate other important steps, such as creating a well-engaged and connected agency that provides leadership and coordinates efforts nation-wide (e.g. to produce necessary information like energy maps) (Vogt et al., 2010).

In overcoming key barriers, there are different types of legal and policy measures. With respect to heat generation in WWTPs, Kretschmer (2017) distinguishes between regulatory, incentive-oriented and actor-supportive measures. Necessary regulations, for example, require utilities to reduce CO2 emissions, to track and improve energy performance through energy audits, or to prescribe phasing out energy-inefficient

technologies. Incentives, in contrast, may link government funding or tariff reforms to the utility's energy performance. Or they remove subsidies for electricity that discourage utilities from taking steps towards more energy-efficient operations. Typical actor-supportive measures help utilities to gain access to information about new innovations, their costs, benefits, and available funding opportunities, or offer educational programs for and advice to utility staff. Governments can further establish policies to shore up financing, such as specific financial vehicles for investments in energy efficiency and renewable production in WWTPs or by facilitating access to cross-sector financing programs (e.g. climate funds).

2. Scope of the Study

The objective of deliverable 2.4.1 is to

I) examine the **legal and policy situation** with respect to energy efficiency (EE) and renewable energy (RE) production outcomes of WTPs in the five countries participating in the project REEF2Water;
II) identify the main **legal and policy barriers;**
III) and discern **drivers and existing approaches** to overcome them.

The analysis is based on **desktop research**, information compiled in D1.1.1 on the legal situation and experience of the authors themselves.

The aim of deliverable D2.4.1 is to contribute **to improving the legal and policy framework conditions** that are central for the uptake of wastewater-to-energy systems in each of the five countries. The resultant outcomes form the basis for D2.4.2, in which concrete recommendations for improving laws and regulations are provided. These will subsequently be shared and discussed with policy makers from the participating countries. Furthermore, D2.4.1 will form the basis of a position paper (D5.2.3), which identifies local legislation and regulatory barriers hindering REEF2Water regional implementation strategies, as well as measures to dismantle them.

The nature of the Reef2Water solutions implies that their implementation is affected by a **complex legal and policy framework**. Given that the solutions are part of the wastewater, energy, and solid waste system, a **cross-sectorial perspective** that relates to legal and policy aspects of each of these three systems was taken. This ensures that necessary **sector linking** is achieved in practice.

The analysis considers the **different ways to exploit energy** from wastewater, including energy from biogas production, on-site renewable generation and operational energy efficiency. Here, it is being distinguished between **thermal and electrical energy.** Given the project's particular ambition to enrich sludge through **organic substrates** in the treatment process, the analysis considers applicable legislation and policies of the solid waste system. Furthermore, as the project aims at exploring the potential for WWTPs to become local providers of energy, legislation and policies regulating **temporary energy storage** (such as power-to-gas solutions) and **feed-in into the grid** (including relevant market-based mechanisms) are considered. All of these aspects are examined for **different political-administrative levels**, at which policy and legislation are given effect

at (international/EU, national, federal, and municipal). This helps to locate barriers more precisely, as well as to find scale-sensitive measures to overcome them.

3. Wastewater-to-energy solution in Czech Republic

4. The EU-Legal and Policy Framework

5. Overview on legal and policy situation in Czech Republic

The WWTP in Prague includes a sludge line with AD thermophilic process. The biogas is now incinerated at the on-site CHP plant, which has a capacity of 5 MW of electricity (gas piston engines). Limited used is made out ofheat. Biogas yields are enhanced by co-fermentation of the sludge with liquid biowaste. In the context of REEF 2W, biogas upgrading unit will be installed, allowing to convert the biogas into biomethane.

5.1. National Level

5.1.1. Water management regulation

Environment Act No. 17/1992 Coll.

The law prescribes that everyone's duty is to prevent pollution or deterioration of water and to minimize the adverse effects of human activities on water quality. According to the act, everyone using water sources is obliged to design and realize structures to prevent water pollution and to restore water sources.

Act No. 274/2001 Coll. on Water Supply and Sewerage for Public Use and on Amendments to certain acts (Act on Water Supply and Sewerage)

The act regulates the relations pertaining to the development, construction and operation of public water supply and sewerage systems.

Decree No. 428/2001 Coll. (Amendment by Decree No. 48/2014 Coll.) implementing the Act No. 74/2001 Coll. on Public Water Supply and Sewerage Systems and on Amendment to certain acts with Amendments No. 146/2004 Coll. and No. 515/2006 Coll.

Act No. 254/2001 Coll. on Water and Amendment to Certain Acts (Water Act)

The act deals with the protection of surface and groundwater, economic use of water resources and improvement of water quality, and safety of water works. The act also protects aquatic ecosystems and regulates legal relations to surface and groundwater. The Decree No. 293/2002 Coll. on Fees for Discharge of Wastewater to

Surface Water (amended by Decree No. 110/2005 Coll.) is an important part of the Water Act. The Decree defines the sources of pollution, levels and thresholds of pollution of wastewater and methods to measure discharged wastewater.

Government Order No. 401/2015 Coll. amending the Government Order No. 61/2003 Coll. on

In accordance with the EU law, this government order determines indicators for assessment of water quality of watercourses, surface waters, for wastewater, indicators and limits of permissible pollution (including for wastewater discharge) and for surface water bodies functioning as sources of drinking water, as well as for several other water systems.

There are a number of other technical standards and industry regulations for the implementation of the wastewater treatment plants and other water supply systems that are not listed.

5.1.2. Waste management

The main waste management regulations are:

- Act No.185/2001 Coll. on Waste and Amendments of Certain Other Acts, as amended
- Government Order No. 197/2003 Coll. on the Waste Management Plan
- Decree No. 294/2005 Coll. on Conditions for the Disposal of Waste at Landfills and its Use on the Surface of the Land, Amendment No. 387/2016 Coll.
- Decree No. 341/2008 Coll. on Details of Biodegradable Waste Management

Especially the Decree No. 341/2008 gives the specific requirements on the quality of treated bio-waste, the level of treatment and the requirements for the quality of output materials from processing plants.

5.1.3. Renewable energy regulation

Legislation in the field of energy is composed of three main regulations - Act No. 458/2000 Coll. on business conditions and public administration in the energy sectors (Energy Act), which regulates the basic conditions of business and state regulation in the electricity, gas and heat industries; Act No. 406/2000 Coll. on Energy Management, which sets the rules for efficient and sustainable use of energy and energy sources; and finally Act No. 165/2012 Coll. on Supported Energy Sources. These acts introduce into the Czech legal order a number of requirements of European Community law. Partial provisions of the acts are specified by dozens of implementing decrees and government orders.

Act No. 458/2000 Coll. on Conditions of Business Activities and State Administration in the Energy Sectors and on the Amendment of certain acts (Energy Act)

This act defines the conditions for production, transmission and distribution of electricity, gas, and energy, as well as for the tradeof these commodities. Licenses for trading energy are granted by the Energy Regulatory Office (ERO). The Act further

defines the conditions of the electricity,gas, and heat market and the rights and obligations of involved actors.. Act No. 458/2000 Coll. also defines renewable energy sources, combined generation of electricity and heat and the mandatory purchase of these energies. The Ministry of Industry and Trade and the ERO are responsible for the state administration, the State Energy Inspectorate is appointed as a control body.

Act No. 406/2000 Coll. on Energy Management

This act sets out measures to increase the sustainable management of energy use and the rights and obligations of energy management and energy sources. The State Energy concept, territorial energy concepts and the State Program to Promote Energy Savings and Use of RES are the basic concepts for efficient energy use. The Act further sets minimum energy efficiency requirements for energy production, energy performance indicators for buildings, heating and hot water preparation, and obliges utilities to perform energy audits for larger energy consumers as well as energy performance certificates for all new buildings and reconstructions of larger buildings. Under this Act, its is mandatory to label electrical appliances with energy labels and their construction is subject to eco-design requirements.

Act No.165/2012 Coll. on Supported Energy Sources and on Amendment of certain Acts regulates the marketisation of electricity, heat and biomethane from renewable energy sources, secondary energy sources, high-efficiency co-generation and decentralised electricity generation, state administration and law enforcement, and the rights and obligations of natural and legal persons involved.

The Act also regulates the Czech Republic's National Action Plan for Renewable Energy, the conditions for the issue, registration and recognition of guarantees of origin of energy from RES, conditions for issuing certificates of origin of electricity produced from high-efficiency cogeneration or secondary sources, financing of support for the costs related to the support of electricity from supported sources, heat from RES, decentralised electricity generation, biomethane, and providing a subsidy to the market operator to cover these costs and the electricity from solar radiation.

The act aims, among others, at supporting the development of RES, high-efficiency co-generation of electricity and heat, bio-methane and decentralized electricity generation, and to contribute to the sustainable use of natural resources. Financial support is provided depending on the type and electricity output capacity, in the case of biomass above that according to fuel quality. The ERO announces annually the minimum redemption prices in accordance with the rules set out in this Act.

ERO price decision - annually determined price of energy from RES.

Decree No. 459/2012 Coll. on Biomethane Requirements, Method of Biomethane Metering and its Quality Injected to the Transmission System, Distribution System or Underground Gas Storage Facilities.

Technical rules GAS TPG 902 02 „Quality and Testing of Gaseous Fuels with High Methane Content“,

Technical recommendation GAS TPG 983 01 – „Injection of the Biogas into Gas Networks, Requirements for the Quality and Metering",

Decree No. 108/2011 Coll. of 14th April 2011 on Gas Metering and the Method of Determining Compensation for Unauthorized Supply, Unauthorized Supply, Unauthorized Storage, Unauthorized Shipments or Unauthorized Distribution of Gas,

Decree No. 345/2002 Coll. specifying metering devices for mandatory verification and metering devices subject to type approval, as amended.

5.1.4. Veterinary legislation

If a plant processes waste containing animal by-products - except the organic fraction of mixed municipal waste, i.e. food wastes, waste from supermarkets with meat content - it must comply with the veterinary legislation.

Act No. 166/1999 Coll. on Veterinary Care and Amendments to Related Acts

Government Order EP 1069/2009 on animal by-products treatment

Decree No. 94/2010 on Certain Veterinary and Hygiene Requirements for the Transport and Animal By-Products Processing, the packaging, containers or vehicles.

5.1.5. General laws of environmental protection

These legal regulations concern practically every project in CR during the preparation, implementation and operation phase. These are the acts on environmental protection (Clean Air Act, Public Health Act), Building Act, Nature and Landscape Protection Act, Environmental Impact Assessment Act and Integrated Prevention Act.

Act No. 100/2001 Coll. on Environmental Impact Assessment applies practically for all waste treatment plants and projects producing emissions. At least, EIA screening procedure must be done.

Act No. 76/2002 Coll. on Integrated Prevention. The obligation to process the IPPC applies for projects with the capacity higher than 75 t/day of other waste treatment, projects with capacity higher than 10 t/day of animal by-products, for all projects processing hazardous waste.

Act No. 258/2000 Coll. on Protection of Public Health - protection of human health from noise and other factors.

Government Ordre No.148/2006 Coll. Sb., on the Health Protection from the Adverse Effects of Noise and Vibrations - noise limits are defined in detail regardless of origin (transport and stationary sources).

In the sphere of construction, territorial planning is very important. The project location must be in accordance with the territorial plans and its regulations in the area. Any modification of the territorial plan is a long-term process with potential complications.

The basic law is Act No. 183/2006 on Territorial Planning and Building Regulations. According to it, projects of waste treatment or energy production must follow a territorial and construction procedure according to this law. These procedures can be merged on request and for small projects only.

6. Main legal and policy Barriers in Czech Republic

The following laws and regulations currently act as barriers to introduce or improve efforts concerning EE and RE production in the WWTP.

Waste management regulation

The Czech legislation defines WWTPs as a public infrastructure that serves to treat municipal and industrial wastewater. There is no legal requirement for a special "permit" for waste processing and management. Development and operation is governed by the Water Act 254/2001 Coll. only. If there is a special step to treat other waste than public or industrial wastewater (normal/concentrated), the WWTP has to fully respect the requirements of waste legislation (Act. No. 185/2001) and the facility or its part shall be classified and approved in line with the waste legislation requirements. This change can be enacted because in some cases, despite minimum technological changes,the EIA process and territorial planning has to be respected. The process of applying for using bio-waste for co-fermentation in WWTPs is complicated.

Pursuant to Czech legislation, WWTP Sludge has its own waste category with specific limits for further handling and utilisation. For a WWTP treating bio-waste there has to be specified, that output remains as "sludge" or "waste processing by-product" by Government order No. 93/2016

WWTP Sludge (both stabilised and also non-stabilised) is categorized as No. 190805 "Sludges produced by municipal waste water treatment" by the Czech waste catalogue – specified by Government order No. 93/2016. These sludges can be utilised as "stabilised sludge" in agriculture according to Government order 437/2016 or disposed as waste or bio-waste. In CR, the bulk of sludge is currently used in agriculture.

By transforming the WWTP to plant with other bio-waste input, there is possibility to have to change output sludge classification to category 190604 "Anaerobic digestion of municipal wastes products" or 190606 "Anaerobic digestion of vegetable and animal by-products residual material". These wastes have to be processed with different technologies with very limited use in agriculture.For wastes with animal by-product content, including gastro waste from restaurants, it is necessary to comply with veterinary legislation, and especially the Hazard Analysis and Critical Control Point (HACCP).

For anaerobic digestion, gastro waste and slaughterhouse meat waste is interesting. Veterinary legislative specified some requirements for waste processing plants:

According to Act EP 1069/2009 (chapter 29) all processing plants for animal by-products (including gastro waste) has to achieve HACCP standards.

Energy regulation

Future development of RE prices is uncertain in the CR. This is mainly because for new RE installations subsidies such as green bonuses have been suspended. Subsidies for existing installations have been reduced or completely withdrawn following achievement of the investment breakpoint time (the complete payback of initial investment – the key indicator is project IRR – for biogas projects it is 10.6%). So there are currently no bonuses for new biomethane projects or other RE projects. The policy situation regarding subsidies for heat utilisation is becoming more complicated. Only for biogas plants operated with manure and biowaste are eligible for subsidies.

Existing WWTP with AD commonly use the biogas in CHP units. Until 2013 fixed prices for electricity produced from biogas were guaranteed for minimum 15 years of operation. After 2013 all subsidies for new projects stopped and no follow-up programme or subsidy policy for RE was introduced. In addition, several additional limitations for existing projects were established. For example, the Energy regulations authority specified efficient heat utilisation (means, that there are specified method what is efficient heat utilisation and what not), also new tool of "recompensation" for existing projects was established – after 10 years of operation project was inspected and if there is too much profit, operator have to reward some part of subsidy).

While the situation is improving, there are many cases where it is uncertain how authorities will determine eligibility criteria for receiving subsidies.

For example: biogas plant started before 2013 has guaranteed electricity price. With main technology change – with some technology improvements Operator should lost the claim for guaranteed price. This is unacceptable for most operators and owners.

Technology barrier

AD is a common method for sludge processing at most mid-sized to large sized WWTPs in CR (>50000 PE).

In most WTTPs in CR, AD facilities were constructed out of concrete or steel tanks, between 1980 and1990. Mixing of digesters is realized by biogas blowers, heating is always external with heat exchanger (desk type mostly). This design is unsuitable for solid waste processing while only liquid wastes can be processed.

For waste processing, it is necessary to replace existing treatment elements for sorting, shredding, storage, and feeding and the reactor technology. This renders building a new waste processing site often more economic.

One example is the Marius Pedersen Rybitví project: Company Marius Pedersen (waste operator company) rebuild part of WWTP to bio-waste processing biogas plant. There was one large non-used activation tank rebuilt into a new fermenter. In addition, new facilities for waste sorting and processing weres built. Despite the fact, that project is situated at WWTP, there is no connection to WWTP operation and technologies are completely divided.

Bio-waste availability

In CR, a large share of the population lives in small cities and villages. Bio-waste production is divided and in past years lots of subsidies went to building small and mid-sized compost plants. Most of bio-waste from rural areas is treated by compost plants and is not available for energy production. A more significant amount of bio-waste is collected in larger cities, and adequate quality of it comprises a significant challenge. This applies particularly to city centers and block housing complexes (built 1970 – 1980). The main problem here is low quality and quantities of yielded bio-waste per inhabitant, making collection a costly enterprise and then high cost of collecting. Exempted from it are residential areas with single-family homes. There, collecting systems attain good results in terms of the quantities and quality of bio-waste (mainly Prague and other big cities).

7. Drivers and existing approaches to overcome barriers in Czech Republic

In order to speed up development of new renewable energy projects, amendments pertaining to the waste-to-energy legislation are necessary.

There is a big issue with processing by-products usage - mainly stabilised fractions of MSW, as well as with WWTP sludges and composts. There are unachieveable limitations at stability (AT4 value) and calorific value for landfilling these materials. This stopped any technology development other than incineration.

The status “end of waste” shall be introduced in the new Waste Act, which will be submitted by the end of 2018. Veolia is striving to emphasise the need for such simplification at the water and waste industry level with relevant stakeholders. Also a careful exclusion of several waste categories from veterinary legislation would simplify the development of projects such as the Prague project.

In the long run, it is absolutely vital to define the optimal share of RE in the national energy mix and assign appropriate resources to develop appropriate projects. The corresponding legislation to the main types of projects must enable simplified project development and operation. At the moment the reality in CP is different: There is no RE policy with a minimum horizon of five years, which would support the most efficient projects.

8. Appendix I: Questionnaire for Legal and Policy Barrier Analysis

This questionnaire is intended for gathering primary and secondary data needed to accomplish D2.4.1. There is no obligation to use it, but you may find it useful drawing on all or several of the proposed guiding questions.

- Conduct 5-10 interviews with experts such as utility staff or policy makers and other experts, separately or in focus groups;

- Adjust questions according to the type of interviewed respondent, characteristics of the treatment facility and utility and country context.

Legal and Policy Barriers in Czech Republic

1. How conducive is the legal and policy framework in supporting the implementation of EE and RE measures in the WWTP(s) of your country?

2. Can you outline and describe in detail the most significant legal and policy barriers, differentiating between the main ways for exploiting energy from wastewater where relevant (such as improving operational energy efficiency or generating electricity and heat from biogas)?

3. Can you identify the political level(s) at which legal and policy barriers may be most severe (EU/International, national, federal and local)?

4. Does the legal and policy situation support or impair interventions for exploiting waste heat more than electricity or vice versa? If so, what barriers apply?

5. Which legal and policy barriers constrain WWUs from using surplus heat and electricity for self-supply?

6. What legal and policy barriers impede supplying waste heat or electricity to the market in your country? For example, regulations may prohibit WWUs from entering business other than managing wastewater while low subsidies for RE might constrain them to gain financial sustainability.

7. What legal and policy barriers particularly apply for integrating systems of solid waste and wastewater to use organic substrates for enrichment of sludge in the co-fermentation process?

Policy and legal drivers and approaches to overcome barriers in Czech Republic

8. Can you outline and describe the most significant legal and policy drivers, differentiating between the main ways for exploiting energy from wastewater where relevant?

9. What governmental or private sector actors do you consider most critical for improving the legal and policy framework for wastewater-to-energy systems?

10. What actor-based instruments (such as a central agency to coordinate interventions with respect to energy-related matters or specific funding or

educational programmes) have been established to promote wastewater-to-energy systems?

11. Are you aware of legal and policy interventions that are currently being planned or already under way to overcome the main barriers you mentioned above (e.g a revision of the sludge ordinance or law with respect to CHP?)

Literature

Ajami, N.K., Thompson Jr, B.H. and Victor, D.G., (2014) The path to water innovation. The Brookings Institution.

European Biogas Association (2016) Position on the revision of the Waste Framework Directive (Position Paper). Retrieved from: http://european-biogas.eu/wp-content/uploads/2016/04/EBA-position-on-WFD-revision_April-2016.pdf

Edwards, J., Othman, M., Burn, S., (2015) A review of policy drivers and barriers for the
use of anaerobic digestion in Europe, the United States and Australia. *Renew. Sustain.Energy Rev.* 52, 815–828.

Dierich, A, Hüesker, F, Ansmann, T. and Gretzschel, O (2017) Rahmenbedingungen für die Sektorkopplung von Abwasserreinigung und Klärschlammbehandlung mit der Energiewirtschaft: Hemmnisse, Treiber und Chancen. *Korrespondenz Abwasser, Abfall* (64)8, 697-706.

Christodoulou, A., & Stamatelatou, K. (2016). Overview of legislation on sewage sludge management in developed countries worldwide. *Water Science and Technology*, 73(3), 453-462.

Iacovidou, E., Ohandja, D. G., & Voulvoulis, N. (2012). Food waste co-digestion with sewage sludge–realising its potential in the UK. *Journal of environmental management*, 112, 267-274.

Kampman, B., Leguijt, C., Scholten, T., Tallat-Kelpsaite, J., Brückmann, R., Maroulis, G., ... & Elbersen, B. (2017). Optimal use of biogas from waste streams: an assessment of the potential of biogas from digestion in the EU beyond 2020. European Commission.

Kilinc-Ata, N. (2016). The evaluation of renewable energy policies across EU countries and US states: An econometric approach. Energy for Sustainable Development, 31, 83-90.

Kiparsky, M., Sedlak, D.L., Thompson Jr, B.H. and Truffer, B., 2013. The innovation deficit in urban water: the need for an integrated perspective on institutions, organizations, and technology. *Environmental engineering science*, 30(8), pp.395-408.

Kretschmer, F (2017) Abwasser als erneuerbare Energiequelle – Potenziale, Chancen und Barrieren im österreichischen Kontext. Wiener Mitteilungen. Volume 246 of Wiener Mitteilungen

Loderer and Hananel (2018) The potential of the wastewater sector in the energy transition (Policy Brief). Retrieved from http://powerstep.eu/system/files/generated/files/resource/policy-brief.pdf

Mateescu, C., Băran, G., & Băbuţanu, C. A. (2008). Opportunities and barriers for development of biogas technologies in Romania. *Environmental engineering and Management Journal*, 7(5), 603-607.

Mininni, G., Blanch, A. R., Lucena, F., & Berselli, S. (2015). EU policy on sewage sludge utilization and perspectives on new approaches of sludge management. Environmental Science and Pollution Research, 22(10), 7361-7374.

Scarlat, N., Dallemand, J. F., & Fahl, F. (2018). Biogas: developments and perspectives in Europe. Renewable Energy.

Speight, V.L., (2015) Innovation in the water industry: barriers and opportunities for US and UK utilities. *Wiley Interdisciplinary Reviews: Water,* 2(4), pp.301-313.

Willis, J., Stone, L., Durden, K., Beecher, N., Hemenway, C. and Greenwood, R. (2012) Barriers to biogas use for renewable energy. Water Environment Research Foundation (WERF).

Vogt, R., Frisch, S. and Pehnt, M. (2010) Klimaschutz- und Energieeffizienz potenziale im Bereich Abfall und Abwasserwirtschaft. Institut für Energie- und Umweltforschung Heidelberg (IFEU).

Werle, S. (2015). Sewage sludge-to-energy management in eastern Europe: a Polish perspective. Ecological Chemistry and Engineering S, 22(3), 459-469.

Willis, J., Stone, L., Durden, K., Beecher, N., Hemenway, C. and Greenwood, R. (2012) Barriers to biogas use for renewable energy. Water Environment Research Foundation (WERF).

Zsirai, I. (2011). Sewage sludge as renewable energy. Journal of Residuals Science & Technology, 8(4).

Yousuf, A., Khan, M.R., Pirozzi, D., Ab Wahid, Z., 2016. Financial sustainability of biogas

technology: barriers, opportunities, and solutions. Energy Sour. Part B Econ. Plann.

Pol. 11, 841–848.

Spinosa, L. Sustainability in sludge management: A combined approach to meet future needs. *Water21*, 31–33.

Torrijos, M. (2016). State of development of biogas production in Europe. *Procedia Environmental Sciences*, 35, 881-889.

D2.4.1: 5 REPORTS ON THE LEGISLATIVE/ADMINISTRATIVE FRAMEWORKS IN THE INVOLVED REGION – STRUCTURE AND QUESTIONNAIRE

GERMANY

11/06/2018

Table of content

1. Introduction

Innovation in the water sector is stifled by multiple barriers, keeping innovation outcomes lower than in other sectors. Factors commonly include risk aversion of water and wastewater utilities, lack of public or commercial funding and too stringent and conflicting regulations (Kiparksy et al., 2013, Ajami et a. 2014, Speight, 2015). A growing body of studies is investigating the barriers that particularly apply to nascent wastewater-to-energy systems. Dierich et al. (2017) for example mentions an unsuitable legal framework, low political priorisation of inter-sectoral action, and insufficient experience in utilities as main barriers. In another study (WERF, 2012), the authors find that "inadequate payback/economies" feature as the most dominant among 10 barriers impeding the implementation of biogas usage in the US wastewater treatment plants (WTPs). Financial hurdles also rank high up in a global study focusing on energy efficiency in US water and wastewater utilities, alongside governance issues and knowledge gaps (ESAMAP, 2012).

These studies indicate that the dissemination of wastewater-to-energy systems is generally confined by a wide range of different barriers, rather than a few single ones. Some of the barriers are applicable to all water-related innovations. Others are unique to wastewater-to-energy systems, their specific type of technological or managerial solution, and the local or regional context the utility is situated in. This becomes obvious in studies that examine specific aspects of wastewater-to-energy systems, for example the "flexibilisation" of energy production and consumption in waste water treatments plants (WWTPs) for optimized energy supply (Dierich et al., 2017). Barriers concern cultural or behavioural aspects within the utility itself (e.g. low commitment of top management) as much as external conditions, for example low regulatory pressure to reduce energy consumption (ESAMAP, 2012). Identifying these barriers is a critical step in order to form measures for setting up framework conditions conducive to the uptake of innovative wastewater-to-energy systems.

As with any other environmental reform, improving the energy performance of wastewater utilities (WWUs) requires strong backing through legislation and policy at various political levels. In this report, we understand legislation and policy and the framework they form to include all laws, policies, regulations, strategies, rules and other instruments used to improve energy outcomes of WWUs. These affect a large host of disciplinary fields, like economics, spatial planning, finance, or utility governance and management relevant to wastewater-to-energy systems. implementing the framework, national and sub-national governments play a key role. They need to grant high-level political support for establishing national legislation and policies, take up the role of the regulator and financier, and initiate other important steps, such as creating a well-engaged and connected agency that provides leadership and coordinates efforts nation-wide (e.g. to produce necessary information like energy maps) (Vogt et al., 2010).

In overcoming key barriers, there are different types of legal and policy measures. With respect to heat generation in WWTPs, Kretschmer (2017) distinguishes between regulatory, incentive-oriented and actor-supportive measures. Necessary regulations, for example, require utilities to reduce CO2 emissions, to track and improve energy performance through energy audits, or to prescribe phasing out energy-inefficient

technologies. Incentives, in contrast, may link government funding or tariff reforms to the utility's energy performance. Or they remove subsidies for electricity that discourage utilities from taking steps towards more energy-efficient operations. Typical actor-supportive measures help utilities to gain access to information about new innovations, their costs, benefits, and available funding opportunities, or offer educational programs for and advice to utility staff. Governments can further establish policies to shore up financing, such as specific financial vehicles for investments in energy efficiency and renewable production in WWTPs or by facilitating access to cross-sector financing programs (e.g. climate funds).

2. Scope of the Study

The objective of deliverable 2.4.1 is to

I) examine the **legal and policy situation** with respect to energy efficiency (EE) and renewable energy (RE) production outcomes of WTPs in the five countries participating in the project REEF2Water;
II) identify the main **legal and policy barriers;**
III) and discern **drivers and existing approaches** to overcome them.

The analysis is based on **desktop research**, information compiled in D1.1.1 on the legal situation and experience of the authors themselves.

The aim of deliverable D2.4.1 is to contribute **to improving the legal and policy framework conditions** that are central for the uptake of wastewater-to-energy systems in each of the five countries. The resultant outcomes form the basis for D2.4.2, in which concrete recommendations for improving laws and regulations are provided. These will subsequently be shared and discussed with policy makers from the participating countries. Furthermore, D2.4.1 will form the basis of a position paper (D5.2.3), which identifies local legislation and regulatory barriers hindering REEF2Water regional implementation strategies, as well as measures to dismantle them.

The nature of the Reef2Water solutions implies that their implementation is affected by a **complex legal and policy framework**. Given that the solutions are part of the wastewater, energy, and solid waste system, a **cross-sectorial perspective** that relates to legal and policy aspects of each of these three systems was taken. This ensures that necessary **sector linking** is achieved in practice.

The analysis considers the **different ways to exploit energy** from wastewater, including energy from biogas production, on-site renewable generation and operational energy efficiency. Here, it is being distinguished between **thermal and electrical energy.** Given the project's particular ambition to enrich sludge through **organic substrates** in the treatment process, the analysis considers applicable legislation and policies of the solid waste system. Furthermore, as the project aims at exploring the potential for WWTPs to become local providers of energy, legislation and policies regulating **temporary energy storage** (such as power-to-gas solutions) and **feed-in into the grid** (including relevant

market-based mechanisms) are considered. All of these aspects are examined for **different political-administrative levels**, at which policy and legislation are given effect at (international/EU, national, federal, and municipal). This helps to locate barriers more precisely, as well as to find scale-sensitive measures to overcome them.

3. Wastewater-to-energy solution at Schönerlinde

In the WWTP Schönerlinde, the following questions will be analysed:

- How effective can be used the waste heat from combined heat and power plant (CHP) for internal purpose such as internal pre-sludge treatment for digestion.
- How effective and economical feasible is biogas upgrading as well as biogas cleaning by different technologies and technology combinations to inject it finally into the gas grid.

4. The EU-Legal and Policy Framework

4.1. Environmental policy and law making in the EU

This chapter summarizes the most relevant EU Directives affecting the implementation of measures to increase EE and RE production in WWTPs. It then analyses a range of legal and policy barriers that are central in doing so.

Directives form the most common regulation in the EU legislative framework. They set the standard conditions and rules. According to the Subsidiarity Principle, member states have to transpose these into national legislative systems, following a clearly defined timetable and a way that best suits national circumstances (LeBlanc et al. 2008).

While member states are aiming at the same goals, the means they use to achieve them can be quite distinct, the heterogeneous development of EU energy markets serving as a very good example.

4.2. Key drivers of wastewater-to-energy solutions and resulting trends across EU member states

The share of renewables in the EU energy mix reached 17 % in 2016. It increased twofold since 2004, being mainly driven by legally binding energy saving and decarbonisation targets (Edwards et al., 2016).

- Renewable energy markets have distinctly developed across member states in what regards their scale and composition of different renewable energy forms. For example, biogas is predominantly used to produce electricity while much of the heat potential remains unexploited (Kampman et al., 2016). Also, only some frontrunners such as Sweden actively pursue producing biomethane for the transport sector.

- Only a few countries, such as Spain, use sewage sludge as a main feedstock for biogas production, making it the feedstock being used the least overall (Scarlat et

al., 2018). In most member states, such as Germany and Italy, crops dominate as a feedstock while the potential to use sewage remains largely untapped (Figure 1.).

- The EU has began to embrace a circular economy approach. Its stringent regulatory regime is changing waste streams and disposal options. Importantly, while bio-waste and sludge production increase (Zsirai, 2011), limits are put on landfilling, and particularly of biodegradable material. Applying sludge as a fertiliser and soil conditioner is still the preferred options in most member states, more stringent rules confine this end-use form (Spinosa 2010). Together these developments have driven wastewater-to-energy solutions.

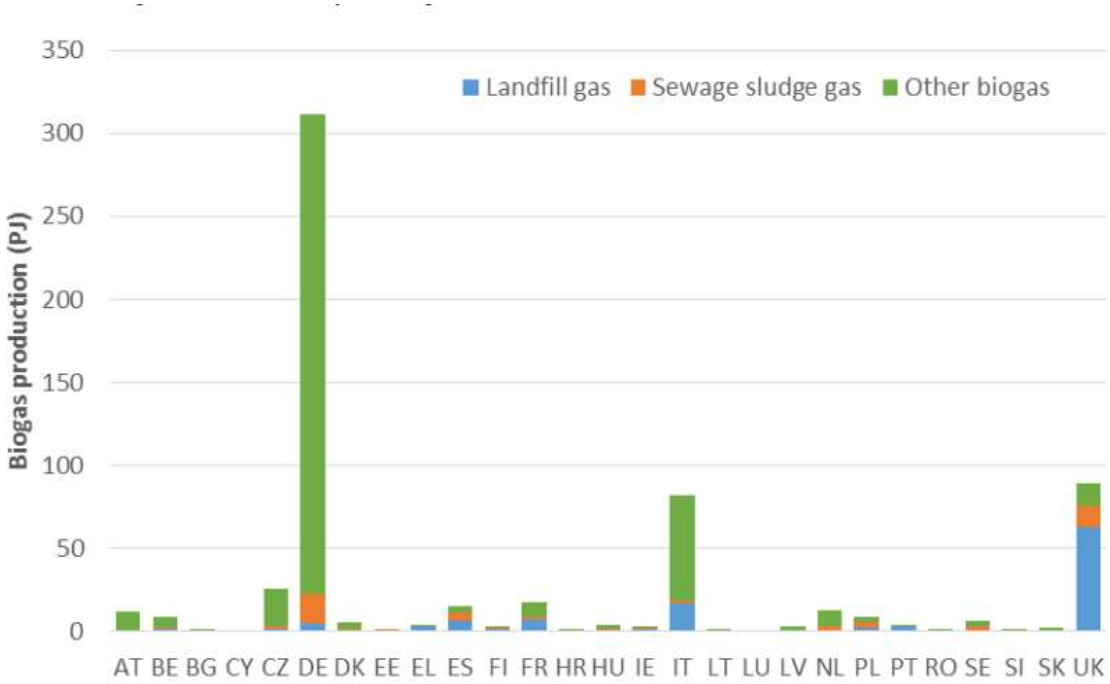

Figure 1: Biogas production per Member State in 2014, differentiated by source (Kampman et al., 2016)

4.3. Overview of key EU legislation and policies

4.3.1. Water & Wastewater

The Water Framework Directive (2000/60/EC)

This directive (here referred to as the WFD) requires that rivers, lakes, transitional waters, coastal waters, and groundwater obtain "good status" by 2027. To achieve this goal, the EU has determined a clear timeline and three six-year management cycles for the member states. One of its main elements is the introduction of River Basin Districts, which form the management units for managing water resources. Importantly, the WFD pertains to services of both water and waste water.

The Urban Waste Water Treatment Directive (91/271/EEC)

The main objective of the Urban Waste Water Treatment Directive (UWWTD) is to protect the environment from negative effects of urban wastewater discharges. It comprises the collection, treatment, and discharge of domestic wastewater, mixture of wastewater, and wastewater from certain industrial sectors. It stipulates the level of treatment and the removal of nutrients and basic sanitary parameters, as well as conditions for sludge disposal and reuse.

The Sewage Sludge Directive (86/278/ EEC)

The Sewage Sludge Directive (SSD) is concerned with the management of sewage sludge. It particularly seeks to encourage the use of sewage sludge as a soil conditioner and fertiliser in agriculture. It bans applying untreated sludge on agricultural land. Also, it sets all the requirements and provisions to prevent potential harmful effects on humans, animals, soil and vegetation as well as surface and groundwater. The Directive lays down the basic limits for potentially toxic elements (PTEs, which are HMs) in SS and soil.

4.3.2. Climate change mitigation

2020 Climate and energy package ("20-20-20 targets")

This package was established in 2007. Its goal is to ensure that the EU meets its climate and energy targets. In consequence, the legislation encompassed three main targets for the year 2020:

- 20% increase in energy produced from renewables
- 20% enhancement in energy efficiency
- 20% cut in greenhouse gas emissions (compared to 1990 level)

Emissions Trading System (ETS)

The ETS is a central element in the EU's policy to tackle climate change and a key tool for reducing greenhouse gas emissions in a cost-effective manner. It is based on a "cap and trade" system. The cab limits the amount of greenhouse gas emissions a certain user or industry is allowed to emit. As the cap is gradually lowered over time, emissions are expected to fall. Within the cap, companies receive or buy emission allowances that cover their emissions. These can be traded.

Effort sharing agreement for the non-ETS sectors

The Effort Sharing Decision establishes binding annual greenhouse gas emission targets for Member States for the period 2013–2020. These targets concern emissions from most sectors not included in the EU Emissions Trading System (EU ETS), such as transport, buildings, agriculture and also waste. The regulation aims to ensure that the non-ETS sectors emissions reduction target of 30% by 2030 compared to 2005 levels.

4.3.3. Renewable energy production and energy efficiency

Renewable Energy Directive (2009/28/EC)

The Renewable Energy Directive (RED),which is currently being revised, establishes a policy framework for producing and encouraging renewable energy in the EU, including biogas. The directive requires that 20 % of the EU's energy mix in 2020 must be renewable. It translates this general goal into individual targets for each of the member states. In a recent proposal to revise the directive the Commission elevated that goal to 27 % by 2030. The RED also defines sustainability criteria for biofuels and bioliquids in the transport sector.

Directive to reduce indirect land use change for biofuels and bioliquids ((EU/2015/1513)

The ILUC was established as response to sustainability challenges concerning bio-energy made out of food-based crops, most importantly indirect land-use change. It amends current legislation on biofuels, including the Renewable Energy Directive (2009/28/EC) and Fuel Quality Directive (2009/30/EC). For example, it limits the share of biofuels produced from crops in the transport sector (7% in overall fuel mix). It also requires that biofuels produced in new installations emit at least 60% fewer greenhouse gases than fossil fuels.

Energy Efficiency Directive (2012/27/EC)

The Energy Efficiency Directive (EED) mandates energy efficiency improvements. It establishes a common framework for the promotion of EE within the EU to meet its EE headline target of 20% by 2020, in all stages and sectors of the supply chain. EU member states have to prepare a National Energy Efficiency Action Plan every three years and report on their progress in the different sectors (i.e. industry, residential, services, public, transportation, electricity and heat generation).

Directive for combined heat and power generation (2004/8/EC)

This directive promotes the use of combined heat and power (CHP) units to improve the efficiency of electricity and heat production. It sets rules on guarantees of origin, efficiency criteria, administrative procedures, and other issues. Member states are encouraged to provide support schemes for CHP units to enable their widespread implementation (including specific support for WTTPs).

4.3.4. Natural Gas

Directive on services in the internal gas market (2009/73/EC)

This 'Gas Directive' establishes common rules for the transmission, distribution, supply and storage of natural gas. It stipulates rules relating to the organisation and functioning of the natural gas sector, access to the market, the criteria and procedures applicable to the granting of authorisations for transmission, distribution, supply and storage of natural gas and the operation of systems. The rules also apply in a non-discriminatory way to biogas and gas from biomass, i.e. sewage gas from WWTPs.

Directive for internal electricity market (2009/72/EC)

This directive establishes common rules for the generation, transmission, distribution and supply of electricity, together with consumer protection provisions, with a view

to improving and integrating competitive electricity markets in the EC. It lays down the rules relating to the organisation and functioning of the electricity sector, open access to the market, the criteria and procedures applicable to calls for tenders and the granting of authorisations and the operation of systems such as transmission or distribution systems, including the request for unbundling of electricity production and

Directive for taxation of electricity and other energy products 2003/96/EC (EU 2003a) sets a framework for taxation of electricity and other energy products, e.g. gas or other fuels. It defines the energy products to be taxed and the minimum amount. The project "Full scale demonstration of energy positive sewage treatment plant concepts towards market penetration" (POWERSTEP) has received funding under the European Union HORIZON 2020 –

4.4. Solid waste management

The Waste ´Framework Directive (2008/98/EC)

This directive defines basic concepts such as the "waste hierarchy" (a priority order set among waste prevention and management options), and stipulates requirements for waste management, such as to up a separate collection of waste, waste management plans, and waste prevention programmes. It also establishes legally binding targets such as for household waste streams including biodegradable materials).

The Landfill Directive (1999/31/EC)

This directive aims at preventing or reducing adverse environmental impacts from landfilling of waste through stringent technical requirements for waste and landfills. It obliges Member States to reduce the amount of biodegradable municipal waste that they landfill to 35% of 1995 levels by 2016 (for some countries by 2020) while current legislative of the proposal of it consider a complete ban of landfilling.

4.5. Legal drivers and barriers

Paucity of energy aspects and targets in water legislation

Energy-related issues remain vastly absent from the EU's legal and policy framework of the water sector. The key water-related directives, the WFD and the UWWTD, make no provisions that specifically focus on targets, measures or incentives to improve EE or renewable production measures in WWTPs, whether motivated by ambitions of cost-efficiency or decarbonisation. Also, more recent water policy documents such as the "Blueprint to Safeguard Europe's Water Resources" (2012) poorly make that linkage. A legislative proposal of the Drinking Water Directive adopted this year comprises one of the first attempts to embrace the water energy-water nexus by encouraging member states to increase energy efficiency.

Lack of overall cross-sectoral and coherent legal framework

The absence of a cross-sectoral approach spanning across various relevant EU energy, waste, water, agricultural and other concerned directives stifles legal backing

needed to more systematically support wastewater-to-energy solutions. Energy-related issues are missing in EU water sector policy and law, which predominantly focus on water quality and quantity goals. The RED, on the other side, fails to articulate specific provisions on how, for example, the waste water sector can contribute to achieving targets concerning carbon reduction and renewable production. Incoherence of the overall legal and policy framework has been ranked as the top barrier for biogas production (Kampmann et al., 2016).

Inadequate priorisation of second generation bio-energy

Member states have been free to opt through which form of renewable energy they accomplish these targets. This flexibility has given rise to divergent developments of the biogas market across the member states (Torrijos, 2016), with in part undesirable outcomes. A prominent example applies to the rise of crop-based biogas, which ranks as the EU's main type of bio-energy and dominant renewable energy form (Kampman et al., 2016). As a feedstock, however, crops have proven adverse environmental impacts (e.g. land use change). The environmental footprint of biogas produced from waste streams, in contrast, is significantly better, but their share in the biogas market lag behind that of crop-based biomass (see. Figure 1). This is because the EU legal and policy does not systematically support renewable energies according to their sustainability performance. Sustainability criteria, which form one central pre-condition towards doing so, exist only for the transport sector while they lack cross-national harmonisation (Kampman et al., 2016).

An improving yet unreliable base of bio-waste feedstock

The EU's stringent regulatory regime for waste functions as a strong driver for wastewater-to-energy systems. The Landfill Directive is viewed as the most important factor propelling the growth of anaerobic digestion (AD) (including on-farm applications) in treating biowaste and industrial feedstock (Edwards et al., 2015). This is because the ban on landfilling and tightening quota for reducing landfilled biodegradable organics increase the need to find solutions for disposing growing amounts of bio-waste (Torrijos, 2016). However, many member states do not have a reliable bio-waste feedstock base (Edwards et al., 2016). Only 25 % of the total bio-waste in the EU is recycled while recycling rates are considerably lower in many member states (Mateescu et al., 2008). In some countries like the UK, access to adequate organic feedstock is already a barrier (Kampman et al., 2016). Additionally, current regulations do not promote AD as a preferable disposal option for biowaste. Legal loopholes still allow member states incinerate or landfill biowaste (Iacovidou et al., 2012). The European Biogas Association (2016) remarks that incineration may become the main disposal option for biowaste as the as the landfilling ban takes effect.

Under-development of heat usage due to weak incentives

Whether WWTPs achieve high potential of energy and carbon emissions savings depends on exploiting both heat and electricity generated during the combustion of biogas. Biogas markets have expanded in several EU member states. However, despite some positive development, often only the electricity generated from biogas is used while the heat potential remains untapped. Currently, only 25 % of the heat is used in Europe's WWTPs (Scarlat et al., 2018). While plant operators face pressure to

improve the economics of biogas plants (ibid), weak incentives at the EU-level comprise one key factor responsible for the slow development of heat usage from biogas (Kampman et al., 2016).

Lacking revenue streams for sewage-based co-digestate

Using co-digestate of sewage sludge and bio-waste as soil conditioner or fertiliser (for example in agriculture) can spur the uptake of wastewater-to-energy solutions (Edwards et al., 2015). Such "end-use" applications guarantee that sewage sludge, whose production in Europe will rise over the next years (Werle, 2015), will be harnessed in the spirit of a circular economy. Currently, however, sludge-based co-digestates are subject to an incoherent and partially conflicting legal and regulatory regime (Iacavidou et al., 2012), which compounds the dissemination of AD technologies. One main barrier is that co-digestate containing sewage sludge is currently classified as waste and not a valuable product. This legal definition only allows WWTP operators to market the biogas, but not its by-products, undermining additional revenue streams (Kampmann et al., 2016).

Ambiguous financial mechanisms for wastewater-to-energy solutions

Access to inexpensive renewable energy will become increasingly important because the cost of sewage sludge treatment is bound to rise due to higher treatment standards and rising energy costs, among others (Zsirai, 2011). Cost pressures, which the imposed by the cost-recovery principle in the WFD, theoretically attractive for WWUs to deploy RE production. However, new technologies such as AD are capital-intensive, generally requiring subsidisation (Edwards et al., 2015). National support schemes (e.g. feed-in tariffs) form the key financial mechanism to drive renewable energy developments in the EU. However, these are still ineffective in many member states, for example due to low or reduced subsidies (Kampman et al., 2016). At the same time, the EU legislation and policies upon which the support schems are based are yet not sufficiently linked to sustainability criteria, as argued above. Furthermore, Green Public Procurement (GPP) for WWTPs currently apply only to EE, but not to producing RE (Loderer and Hananel, 2018).

Grid injection of bio-energy

If not used for self-supply in on-site CHP plants, WWUs have several options to bring bioenergy to the market: As biogas or biomethane via the gas network; as heat via the district heating network; or as electric power via the electric grid. Arguably, a range of barriers apply to each of these options. Generally, decentralized energy forms – such as wastewater-to-energy solutions – lack a common EU framework that explicitly supports them. Across member states + small market entrants providing distributed energy (DE) still face various challenges, including a lack of explicit incentives in planning and operations of networks, high connection charges, or high trading fees (Ropenus and Skytte, 2005). Another specific example concerns cross-border trade of biomethane, which is hindered substantially by national quality standards, which lack harmonisation (Kampan et al., 2016).

5. Overview on legal and policy situation in Germany

The legal framework of energy management in Germany is highly complex, mainly due to the deregulation of the public energy market in the 1990s and the on-going political "energy transition" to increase the use of renewable energy (RE) sources for energy production. This process is framed by a variety of relevant laws and regulations for the energy market, energy efficiency targets, energy taxes, and the management of RE in electricity and heat supply including the production of combined heat and power. In total, there are currently 62 laws and ordinances (> 1600 pages) which affect this sector in Germany (Seibert-Ehling 2016).

5.1. National Level:

For the implementation of increased EE and RE outcomes in the WWTP, the following laws are most relevant:

- Energiewirtschaftsgesetz – EnWG ((EnWG, 2017)) (Energy Economy Law)
- Erneuerbare-Energien-Gesetz – EEG ((EEG, 2017)) (Renewable Energy Sources Act)
- Kraft-Wärme-Kopplungsgesetz – KWKG ((KWKG, 2016)) (Combined Heat and Power Act)
- Stromsteuergesetz – StromStG ((StromStG, 2016)) (Electricity Tax Law)
- Energiesteuergesetz – EnergieStG ((EnergieStG, 2017)) (Energy Tax Law)
- Treibhausgas-Emissionshandelsgesetz (TEHG 2017) (Greenhouse Gas Emissions Trading Act)
- Erneuerbare-Energien-Wärmegesetz (EEWärmeG 2015) (Renewable Energies Heat Act)
- Bundes-Immissionsschutzgesetz (BImSchG) (Federal Immission Control Act).

Whereas the EnWG regulates the general energy market (e.g. consumption and production of energy, sales, grid management, etc.), the EEG is focused on the promotion and management of RE in form of rules for grid supply, subsidies for RE, and taxes for other energy sources to cover the societal cost of the energy transition. For combined heat and power (CHP) generation, the KWKG regulates subsidies for energy from CHP units to promote this very efficient use of energy sources at smaller scale. The StromStG regulates the taxable use of electricity, also including the waiving of electricity tax for self-consumption. Sewage gas is also a combustible gas according to the EnergieStG, but is currently freed from this tax (Ravn et al., 2017). TEHG regulates greenhouse gas emission allowance trading and the duty to surrender emission allowances. The EEWärmeG regulates the use of RE to cover the heat demand of new erected buildings. By 2020, the share of RE in heat supply has to be 14%. (International Energy Agency, 2015)

The key stakeholders in the mentioned laws are Federal Ministry for Economic and Affairs and Energy (BMWi) and Federal Ministry for Environment, Nature Conservation, Building and Nuclear Safety (BMUB). BMWi plays a central role in implementing of mentioned regulations and is a driving force in the Energiewende. BMWi and BMUB are mostly responsible for energy legislation. Regulation on transport

and the energy transition are drafted by the Federal Ministry for Transport and Digital Infrastructure (BMVI). In addition, there are many other institutions such as the Federal Environment Agency (UBA), the Federal Network Agency (BNetzA), the German Council for Sustainable Development, the independent expert commission on Energiewende monitoring and German Energy Agency (dena) which provide data and give policy advice. Furthermore, different lobby groups and stakeholders from industry try to influence the relevant political processes. (Egenter, Ruby, & Wettengel, 2017)

5.2. Federal and Municipal Level:

Federal states implement these laws and can decide how they incorporate the adapted legislation. They mostly have their own aims for implementation of increased EE and RE outcomes in WWTP. They can influence, for instance, how easy it is to integrate renewable energies with wastewater treatment plants.

The most important stakeholder to improve the energy efficiency and renewable energy resources production is finally the customer. The following stakeholders determine the improvement of energy efficiency / energy production through renewable energy:

- Climate Protection Agreement BWB – Senate of Berlin
- Berliner Energiewendegesetz (EWG Bln) – SEUVK of Berlin
- Guide values e.g. the DWA (German Association for Water, Wastewater and Waste)
- Benchmarking of sewage treatment plants
- BWB company

State regulatory authorities such as Senate Department for the Environment, Transport and Climate Protection (SEUVK) play a central role in implementing energy regulations in Berlin. There are several institutions, which control the wastewater sector. Berliner Wasserbetriebe (BWB) is a public law corporation and is the largest company in the field of water supply and wastewater treatment in Germany. Since the treated wastewater is discharged into the Berlin rivers, the Berlin water authority is responsible for the discharge licence and water quality. The sewage treatment plant Schönerlinde is located in Brandenburg, so the land Brandenburg has the permission for operation. The authoritative law for air quality control in the unit of sludge drying is the Federal Immission Control Act (Bundes-Immissionsschutzgesetz, BImSchG).

6. Main legal and policy Barriers in Germany

The main barrier to further development of EE and RE measures in the Schönerlinde WWTP is the lack of coherent support schemes that sufficiently promote effort to increase of RE in WWTP. Wastewater regulations and legislation are too unspecific (they are not specially for WWTPs and do not focus on it; for example EEG is for renewable energy sources) and waste or even pose a barrier to energy flexibility and sector coupling of WWTPs (Axel Dierich at el., 2017).

Self-supply with CHP electricity

In Germany, using electricity for self-supply of WWTPs is economically more viable than supplying it to the grid. The main reason for this are high market prices for electricity. The current market price lies above 170 €/MWh, which is mainly determined by taxes and fees (80%) and only partially by the market price (20%). The high taxation implies a low price, for which utilities can sell electricity. Through producing electricity for self-supply, utilities can avoid large costs for purchasing electricity from the market. Regulations for self-supply through electricity produced in biogase-fuelled CHP units imply specific EEG fees and obligations to follow:

- Self-supply from new CHP units is subject to a reduced EEG fee (40% or 25 €/MWh).
- Self-supply from existing or re-powered CHP (up to +30% of capacity) is fully waived from EEG fee (existing or approval for operation before August 2014 (BNA 2016)). From 2018 onwards, the repowering of CHP leads to the loss of this economic advantage, and a 40% EEG fee will apply for repowered CHPs. Comparably, modernisation or replacing of an existing CHP (e.g. after full depreciation or ending of EEG remuneration time) will lead to a 20% EEG fee from 2018 onwards.
- The operators have to monitor production and self-supply in 15min intervals to prove the matching of power profiles, unless technical conditions are such that this can be deemed to be always the case. Furthermore, the grid operator has to be notified about the self-supply in monthly and yearly intervals; if not notified, a certain amount of EEG fee falls due.
- KWK bonus (4 Cent/kWh) is no longer applicable for self-supply with CHP > 100 kilowatt electric (kW_{el}) (KWK Gesetz, 2015)

These regulations decrease the attractiveness of self-supply of a WWTP when building new CHP units, and impose new obligations to WWTP operators who are using their CHP for self-supply.

Legal definition of self-supply

For the potential waiving of EEG fees in case of self-supply, the exact legal definition of “self-supply” is crucial to enable access to this economic advantage.

In particular, the following conditions have to be met according to the latest version of EEG (EEG 2017):

- The producer of electricity and the end consumer have to be an identical natural or legal person.
- The electricity produced has to be consumed in “actual spatial relation”, i.e. locally close to the production location and without using a public grid. This criterion is checked on a case-by-case basis, but usually applies for any self-supply on the same premises of the operator (i.e. on the same property). (BNA, 2016)

Previous versions of the EEG (EEG 2012) have defined less strict conditions for self-supply, so that existing RE systems at WWTPs (e.g. CHP plants constructed before 2014) were eligible for more subsidies. As mentioned above, the EEG 2017 changes the condition for the self-supply. For example, it cannot be regarded as self-supply if the produced electricity is injected into the public power grid first and subsequently withdrawn from it (Ravn et al., 2017).

Grid supply of CHP electricity

If electricity from CHP units smaller than > 100 kW_{el} is sold to the grid, the operator has to engage in direct marketing, which usually means that a third party (e.g. EEX electricity exchange) takes over the sale of this electricity. During direct marketing, two main schemes are available for subsidies: the EEG scheme and the KWK scheme. One can only apply to either of the schemes, so the operator has to decide which subsidy scheme is more beneficial for the specific conditions (i.e. either EEG or KWK). Both laws differentiate between level of support and the incentive period. For example, according to the KWK, the CHP operators receive subsidy for 30,000 full-load hours. However, the EEG provides the subsidy for 20 years. Electricity production for grid supply is less attractive due to the low market price for electricity and the limited subsidy schemes, which enable a maximum revenue of 70-90 €/MWh depending on the selected subsidy scheme. This means that the cost of energy production with CHP (around 170 €/MWh) is more than the reached revenue. In addition, electricity sale is connected to specific conditions such as direct marketing by third parties, remote control of production, and proof of high efficiency in energy usage in case of using the combined heat and power subsidy scheme. This means that a plant operator is obliged to collaborate with a direct seller. If they fail to find a seller, then they will not be able to feed into the grid. Additionally, the remote control means that the WWTPs have to be flexible with grid supply. As a result, the operator of a WWTP must have enough storage space (gas storage tank) for the produced biogas in order to operate flexible. Due to the complex rules and frequent changes in the subsidy schemes, the future situation for grid supply is highly difficult to predict, which adds a high factor of uncertainty to this marketing option. Furthermore, EEG bonus and subsidies decrease continuously. For grid supply of electricity, subsidy schemes have been reduced in recent revisions of the RE energy laws, so that this route is becoming less attractive. Due to the rapidly decreasing production costs of renewable electricity from wind and PV technologies, electricity from wastewater treatment plants may not be fully competitive in the electricity market (Powerstep, 2017).

Production of heat for external supply

In general, the market for heat has less complex regulations than the electricity market, which leads to a simpler and more stable price structure. Natural gas and fuel oil are the main energy sources for heat production, and the heat market is thus strongly correlated with the fuel prices. Due to the high losses during physical transport of heat, the actual heat price is heavily depending on the local heat demand and supply and when suitable consumers and grid connection are available. The current price for heat is 20-50 €/MWh for both purchase and sale. Compared to

the electricity price (170 €/MWh), this is too low to be feasible. Regarding heat produced in CHP units, no subsidizes for heat sales are applicable (e.g. for export to a district heating network). However, KWK subsidies can be applicable for financing the connection to heating or cooling networks or storage facilities. Potentials in heat sale are heavily depending on local conditions (demand) and the existence of infrastructure (e.g. district heating) nearby. A sectoral coupling between heat and electricity has a high potential to save greenhouse gases if the heat produced in a CHP is mostly used for other purposes such as heat supply of buildings (Powerstep, 2017).

The EEWärmeG regulates the use of RE to cover the heat demand of new erected buildings. This legislation does not consider synthetic renewable gases (biomethane upgraded from biogas) as RE. Consequently, the use of biomethane or hydrogen in this sector is not promoted by the EEWärmeG. (dena, 2017).Creating an adequate regulatory framework can make the use of biomethane attractive in this sector.

Production of biomethane for grid injection or as biofuel for vehicles

Biomethane production may be a viable option for the future due to the constant prices at the gas market and the rising demand of "green" gas to reach EU policy targets in the heating and transport sector. The legal, organisational and quality requirements for grid injection of biomethane are regulated in a specific ordinance (GasNZV 2017). Fees for injection and transport of biomethane via the gas grid are regulated in another ordinance (GasNEV 2017). Investment costs for grid connection to enable direct injection of biomethane into the gas grid have to be mainly covered by the grid operator and can be added to the entire network costs. However, this is only the case if the length of connection pipe is less than one kilometre. In general, marketing of biomethane is third party business, and no specific subsidy scheme exists (such as EEG for electricity). Prices will be agreed on between the parties (e.g. the grid operator or consumer) and are determined by supply and demand. If there is low demand, the price decreases and vice versa (Ravn et al., 2017).

Status of upgraded digester gas and PtG products produced at a WWTP

The existence and design of infrastructures for electricity and gas grid are critical elements for the implementation of power-to-gas technology. WWTPs are mainly located in rural areas, where the infrastructure can be underdeveloped, making a connection to the grid difficult. Furthermore, the current developing scheme of electricity and gas grid does not correlate and makes the planning of P2G technology excessively difficult.

Besides, the implementation of P2G technology in Germany must still be further promoted with a couple of specific regulations and policy actions. The following legislations are the most pressing legal and policy barriers in this sector:

- P2G units are currently defined as "ultimate consumers" of electricity and can thus be affected by fees for electricity consumption as defined in the EnWG (e.g. EEG fee, grid fee). However, they should be seen as "storage

technology" of the energy system which would make them exempt of these fees and improve their economic feasibility (Ravn et al., 2017).

- The EEG subsidy scheme does not promote local P2G technology over direct grid supply of excess renewable electricity. In fact, current EEG "hardship provision" fully compensates lost profits of RE suppliers during times of excess supply of electricity into the grid, thus favouring excess supply of electricity to the grid over intelligent storage schemes such as P2G. The phase-out of this compensation mechanism would make storage technologies such as P2G more attractive for RE providers. (BNA, 2016)
- The marketing barriers of P2G biogas can be decreased, if the definition of "biofuel" is changed as stated in latest EC guidelines. Defining P2G biomethane as biofuel (e.g. in BImschG) would enable the marketing of this biomethane in the framework of climate goals in the transport sector (dena, 2017).
- Biomethane, which is produced in P2G units, has to use 100% electricity from renewable sources (§3 Nr. 42 EEG). The usage of grid electricity for P2G cannot receive the EEG subsidy. This requirement makes P2G technology unattractive.
- The EEG fee only has to be paid when the stored electricity is re-injected into grid. This exemption from the obligation to pay the EEG fee is possible for P2G if the biomethane or hydrogen from P2G is reused for producing electricity after the injection into the gas grid (§ 61k EEG 2017). This section of law restricts to apply biomethane flexibly.
- According to TEHG, the industry can use biomass as a measure for the reduction of its emission. However, the law does not consider the use of biomethane or hydrogen in industrial sector as an action that can be taken to reduce emission (dena, 2017).
- The injection of hydrogen into the gas grid is limited cannot be larger than 10% (DVGW-Regelwerk G262) and is also restricted by federal authorities such as BNetzA. The approval procedures are complex and constitute a risk for operator (dena, 2017).
- Treatmentreatment of biogas by-products and the access to the suitable waste stream disposal are barriers related to the biogas upgrading process.

Overall, investments in P2G highly depend on an attractive and stable policy support scheme, and a positive long-term outlook.

7. Drivers and existing approaches to overcome barriers in Germany

In Germany, several laws are in place to boost the production of RE within the market. The EEG and EnWG support the producers with subsidy schemes, feed-in tariffs and tax incentives. However, the KWK Act has been driving the

implementation of EE and RE production in WWTP in the last years. Furthermore, one of the important drivers is to integrate WWTPs into regional and national smart grid concepts to manage renewable energy production. WWTPs can store, produce or use large amounts of electricity or heat on demand and can therefore play a significant role in a region's sector coupling strategy (Loderer, Lesjean, & el.).

Conventional WWTPs still consume a lot of energy from the grid. An energy efficient concept can transform these plants into energy neutral or even energy positive operations. As a result, reduction of energy demand by efficient operation is also a driving factor for the operators (Loderer, Lesjean, & el.).

Currently, legal regulations and subsidy schemes favour the use of WWTP energy for electricity production to cover the electricity demand of the WWTP (= self-supply). Due to the high price of electricity (> 170 €/MWh), which is mainly determined by taxes and fees (80%) and only partially by the market price (20%), self-supply is an attractive option to avoid these significant costs by producing electricity on –site to cover the demand of the WWTP, for example in a CHP unit. In addition, the increase of biogas production from sewage sludge is also a driver factor for the plant operators. The increase of biogas production leads towards more efficient 'primary treatment' to transfer a maximum amount of organic matter into anaerobic digestion to produce more biogas. Consequently, the energy efficiency of WWTP is getting more and more important. (Loderer, Lesjean, & el.)

Heat valorisation can be a driving factor as well if there are suitable customers in the vicinity of the WWTP or an existing connection to a heating network, e.g. for district heating. Typical revenues for heat are 20-50 €/MWh depending on local demand and seasonal factors.

Grid injection of upgraded biogas to bio-methane can yield stable revenues in the range of at least 47-58 €/MWh. This route is further promoted by connection to and injection into the gas grid, which also lowers the financial burden of grid connection for the WWTP operator. Investment costs for grid connection to enable direct injection of biomethane into the gas grid have to be mainly covered by the grid operator and can be allocated to the entire network costs. The grid injection of biomethane is a viable option which will be increasingly attractive for WWTP operators in the future.

P2G technologies are seen as an important building block of the energy transition in Germany and will receive further political support in the next decade, making them an interesting technology also for the WWTP sector.

There are some governmentally initiated promotion programs which support EE in WWTPs. For example, BMUB has promoted a program called energy-efficient WWTP between 2010 and 2016. (UBA, 2016) The other programs such as STEP up and FONA3 support the research and development of EE in WWTP.

8. Appendix I: Questionnaire for Legal and Policy Barrier Analysis

This questionnaire is intended for gathering primary and secondary data needed to accomplish D2.4.1. There is no obligation to use it, but you may find it useful drawing on all or several of the proposed guiding questions.

- Conduct 5-10 interviews with experts such as utility staff or policy makers and other experts, separately or in focus groups;
- Adjust questions according to the type of interviewed respondent, characteristics of the treatment facility and utility and country context.

Legal and Policy Barriers in Germany

1. How conducive is the legal and policy framework in supporting the implementation of EE and RE measures in the WWTP(s) of your country?

2. Can you outline and describe in detail the most significant legal and policy barriers, differentiating between the main ways for exploiting energy from wastewater where relevant (such as improving operational energy efficiency or generating electricity and heat from biogas)?

3. Can you identify the political level(s) at which legal and policy barriers may be most severe (EU/International, national, federal and local)?

4. Does the legal and policy situation support or impair interventions for exploiting waste heat more than electricity or vice versa? If so, what barriers apply?

5. Which legal and policy barriers constrain WWUs from using surplus heat and electricity for self-supply?

6. What legal and policy barriers impede supplying waste heat or electricity to the market in your country? For example, regulations may prohibit WWUs from entering business other than managing wastewater while low subsidies for RE might constrain them to gain financial sustainability.

7. What legal and policy barriers particularly apply for integrating systems of solid waste and wastewater to use organic substrates for enrichment of sludge in the co-fermentation process?

Policy and legal drivers and approaches to overcome barriers in Germany

8. Can you outline and describe the most significant legal and policy drivers, differentiating between the main ways for exploiting energy from wastewater where relevant?

9. What governmental or private sector actors do you consider most critical for improving the legal and policy framework for wastewater-to-energy systems?

10. What actor-based instruments (such as a central agency to coordinate interventions with respect to energy-related matters or specific funding or educational programmes) have been established to promote wastewater-to-energy systems?

11. Are you aware of legal and policy interventions that are currently being planned or already under way to overcome the main barriers you mentioned above (e.g. a revision of the sludge ordinance or law with respect to CHP?)

Literature

Ajami, N.K., Thompson Jr, B.H. and Victor, D.G., (2014) The path to water innovation. The Brookings Institution.

dena. (10 2017). Baustein einer Integrierten Energiewende. Abgerufen am 03. 05 2018 von Roadmap Power to Gas: http://www.powertogas.info/fileadmin/content/Downloads_PtG_neu/Roadmap_PtG/171127_dena_Roadmap_PtG.pdf

Dierich, A, Hüesker, F, Ansmann, T. and Gretzschel, O (2017) Rahmenbedingungen für die Sektorkopplung von Abwasserreinigung und Klärschlammbehandlung mit der Energiewirtschaft: Hemmnisse, Treiber und Chancen. *Korrespondenz Abwasser, Abfall* (64)8, 697-706.

EEG (2017): Gesetz für den Ausbau erneuerbarer Energien (Erneuerbare-Energien-Gesetz - EEG 2017). Bundesgesetzblatt I 2. 1066 vom 21. Juli 2014, zuletzt geändert durch Artikel 2 G vom 22.12.2016 I 3106,

Egenter, S., Ruby, R., & Wettengel, J. (20. April 2017). Key stakeholders in Germany's Energiewende. Abgerufen am 2018 von https://www.cleanenergywire.org/factsheets/key-stakeholders-germanys-energiewende

European Biogas Association (2016) Position on the revision of the Waste Framework Directive (Position Paper). Retrieved from: http://european-biogas.eu/wp-content/uploads/2016/04/EBA-position-on-WFD-revision_April-2016.pdf

Edwards, J., Othman, M., Burn, S., (2015) A review of policy drivers and barriers for the
use of anaerobic digestion in Europe, the United States and Australia. *Renew. Sustain.*
Energy Rev. 52, 815–828.

Iacovidou, E., Ohandja, D. G., & Voulvoulis, N. (2012). Food waste co-digestion with sewage sludge–realising its potential in the UK. *Journal of environmental management*, 112, 267-274.

International Energy Agency. (22 Jun 2015). Renewable Energies Heat Act (EEWärmeG). Von https://www.iea.org/policiesandmeasures/pams/germany/name-24388-en.php abgerufen

Kampman, B., Leguijt, C., Scholten, T., Tallat-Kelpsaite, J., Brückmann, R., Maroulis, G., ... & Elbersen, B. (2017). Optimal use of biogas from waste streams: an assessment of the potential of biogas from digestion in the EU beyond 2020. European Commission.

Kilinc-Ata, N. (2016). The evaluation of renewable energy policies across EU countries and US states: An econometric approach. Energy for Sustainable Development, 31, 83-90.

Kiparsky, M., Sedlak, D.L., Thompson Jr, B.H. and Truffer, B., 2013. The innovation deficit in urban water: the need for an integrated perspective on institutions, organizations, and technology. *Environmental engineering science*, 30(8), pp.395-408.

Kretschmer, F (2017) Abwasser als erneuerbare Energiequelle – Potenziale, Chancen und Barrieren im österreichischen Kontext. Wiener Mitteilungen. Volume 246 of Wiener Mitteilungen

KWK Gesetz. (21. 12 2015). Gesetz für die Erhaltung, die Modernisierung und den Ausbau der Kraft-Wärme-Kopplung. Von https://www.gesetze-im-internet.de/kwkg_2016/KWKG.pdf abgerufen

Loderer and Hananel (2018) The potential of the wastewater sector in the energy transition (Policy Brief). Retrieved from http://powerstep.eu/system/files/generated/files/resource/policy-brief.pdf

Mateescu, C., Băran, G., & Băbuţanu, C. A. (2008). Opportunities and barriers for development of biogas technologies in Romania. *Environmental engineering and Management Journal*, 7(5), 603-607.

Mininni, G., Blanch, A. R., Lucena, F., & Berselli, S. (2015). EU policy on sewage sludge utilization and perspectives on new approaches of sludge management. Environmental Science and Pollution Research, 22(10), 7361-7374.

Ravn, L.H., Jankowski, M., Rasmussen, L.H., Remy, C., Heinel, T., 2017. Powerstep Deliverable 5.2: Recommendations for WWTP operators, municipalities and WWTP technology providers willing to engage in renewable energy market, www.powerstep.eu.

Scarlat, N., Dallemand, J. F., & Fahl, F. (2018). Biogas: developments and perspectives in Europe. Renewable Energy.

Speight, V.L., (2015) Innovation in the water industry: barriers and opportunities for US and UK utilities. *Wiley Interdisciplinary Reviews: Water,* 2(4), pp.301-313.

Spinosa, L. Sustainability in sludge management: A combined approach to meet future needs. *Water21*, 31–33.

Torrijos, M. (2016). State of development of biogas production in Europe. *Procedia Environmental Sciences*, 35, 881-889.

Tedeschi, S., Malus D., Vouk D. (2012) Final treatment of wastewater sludge in the City of Zagreb. Građevinar Werle, S. (2015). Sewage sludge-to-energy management in eastern Europe: a Polish perspective. Ecological Chemistry and Engineering S, 22(3), 459-469.

UBA. (05.12. 2016). Förderprogramm für energieeffiziente Abwasseranlagen zieht Bilanz. Abgerufen am 2018 von https://www.umweltbundesamt.de/themen/foerderprogramm-fuer-energieeffiziente

Willis, J., Stone, L., Durden, K., Beecher, N., Hemenway, C. and Greenwood, R. (2012) Barriers to biogas use for renewable energy. Water Environment Research Foundation (WERF).

Vogt, R., Frisch, S. and Pehnt, M. (2010) Klimaschutz- und Energieeffizienz potenziale im Bereich Abfall und Abwasserwirtschaft. Institut für Energie- und Umweltforschung Heidelberg (IFEU). Federal Ministry for Econmic Affairs and Energy. (2018). Das Erneuerbare-Energien-Gesetz. Abgerufen am 09. 04 2018 von https://www.erneuerbare-energien.de/EE/Redaktion/DE/Dossier/eeg.html?cms_docId=71110

International Energy Agency. (22 Jun 2015). Renewable Energies Heat Act (EEWärmeG). Von https://www.iea.org/policiesandmeasures/pams/germany/name-24388-en.php abgerufen

D2.4.1: 5 REPORTS ON THE LEGISLATIVE/ADMINISTRATIVE FRAMEWORKS IN THE INVOLVED REGION – STRUCTURE AND QUESTIONNAIRE

AUSTRIA

19/06/2018

Table of content

1. Introduction

Innovation in the water sector is stifled by multiple barriers, keeping innovation outcomes lower than in other sectors. Factors commonly include risk aversion of water and wastewater utilities, lack of public or commercial funding and too stringent and conflicting regulations (Kiparksy et al., 2013, Ajami et a. 2014, Speight, 2015). A growing body of studies is investigating the barriers that particularly apply to nascent wastewater-to-energy systems. Dierich et al. (2017) for example mentions an unsuitable legal framework, low political priorisation of inter-sectoral action, and insufficient experience in utilities as main barriers. In another study (WERF, 2012), the authors find that "inadequate payback/economies" feature as the most dominant among 10 barriers impeding the implementation of biogas usage in the US wastewater treatment plants (WTPs). Financial hurdles also rank high up in a global study focusing on energy efficiency in US water and wastewater utilities, alongside governance issues and knowledge gaps (ESAMAP, 2012).

These studies indicate that the dissemination of wastewater-to-energy systems is generally confined by a wide range of different barriers, rather than a few single ones. Some of the barriers are applicable to all water-related innovations. Others are unique to wastewater-to-energy systems, their specific type of technological or managerial solution, and the local or regional context the utility is situated in. This becomes obvious in studies that examine specific aspects of wastewater-to-energy systems, for example the "flexibilisation" of energy production and consumption in waste water treatments plants (WWTPs) for optimized energy supply (Dierich et al., 2017). Barriers concern cultural or behavioural aspects within the utility itself (e.g. low commitment of top management) as much as external conditions, for example low regulatory pressure to reduce energy consumption (ESAMAP, 2012). Identifying these barriers is a critical step in order to form measures for setting up framework conditions conducive to the uptake of innovative wastewater-to-energy systems.

As with any other environmental reform, improving the energy performance of wastewater utilities (WWUs) requires strong backing through legislation and policy at various political levels. In this report, we understand legislation and policy and the framework they form to include all laws, policies, regulations, strategies, rules and other instruments used to improve energy outcomes of WWUs. These affect a large host of disciplinary fields, like economics, spatial planning, finance, or utility governance and management relevant to wastewater-to-energy systems. implementing the framework, national and sub-national governments play a key role. They need to grant high-level political support for establishing national legislation and policies, take up the role of the regulator and financier, and initiate other important steps, such as creating a well-engaged and connected agency that provides leadership and coordinates efforts nation-wide (e.g. to produce necessary information like energy maps) (Vogt et al., 2010).

In overcoming key barriers, there are different types of legal and policy measures. With respect to heat generation in WWTPs, Kretschmer (2017) distinguishes between regulatory, incentive-oriented and actor-supportive measures. Necessary regulations, for example, require utilities to reduce CO2 emissions, to track and improve energy performance through energy audits, or to prescribe phasing out energy-inefficient

technologies. Incentives, in contrast, may link government funding or tariff reforms to the utility's energy performance. Or they remove subsidies for electricity that discourage utilities from taking steps towards more energy-efficient operations. Typical actor-supportive measures help utilities to gain access to information about new innovations, their costs, benefits, and available funding opportunities, or offer educational programs for and advice to utility staff. Governments can further establish policies to shore up financing, such as specific financial vehicles for investments in energy efficiency and renewable production in WWTPs or by facilitating access to cross-sector financing programs (e.g. climate funds).

2. Scope of the Study

The objective of deliverable 2.4.1 is to

I) examine the **legal and policy situation** with respect to energy efficiency (EE) and renewable energy (RE) production outcomes of WTPs in the five countries participating in the project REEF2Water;
II) identify the main **legal and policy barriers;**
III) and discern **drivers and existing approaches** to overcome them.

The analysis is based on **desktop research**, information compiled in D1.1.1 on the legal situation and experience of the authors themselves.

The aim of deliverable D2.4.1 is to contribute **to improving the legal and policy framework conditions** that are central for the uptake of wastewater-to-energy systems in each of the five countries. The resultant outcomes form the basis for D2.4.2, in which concrete recommendations for improving laws and regulations are provided. These will subsequently be shared and discussed with policy makers from the participating countries. Furthermore, D2.4.1 will form the basis of a position paper (D5.2.3), which identifies local legislation and regulatory barriers hindering REEF2Water regional implementation strategies, as well as measures to dismantle them.

The nature of the Reef2Water solutions implies that their implementation is affected by a **complex legal and policy framework**. Given that the solutions are part of the wastewater, energy, and solid waste system, a **cross-sectorial perspective** that relates to legal and policy aspects of each of these three systems was taken. This ensures that necessary **sector linking** is achieved in practice.

The analysis considers the **different ways to exploit energy** from wastewater, including energy from biogas production, on-site renewable generation and operational energy efficiency. Here, it is being distinguished between **thermal and electrical energy.** Given the project's particular ambition to enrich sludge through **organic substrates** in the treatment process, the analysis considers applicable legislation and policies of the solid waste system. Furthermore, as the project aims at exploring the potential for WWTPs to become local providers of energy, legislation and policies regulating **temporary energy storage** (such as power-to-gas solutions) and **feed-in into the grid** (including relevant

market-based mechanisms) are considered. All of these aspects are examined for **different political-administrative levels**, at which policy and legislation are given effect at (international/EU, national, federal, and municipal). This helps to locate barriers more precisely, as well as to find scale-sensitive measures to overcome them.

3. The EU-Legal and Policy Framework

3.1. Environmental policy and law making in the EU

This chapter summarizes the most relevant EU Directives affecting the implementation of measures to increase EE and RE production in WWTPs. It then analyses a range of legal and policy barriers that are central in doing so.

Directives form the most common regulation in the EU legislative framework. They set the standard conditions and rules. According to the Subsidiarity Principle, member states have to transpose these into national legislative systems, following a clearly defined timetable and a way that best suits national circumstances (LeBlanc et al. 2008).

While member states are aiming at the same goals, the means they use to achieve them can be quite distinct, the heterogeneous development of EU energy markets serving as a very good example.

3.2. Key drivers of wastewater-to-energy solutions and resulting trends across EU member states

The share of renewables in the EU energy mix reached 17 % in 2016. It increased twofold since 2004, being mainly driven by legally binding energy saving and decarbonisation targets (Edwards et al., 2016).

- Renewable energy markets have distinctly developed across member states in what regards their scale and composition of different renewable energy forms. For example, biogas is predominantly used to produce electricity while much of the heat potential remains unexploited (Kampman et al., 2016). Also, only some frontrunners such as Sweden actively pursue producing biomethane for the transport sector.

- Only a few countries, such as Spain, use sewage sludge as a main feedstock for biogas production, making it the feedstock being used the least overall (Scarlat et al., 2018). In most member states, such as Germany and Italy, crops dominate as a feedstock while the potential to use sewage remains largely untapped (Figure 1.).

- The EU has began to embrace a circular economy approach. Its stringent regulatory regime is changing waste streams and disposal options. Importantly, while bio-waste and sludge production increase (Zsirai, 2011), limits are put on landfilling, and particularly of biodegradable material. Applying sludge as a fertiliser and soil conditioner is still the preferred options in most member states, more stringent rules

confine this end-use form (Spinosa 2010). Together these developments have driven wastewater-to-energy solutions.

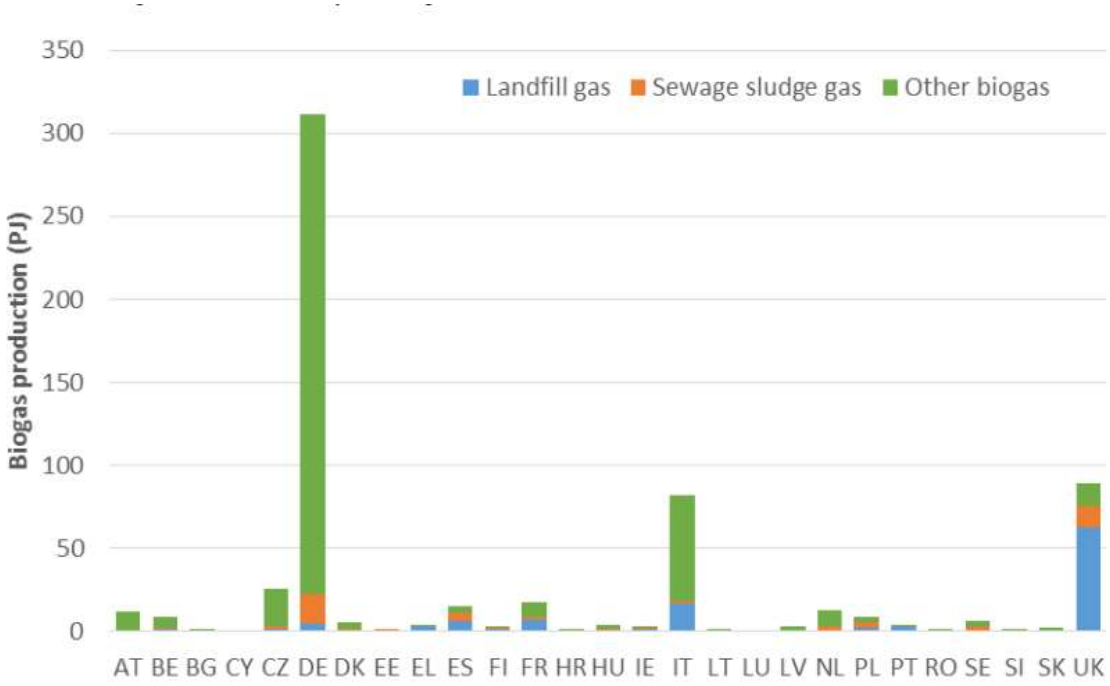

Figure 1: Biogas production per Member State in 2014, differentiated by source (Kampman et al., 2016)

3.3. Overview of key EU legislation and policies

3.3.1. Water & Wastewater

The Water Framework Directive (2000/60/EC)

This directive (here referred to as the WFD) requires that rivers, lakes, transitional waters, coastal waters, and groundwater obtain "good status" by 2027. To achieve this goal, the EU has determined a clear timeline and three six-year management cycles for the member states. One of its main elements is the introduction of River Basin Districts, which form the management units for managing water resources. Importantly, the WFD pertains to services of both water and waste water.

The Urban Waste Water Treatment Directive (91/271/EEC)

The main objective of the Urban Waste Water Treatment Directive (UWWTD) is to protect the environment from negative effects of urban wastewater discharges. It comprises the collection, treatment, and discharge of domestic wastewater, mixture of wastewater, and wastewater from certain industrial sectors. It stipulates the level of treatment and the removal of nutrients and basic sanitary parameters, as well as conditions for sludge disposal and reuse.

The Sewage Sludge Directive (86/278/ EEC)

The Sewage Sludge Directive (SSD) is concerned with the management of sewage sludge. It particularly seeks to encourage the use of sewage sludge as a soil conditioner and fertiliser in agriculture. It bans applying untreated sludge on agricultural land. Also, it sets all the requirements and provisions to prevent potential harmful effects on humans, animals, soil and vegetation as well as surface and groundwater. The Directive lays down the basic limits for potentially toxic elements (PTEs, which are HMs) in SS and soil.

3.3.2. Climate change mitigation

2020 Climate and energy package ("20-20-20 targets")

This package was established in 2007. Its goal is to ensure that the EU meets its climate and energy targets. In consequence, the legislation encompassed three main targets for the year 2020:

- 20% increase in energy produced from renewables
- 20% enhancement in energy efficiency
- 20% cut in greenhouse gas emissions (compared to 1990 level)

Emissions Trading System (ETS)

The ETS is a central element in the EU's policy to tackle climate change and a key tool for reducing greenhouse gas emissions in a cost-effective manner. It is based on a "cap and trade" system. The cab limits the amount of greenhouse gas emissions a certain user or industry is allowed to emit. As the cap is gradually lowered over time, emissions are expected to fall. Within the cap, companies receive or buy emission allowances that cover their emissions. These can be traded.

Effort sharing agreement for the non-ETS sectors

The Effort Sharing Decision establishes binding annual greenhouse gas emission targets for Member States for the period 2013–2020. These targets concern emissions from most sectors not included in the EU Emissions Trading System (EU ETS), such as transport, buildings, agriculture and also waste. The regulation aims to ensure that the non-ETS sectors emissions reduction target of 30% by 2030 compared to 2005 levels.

3.3.3. Renewable energy production and energy efficiency

Renewable Energy Directive (2009/28/EC)

The Renewable Energy Directive (RED),which is currently being revised, establishes a policy framework for producing and encouraging renewable energy in the EU, including biogas. The directive requires that 20 % of the EU's energy mix in 2020 must be renewable. It translates this general goal into individual targets for each of the member states. In a recent proposal to revise the directive the Commission elevated that goal to 27 % by 2030. The RED also defines sustainability criteria for biofuels and bioliquids in the transport sector.

Directive to reduce indirect land use change for biofuels and bioliquids ((EU/2015/1513)

The ILUC was established as response to sustainability challenges concerning bio-energy made out of food-based crops, most importantly indirect land-use change. It amends current legislation on biofuels, including the Renewable Energy Directive (2009/28/EC) and Fuel Quality Directive (2009/30/EC). For example, it limits the share of biofuels produced from crops in the transport sector (7% in overall fuel mix). It also requires that biofuels produced in new installations emit at least 60% fewer greenhouse gases than fossil fuels.

Energy Efficiency Directive (2012/27/EC)

The Energy Efficiency Directive (EED) mandates energy efficiency improvements. It establishes a common framework for the promotion of EE within the EU to meet its EE headline target of 20% by 2020, in all stages and sectors of the supply chain. EU member states have to prepare a National Energy Efficiency Action Plan every three years and report on their progress in the different sectors (i.e. industry, residential, services, public, transportation, electricity and heat generation).

Directive for combined heat and power generation (2004/8/EC)

This directive promotes the use of combined heat and power (CHP) units to improve the efficiency of electricity and heat production. It sets rules on guarantees of origin, efficiency criteria, administrative procedures, and other issues. Member states are encouraged to provide support schemes for CHP units to enable their widespread implementation (including specific support for WTTPs).

3.3.4. Natural Gas

Directive on services in the internal gas market (2009/73/EC)

This 'Gas Directive' establishes common rules for the transmission, distribution, supply and storage of natural gas. It stipulates rules relating to the organisation and functioning of the natural gas sector, access to the market, the criteria and procedures applicable to the granting of authorisations for transmission, distribution, supply and storage of natural gas and the operation of systems. The rules also apply in a non-discriminatory way to biogas and gas from biomass, i.e. sewage gas from WWTPs.

Directive for internal electricity market (2009/72/EC)

This directive establishes common rules for the generation, transmission, distribution and supply of electricity, together with consumer protection provisions, with a view to improving and integrating competitive electricity markets in the EC. It lays down the rules relating to the organisation and functioning of the electricity sector, open access to the market, the criteria and procedures applicable to calls for tenders and the granting of authorisations and the operation of systems such as transmission or distribution systems, including the request for unbundling of electricity production and

Directive for taxation of electricity and other energy products 2003/96/EC (EU 2003a) sets a framework for taxation of electricity and other energy products, e.g. gas or other fuels. It defines the energy products to be taxed and the minimum amount. The project "Full scale demonstration of energy positive sewage treatment plant concepts towards market penetration" (POWERSTEP) has received funding under the European Union HORIZON 2020 –

3.4. Solid waste management

The Waste ´Framework Directive (2008/98/EC)

This directive defines basic concepts such as the "waste hierarchy" (a priority order set among waste prevention and management options), and stipulates requirements for waste management, such as to up a separate collection of waste, waste management plans, and waste prevention programmes. It also establishes legally binding targets such as for household waste streams including biodegradable materials).

The Landfill Directive (1999/31/EC)

This directive aims at preventing or reducing adverse environmental impacts from landfilling of waste through stringent technical requirements for waste and landfills. It obliges Member States to reduce the amount of biodegradable municipal waste that they landfill to 35% of 1995 levels by 2016 (for some countries by 2020) while current legislative of the proposal of it consider a complete ban of landfilling.

3.5. Legal drivers and barriers

Paucity of energy aspects and targets in water legislation

Energy-related issues remain vastly absent from the EU's legal and policy framework of the water sector. The key water-related directives, the WFD and the UWWTD, make no provisions that specifically focus on targets, measures or incentives to improve EE or renewable production measures in WWTPs, whether motivated by ambitions of cost-efficiency or decarbonisation. Also, more recent water policy documents such as the "Blueprint to Safeguard Europe's Water Resources" (2012) poorly make that linkage. A legislative proposal of the Drinking Water Directive adopted this year comprises one of the first attempts to embrace the water energy-water nexus by encouraging member states to increase energy efficiency.

Lack of overall cross-sectoral and coherent legal framework

The absence of a cross-sectoral approach spanning across various relevant EU energy, waste, water, agricultural and other concerned directives stifles legal backing needed to more systematically support wastewater-to-energy solutions. Energy-related issues are missing in EU water sector policy and law, which predominantly focus on water quality and quantity goals. The RED, on the other side, fails to articulate specific provisions on how, for example, the waste water sector can contribute to achieving targets concerning carbon reduction and renewable

production. Incoherence of the overall legal and policy framework has been ranked as the top barrier for biogas production (Kampmann et al., 2016).

Inadequate priorisation of second generation bio-energy

Member states have been free to opt through which form of renewable energy they accomplish these targets. This flexibility has given rise to divergent developments of the biogas market across the member states (Torrijos, 2016), with in part undesirable outcomes. A prominent example applies to the rise of crop-based biogas, which ranks as the EU's main type of bio-energy and dominant renewable energy form (Kampman et al., 2016). As a feedstock, however, crops have proven adverse environmental impacts (e.g. land use change). The environmental footprint of biogas produced from waste streams, in contrast, is significantly better, but their share in the biogas market lag behind that of crop-based biomass (see. Figure 1). This is because the EU legal and policy does not systematically support renewable energies according to their sustainability performance. Sustainability criteria, which form one central pre-condition towards doing so, exist only for the transport sector while they lack cross-national harmonisation (Kampman et al., 2016).

An improving yet unreliable base of bio-waste feedstock

The EU's stringent regulatory regime for waste functions as a strong driver for wastewater-to-energy systems. The Landfill Directive is viewed as the most important factor propelling the growth of anaerobic digestion (AD) (including on-farm applications) in treating biowaste and industrial feedstock (Edwards et al., 2015). This is because the ban on landfilling and tightening quota for reducing landfilled biodegradable organics increase the need to find solutions for disposing growing amounts of bio-waste (Torrijos, 2016). However, many member states do not have a reliable bio-waste feedstock base (Edwards et al., 2016). Only 25 % of the total bio-waste in the EU is recycled while recycling rates are considerably lower in many member states (Mateescu et al., 2008). In some countries like the UK, access to adequate organic feedstock is already a barrier (Kampman et al., 2016). Additionally, current regulations do not promote AD as a preferable disposal option for biowaste. Legal loopholes still allow member states incinerate or landfill biowaste (Iacovidou et al., 2012). The European Biogas Association (2016) remarks that incineration may become the main disposal option for biowaste as the as the landfilling ban takes effect.

Under-development of heat usage due to weak incentives

Whether WWTPs achieve high potential of energy and carbon emissions savings depends on exploiting both heat and electricity generated during the combustion of biogas. Biogas markets have expanded in several EU member states. However, despite some positive development, often only the electricity generated from biogas is used while the heat potential remains untapped. Currently, only 25 % of the heat is used in Europe's WWTPs (Scarlat et al., 2018). While plant operators face pressure to improve the economics of biogas plants (ibid), weak incentives at the EU-level comprise one key factor responsible for the slow development of heat usage from biogas (Kampman et al., 2016).

Lacking revenue streams for sewage-based co-digestate

Using co-digestate of sewage sludge and bio-waste as soil conditioner or fertiliser (for example in agriculture) can spur the uptake of wastewater-to-energy solutions (Edwards et al., 2015). Such "end-use" applications guarantee that sewage sludge, whose production in Europe will rise over the next years (Werle, 2015), will be harnessed in the spirit of a circular economy. Currently, however, sludge-based co-digestates are subject to an incoherent and partially conflicting legal and regulatory regime (Iacavidou et al., 2012), which compounds the dissemination of AD technologies. One main barrier is that co-digestate containing sewage sludge is currently classified as waste and not a valuable product. This legal definition only allows WWTP operators to market the biogas, but not its by-products, undermining additional revenue streams (Kampmann et al., 2016).

Ambiguous financial mechanisms for wastewater-to-energy solutions

Access to inexpensive renewable energy will become increasingly important because the cost of sewage sludge treatment is bound to rise due to higher treatment standards and rising energy costs, among others (Zsirai, 2011). Cost pressures, which the imposed by the cost-recovery principle in the WFD, theoretically attractive for WWUs to deploy RE production. However, new technologies such as AD are capital-intensive, generally requiring subsidisation (Edwards et al., 2015). National support schemes (e.g. feed-in tariffs) form the key financial mechanism to drive renewable energy developments in the EU. However, these are still ineffective in many member states, for example due to low or reduced subsidies (Kampman et al., 2016). At the same time, the EU legislation and policies upon which the support schems are based are yet not sufficiently linked to sustainability criteria, as argued above. Furthermore, Green Public Procurement (GPP) for WWTPs currently apply only to EE, but not to producing RE (Loderer and Hananel, 2018).

Grid injection of bio-energy

If not used for self-supply in on-site CHP plants, WWUs have several options to bring bioenergy to the market: As biogas or biomethane via the gas network; as heat via the district heating network; or as electric power via the electric grid. Arguably, a range of barriers apply to each of these options. Generally, decentralized energy forms – such as wastewater-to-energy solutions – lack a common EU framework that explicitly supports them. Across member states + small market entrants providing distributed energy (DE) still face various challenges, including a lack of explicit incentives in planning and operations of networks, high connection charges, or high trading fees (Ropenus and Skytte, 2005). Another specific example concerns cross-border trade of biomethane, which is hindered substantially by national quality standards, which lack harmonisation (Kampan et al., 2016).

4. Overview on legal and policy situation in Austria concerning a waste treatment plant

In Austria parts of the legislation are set on country level, others at regional level. Austria consists of nine provinces, so federal law exists in nine variants. As the pilot plant in Austria is situated in Upper Austria, the section about federal laws focuses on this province.

4.1. National Level

At national level, the following laws are of relevance:
Austrian waste management law (Abfallwirtschaftsgesetz 2002)
Water act (Wasserrechtsgesetz 1959)
Gas economy law (Gaswirtschaftsgesetz)/ÖVGW-Richtlinien G31 + G33
CHP act (KWK-Gesetz 2009)
Green electricity law (Ökostromgesetz)
Climate protection law (Klimaschutzgesetz)
Law about the organisation of the electricity economy
(Elektrizitätswirtschaftsorganisationsgesetz – ElWOG)
Trade Law (Gewerbeordnung)

The most important ones are described in the following, including a brief analysis about the main drivers and barriers for waste and wastewater energy use.

4.1.1. Austrian waste management law (AWG 2002)

The basic law concerning waste management in Austria is the Waste Management Law (Abfallwirtschaftsgesetz, AWG 2002). Additionally all nine provinces have federal state laws, which regulate all those waste management aspects which are part of their responsibility. These are mainly the costs the legal framework of the waste collection.

The main issues of the AWG 2002 are the prevention, the preparation of recycling; the recycling and any other use and disposal of waste; duties of persons working with waste; and specifications for waste processing sites. It also stipulates to end landfilling of untreated waste by setting a maximum organic carbon threshold of 5%, which can only be reached via incinerating or mechanical-biological treatment.

Organic waste like bio-waste and used cooking fat are collected and treated separately from non-biological fractions via composting or biogas.

Every sampling, depositing or treatment of waste has to be permitted according to the AWG 2002. The federal government, and not the local major, holds the authority to do so. The rules for obtaining a waste processing permit are in many cases stricter

than receiving permits for wastewater. This is mainly because wastewater processing is seen as a public task while waste processing is mainly done by private companies.

The RHV-Trattnachtal could do the waste processing without an additional legal unit like a company, but it seems that the contrast of public wastewater processing and commercial waste processing led to the formation of two legal bodies, the public RHV-Trattnachtal and the commercial Biogas Trattnachtal GmbH.

The following aspects have to be clarified to acquire a permit:

- Amount of processed waste per year in tons
- Processed waste defined by key number
- Animal waste needs an additional permit (in Austria called “Tiermaterialien Gesetz”)
- Certain animal waste like slaughterhouse waste needs a sanitation unit that can provide 70°C for 60 minutes with particle size <12mm
- The waste emits odor, so the storing and processing likely needs to be a closed process with combined biological filter
- The produced end product after fermentation and its minimum quality for proper use has to be defined. Because of the co-fermentation at the RHV-site the produced end product is still sewage sludge. In Austria this is because of the 50% rule that means: if the end product contains more than 50% sludge, it stays legally sludge. If there was a surplus of waste it would be then biogas waste manure.

Possible barrier: The sewage sludge from the RHV-Trattnachtal can still be used in agriculture, which is also the cheapest way for disposing sludge. In other Austrian regions sewage sludge used in agriculture is not allowed anymore. In the future this will lead to an increase of costs for sludge disposal.

4.1.2. Water act (WRG 1959)

Every use of water that has an effect on lakes, rivers or the ground water has to get approval from the federal government according to the water act. The responsible authority is the federal government.

Barrier: The wastewater permit for a sewage plant deals mainly with incoming wastewater und defines the reduction values for nitrogen, ammonia, phosphorus, COD and BOD without any connection to the treated waste from the co-fermentation, because it does not enter the plant via the sewer, but it comes in per lorry.

That means that reduction values in % are much harder to fulfil than in fixed numbers.

This can be shown with the following example:

- Goal: 70% reduction of nitrogen = 500kg N incoming and <150 kg N outgoing
- But the treated waste can add 100 kg N without being counted
- so the 70% rule is affected to its disadvantage.
- = 600kg N incoming and 150 kg N outgoing means a 75% reduction

So the waste treatment can result in a conflict between the sewage plant and its reduction values!

The RHV-Trattnachtal finally achieved an agreement with the local authorities, that the N-value of the waste can be measured regularly in a laboratory and then be added do the nitrogen, coming in from the sewer. A general methodology for all Austrians wastewater treatment plants should be achieved.

All other waste ingredients have normally no real negative impact and are therefore not additionally measured.

4.1.3. Gas economy law – Gaswirtschaftsgesetz

The Austrian gas economy law is the basis for feeding in biogas into the Austrian gas grid. According to this law, producers of biogas have the right to feed in biogas into the grid, even on behalf of their customers. Gas quality and feeding points are regulated.

The ÖVGW-Richtlinie G31 contains the main quality criteria and G33 deals with the marketing rules.

Possible barrier: A legal threat to the further operation of biogas/sewage gas feeding into the grid is that the mean H_i (higher heating value) of gas in the grid shall be increased up to 11.2 kWh/Nm^3 and the tolerance shall be decreased from 3 to 2% in the next years. This would mean that large amounts of propane would have to be added in order to increase H_i.

4.1.4. Trade Law (Gewerbeordnung) – heat supplier

In order to be allowed to act as a heat supplier.

4.2. Federal level (Upper Austria)

4.2.1. Sewage sludge act (2006)

The agricultural use of sewage sludge has to be approved according to the Upper Austrian sewage sludge act from 2006. Sludge application is regimented in Austria by 9 federal state decrees. The use as a fertilizer in agriculture is limited to five federal states, four have banned sewage sludge to be used this way. In Upper Austria the sludge can be used if it fulfils the following requirements:

heavy metal	sludge threshold value	soil* threshold value
Pb	< 400 mg/kg TS	< 100 mg/kg TS
Cd	< 5 mg/kg TS	< 0,5 mg/kg TS

Cr	< 400 mg/kg TS	< 100 mg/kg TS
Cu	< 400 mg/kg TS	< 60 mg/kg TS
Ni	< 80 mg/kg TS	< 60 mg/kg TS
Hg	< 7 mg/kg TS	< 0,5 mg/kg TS
Sn	1600 mg/kg TS	150 mg/kg TS
Adsorbed organic halogens	threshold value	threshold value
AOX	<500mg/kg TS	<500mg/kg TS

Additional parameters without threshold values:

- Dry matter
- Organic substance
- pH-level
- Ammonia
- P/K/Ca/Mg

Barrier: If the sludge is used on fields, the farmers have to register their fields at the local government, because the fields have to be frequently analysed externally on their heavy metal contents to prove that they are below the federal threshold values for soil*. Additionally soils with a pH-level below 5 are banned from sludge use. On soils with a pH-level from 5 to 5,5 sludge may be used if their chalk value (as CaO) is at least 25% of the dry matter. This is only possible, if chalk is used as a pressing aid, or if the sludge is mixed with chalk after the pressing procedure.

If prohibition of sewage sludge use in agriculture is extended nationwide, its disposal will become more expensive, thus making it necessary to increase waste water prices for customers.

4.2.2. Law on animal substances (2003)

It regulates the collection, storage, transport, treatment, processing, disposal and use of animal by-products and their placement on the market. The authority is represented by the district government. It defines the rules for the Biogas Trattnachtal, which animal by--products have to be sanitized and what control mechanisms have to be fulfilled to secure proper sanitation and prevent spreading of diseases.

4.2.3. License for collection and treatment of waste according §24a AWG 2002

This license is like a “driving license”, because it names a person, which is personally fully responsible for the proper collection and treatment of waste. Therefore the named person has to verify his knowledge in waste and waste management before applying for the license. The permission is granted by the federal government.

4.2.4. Upper Austrian fire- and hazard police act (FPG-1994)

§ 2 of the Upper Austrian fire- and hazard police act (FPG) states that everybody is in charge of preventing and minimizing fires and fire hazards.

§ 10 des OÖ FPG obliges local communities with the duties to execute fire controls in fixed intervals. These intervals are:

- By imminent danger – anytime
- Objects belonging to a risk group – every 5 years
- Objects not belonging to a risk group – every 10 years
- Small buildings - every 20 years

5. Main legal and policy barriers in Austria

The main barriers in Austria are

- Too many different regulations concerning the same topic
- Too many different competences lead to contradictory platings
- The technical state of the art is quite complex and therefore expensive to build and operate
- The protection of neighbors and the environment makes it hard to find a suitable location for a waste treatment plant
- The bureaucracy requires extensive documentation for waste management
- The renewable energy tariffs for biogas from waste are quite low, providing calculate making investments unattractive financially
- There is no renewable heat or renewable gas regulation in Austria stipulating the use of biogas

The waste collection has a good standard in Austria, but especially household waste still contains a considerable organic share. Other waste should be collected separately like glass and paper.

The main task is to run and maintain all the existing waste facilities, because the requirements concerning employees and machinery are constantly rising. The volumes of produced waste are also rising due to increasing population and good economic growth.

There is already a lack of incineration capacity in Austria, which enlarges as all sewage sludge will need to be incinerated in ten years time.

In Austria it depends on the staff and especially the lead operator of a wastewater treatment plant if RES are used or not. There are no promotion programs nor special funding nor feed-in tariffs for electricity. Sewage sludge and sewage gas are explicitly denominated as renewable energy carrier in the Green electricity law, but there is no obligation to contract electricity from sewage sludge for the Green electricity management body (contrary to most other renewables - § 13) and is explicitly excluded in the technology funding program § 43.

Future legislations should aim on building a level playing field for all renewable energy carriers, including all the RES on wastewater treatment plants.

Moreover regulations on the gas quality in the grid should not be increased if it is a threat for renewable gas injection, such as from sewage gas, which is currently under discussion in Austria.

6. Drivers and existing approaches to overcome barriers in Austria

Energy from waste water compared to wastewater treatment plants is no priority in the legislation, neither on national nor on regional level. Wastewater treatment plants are designed for cleaning waste water. Certain barriers were addressed before that might add additional problems for wastewater treatment plants in applying energy supply systems.

There is no encouragement from policy makers for the management of wastewater treatment plants to act as an energy supplier. Also spatial planning regulations until now do not consider the existence /absence of local surplus energy as a reason for dedicating land as building area or not.

Successful examples are needed and have to be promoted in order to raise awareness of this important energy potential to gain more relevance in legislation.

7. Appendix I: Questionnaire for Legal and Policy Barrier Analysis

This questionnaire is intended for gathering primary and secondary data needed to accomplish D2.4.1. There is no obligation to use it, but you may find it useful drawing on all or several of the proposed guiding questions.

- Conduct 5-10 interviews with experts such as utility staff or policy makers and other experts, separately or in focus groups;
- Adjust questions according to the type of interviewed respondent, characteristics of the treatment facility and utility and country context.

Comment: No interviews were made so far on specifically this topic, so this section remains empty until the stakeholder dialogue has been performed.

Legal and Policy Barriers in Country X

1. How conducive is the legal and policy framework in supporting the implementation of EE and RE measures in the WWTP(s) of your country?

2. Can you outline and describe in detail the most significant legal and policy barriers, differentiating between the main ways for exploiting energy from wastewater where relevant (such as improving operational energy efficiency or generating electricity and heat from biogas)?

3. Can you identify the political level(s) at which legal and policy barriers may be most severe (EU/International, national, federal and local)?

4. Does the legal and policy situation support or impair interventions for exploiting waste heat more than electricity or vice versa? If so, what barriers apply?
5. Which legal and policy barriers constrain WWUs from using surplus heat and electricity for self-supply?

6. What legal and policy barriers impede supplying waste heat or electricity to the market in your country? For example, regulations may prohibit WWUs from entering business other than managing wastewater while low subsidies for RE might constrain them to gain financial sustainability.

7. What legal and policy barriers particularly apply for integrating systems of solid waste and wastewater to use organic substrates for enrichment of sludge in the co-fermentation process?

Policy and legal drivers and approaches to overcome barriers in Country X

8. Can you outline and describe the most significant legal and policy drivers, differentiating between the main ways for exploiting energy from wastewater where relevant?

9. What governmental or private sector actors do you consider most critical for improving the legal and policy framework for wastewater-to-energy systems?

10. What actor-based instruments (such as a central agency to coordinate interventions with respect to energy-related matters or specific funding or educational programmes) have been established to promote wastewater-to-energy systems?

11. Are you aware of legal and policy interventions that are currently being planned or already under way to overcome the main barriers you mentioned above (e.g a revision of the sludge ordinance or law with respect to CHP?)

Literature

Ajami, N.K., Thompson Jr, B.H. and Victor, D.G., (2014) The path to water innovation. The Brookings Institution.

Dierich, A, Hüesker, F, Ansmann, T. and Gretzschel, O (2017) Rahmenbedingungen für die Sektorkopplung von Abwasserreinigung und Klärschlammbehandlung mit der Energiewirtschaft: Hemmnisse, Treiber und Chancen. *Korrespondenz Abwasser, Abfall* (64)8, 697-706.

European Biogas Association (2016) Position on the revision of the Waste Framework Directive (Position Paper). Retrieved from: http://european-biogas.eu/wp-content/uploads/2016/04/EBA-position-on-WFD-revision_April-2016.pdf

Edwards, J., Othman, M., Burn, S., (2015) A review of policy drivers and barriers for the
use of anaerobic digestion in Europe, the United States and Australia. *Renew. Sustain.*
Energy Rev. 52, 815–828.

Iacovidou, E., Ohandja, D. G., & Voulvoulis, N. (2012). Food waste co-digestion with sewage sludge–realising its potential in the UK. *Journal of environmental management*, 112, 267-274.

Kilinc-Ata, N. (2016). The evaluation of renewable energy policies across EU countries and US states: An econometric approach. Energy for Sustainable Development, 31, 83-90.

Kiparsky, M., Sedlak, D.L., Thompson Jr, B.H. and Truffer, B., 2013. The innovation deficit in urban water: the need for an integrated perspective on institutions, organizations, and technology. *Environmental engineering science*, 30(8), pp.395-408.

Loderer and Hananel (2018) The potential of the wastewater sector in the energy transition (Policy Brief). Retrieved from http://powerstep.eu/system/files/generated/files/resource/policy-brief.pdf

Mateescu, C., Băran, G., & Băbuţanu, C. A. (2008). Opportunities and barriers for development of biogas technologies in Romania. *Environmental engineering and Management Journal*, 7(5), 603-607.

Mininni, G., Blanch, A. R., Lucena, F., & Berselli, S. (2015). EU policy on sewage sludge utilization and perspectives on new approaches of sludge management. Environmental Science and Pollution Research, 22(10), 7361-7374.

Scarlat, N., Dallemand, J. F., & Fahl, F. (2018). Biogas: developments and perspectives in Europe. Renewable Energy.

Speight, V.L., (2015) Innovation in the water industry: barriers and opportunities for US and UK utilities. *Wiley Interdisciplinary Reviews: Water,* 2(4), pp.301-313.

Spinosa, L. Sustainability in sludge management: A combined approach to meet future needs. *Water21*, 31–33.

Torrijos, M. (2016). State of development of biogas production in Europe. *Procedia Environmental Sciences*, 35, 881-889.

Kretschmer, F (2017) Abwasser als erneuerbare Energiequelle – Potenziale, Chancen und Barrieren im österreichischen Kontext. Wiener Mitteilungen. Volume 246 of Wiener Mitteilungen

Willis, J., Stone, L., Durden, K., Beecher, N., Hemenway, C. and Greenwood, R. (2012) Barriers to biogas use for renewable energy. Water Environment Research Foundation (WERF).

Vogt, R., Frisch, S. and Pehnt, M. (2010) Klimaschutz- und Energieeffizienz potenziale im Bereich Abfall und Abwasserwirtschaft. Institut für Energie- und Umweltforschung Heidelberg (IFEU).

Tedeschi, S., Malus D., Vouk D. (2012) Final treatment of wastewater sludge in the City of Zagreb. Građevinar

D2.4.1: 5 REPORTS ON THE LEGISLATIVE/ADMINISTRATIVE REGIONAL FRAMEWORKS

ITALY

24/07/2018

Table of content

1. Introduction

Innovation in the water sector is stifled by multiple barriers, keeping innovation outcomes lower than in other sectors. Factors commonly include risk aversion of water and wastewater utilities, lack of public or commercial funding or, too stringent and conflicting regulations (Kiparksy et al., 2013, Ajami et a. 2014, Speight, 2015). A growing body of studies is investigating the barriers that particularly apply to nascent wastewater-to-energy systems. Dierich et al. (2017) for example mentions an unsuitable legal framework, low political priorisation of inter-sectoral action, and insufficient experience in utilities as main barriers. In another study (WERF, 2012), the authors find that "inadequate payback/economies" feature as the most dominant among 10 barriers impeding the implementation of biogas usage in the US wastewater treatment plants (WTPs). Financial hurdles also rank high up in a global study focusing on energy efficiency in US water and wastewater utilities, alongside governance issues and knowledge gaps (ESAMAP, 2012).

These studies indicate that the dissemination of wastewater-to-energy systems is generally confined by a large range of different barriers, rather than a few single ones. Some of the barriers are applicable to all water-related innovation. Others are unique to wastewater-to-energy systems, their specific type of technological or managerial solution, and the local or regional context the utility is situated in. This becomes obvious in studies that examine specific aspects of wastewater-to-energy systems, for example the "flexibilisation" of energy production and consumption in waste water treatments plants (WWTPs) for optimized energy supply (Dierich et al., 2017). Barriers concern cultural or behavioural aspects within the utility itself (e.g. low commitment of top management) as much as external conditions, for example low regulatory pressure to reduce energy consumption (ESAMAP, 2012). Identifying these barriers is a critical step in order to form measures for setting up framework conditions conducive to the uptake of innovate wastewater-to-energy systems.

As with any other environmental reform, improving the energy performance of wastewater utilities (WWUs) requires strong backing through legislation and policy at various political levels. In this report, we understand legislation and policy and the framework they form to include all laws, policies, regulations, strategies, rules and other instruments used to improve energy outcomes of WWUs. These affect a large host of disciplinary fields, like economics, spatial planning, finance, or utility governance and management relevant to wasterwater-to-energy systems. In implementing the framework, national and sub-national governments play a key role. They need to grant high-level political support for establishing national legislation and policies, take up the role of the regulator and financier, and initiate other important steps, such as creating a well-engaged and connected agency that provides leadership and coordinates efforts nation-wide (e.g. to produce necessary information like energy maps) (Vogt et al., 2010).

In overcoming key barriers, there are different types of legal and policy measures. With respect to heat generation in WWTPs, Kretschmer (2017) distinguishes between regulatory, incentive-oriented and actor-supportive measures. Necessary regulations, for example, require utilities to reduce CO2 emissions, to track and improve energy performance through energy audits, or to prescribe phasing out energy-inefficient

technologies. Incentives, in contrast, may link government funding or tariff reforms to the utility's energy performance. Or they remove subsidies for electricity that discourage utilities from taking steps towards more energy-efficient operations. Typical actor-supportive measures help utilities to gain access to information about new innovations, their costs, benefits, and available funding opportunities, or offer educational programs for and advice to utility staff. Governments can further establish policies to shore up financing, such as specific financial vehicles for investments in energy efficiency and renewable production in WWTPs or by facilitating access to cross-sector financing programs (e.g. climate funds).

2. Scope of the Study

The objective of deliverable 2.4.1 is to

I) examine the **legal and policy situation** with respect to energy efficiency (EE) and renewable energy (RE) production outcomes of WTPs in the five countries participating in the project REEF2Water;
II) identify the main **legal and policy barriers;**
III) and discern **drivers and existing approaches** to overcome them.

The analysis is based on **desktop research**, information compiled in D1.1.1 on the legal situation and experience of the authors themselves.

The aim of deliverable D2.4.1 is to contribute **to improving the legal and policy framework conditions** that are central for the uptake of wastewater-to-energy systems in each of the five countries. The resultant outcomes form the basis for D2.4.2, in which concrete recommendations for improving laws and regulations are provided. These will subsequently be shared and discussed with policy makers from the participating countries. Furthermore, D2.4.1 will form the basis of a position paper (D5.2.3), which identifies local legislation and regulatory barriers hindering REEF2Water regional implementation strategies, as well as measures to dismantle them.

The nature of the Reef2Water solutions implies that their implementation is affected by a **complex legal and policy framework**. Given that the solutions are part of the wastewater, energy, and solid waste system, a **cross-sectorial perspective** that relates to legal and policy aspects of each of these three systems was taken. This ensures that necessary **sector linking** is achieved in practice.

The analysis considers the **different ways to exploit energy** from wastewater, including energy from biogas production, on-site renewable generation and operational energy efficiency. Here, it is being distinguished between **thermal and electrical energy.** Given the project's particular ambition to enrich sludge through **organic substrates** in the treatment process, the analysis considers applicable legislation and policies of the solid waste system. Furthermore, as the project aims at exploring the potential for WWTPs to become local providers of energy, legislation and policies regulating **temporary energy storage** (such as power-to-gas solutions) and **feed-in into the grid** (including relevant market-based mechanisms) are considered. All of these aspects are examined for

different political-administrative levels, at which policy and legislation are given effect at (international/EU, national, federal, and municipal). This helps to locate barriers more precisely, as well as to find scale-sensitive measures to overcome them.

3. The EU-Legal and Policy Framework

3.1. Environmental policy and law making in the EU

This chapter summarizes the most relevant EU Directives affecting the implementation of measures to increase EE and RE production in WWTPs. It then analyses a range of legal and policy barriers that are central in doing so.

Directives form the most common regulation in the EU legislative framework. They set the standard conditions and rules. According to the Subsidiarity Principle, member states have to transpose these into national legislative systems, following a clearly defined timetable and a way that best suits national circumstances (LeBlanc et al. 2008).

While member states are aiming at the same goals, the means they use to achieve them can be quite distinct, the heterogeneous development of EU energy markets serving as a very good example.

3.2. Key drivers of wastewater-to-energy solutions and resulting trends across EU member states

The share of renewables in the EU energy mix reached 17 % in 2016. It increased twofold since 2004, being mainly driven by legally binding energy saving and decarbonisation targets (Edwards et al., 2016).

- Renewable energy markets have distinctly developed across member states in what regards their scale and composition of different renewable energy forms. For example, biogas is predominantly used to produce electricity while much of the heat potential remains unexploited (Kampman et al., 2016). Also, only some frontrunners such as Sweden actively pursue producing biomethane for the transport sector.

- Only a few countries, such as Spain, use sewage sludge as a main feedstock for biogas production, making it the feedstock being used the least overall (Scarlat et al., 2018). In most member states, such as Germany and Italy, crops dominate as a feedstock while the potential to use sewage remains largely untapped (Figure 1.).

- The EU has began to embrace a circular economy approach. Its stringent regulatory regime is changing waste streams and disposal options. Importantly, while bio-waste and sludge production increase (Zsirai, 2011), limits are put on landfilling, and particularly of biodegradable material. Applying sludge as a fertiliser and soil conditioner is still the preferred options in most member states, more stringent rules confine this end-use form (Spinosa 2010). Together these developments have driven wastewater-to-energy solutions.

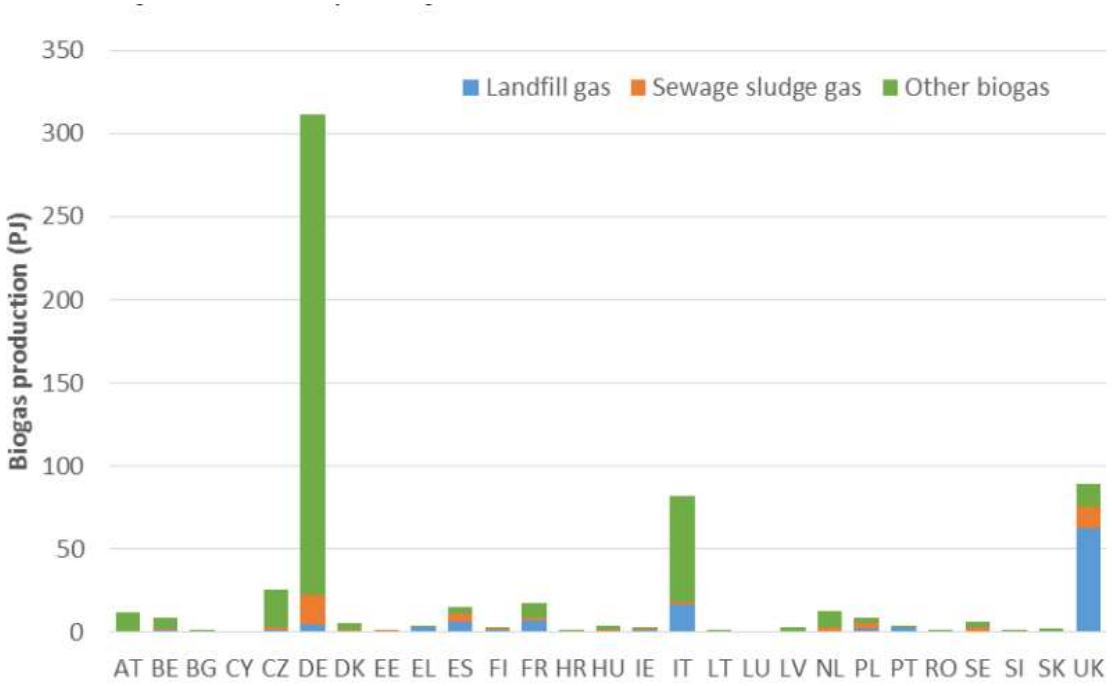

Figure 1: Biogas production per Member State in 2014, differentiated by source (Kampman et al., 2016)

3.3. Overview of key EU legislation and policies

3.3.1. Water & Wastewater

The Water Framework Directive (2000/60/EC)

This directive (here referred to as the WFD) requires that rivers, lakes, transitional waters, coastal waters, and groundwater obtain "good status" by 2027. To achieve this goal, the EU has determined a clear timeline and three six-year management cycles for the member states. One of its main elements is the introduction of River Basin Districts, which form the management units for managing water resources. Importantly, the WFD pertains to services of both water and waste water.

The Urban Waste Water Treatment Directive (91/271/EEC)

The main objective of the Urban Waste Water Treatment Directive (UWWTD) is to protect the environment from negative effects of urban wastewater discharges. It comprises the collection, treatment, and discharge of domestic wastewater, mixture of wastewater, and wastewater from certain industrial sectors. It stipulates the level of treatment and the removal of nutrients and basic sanitary parameters, as well as conditions for sludge disposal and reuse.

The Sewage Sludge Directive (86/278/ EEC)

The Sewage Sludge Directive (SSD) is concerned with the management of sewage sludge. It particularly seeks to encourage the use of sewage sludge as a soil conditioner and fertiliser in agriculture. It bans applying untreated sludge on

agricultural land. Also, it sets all the requirements and provisions to prevent potential harmful effects on humans, animals, soil and vegetation as well as surface and groundwater. The Directive lays down the basic limits for potentially toxic elements (PTEs, which are HMs) in SS and soil.

3.3.2. Climate change mitigation

2020 Climate and energy package ("20-20-20 targets")

This package was established in 2007. Its goal is to ensure that the EU meets its climate and energy targets. In consequence, the legislation encompassed three main targets for the year 2020:

- 20% increase in energy produced from renewables
- 20% enhancement in energy efficiency
- 20% cut in greenhouse gas emissions (compared to 1990 level)

Emissions Trading System (ETS)

The ETS is a central element in the EU's policy to tackle climate change and a key tool for reducing greenhouse gas emissions in a cost-effective manner. It is based on a "cap and trade" system. The cab limits the amount of greenhouse gas emissions a certain user or industry is allowed to emit. As the cap is gradually lowered over time, emissions are expected to fall. Within the cap, companies receive or buy emission allowances that cover their emissions. These can be traded.

Effort sharing agreement for the non-ETS sectors

The Effort Sharing Decision establishes binding annual greenhouse gas emission targets for Member States for the period 2013–2020. These targets concern emissions from most sectors not included in the EU Emissions Trading System (EU ETS), such as transport, buildings, agriculture and also waste. The regulation aims to ensure that the non-ETS sectors emissions reduction target of 30% by 2030 compared to 2005 levels.

3.3.3. Renewable energy production and energy efficiency

Renewable Energy Directive (2009/28/EC)

The Renewable Energy Directive (RED),which is currently being revised, establishes a policy framework for producing and encouraging renewable energy in the EU, including biogas. The directive requires that 20 % of the EU's energy mix in 2020 must be renewable. It translates this general goal into individual targets for each of the member states. In a recent proposal to revise the directive the Commission elevated that goal to 27 % by 2030. The RED also defines sustainability criteria for biofuels and bioliquids in the transport sector.

Directive to reduce indirect land use change for biofuels and bioliquids ((EU/2015/1513)

The ILUC was established as response to sustainability challenges concerning bio-energy made out of food-based crops, most importantly indirect land-use change. It amends current legislation on biofuels, including the Renewable Energy Directive (2009/28/EC) and Fuel Quality Directive (2009/30/EC). For example, it limits the share of biofuels produced from crops in the transport sector (7% in overall fuel mix). It also requires that biofuels produced in new installations emit at least 60% fewer greenhouse gases than fossil fuels.

Energy Efficiency Directive (2012/27/EC)

The Energy Efficiency Directive (EED) mandates energy efficiency improvements. It establishes a common framework for the promotion of EE within the EU to meet its EE headline target of 20% by 2020, in all stages and sectors of the supply chain. EU member states have to prepare a National Energy Efficiency Action Plan every three years and report on their progress in the different sectors (i.e. industry, residential, services, public, transportation, electricity and heat generation).

Directive for combined heat and power generation (2004/8/EC)

This directive promotes the use of combined heat and power (CHP) units to improve the efficiency of electricity and heat production. It sets rules on guarantees of origin, efficiency criteria, administrative procedures, and other issues. Member states are encouraged to provide support schemes for CHP units to enable their widespread implementation (including specific support for WTTPs).

3.3.4. Natural Gas

Directive on services in the internal gas market (2009/73/EC)

This 'Gas Directive' establishes common rules for the transmission, distribution, supply and storage of natural gas. It stipulates rules relating to the organisation and functioning of the natural gas sector, access to the market, the criteria and procedures applicable to the granting of authorisations for transmission, distribution, supply and storage of natural gas and the operation of systems. The rules also apply in a non-discriminatory way to biogas and gas from biomass, i.e. sewage gas from WWTPs.

Directive for internal electricity market (2009/72/EC)

This directive establishes common rules for the generation, transmission, distribution and supply of electricity, together with consumer protection provisions, with a view to improving and integrating competitive electricity markets in the EC. It lays down the rules relating to the organisation and functioning of the electricity sector, open access to the market, the criteria and procedures applicable to calls for tenders and the granting of authorisations and the operation of systems such as transmission or distribution systems, including the request for unbundling of electricity production and

Directive for taxation of electricity and other energy products 2003/96/EC (EU 2003a) sets a framework for taxation of electricity and other energy products, e.g. gas or other fuels. It defines the energy products to be taxed and the minimum amount. The project "Full scale demonstration of energy positive sewage treatment

plant concepts towards market penetration" (POWERSTEP) has received funding under the European Union HORIZON 2020 –

3.4. Solid waste management

The Waste ´Framework Directive (2008/98/EC)

This directive defines basic concepts such as the "waste hierarchy" (a priority order set among waste prevention and management options), and stipulates requirements for waste management, such as to up a separate collection of waste, waste management plans, and waste prevention programmes. It also establishes legally binding targets such as for household waste streams including biodegradable materials).

The Landfill Directive (1999/31/EC)

This directive aims at preventing or reducing adverse environmental impacts from landfilling of waste through stringent technical requirements for waste and landfills. It obliges Member States to reduce the amount of biodegradable municipal waste that they landfill to 35% of 1995 levels by 2016 (for some countries by 2020) while current legislative of the proposal of it consider a complete ban of landfilling.

3.5. Legal drivers and barriers

Paucity of energy aspects and targets in water legislation

Energy-related issues remain vastly absent from the EU's legal and policy framework of the water sector. The key water-related directives, the WFD and the UWWTD, make no provisions that specifically focus on targets, measures or incentives to improve EE or renewable production measures in WWTPs, whether motivated by ambitions of cost-efficiency or decarbonisation. Also, more recent water policy documents such as the "Blueprint to Safeguard Europe's Water Resources" (2012) poorly make that linkage. A legislative proposal of the Drinking Water Directive adopted this year comprises one of the first attempts to embrace the water energy-water nexus by encouraging member states to increase energy efficiency.

Lack of overall cross-sectoral and coherent legal framework

The absence of a cross-sectoral approach spanning across various relevant EU energy, waste, water, agricultural and other concerned directives stifles legal backing needed to more systematically support wastewater-to-energy solutions. Energy-related issues are missing in EU water sector policy and law, which predominantly focus on water quality and quantity goals. The RED, on the other side, fails to articulate specific provisions on how, for example, the waste water sector can contribute to achieving targets concerning carbon reduction and renewable production. Incoherence of the overall legal and policy framework has been ranked as the top barrier for biogas production (Kampmann et al., 2016).

Inadequate priorisation of second generation bio-energy

Member states have been free to opt through which form of renewable energy they accomplish these targets. This flexibility has given rise to divergent developments of

the biogas market across the member states (Torrijos, 2016), with in part undesirable outcomes. A prominent example applies to the rise of crop-based biogas, which ranks as the EU's main type of bio-energy and dominant renewable energy form (Kampman et al., 2016). As a feedstock, however, crops have proven adverse environmental impacts (e.g. land use change). The environmental footprint of biogas produced from waste streams, in contrast, is significantly better, but their share in the biogas market lag behind that of crop-based biomass (see. Figure 1). This is because the EU legal and policy does not systematically support renewable energies according to their sustainability performance. Sustainability criteria, which form one central pre-condition towards doing so, exist only for the transport sector while they lack cross-national harmonisation (Kampman et al., 2016).

An improving yet unreliable base of bio-waste feedstock

The EU's stringent regulatory regime for waste functions as a strong driver for wastewater-to-energy systems. The Landfill Directive is viewed as the most important factor propelling the growth of anaerobic digestion (AD) (including on-farm applications) in treating biowaste and industrial feedstock (Edwards et al., 2015). This is because the ban on landfilling and tightening quota for reducing landfilled biodegradable organics increase the need to find solutions for disposing growing amounts of bio-waste (Torrijos, 2016). However, many member states do not have a reliable bio-waste feedstock base (Edwards et al., 2016). Only 25 % of the total bio-waste in the EU is recycled while recycling rates are considerably lower in many member states (Mateescu et al., 2008). In some countries like the UK, access to adequate organic feedstock is already a barrier (Kampman et al., 2016). Additionally, current regulations do not promote AD as a preferable disposal option for biowaste. Legal loopholes still allow member states incinerate or landfill biowaste (Iacovidou et al., 2012). The European Biogas Association (2016) remarks that incineration may become the main disposal option for biowaste as the as the landfilling ban takes effect.

Under-development of heat usage due to weak incentives

Whether WWTPs achieve high potential of energy and carbon emissions savings depends on exploiting both heat and electricity generated during the combustion of biogas. Biogas markets have expanded in several EU member states. However, despite some positive development, often only the electricity generated from biogas is used while the heat potential remains untapped. Currently, only 25 % of the heat is used in Europe's WWTPs (Scarlat et al., 2018). While plant operators face pressure to improve the economics of biogas plants (ibid), weak incentives at the EU-level comprise one key factor responsible for the slow development of heat usage from biogas (Kampman et al., 2016).

Lacking revenue streams for sewage-based co-digestate

Using co-digestate of sewage sludge and bio-waste as soil conditioner or fertiliser (for example in agriculture) can spur the uptake of wastewater-to-energy solutions (Edwards et al., 2015). Such "end-use" applications guarantee that sewage sludge, whose production in Europe will rise over the next years (Werle, 2015), will be harnessed in the spirit of a circular economy. Currently, however, sludge-based co-

digestates are subject to an incoherent and partially conflicting legal and regulatory regime (Iacavidou et al., 2012), which compounds the dissemination of AD technologies. One main barrier is that co-digestate containing sewage sludge is currently classified as waste and not a valuable product. This legal definition only allows WWTP operators to market the biogas, but not its by-products, undermining additional revenue streams (Kampmann et al., 2016).

Ambiguous financial mechanisms for wastewater-to-energy solutions

Access to inexpensive renewable energy will become increasingly important because the cost of sewage sludge treatment is bound to rise due to higher treatment standards and rising energy costs, among others (Zsirai, 2011). Cost pressures, which the imposed by the cost-recovery principle in the WFD, theoretically attractive for WWUs to deploy RE production. However, new technologies such as AD are capital-intensive, generally requiring subsidisation (Edwards et al., 2015). National support schemes (e.g. feed-in tariffs) form the key financial mechanism to drive renewable energy developments in the EU. However, these are still ineffective in many member states, for example due to low or reduced subsidies (Kampman et al., 2016). At the same time, the EU legislation and policies upon which the support schems are based are yet not sufficiently linked to sustainability criteria, as argued above. Furthermore, Green Public Procurement (GPP) for WWTPs currently apply only to EE, but not to producing RE (Loderer and Hananel, 2018).

Grid injection of bio-energy

If not used for self-supply in on-site CHP plants, WWUs have several options to bring bioenergy to the market: As biogas or biomethane via the gas network; as heat via the district heating network; or as electric power via the electric grid. Arguably, a range of barriers apply to each of these options. Generally, decentralized energy forms – such as wastewater-to-energy solutions – lack a common EU framework that explicitly supports them. Across member states + small market entrants providing distributed energy (DE) still face various challenges, including a lack of explicit incentives in planning and operations of networks, high connection charges, or high trading fees (Ropenus and Skytte, 2005). Another specific example concerns cross-border trade of biomethane, which is hindered substantially by national quality standards, which lack harmonisation (Kampan et al., 2016).

4. Overview on legal and policy situation in Italy

The Italian regulatory framework for renewable energy that is produced from waste and wastewater is very complex and in continuous evolution, with more than 1700 acts at national and regional level. Renewable energies have been receiving financial support since the early 2000's when the EU Directive 2001/77/EC concerned with the promotion of the use of electric energy produced by renewable sources was transposed into national law (Decree 29 December 2003, n. 387)

4.1. National Level:

Decreto Legislativo n.28/2011 stipulates provisions made in the EU Directive 2009/28/EC, which promotes renewable energy production. Legislation regarding waste and wastewater treatment and management is regulated by the legislative decree 152/2006 (GU, D.Lgs. 3 April 2006) and its subsequent modifications. This decree relates to and reorganises all legislation on environmental issues and, as a consequence, also on waste and wastewater management established by EU law. For this reason the laws mentioned above, which were introduced before the 2006, have been repealed and renewed through this decree while it implements all European directives.

The decree describes procedures and limits for the use of waste and waste water and requirements for disposal and recycling. The decree does not address to the energetic aspects, but only the protection of the environment. The energy production processes are affected by this decree, and in particular anaerobic digestion process and wastewater management and sludge treatment and disposal, relating at their effects on the environment.

Only the use of specific wastes that possibly cause negative environmental effects is specifically and strictly regulated. This is of particular relevance in the case of sewage sludge. The organic components of sludge enable application, as organic fertilizer, in agriculture (Maglia e Balossi 2017). The potential health risk from this has led to the development of specific regulations. In this case sludge or the final products it is a part of (such as co-digestate with food waste) must respect stipulated concentration limits in order to qualify as a fertilizer or compost.

Legislation requires to examine values for pollutants of sludge that is going to be used as fertiliser regularly: Plants larger than 100.000 PE have to conduct an assessment every three months and plants with PE smaller than 5.000 every year.

In several cases this strict legislation suggests local wastewater utilities to identify other solutions for the sludge management instead of the biogas digestion or co-digestion. These can include incineration or other stabilization technologies.

Renewable energy production is regulated by the Decree 23 June 2016 that takes into account all renewable energy forms.

An important new decree published on 2nd March 2018 named “Promozione dell'uso del biometano e degli altri biocarburanti avanzati nel settore dei trasporti” (Promotion of the use of biomethane and other advanced biofuels in the transport sector”) determines the rules for biogas upgrading, grid injection, and for the use as biofuel.

This decree is of particular relevance. According to the 2020 climate & energy package Italy has already reached its renewable energy targets. However, it has not yet reached the objectives for increasing the fraction of biofuels used in the transport sector. This was particularly because legislation failed to define rules and procedures for grid injection and for the use of upgraded biogas as biofuel.

Decree 2 March 2018 overcame this “legal gap” and it can be expected that amendments relating to biogas upgrading will come into force within the next months.

In particular, the new Decree has the following objectives:

• to further promote the use of biomethane for transportation and for achieving the objectives set for Italy by the European directives in terms of the use of renewable fuels in transport. The incentive charge is distributed to the parties who are obliged to release biofuels for consumption (Obligated Subjects);

• promote retrofitting of existing plants, actually producing electricity, to bio-methane plants distributing methane for the grid or as biofuel with the aim to reduce the operational costs for the electricity consumption;

• promote production facilities for advanced biofuels other than biomethane.

The decree will establish a transparent and reliable scheme for the production of biomethane and the subsidies that energy producers can apply for.

It is based on an instrument called Cetificato di Immissione al Consumo (CIC Consume Admission Certificate). This certificate has a value of 10 Gcal for biofuels and five Gcal for advanced biofuels as biomethane produced with a list of biomasses listed in the annex 3 part A of the of the Decree 2 March 2018. It is possible to use also other biomasses, but it is forbidden to exceed the limit of 30% of the weight of the total feeding.

The value of each CIC is 375€. In addition to this amount, each producer will receive a subsidy if the feedstock used is renewable and is by definition no food. An additional subsidy is also available if the biomethane technology used to produce it is listed in the annex of the decree.

4.2. Regional Level:

In Italy each region is legitimised to modify national legislation only in the sense of an higher environment protection. Most of the regions take this opportunity to develop their own legislation for several reasons.

As the Italian Reef 2W pilot site is located in the Emilia Romagna Region below is a short list of the legislation developed in this region that is more or less closely related to the production of biogas:

- ✓ Legislative Assembly Resolution no. 51 of 26 July 2011 "Identification areas and sites for the installation of electricity production facilities through the use of renewable wind energy sources, from biogas, from biomass and hydroelectric ";
- ✓ Resolution of the Regional Council n. 1495/2011 "Technical criteria for mitigation environmental impacts in the design and management of biogas plants ";
- ✓ Resolution of the Regional Council n. 1496/2011 "General authorization for energy production plants with engines with rated thermal power less than 10 MWt powered by biogas ": establishes limits on emissions into the atmosphere for biogas combustion engines;

- ✓ Resolution of the Regional Council n. 362/2012 "Implementation of the D.A.L[1]. 51 of the 26 July 2011 ": approval of the criteria for the calculation of the emission calculation for biomass energy production plants (for checking the balance of emissions of PM10 and NO2).
- ✓ Regional regulation 4 Janury 2016 that define the use of sludge in agriculture that results from wastewater treatment

Moreover the Agenzia Regionale per l'Ambiente Emilia Romagna (ARPAE Regional Envioromental Agency Emilia Romagna) has the obligation to provide its opinion on each energy facility with respect to the biomass uses and the effects on the environment as well as on human health. This opinion must be taken into account while considering legislation in force, as well as the local environmental situation.

All the above mentioned laws/decrees addresses the use of the final products resulting from the anaerobic digestion process in agriculture. It specifically provides more strict rules for its application in agriculture and emission of air pollution.

5. Main legal and policy barriers in Italy

In Italy, the share of biogas produced from sewage sludge is low compared with crop-based biogas. Landfilling and incineration of sludge have been the preferred disposal options for sludge historically. Their dominance has impeded the development of biogas produced from waste streams including wastewater. Legislation in Italy focuses mainly on the environment and human health protection and it has been developed mainly looking at the agricultural sector rather than the increase of efficiency of urban waste and wastewater treatment plants. For this reason it is probable that a specific legislation developed for the sludge and waste conversion to biogas has not evolved to date. Previous legislation does not make specific provisions for biogas production and fails to define preferences or requirements for which feedstocks to used. Additionally, there were several levels of subsidies for electricity generated from renewable energy sources according to the year of installation of the anaerobic digestor. This is a consequence of the development of legislation in different years. The problem with the different levels of subsidies was that during the last years the number of plants constructed decreased considerably, and "new" biomasses available were not used for energy production because it was not economically convenient.

As aforementioned, the 2020 objective for the electricity from renewable energy in Italy is already reached. For this reason two main strategies for new plants have been developed: The first seeks to decrease the subsidy for electricity production; the second aims at promoting the increase of the heat use. Unfortunately most of the plants are far away from easy utilisation and for this reasons it is difficult to use this energy.

[1] D.A.L.: Deacreto Assemblea Legislativa, Decree of the Legislative Assemblee regional legislative body

Thanks to the decree of March 2018 the last barrier for the biogas upgrading has fallen and shortly the biomethane production for vehicles or grid injection could start. (GSE, Biometano s.d.)

The first national legislation for biomethane production was introduced in 2016, the application rules of the legislation has been published in 2018 and after another four month the procedures will be published.

The extensive processes to develop and implement legislation in Italy is likely the main barrier for the development of the RES in Italy. Additional barriers are the unpredictable development of the energy market and legislation and the competition with fossil energies. According to European policy Italy has developed its own energy plan in 2017. Therein no specific provisions are made relating to the production of energy from solid waste or wastewater. Yet it contains objectives to reduce the use of biogas for the energy production. All large and medium-sized plants built in the future should transform the biomass in biomethane or other biofuels. This is due to the still unreached objective for the biofuel production in Italy and in the meantime for the strong request that most the population ask for a better quality of the air in the urban areas.

6. Drivers and existing approaches to overcome barriers in Italy

The new Italian National Energy Strategy (SEN2017), adopted in November 2017 by a Joint Decree of the Ministry of Economic Development and the Ministry of the Environment, assigns to the RES a central role for the sustainable development of the country. It sets, among other things, targets for the development of renewable energies until 2030, which are more ambitious than those currently proposed at European level. The strategy aims to make the national energy system more:

- Competitive, continuing to reduce the sales price gap and the cost of energy compared to Europe, in a context of increasing international prices.
- Sustainable, achieving environmental and de-carbonisation objectives defined at European level in an ecological way.
- Safe, continuing to improve the security of supply and the flexibility of energy systems and infrastructures, strengthening Italy's energy independence.

Among the quantitative targets envisaged by SEN2017, it is necessary to mention (MiSE 2017):

- Energy efficiency: reduction of final consumption from 118 to 108 Mtep with a saving of about 10 Mtep to 2030.
- Renewable sources: 28% of renewables on total consumption in 2030; in sector terms, the objective is divided into a share of renewables on electricity consumption of 55% to 2030, on thermal uses of 30% and in transport to 21%.

- Cessation of the production of electricity from coal with an acceleration target of 2025, to be achieved through a precise plan of infrastructural interventions.
- Decarbonisation in 2050: compared to 1990, a decrease in emissions of 39% in 2030 and of 63% in 2050.
- Redouble research and technological development investments in clean energy.

Another driver is the national target to reduce Italy's dependence on foreign energy from 76% (2015) to 64% by 2030 (the ratio between the import / export balance of primary energy needed to cover the needs and gross domestic consumption), thanks to the strong growth of renewables and 'energy efficiency.

At the moment, this is the only existing strategy. Other technological approaches like Power-to-Gas are not considered in the current legislation. It is thus unlikely that these technologies will gain traction in the next few years. A more holistic legal approach could be useful because biomethane generates a surplus of pure carbon dioxide that could be utilized for the production of other biomethane using the excess of electricity deriving from the photovoltaic plants.

7. Appendix I: Questionnaire for Legal and Policy Barrier Analysis

This questionnaire is intended for gathering primary and secondary data needed to accomplish D2.4.1. There is no obligation to use it, but you may find it useful drawing on all or several of the proposed guiding questions.

- Conduct 5-10 interviews with experts such as utility staff or policy makers and other experts, separately or in focus groups;
- Adjust questions according to the type of interviewed respondent, characteristics of the treatment facility and utility and country context.

Legal and Policy Barriers in Country X

1. How conducive is the legal and policy framework in supporting the implementation of EE and RE measures in the WWTP(s) of your country?

2. Can you outline and describe in detail the most significant legal and policy barriers, differentiating between the main ways for exploiting energy from wastewater where relevant (such as improving operational energy efficiency or generating electricity and heat from biogas)?

3. Can you identify the political level(s) at which legal and policy barriers may be most severe (EU/International, national, federal and local)?

4. Does the legal and policy situation support or impair interventions for exploiting waste heat more than electricity or vice versa? If so, what barriers apply?

5. Which legal and policy barriers constrain WWUs from using surplus heat and electricity for self-supply?

6. What legal and policy barriers impede supplying waste heat or electricity to the market in your country? For example, regulations may prohibit WWUs from entering business other than managing wastewater while low subsidies for RE might constrain them to gain financial sustainability.

7. What legal and policy barriers particularly apply for integrating systems of solid waste and wastewater to use organic substrates for enrichment of sludge in the co-fermentation process?

Policy and legal drivers and approaches to overcome barriers in Country X

8. Can you outline and describe the most significant legal and policy drivers, differentiating between the main ways for exploiting energy from wastewater where relevant?

9. What governmental or private sector actors do you consider most critical for improving the legal and policy framework for wastewater-to-energy systems?

10. What actor-based instruments (such as a central agency to coordinate interventions with respect to energy-related matters or specific funding or educational programmes) have been established to promote wastewater-to-energy systems?

11. Are you aware of legal and policy interventions that are currently being planned or already under way to overcome the main barriers you mentioned above (e.g a revision of the sludge ordinance or law with respect to CHP?)

Literature

Ajami, N.K., Thompson Jr, B.H. and Victor, D.G., (2014) The path to water innovation. The Brookings Institution.

DECRETO LEGISLATIVO 29 dicembre 2003, n. 387; Attuazione della direttiva 2001/77/EC relativa alla promozione dell'energia elettrica prodotta da fonti energetiche rinnovabili nel mercato interno dell'elettricità.

Dierich, A, Hüesker, F, Ansmann, T. and Gretzschel, O (2017) Rahmenbedingungen für die Sektorkopplung von Abwasserreinigung und Klärschlammbehandlung mit der Energiewirtschaft: Hemmnisse, Treiber und Chancen. Korrespondenz Abwasser, Abfall (64)8, 697-706.

GU, D.Lgs. 3 aprile. «Norme in materia ambientale.» 14 April 2006.

European Biogas Association (2016) Position on the revision of the Waste Framework Directive (Position Paper). Retrieved from: http://european-biogas.eu/wp-content/uploads/2016/04/EBA-position-on-WFD-revision_April-2016.pdf
Edwards, J., Othman, M., Burn, S., (2015) A review of policy drivers and barriers for the
use of anaerobic digestion in Europe, the United States and Australia. *Renew. Sustain.*
Energy Rev. 52, 815–828.

Iacovidou, E., Ohandja, D. G., & Voulvoulis, N. (2012). Food waste co-digestion with sewage sludge–realising its potential in the UK. *Journal of environmental management*, 112, 267-274.

Kampman, B., Leguijt, C., Scholten, T., Tallat-Kelpsaite, J., Brückmann, R., Maroulis, G., ... & Elbersen, B. (2017). Optimal use of biogas from waste streams: an assessment of the potential of biogas from digestion in the EU beyond 2020. European Commission.

Kilinc-Ata, N. (2016). The evaluation of renewable energy policies across EU countries and US states: An econometric approach. Energy for Sustainable Development, 31, 83-90.

Kiparsky, M., Sedlak, D.L., Thompson Jr, B.H. and Truffer, B., 2013. The innovation deficit in urban water: the need for an integrated perspective on institutions, organizations, and technology. *Environmental engineering science*, 30(8), pp.395-408.

Kretschmer, F (2017) Abwasser als erneuerbare Energiequelle – Potenziale, Chancen und Barrieren im österreichischen Kontext. Wiener Mitteilungen. Volume 246 of Wiener Mitteilungen

Loderer and Hananel (2018) The potential of the wastewater sector in the energy transition (Policy Brief). Retrieved from http://powerstep.eu/system/files/generated/files/resource/policy-brief.pdf

Mateescu, C., Băran, G., & Băbuţanu, C. A. (2008). Opportunities and barriers for development of biogas technologies in Romania. *Environmental engineering and Management Journal*, 7(5), 603-607.

Mininni, G., Blanch, A. R., Lucena, F., & Berselli, S. (2015). EU policy on sewage sludge utilization and perspectives on new approaches of sludge management. Environmental Science and Pollution Research, 22(10), 7361-7374.

Maglia, S., e V. Balossi. «Fanghi da depurazione in agricoltura: quale normativa si applica?» 10 October 2017. https://www.tuttoambiente.it/commenti-premium/fanghi-depurazione-agricoltura-normativa/ (consultato il giorno February 6, 2018).Speight, V.L., (2015) Innovation in the water industry: barriers and

opportunities for US and UK utilities. *Wiley Interdisciplinary Reviews: Water*, 2(4), pp.301-313.

Kretschmer, F (2017) Abwasser als erneuerbare Energiequelle – Potenziale, Chancen und Barrieren im österreichischen Kontext. Wiener Mitteilungen. Volume 246 of Wiener Mitteilungen

REGOLAMENTO REGIONALE 04 gennaio 2016, n. 1#RR-ER-2016-1# REGOLAMENTO REGIONALE IN MATERIA DI UTILIZZAZIONE AGRONOMICA DEGLI EFFLUENTI DI ALLEVAMENTO E DELLE ACQUE REFLUE DERIVANTI DA AZIENDE AGRICOLE E PICCOLE AZIENDE AGRO-ALIMENTARI

Scarlat, N., Dallemand, J. F., & Fahl, F. (2018). Biogas: developments and perspectives in Europe. Renewable Energy.

Speight, V.L., (2015) Innovation in the water industry: barriers and opportunities for US and UK utilities. *Wiley Interdisciplinary Reviews: Water*, 2(4), pp.301-313.

Spinosa, L. Sustainability in sludge management: A combined approach to meet future needs. *Water21*, 31–33.

Torrijos, M. (2016). State of development of biogas production in Europe. *Procedia Environmental Sciences*, 35, 881-889.

Willis, J., Stone, L., Durden, K., Beecher, N., Hemenway, C. and Greenwood, R. (2012) Barriers to biogas use for renewable energy. Water Environment Research Foundation (WERF).

Vogt, R., Frisch, S. and Pehnt, M. (2010) Klimaschutz- und Energieeffizienz potenziale im Bereich Abfall und Abwasserwirtschaft. Institut für Energie- und Umweltforschung Heidelberg (IFEU).