D.T.2.4.2 ANALYSIS AND RECOMMENDATION DOCUMENT

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1. Introduction

1.1. REEF 2W project

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

The project REEF 2W recognizes that waste plays a key role in transforming energy systems. The project is funded by the European Regional Development Fund Interreg Central Europe Programme and is carried out through 11 research institutes and wastewater utilities from Italy, Czech Republic, Germany, Croatia, and Austria. The project's main objective is to drive up energy efficiency and renewable energy production in solid waste and wastewater facilities. It focuses on solutions that integrate organic waste and wastewater streams and the development of new infrastructures. Where beneficial, bio-waste will be used to enrich the organic content of sewage sludge, helping to elevate outputs of heat and electricity in a process called co-digestion. To prove that the new technologies can be technically feasible and make economic viable, project partners will develop a comprehensive assessment tool in close collaboration with utility operators in a series of workshops. Another key task of REEF 2W is to investigate the legal and policy framework conditions and to advocate for policy alternatives that spur the large-scale use of wastewater-to-energy solutions.

1.2. Scope of deliverable

The purpose of this deliverable is to, first, summarize the legal and policy barriers discerned in each of the five countries (DT.2.4.1). On this basis policy recommendations have been developed, which are presented and discussed in the second part of this document. These findings are used to write a Position Paper (DT.2.5.3), which will shared and discussed with representatives from muncipal goverments and policy makers.They are also going to be used in multiple other deliverables of the project, such as the Five Regional Strategies (DT.2.5.1) or during a high-level event in Brussels (D.C.7.4).

While originally intended to only look at legal aspects, the project consortium decided to also consider financial and institutional aspects. This will enable a more holistic and multidisciplinary approach, which is critical for successfully scaling up the waste-to-energy solutions investigated in REEF 2W. The analysis draws on interviews with utility operators, scientists and representatives from local governments from five European countries and has been consolidated through a literature review. The analysis also includes studies from other than the pilot countries in REEF 2W. In the following seven barriers are analysed in detail and six policy recommendations are provided.

2. Background

Solid waste and wastewater utilities have different options at hand to optimise their energy performance. Alongside energy efficiency measures operators can increase biogas yields, most effectively through co-digestion with organic waste. Moreover technologies such as biogas upgrading or power-to-gas can further improve the rates at which biogas is exploited energetically. The degree to which these opimisation forms are implemented varies greatly across EU member states. For example, using sewage sludge to produce biogas has been practiced for several decades in countries like Germany. Waste heat capture through heat pumps in sewer networks, in contrast, has only gained currency in recent years (Steinmetz 2012). In Germany and Denmark, the potential to exploit biogas in WWTPs has almost peaked, whereas France, Italy, and Spain have realised relatively little of their actual potential (Bodík et al. 2011). Especially rather new technologies like biogas upgrading and power-to-gas are yet not very common.

Multiple interconnected barriers usually cause the slow uptake of innovation in the water sector (Kiparksy et al., 2013, Ajami et a. 2014). This also applies to “waste-to-energy” solutions in Europe. The barriers are technical, cultural, legal, financial, political and institutional. The research within the REEF 2W project shows that legislation, policy and regulation impair utility operators in many countries to venture outside their core business of treating soild waste and wastewater. Those that want to pioneer them generally confront high upfront costs and additional work that often outweigh economic benefits, especially when co-digestion with biowaste is part of the technological upgrade. Moreover, rarely is there regulatory pressure to save energy or low incentives to produce and sell energy to the grid. This is because a policy and legislation framework for solid waste and wastewater-to-energy solutions at both EU and national is only in the making.

Its design, too, is a challenging task. The waste-to-energy solutions do not only involve a variety of different technologies harnessing different kinds of energy, all of which demand specific legal and regulatory provisions. These solutions also need to align different objectives stretching beyond treating soild waste and wastewater, including energy security and flexibilisation of the energy system, reducing carbon emissions, costs savings and the management of other resources (such as phosphorous). Moreover given the solutions touch across the water, energy, and solid waste system, a multi-sector approach is of utmost importance. This necessarily involves also a broad range of stakeholders from these different sectors, whose participation is crucial for implementing new innovations. It is also important to consider the spatial connections and dependencies of waste-to-energy solutions involving co-digestion with organic waste. To implement them, there need to be sufficient availability of organic waste streams in the region. So are selling surplus energy to the grid, as well as disposing co-digestate in economically viable and sustainable ways, dependent on nearby demand for these products.

3. A synthesis of the main legal barriers

3.1. Legal and institutional approaches are largely inexistent, incoherent and lack cross-sectoral linkages

Energy-related concerns and goals are almost non-existent in the EU's legal and policy frameworks of the water sector, which predominantly focus on water quality and quantity goals. Key sectoral laws such as the Water Framework Directive (2000/60/EC) and the Urban Waste Water Treatment Directive (91/271/EEC) make no provisions for water or wastewater utilities to reduce carbon emission by increasing energy efficiency or renewable production. Also, more recent water policy documents such as the "Blueprint to Safeguard Europe's Water Resources" (2012) poorly make that linkage. Simultaneously energy directives fail to articulate specific provisions on how the waste water sector can contribute to achieving targets concerning carbon reduction and renewable production and do not formulate specific CO_2 emission targets for WWTPs. 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. The Urban Waste Water Treatment Directive will be "re-considered" but the outcome and consequences remain uncertain as of yet (EU, 2018b).

Lacking integration of sectors is particularly problematic for co-digestion of sewage with organic waste, which is often organized in separate regulatory and management regimes. Iacovidou et al. (2012) describes this for the case of co-digestion with food waste in the UK, where regulation consequently becomes more complex and ambiguous and hence discourages new enterprises or projects. The lack of integration also concerns the way governmental institutions are designed. Staying with the example of the UK, the Department of Sanitation is not tasked to deal with energy that can be generated from wastewater through anaerobic digestion. At the same time the Department of Energy has no mandate and obligation to use anaerobic digestion as a technology to treat organic waste in a sustainable way (Edwards et al., 2016).

The support of innovations in the waste-to-energy field is furthermore not systematic. Such a systematic approach needs to make it mandatory for utilities to maximise energy efficiency measures as a first step. The EU has committed to the Energy Efficiency First principle in energy and climate policy, planning and finance (EU, 2016). The Principle aims at allocating financial resources in a more cost-effective manner. Investment decisions are assessed as to whether it is cheaper to implement measures saving energy instead of financing, for example, supply-side networks, fuels, and infrastructure (Bayer, 2018).

Furthermore the REEF 2W approach encompasses a wide range of technologies that use energy more efficiently or increase energy outputs. To harness the full energy potential in waste and wastewater facilities, it is necessary to take on a holistic approach of optimising the energy performance. That is, all options including technologies and management measures to maximise improvements should be considered. However, this is currently not reflected in the legal and policy framework of the EU and its member states. While some components of waste-to-energy solutions are acknowledged by European support schemes (e.g. anaerobic digestion from waste streams), others such as biomethane production, Power-to-Gas or waste heat capture receive little to no support as of yet. In Italy, the legal status of Power-to-Gas, for example, is unclear while no support is provided, giving operators limited incentive to adopt the technology.

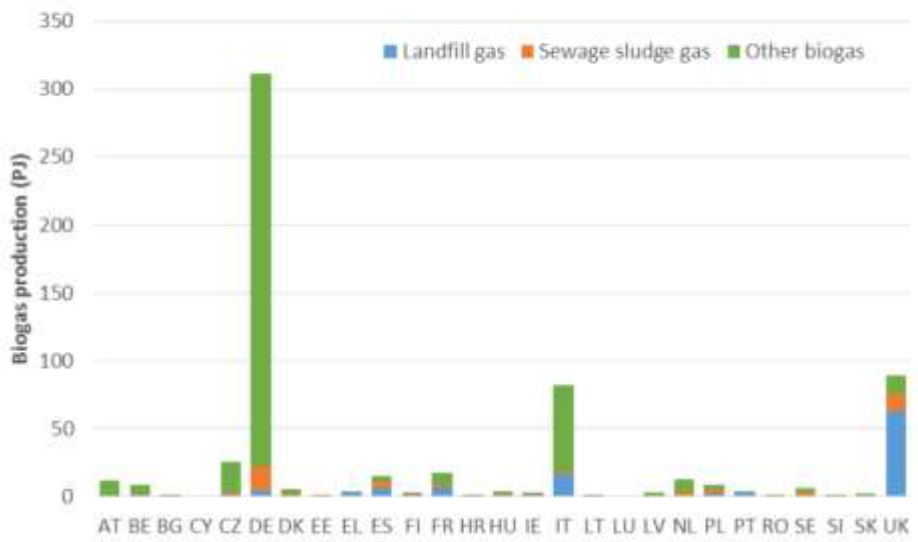
Such an approach needs to be aligned with other objectives around sustainable resource management. Most fundamentally, optimising the energy performance of waste utilities can clash with their primary mandate of treating the waste. For example, operators show concern about engaging with energy aspects because they lack resource and would consequently have to neglect their primary mandate. Another example relates to co-digestion of sludge and organic waste, which automatically conflicts with goals and methods to recover phosphorus. Mono-incineration may be better suited for retrieving phosphorous from sludge. Yet, co-digesting biowaste with sludge can achieve higher value in terms of a circular resource use, putting the two at conflict.

3.2. Limited priorisation of waste-to-energy solutions

An obligation for elevating bioenergy generation in wastewater utilities remains vastly absent in EU and national energy legislations. EU countries are free to opt through which forms of renewable energy they meet decarbonisation targets and renewable energy targets (Torrijos, 2016). The flexibility allowed by the legal framework has given rise to divergent developments of national biogas markets, in which energy crops dominate as a feedstock for producing bioenergy. As can be seen in Figure 1 Germany is the best example for this phenomenon. In Italy, too, but biogas development was driven through crop-based feedstocks.

Compared to other renewable feedstocks like corn or rapeseed the energy generation from sewage does not require arable land. It hence does not compete with other land uses such as agriculture or natural ecosystems. It thereby also avoids environmental problems such as water pollution nearby or within farming systems, or destruction of natural habitat, which is a common side effects of energy crops (Loderer and Hananel, 2018). Additionally, studies show that wastewater as a feedstock has substantially less carbon emissions. If the yielded biogas is upgraded to biomethane and subsequently provided to the market, waste facilities can help to flexibilise the energy market.

Emerging evidence about the adverse environmental effects of crop-based biogas feedstock production has led the EU to introduce legislative measures that cap the production of energy crops. For example the EU has introduced sustainability criteria for biofuels used in vehicles and bioliquids used for electricity generation and heating to make bioenergy less carbon-intensive and curb other side effects such as biodiversity loss. The EU is currently revising a proposal from the European Commission for a revised Renewable Energy Directive that includes these sustainability criteria for biofuels used in transport and bioliquids (EU, 2019).



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

However these legal provisions are insufficient to enable further scaling of sewage as a feedstock for generating bioenergy in waste utilities. Fundamentally policies and legislation yet fail to systematically recognize the better environmental footprint of waste-to-energy products and prioritise them over crop-based feedstocks. Waste receives insufficient targeted support over crop-based feedstocks, for example in feed-in tariffs. Moreover, unambitious or already reached national renewable energy targets can pose a barrier for the production of a specific energy form and prompt a policy maker to stimulate others instead. In Italy, for instance, because the National 2020 objectives for electricity from renewable electric energy are already met, upgrading of wastewater-to-energy solutions such as biomethane is strongly requested but on the other side the legislation linked to this opportunity only recently has been approved.

3.3. Insufficient biowaste availability hinders co-digestion in waste treatment plants

A strict regulatory waste regime that is able to increase the availability of biowaste on the market can incentivise wastewater utilities to adopt co-digestion as a disposal route for organic waste. Such a waste regime does not encourage further production of biowaste, but to make existing resources accessible in commercial and municipal waste streams, for example through better solid waste collection.

The waste hierarchy propagated by the EU Waste Framework Directive (2008/98/EC) encourages waste treatment strategies that prefer prevention followed by reuse and recycling of resources over strategies that incinerate or just landfill it. The waste hierarchy is in line with a sustainable and circular model of managing natural resources (EU, 2010). It should hence promote co-digestion, where instead of being landfilled or merely incinerated, organic waste is used to generate renewable energy before being applied in agriculture as a fertiliser.

One of the main ways to enforce the EU's Waste Hierarchy, and in turn promotes co-digestion with organic waste, is to phase out landfilling of biowaste. The second one discerned in this research relates to establishing a functioning municipal solid waste collection system wherein biowaste is "separated out" from other debris and becomes available for reuse. In some industries, such as the food industry, the organic waste may be ready for use as it is disposed . The EU Landfill Directive (1999/31/EC) landfilling has been the single most important driver for co-digestion projects using bio-waste (including those for on-farm biogas plants) (Edwards et al., 2016).

However, waste management policies appear to still prioritise resource recovery goals for biowaste. Legal loopholes, for example in the Waste Framework Directive, allow member states to incinerate or landfill biowaste if alternatives such as co-digestion in waste utilities it is not feasible from an economic or technological point of view to reduce or recycle (Edwards et. al 2016). In the UK the aim for reduction of biodegradable waste disposed at landfills therefore remains only 35% by 2020. In some countries landfilling is the cheapest disposal option, often because it does not internalise the future costs of pollution prevention, clean up, and loss of finite resources (Iacovidou et al., 2012). The European Commission has acknowledged this deficiency and is in the process of tightening the Waste Hierarchy, most strongly through a complete ban on landfilling of biowaste by 2025 (Edwards et al., 2016). With respect to this gradual phase out, the European Biogas Association (2016) stresses that incineration may become the main disposal option for biowaste as the as the landfilling ban takes effect.

The degree to which biowaste is collected and available varies strongly across EU member states. Many 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). For instance in countries like Croatia municipal waste separation is still poorly established, leading to supply shortages as different sectors compete for scarce resources. In Germany, whose solid waste collection system is sophisticated compared to other EU member states, still 56 % of the population is not connected to an organic waste connection bin and cannot separate organic waste from other waste (UBA, 2009). The scarcity leads to high competition for biowaste, as a consequence of which the feedstock becomes increasingly expensive (Dietrich et al., 2017). In the case of Austria, some forms of biowaste, for example from food and other industries, are widely available and causes no bottleneck to co-digestion. The availability can be further reduced because the regulatory situation in many countries, which is more conducive to using liquid waste. Dry waste needs more steps like sanitation-retreatment and is therefore not used in co-digestion processes, which reduces the available amount of co-substrate. Yet not only the availability can be a problem. Especially municipal biowaste often has a low quality. As a consequence, plastics and other debris can reduce the operational efficiency of co-digestion (Iacovidou et al. 2012).

3.4. Co-Digestion with organic waste causes higher costs

The costs associated with the sludge disposal pose one of the highest cost factors for wastewater utilities. Disposal costs can make up for 15 to 50 % of the total operation costs (Wendland, 2005). At the same time co-digestion produces larger quantities of disposable (co-digested) sludge, which additionally increases the overall costs. For example, special permits that are generally costly are required while existing technologies are often not suitable for co-digestion and need to be replaced or retrofitted, which can involve large capital costs. Costs additionally accrue from storing the organic waste (Dietrich et al., 2017).

The application of sludge on land as fertilizer or soil conditioner is among the most inexpensive strategies, while following the objectives of a circular waste approach (Zsirari, 2011). However, due to concerns about health and environmental hazards, many European countries have increasingly tightened regulations on sludge application in agriculture. In countries like Croatia and Germany prohibitions to apply sludge in agriculture during certain times and growing health concerns have led to a complete ban of sludge application in agriculture. In Austria, for example, where co-digested sludge cannot be applied, it has to be incinerated.

When applying organic material to the digesters, additional regulations such as the EU Animal By-products Regulation (EC 1774/2002) may have to be considered. This in turn may require to install additional process units, like those for pasteurization (Zsirari, 2011). The affordability of these extensions strongly depends on the balance of required investments and later operational costs and the revenue due to increased energy outputs. An enhanced production of co-digestate is therefore particularly becoming a challenge where application in agriculture is strictly regulated or prohibited and incentives for alternative sludge disposal applications are low. In the Czech Republic for instance, where sludge application in agriculture is still allowed, adding bio-waste as an input substrate poses the possibility of having 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 by different technologies with a very limited use in agriculture.

3.5. National support schemes are insufficient, unreliable and gradually reduced

The implementation of waste-to-energy solutions entails high initial investment costs, which increase if co-digestion is additionally introduced as aforementioned. Whether these can be offset eventually through higher energy yields and cost savings gained through self-supply or sales to the grid needs to be determined through cost-benefit analysis.

Given these high additional costs utility operators generally depend on subsidies. In some of the pilot countries subsidies are non-existent, insufficient, and, if available, only guaranteed over short periods. This applies to the general financial support for renewable energies. The situation becomes yet more challenging when it comes to more specific technologies that play a key role in the portfolio to optimise the energy performance of waste utilities (Voigt et al., 2010). For example subsidies for heat capture, biogas upgrading and or Power-to-Gas systems is rare. A biomethane subsidy scheme as implemented in Italy poses an exception in the EU; in countries like Germany and Czech Republic, a subsidy scheme for biomethane is missing. As a consequence, in Austria or Italy utility operators producing biomethane can barely compete with "Russian" natural gas prices. This makes it difficult for utility operators to obtain a positive business case when wanting to venture in waste-to-energy solutions.

Even if a subsidy scheme specifically tailored for promoting such technologies may be in place, there are many cases where certain provisions or definitional issues cause problems. In the UK, there is a regulatory conflict regarding incentives for biogas produced from co-digestion of sewage sludge and food waste. While these are clearly defined for either of them, they become unclear when the two are co-digested (Iacovidou et al., 2012). In Germany the Erneuerbaren Energie Gesetz (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). 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.

Furthermore, the duration subsidies are provided for, as well as their rates, have volatile . The unpredictability for operators to foresee changes acts as a strong barrier for investments. A study carried out in Germany (Dierich et. al, 2017) found that the complex rules and frequent changes in the subsidy schemes make it difficult for utility operators to predict how the financial situation with respect to grid supply is going to evolve in the future. Their highest concerns are cost increases and the uncertain situation about how regulations about phosphorus recovery in mono-incinerations plants would evolve in the future. Such volatility was also occurred in Croatia, where the application of biogas for electricity generation and co-digestion technologies was mainly encouraged through feed-in tariffs for renewable energies.. The subsidy system was suspended in 2015 which, from an economic point of view, has made it much less attractive to produce biogas and biomethane in WWTPs.

3.6. Revenue streams to become self-sufficient stay locked due to high requirements and non-harmonised trade

To offset high upfront and maintenance costs for waste-to-energy solutions, utilities need to tap into multiple revenue streams. This will also help them to become independent of subsidies in the long term. The main revenues, depending on the local circumstances, include:

- Charging gate fees for recycling organic waste;
- Increasing energy generation through co-digestion with organic waste, biogas upgrading, and power-to-gas;
- Increasing self-supply and selling surplus energy;
- Marketing co-digestate.

Currently the legal and policy framework does not systematically support a systematic exploitation of these revenue possibilities. One fundamental problem is that in many European countries such as Italy and Austria utilities can reinvest revenues earned from wastewater fees only for specific purposes. Often these are limited to treating wastewater, but not for improving energy efficiency or generation of renewable energy.

Utilities can charge gate fees from local authorities for recycling organic waste, which constitutes a considerable revenue stream for utilities. Where organic waste is competed for, utilities need to be able to offer the cheapest gate fees if they want to secure contracts for disposing biowaste. However, often gate fees or levies at landfill sites are low, in part because various external costs are not reflected in the price charged for. As long as a ban on landfilling biowaste is not entirely enforced, regulating gate fees for organic matter in favour of waste utilities using co-digestion is crucial. However competition to offer the lowest price between different recipients of biowaste is not the only challenge. Local authorities typically tender contracts on biowaste treatment of less than five years. This planning insecurity can discourage utilities from adopting co-digestion technologies that usually have long payback times (Edwards et al, 2016).

The most cost-effective strategy for WWTPs is to first supply their own energy demands before feeding into the grid (Edwards et al., 2016). Where providing surplus energy to the grid or district heating network is technically feasible, waste utilities confront various hurdles. The process to do so starts with comprehensive administrative procedures. This is especially a challenge for small and medium-sized energy providers, so are the high costs due to standby charges, licencing fees and regulatory constraints (Sullivan, 2011). Moreover studies have shown that network operators may show resistance for grid extension and act as gatekeepers (Moss and Hüesker, 2016). Utilities in Germany face high fines if the effluent quality is inappropriate. Yet the organic waste introduced to the digestion process adds more nutrients and other substances, making it more difficult to control the quality as these can change from waste load to waste load. In addition requirements for biogas quality are strict and standards differ across EU countries. These conditions impede that biogas from a WWTP is fed into the natural gas grid and traded over country boarders (Kampmann et al., 2016).

Finally the marketization of co-digestate, for example as a compost or fertiliser, serves as another potential revenue stream. The agriculture sector is key here as land owners and farmers ideally pay for the co-digestate sold to them by utilities. However this potential is currently not exploited, in part because a coherent policy approach to establish such a market is lacking (Iacovidou et al. 2012). Co-digestate containing sewage sludge is classified as waste and not as a valuable product. It hence only allows WWTP operators to market the biogas, but not its by-products, undermining additional revenue streams (Kampmann et al., 2016). Enabling utilities to use co-digestate of sewage sludge and bio-waste as soil conditioner or fertiliser (for example in agriculture) is seen as an important measure for the uptake of wastewater-to-energy solutions (Edwards et al., 2016), although it is more complicated in that more processes are involved. 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. Additionally, prices for co-digestate are often below cost recovery. This is in partially because, as pointed out by Edwards et. al (2016), the perceived quality of co-digestate as a fertilizer for agricultural use is generally low. If instead processed into dry pellets and therefore comparable to compost substrate the higher market prices could be achieved. In the UK the co-substrate resulting from co-digestion of sludge and foodwaste faces regulatory gaps. Once being co-digested, sludge regulations no longer apply, leaving the co-digestates between two regulatory regimes. These regulatory gaps hinder to unlock marketing opportunities (ibid).

3.7. Multi-level stakeholder participation is missing and internal capacities are limited

Waste-to-energy solutions, especially those drawing on co-digestion with organic waste, involve a large set of stakeholders from the sectors of wastewater, solid waste, and energy. To successfully establish solutions involving energy optimisation, not only the technical economic and leadership within a wastewater or waste utility, but all staff in a plant need to adopt the new technical approaches and ways of thinking. This does not only require to acquire new technical knowledge. Efforts of persuading utility leadership and staff on the opportunities and benefits often become necessary (Dietrich et al., 2017). At the same, even if a utility is willing to adopt new innovation, local energy suppliers, politicians, and waste operators need to play along. These as well need to be included in stakeholder participation strategies.

Moreover, the water and wastewater sector is generally known for its risk aversion towards innovation (Kiparksy et al., 2013, Ajami et a. 2014). Research emerging within the project showed that whether waste-to-energy systems are implemented is highly dependent on utility operators who share an entrepreneurial mindset and are motivated to invest additional work. A study focusing on co-digestion in WWTPs in the US showed that the leadership was unwilling to adopt co-digestion because they lacked information about its benefits and because they believed it could threaten to realise their core responsibility of treating wastewater (Abold et al., 2014).

Another barrier is presented by the limited internal capacity within utilities. A study by Dierich et al. (2017) identified insufficient experience in utilities as one of the important barriers for wastewater-to-energy solution uptake. This was also a finding emerging from interviews carried out within the project. Especially small municipalities and utilities lack time, financial resources and expertise to engage with and implement new innovations. As a consequence, the staff in WWTPs may be unable to assess the costs and benefits of co-digestion because they find it difficult to gain access to the required information or methods or knowledge about suitable business models. The same study found that they also lack information on how to access organic waste for co-digestion (Abhold et al., 2014).

4. Recommendations for establishing a systematic approach to unlock the energy potentials in solid waste and wastewater treatment plants

Tapping into the energy potential of the wastewater and solid waste sector is imperative for realising Europe's energy transition. However wastewater utilities face *many obstacles to become more energy-efficient and net producers of renewable energy. Analyses within the project REEF 2W showed that typical barriers do not only concern legal aspects (fragmented policies and laws, conflicting and overly restrictive regulations) but also include economic (low subsidies, low prices for fossil energy source) and social issues (need for a multi-sectoral approach, lack of awareness). This policy brief provides recommendations for decision-makers at both EU and national levels to overcome these barriers. It highlights the need for policies and legislation to be better integrated across sectors, to better prioritise energy generated from wastewater, to increase targeted financial support while strengthening utilities' economic self-sufficiency.*

A systematic and cross-sectoral legal and institutional approach

Energy-related concerns and goals are almost non-existent in the EU's legal and policy framework of the solid waste and wastewater sector. Key sectoral laws such as the Water Framework Directive make no provisions for water or wastewater utilities to increase energy efficiency or renewable energy generation. Simultaneously energy directives do not formulate specific $CO2$ emission targets for the wastewater sector. To scale solutions developed in REEF 2W, however, requires a legal framework that anchors water-energy linkages in all concerned sectoral laws and policies. On the long-term policies and laws need to provide targeted support for the whole range of wastewater-to-energy solutions, from waste heat capture in sewers over improving energy outputs through co-digestion to biogas upgrading and power-to-gas. Following the Energy Efficiency First Principle, wastewater utilities must maximise energy efficiency before starting to generate renewable energy. At national level establishing a coordinating agency that raises awareness across government levels and institutions and provides knowledge and capacity building (e.g. on how to conduct energy audits) is critical.

Prioritisation of biogas produced from waste feedstocks in energy law and policies

A requirement for elevating biogas production in wastewater treatment plants remains vastly absent in EU and national energy legislation. EU countries are free to opt through which forms of renewable energy they meet decarbonisation targets. This flexibility has given rise to divergent developments of national biogas markets (See figure 1), in which energy crops dominate as a feedstock. Emerging evidence about their adverse environmental effects has led the EU to introduce legislative measures that cap the production of energy crops. Yet governments and environmental agencies have placed only low priority on promoting biogas produced from wastewater in a targeted way. Sustainable feedstocks should receive more support to scale their market shares. Extending sustainability criteria beyond biofuels in the transport sector, in addition to harmonizing them across member states, is a central element in doing so. The uptake of wastewater-to-energy solutions will further profit from specific renewable energy targets for sustainable feedstocks like wastewater and for biomethane production.

An increasing availability of biowaste stimulates co-digestion in WWTPs as a preferred economically attractive disposal pathway

A strict regulatory waste regime incentivises utilities to adopt co-digestion technology that use organic waste. Utilities can charge gate fees for organic waste they accept from municipalities while enhancing energy performance through a more productive feedstock mix, both of which improves their business case. Studies show that an increased production of biowaste as a result of a ban on landfilling and policies requiring solid waste separation has encouraged projects using co-digestion with biowaste. However, in EU countries like Croatia waste separation is still poorly established, leading to supply shortages as different sectors compete for scarce resources. To further unlock biowaste feedstock from residential, commercial and industrial streams, it is necessary to enforce the municipal separate collection of solid waste while phasing out the option to landfill biowaste (e.g. through complete bans, diversion targets, or taxing of landfilled wastes). Gate fees reflecting the external costs for landfilling and other less preferred disposal options need to be raised and introduced where yet non-existent. This will be crucial to make gate fees charged by waste utilities using co-digestion more competitive and helps them to secure a reliable biowaste feedstock.

Providing appropriate subsidies through national support schemes

Waste-to-energy solutions have high upfront costs, which increase if co-digestion is introduced additionally (e.g. for special permits). Utility operators therefore depend on subsidies (or potential CO_2 taxes) to be more competitive given that prices for fossil energy are rather moderate. In many EU countries subsidies for renewable energies are non-existent, insufficient and, usually guaranteed over short periods while market energy prices have remained too low. For example, in some countries utility operators producing biomethane can barely compete with “Russian” natural gas prices. This undermines the economic viability of wastewater-to-energy solutions and discourages new investments into them. National governments and energy agencies therefore need to increase support schemes for renewables and introduce specific support for biogas produced from wastewater. Germany, for example, established bonuses of up to €0.13/kWh of electricity on top of the Feed-in Tariffs to promote demand for certain feedstocks. National support schemes, however, should not only promote “green electricity” production, but the full spectrum waste-to-energy solutions (including heat capture, biogas upgrading, sale-to-grid, and power-to-gas). And the rates and duration of subsidies must be predictable, transparent, and relatively stable to motivate investments. Additionally grants and loans become necessary to mitigate high financial risks due to long payback periods.

Unlocking multiple revenue streams to achieve self-sufficiency

For waste-to-energy solutions to be economically viable utilities need to tap into multiple revenue streams. Converting biogas into electricity and heat in Combined Heat and Power systems or upgrading it to biomethane for sale to the grid, charging gate fees for processing organic waste, selling co-digestate as bio-fertiliser or soil conditioner, or using power-to-gas are all options to minimize payback time and attract investments. To overcome the wide range of barriers ranging from poor grid accessibility for small energy provider to restrictive quality standards biomethane, a holistic regulatory approach is needed. Given the increasing amounts of sludge resulting from co-digestion, it is especially urgent to develop a coherent strategy for the disposal (and ideally) marketization of co-digestate (e.g. including quality criteria).

Increase cross sectoral awareness and establish a national platform for promoting energetic use of wastewater

Today, the energetic use of wastewater outside the premises of a wastewater utility is still not widespread. Wastewater-based external energy supply involves multiple stakeholders or stakeholder groups which implies more complex planning approaches compared to a sole internal use in the wastewater infrastructure. Furthermore, the awareness and the knowledge concerning energy generation from wastewater differs widely between the different stakeholders. To deal with these challenges, in other countries a central agency like a non-profit organization, functioning as a knowledge broker and support provider has been proven beneficial. It would coordinate educational and financial interventions regarding energy optimisation of waste utilities across different governmental levels and institutions, but also to integrate policies. Further effective measures emerging from other studies also included a "buddy system" which matches experienced utilities with technologies with those being interested to adopt new innovations. This provides for exchange about the short-term and long-term benefits and costs of investing in the process or permitting and regulatory requirements and advice on how to overcome these challenges.

Recommendations

Wastewater-to-energy solutions, specifically when including co-digestion with organic waste, touch upon policies and legislation of the water, energy and solid waste sector. To scale them up and unleash their potential for enhancing energy security and grid flexibilisation, mitigating climate change and improving municipal budgets, the future legal and policy framework at both EU and national level should:

- Establish cross-sectoral policies and legislation that integrate critical interlinkages between the energy, water and solid waste systems innate to wastewater-to-energy solutions so as to maximise their synergies and avoid overlaps and conflicts;

- Recognize the superior environmental performance of bioenergy produced from solid waste and wastewater compared to forms using unsustainable feedstocks and prop up targeted support through legal and regulatory instruments;
- Foster a waste regime that drives up the production of organic waste and consequently stimulates co-digestion in wastewater treatment plants as an economically attractive disposal pathway;
- Set up National Support Schemes that offer sufficient, predictable and long-term subsidies for renewables and specifically promote electricity, gas and heat produced from wastewater;
- Enable utilities to exploit multiple revenue streams around treating wastewater to improve their business case and become independent of subsidies in the long-term with a focus of developing a profitable way of disposing co-digestate;
- Increase multi-sectoral information transfer, education as well as targeted knowledge building and establish a national platform in charge of promoting energetic use of wastewater beyond the premises of wastewater utilities.

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