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

GERMANY

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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.

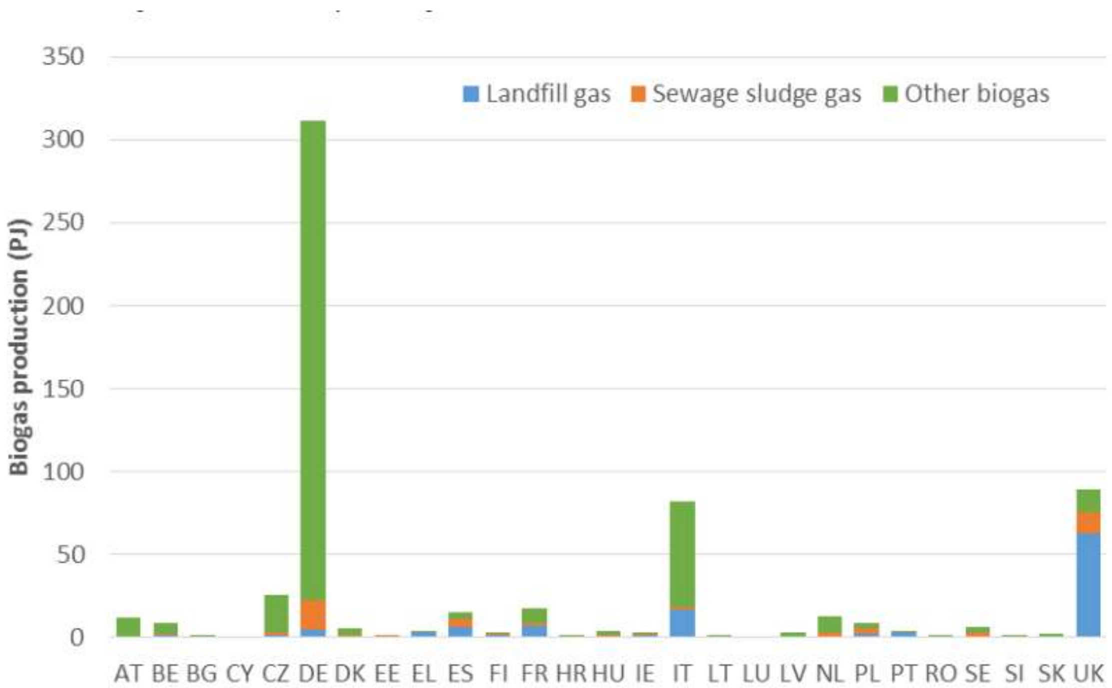

Figure 1: Biogas production per Member State in 2014, differentiated by source (Kampman et al., 2016)

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?)

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