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Waste-to-Energy in the Danube Strategy Region: Challenges and Prospects

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Executive Summary & Recommendations

Policy & technology background

This report presents the current state and main challenges for the development of the waste-to-energy (WtE) industry in the countries of the Danube Strategy Region (DSR). In general, waste-to-energy systems constitute a broad range of technologies for converting various types of waste either directly into electricity and/or heat or into a fuel for subsequent use. These technologies, furthermore, are dependent on complementary systems and services, in particular waste management. WtE is thus a complex topic overlapping with other prominent issues within the broader European context, such as renewable energy, sustainability, resource security, and the circular economy.

At present, **initiatives and legislation at the EU level** appear to be key drivers for developments in the waste management sector. This is true for both EU member states and non-member states of the DSR, given such initiatives as the Energy Community and the European Neighbourhood Policy as well as the very nature of the EU Strategy for the Danube Region. One aim of these initiatives is to bring national policy and practice in line with EU legislation, while at the same time recognizing national and regional particularities.

In the context of waste management and waste to energy, **Directive 2008/98/EC on Waste (the Waste Framework Directive [WFD])**, which stipulates proper waste management and disposal practices, is a critical piece of legislation. Its most recent iteration also establishes the so-called *waste hierarchy*. This hierarchy is part of a broader move at the EU level to push towards a *circular economy* in which resources are kept within the economy for as long as possible. The relevance of the hierarchy for WtE is that such treatment of waste is now considered a viable option only where the given waste cannot be first prevented, reused or recycled.

As is evident, the issue of waste in a European context concerns not only energy but also the environment and the economy. Thus, **WtE plays a potential role in several critical areas of EU policy**. In its Energy Union Package, the Commission notes the need to create synergies between energy efficiency, resource efficiency, and the circular economy. WtE can play a role in all three areas. Moreover, given that some waste streams may be regarded as renewable sources (in particular, biomass and biofuels derived from biodegradable wastes), WtE is also relevant for the energy transition. WtE can thus serve to reduce emissions in the heating/cooling sector, facilitate market entry for RES, and increase the use of RES in transport, all areas earmarked by the European Commission. [See chapter 1.1]

The same can be said for the DSR, for which WtE may perhaps be even more important. As part of this initiative, member countries cooperate on 4 key pillar issues encompassing 12 priority areas. Of relevance to the topic of WtE, the DSR countries cooperate on initiatives relating to **sustainable energy and environmental protection**. The region is generally characterized by relatively high energy prices and reliance on imports. Thus, **energy security** is of particular relevance to the region, especially in terms of supply and affordability. On the other hand, the region boasts significant potential for domestic alternative sources of energy, such as waste and biomass. Both sources can help these countries to address supply security issues while also helping them to meet renewable energy and efficiency targets. Thus the significance of WtE within the DSR region is evident. [See chapter 1.2]

As regards **waste management and WtE technologies**, a few key issues are worth mentioning from the outset. First, not all wastes are created equal. Some forms of waste are more suitable for generating energy than others; some not at all. Moreover, those waste streams that may be used to generate energy may be more appropriate for a certain WtE technology. Wastes may also be characterized by their point of origin and method of collection. Many studies on waste to energy and waste management focus on *municipal solid waste (MSW)*, which may encompass many types of waste. MSW is also of critical importance within the EU policy framework on waste due to its complexity and the fact that waste management practices are often focused on this particular waste stream.

As regards WtE technologies, they can be categorized according to the physiochemical process of converting the given waste into energy. Three broad categories can thus be identified: thermal, biological and sanitary landfilling. The first two may be further subdivided, and all categories have their respective technological features and specifications. The two most prevalent means of converting waste to energy in use at present are **incineration and anaerobic digestion**

(AD). The former is a means of thermal treatment whereby waste is burned as a fuel in order to generate electricity and/or heat. The latter is a biological treatment method used especially with biodegradable waste fractions in order to produce biogas. This gas can then be used in various energy applications. Other WtE technologies are less common due to weaker commercial viability at scale (e.g. pyrolysis and gasification) or unfavourable environmental characteristics (e.g. sanitary landfilling). Finally, it is important to note that WtE technologies are categorized differently under the WFD. AD and incineration, for example, are regarded as recycling and energy recovery processes, respectively, and thus occupy different positions on the waste hierarchy. [See chapter 1.3]

Waste to energy is a topic that touches on several critical areas within the broader EU policy context. Use of such technologies can play a role in waste management, energy transition, energy security and the circular economy. Indeed, the future development of WtE will depend on developments in those key areas and will need to take into consideration the inherent synergies. In this context, the apparent shift at the EU level towards a circular economy will likely have a significant impact on the future of the two most common forms of WtE, incineration and AD, as waste is shifter higher up the hierarchy.

Drivers & barriers to WtE development

Despite its apparent advantages, WtE technology is not widespread throughout the DSR. What then explains the shortcomings in the broader dissemination of WtE technologies in the states of the Danube region? Several key barriers restrain the development and dissemination of WtE technologies in the region, falling broadly into the following categories: political/legislative, economic, infrastructural, technical/environmental and social barriers.

The WtE sector is part of mainly two jurisdictions—**waste and energy policies**. Furthermore, relevant policies in these areas can be found at supranational, national and local levels. At the **supranational level**, the European Union is setting new rules in order to become a front-runner in waste management and recycling. Although WtE technologies are part of this concept, the EU has decided that for now it will focus (both politically and financially) on achieving greater recycling rates and preventing WtE overcapacities, with specific targets for reducing landfilling and increasing recycling. Depending on the technology and its efficiency, WtE may be considered a recycling, recovery or disposal operation. EU legislation may therefore favour certain WtE technologies over others, and the binding targets can make a significant difference in waste management practices for the majority of DSR countries.

At the **national level**, WtE is typically not directly addressed in the law but rather subject to a wider range of legislative acts. For EU member states, transposition of EU waste policies into national law is of course expected. Nevertheless, some states suffer from a lack of implementation. As a result, several sectoral targets have not been met in these states. For non-EU members, efforts to bring national legislation in line with the EU waste acquis are also present, but less pressing. One of the key areas in this regard is landfilling regulation, which varies considerably across the region. On the one hand, countries like Germany and Austria evidence the positive impact that extensive landfill bans and/or high landfill taxes can have on reducing landfilling and thereby driving waste higher up the hierarchy, including to energy recovery processes. Countries such as Bosnia & Herzegovina and Serbia, on the other hand, have drastically high levels of landfilling and negligible or non-existent levels of energy recovery and recycling, presumably due to a lack of effective legislation.

Local politics can also play a role. Local politicians are often uninterested in discussing the waste management topic because implementing advanced WtE technologies results in an increase in waste management fees for citizens, and thus the cost of improving waste management systems, especially for populations with lower incomes, is a significant barrier. Insufficient legislative support and lack of political will thus create an unpredictable market environment, which is not very attractive for investors. [See chapters 1.1 & 2.1]

As regards **economic challenges**, WtE are capital-intensive projects requiring supporting economic instruments for their faster dissemination. Such instruments include direct tools, such as subsidies, grants and loan guarantees, as well as indirect measures, such as high landfill taxes. Implementation of such measures improves the competitiveness of WtE technologies and can help to address other crucial economic issues. Nevertheless, the risk of stranded assets must be taken seriously and therefore proper evaluation of the economic viability of any given WtE project is crucial. Additional factors to be taken into consideration include cost structure, ownership model, and expected return on investment as well as how these issues may overlap. Furthermore, WtE projects are also costly during the phase of operation, and thus any WtE plant should run as continuously as possible for both economic and technical reasons. For this purpose, careful consideration of the local waste landscape (i.e. existing waste management system, composition and availability of waste) is also important. [See chapter 2.2]

The primary **infrastructural challenges** facing WtE projects stem from their two main outputs: heat and electricity. Within this context, WtE projects may face problems such as insufficient interconnection with the electricity grid or other associated infrastructure or occurrence of technical and capacity problems within the site. For plants generating heat, facilities should be located in close proximity to consumers in order to avoid relative heat loss caused by long transmission. Siting near larger municipalities and interconnection with district heating systems can be especially beneficial. Access to infrastructure in comparison to other producers of heat or electricity is also of relevance, and relative access mainly depends on the ownership of the competing plants and the authority deciding about access issues. Furthermore, access to the site itself may also be critical with regard to waste delivery, and thus adequate rail and/or road infrastructure must be considered. A plant's siting process must therefore navigate between optimal location in terms of the waste supply chain and optimal location in terms of interconnection to the electricity/heating grid. Close cooperation with existing infrastructure (local thermal plants, coal-burning plants) can also generate innovative technical solutions. Existing infrastructure, however, is considerably influenced by past choices concerning energy and waste management needs. Similar to the political and legislative landscape, infrastructure can thus be affected by lock-in and path dependency. The state of existing infrastructure can also have economic impacts on WtE projects given the high capital costs discussed above. Any WtE project should therefore give careful consideration to this issue. [See chapter 2.3]

Technical and environmental challenges are understood to include the difficulty of choosing cost-effective technologies suitable for local conditions and potential negative environmental impacts. The primary technical challenge concerns the composition of the waste itself, while the main environmental impact regards associated emissions. The composition of waste may vary from year to year and region to region, and WtE technology needs to adjust accordingly. For WtE facilities, the primary concern is the calorific value of the waste stream being used. Too low or too high a calorific value can have negative technical impacts on a facility, while specific types of waste may also cause physiochemical damage, thus impacting operating costs. The local waste management system plays a role, as separate collection and recycling can impact waste's calorific value. Careful consideration of the available waste stream is therefore critical for any WtE project.

As regards emissions, greenhouse gases (GHGs) and dioxins are the primary concerns for WtE facilities. In a sense, however, this too is rather a technical issue as WtE is regarded as a more environmentally friendly alternative to landfilling, facilitating the reduction of GHG emissions from landfills, and in some cases may even be regarded as a renewable source of energy (in the case of organic and biodegradable waste fractions). Furthermore, due to advances in the technology and strict emissions limits WtE is no longer considered a significant source of dioxin emissions. The key challenge in this regard, therefore, is to use the technology as efficiently as possible and ensure adherence to existing standards and best practices accompanied with rigorous emissions monitoring. [See chapter 2.4]

In addition to the challenges presented above, the development of WtE facilities is also highly dependent on public acceptance of proposed projects in a particular locality. More specifically, three dimensions of social acceptance can be distinguished: **socio-political, community and market acceptance**. Socio-political acceptance is related mainly to the embracing of technologies and policies by the public, key stakeholders and policymakers. The second dimension, community acceptance, is based on procedural justice, distributive justice and trust. In that regard, the participation of local communities in decision-making processes is crucial; otherwise, protests may become a factor. From the market point of view, the key problem is market adoption and the diffusion of innovation, reflecting acceptance by investors, companies and consumers. Social acceptance/rejection of WtE technologies is the rational outcome of psychological, social and economic factors. These can be addressed through careful management within all phases of a project. Every project is more or less endangered by all three dimensions of social rejection, but the key issue for authorities is to learn how to work with social aspects in favour of the given project. [See chapter 2.5]

WtE technologies face a number of challenges, and every new project needs to overcome each of them. These challenges fall into five categories: political, economic, technical and environmental, infrastructural, and social. Addressing each of them separately, however, is not optimal, as there is much overlap between them. Political challenges also impact economic challenges, as evidenced by the issue of landfill bans and taxes. Infrastructural, technical and environmental challenges are all closely interconnected and also influence a given WtE project's economics. Finally, the social acceptance issue has strong linkages to all other challenges. All these issues thus have overlapping implications, and successful implementation of any WtE project therefore necessitates a holistic strategy for dealing with them. No one-size-fits-all strategy exists. Careful consideration of local, national and even supranational conditions impacting all the aforementioned areas is crucial. [See chapter 2.6]

WtE & waste management in the DSR

Waste management practices vary significantly across Europe. The countries of the DSR are no different, and indeed represent the full spectrum of practices at the broader European level. Nevertheless, the push towards a circular economy will have a considerable impact on such practices across Europe. The targets for landfilling and recycling proposed in the WFD and Circular Economy Package are especially important in this regard. By 2035, landfilling should account for no more than 10% of MSW treatment while 65% of MSW should be recycled, thus leaving at least 25% for energy recovery.

Based on current **waste management practices** and the established **circular economy targets**, the potential for WtE development in the DSR appears significant. The region is generally characterized by high levels of landfilling and underdeveloped recycling and energy recovery, with some exceptions. Most countries in the DSR are thus a rather long way from achieving the circular economy goals. Those countries in the region (and indeed across Europe) with more developed waste management systems indicate that with proper legislation in place even lower levels of landfilling than 10% are possible and recycling and recovery are complementary treatment methods.

Looking at current waste management practices and WtE capacities, **estimated gaps in WtE capacities** were calculated for the DSR countries. Based on these estimates, the majority seem to have significant gaps in WtE capacities to make use of the 25% of MSW (at least) that should be available for energy recovery in 2035. This target may even be regarded as rather conservative given the assumptions that underpin the recycling and landfilling targets. As mentioned, those countries with more advanced waste management systems in place show that even lower landfilling levels are achievable. Moreover, the 65% recycling target is based on separately collected waste, not all of which is ultimately recyclable. Thus even more than 25% of MSW would realistically be available for energy recovery purposes. Finally, it is worth mentioning that additional capacities may also be necessary for handling commercial and industrial wastes, which are not taken into consideration in this calculation. [See chapters 3.1]

Implementation of WtE processes of course necessitates the **availability of the required feedstock**. In calculating the estimated gaps in WtE capacities in the DSR countries, it was assumed that waste generation would remain stable through 2035. To test the validity of this assumption, basic data regarding waste generation were analysed in order to get a better picture of developments in the DSR countries in this area. Looking at the *absolute values of MSW generated* in individual countries over a 10-year period from 2007 to 2016, a generally flat and stable trend was apparent in most countries, with some countries even showing declines. *Waste intensity*, which measures the amount of waste generated per unit of GDP, indicated an overall downward trend for most DSR countries, suggesting a decoupling of economic growth and waste generation. Again, there were exceptions, with certain countries showing slightly increasing waste intensity. Overall it would seem that the assumption of stable MSW generation made in the capacity gap calculation in the previous section may be rather realistic. [See chapter 3.2]

Given that WtE is often discussed as an **alternative fuel source** enabling reduction of GHG emissions, and in some cases may even be regarded as a renewable source of energy, we also looked at relevant energy statistics. The countries of the DSR region generally perform rather well in terms of renewables development as measured against their respective 2020 targets. Overall, the case for WtE as an alternative fuel appears most promising in the heating/cooling and transport sectors. To some extent, WtE can help to achieve renewables targets but the greatest overall benefit is the potential combined reduction in GHG emissions by replacing landfilling in the waste management sector and fossil fuels in the respective energy sectors. [See chapter 3.3]

The overall drive for WtE development would appear to stem from its crucial role in the waste management sector. In particular, further development of WtE would seem to be a crucial measure towards achieving the targets of the circular economy. Additional advantages are also evident in the energy sector. While the potential for WtE to contribute to electricity generation appears more limited, it seems to have more significant potential in heating/cooling and transportation. Regardless of the particular sector, WtE as an alternative fuel source can yield benefits in terms of increased use of RES, reduced GHG emissions, improved energy efficiency and even energy security. Overall, greater development of WtE thus appears advisable throughout the DSR, offering several important benefits.

Zwentendorf WtE plant

In order to shed further light on the presented challenges and how they might be addressed, this report presents an *inductive case study* of a highly regarded WtE facility. The **EVN Abfallverwertung NÖ in Zwentendorf, Austria** is considered to be the most advanced operating thermal waste utilization plant in Europe. Thus, it can provide us with important insights into the tools, incentives and legislative setting which precede best possible outcomes. [See chapter 4]

As challenges occur during all phases of a WtE project, looking into a specific case can reveal some general patterns of **best practices** that could be relevant beyond the individual case. While examining the Zwentendorf case, several steps were tracked to uncover the best practises ensuring successful completion of the project leading to the facility's current operations. [See chapter 4.7]

Firstly, **national waste management policy** in Austria was created after years of discussion and taking into consideration best practices in Switzerland and Germany. Key pieces of legislation were gradually introduced with long enough timeframes for both citizens and industries to adapt. Support for these efforts came not only from law but also through several economic tools such as subsidies, insurance of investments, and the establishment of higher landfill taxes. These tools created an environment where investment in WtE was stable and appealing. [See chapters 4.2 & 4.3]

The local government of Lower Austria, where the facility is located, also played an important role in fulfilling new national waste management goals. To improve waste management in the region, the decision to build a WtE plant was made very early in 1994 under the **public–private partnership company** EVN Abfallverwertung NÖ. The initiative was then driven by both the private company and the regional government with the aim to improve waste management for local citizens. Thanks to the synergy of political will and the company's knowhow, the plant was finished in 18 months upon receiving all necessary approvals. [See chapters 4.2 & 4.3]

Secondly, the operation of the plant is highly efficient due to the idea of **energetic interplay**, wherein the WtE plant is interconnected to an adjacent power plant thereby reducing the burning of fossil fuels and decreasing emissions. The plant is also connected to the local district heating systems in St. Pölten and Zwentendorf and to a nearby bioethanol plant. Furthermore, Zwentendorf's **continual operation** is guaranteed by the delivery of waste by both rail and truck both domestically and internationally. The rail connection in particular allows the plant to import waste from long distances and thereby benefit from waste management imbalances in neighbouring countries such as Italy. Such synergies should certainly be considered when developing any new WtE project. [See chapters 4.1, 4.4 & 4.5]

Thirdly, Zwentendorf achieved unusually **high public support levels** in a referendum held prior to facility construction. Despite the generally recognized complexity of gaining social acceptance, convincing the local citizens in Zwentendorf appears not to have been problematic. Several measures seem to have been key. First, national waste management policies and the necessary steps for implementation, such as the building of WtE plants, were explained to citizens through open dialogue. Furthermore, possible conflicts were settled through compromises, such as in the case of road transport limits. Finally, the potential positive impact on the region and local communities was promoted and ultimately achieved by hiring and training mostly locals, who also then act as spokespeople for the plant within the broader community. [See chapter 4.6]

Recommendations

Taking all of the above into consideration, some general recommendations may be made. These recommendations generally apply at a governmental level or on a project basis, though there is of course some overlap. The following recommendations thus reflect legislative developments at the EU level, the current landscape of waste management and WtE in DSR countries, and the identified best practices from the case study of the Zwentendorf WtE facility in Austria.

As mentioned above, developments at the EU level are focused on shifting waste management practices towards a circular economy model. One of the guiding principles of this effort is the so-called waste hierarchy, which sets out the priorities for waste management starting with waste prevention and continuing down the ladder to reuse, recycling, recovery and disposal. These initiatives have obvious implications for WtE, which generally falls into one of the bottom three categories depending on the respective technology. For example, the two most commonly employed technologies, AD and incineration, are regarded as recycling and recovery processes, respectively. Thus, from a circular economy perspective, AD would appear to be the preferred method of WtE. Nevertheless, as the European Commission points out in its report on the future role of WtE, individual countries have a degree of flexibility in how they apply the waste hierarchy provided the best possible environmental benefits are achieved.

Similar to the recommendations made therein, based on the country-level analysis conducted in this report, some general national-level considerations may be suggested. Firstly, for those countries with low WtE capacity and high levels of landfilling, the first priority would be to improve waste management systems generally, focusing on separate collection and higher recycling rates. To support such waste management transition, national governments should in particular look at the best practices of other countries, including the use of landfill bans and taxes. For those countries already having relatively developed WtE industries, the main risk posed by the circular economy is that of stranded assets. For such cases, the European Commission is pushing strongly to introduce incineration taxes, reduce support schemes, and even establish a moratorium on construction. Nevertheless, it is likely that additional capacities will be needed in future, albeit at lower relative levels. Potential energetic synergies with existing facilities and industries may be more practical in such cases. The key for all countries will be careful consideration of the practicality and feasibility of new WtE facilities across their life cycles.

While the EU previously supported the development of new waste incineration plants, more recent waste policies have adopted a more holistic approach to waste management based on the duel concepts of circular economy and waste hierarchy. Nevertheless, WtE continues to be a legitimate and crucial element of waste management practice and regions with underdeveloped WtE capacities have the option to develop these facilities as needed. As discussed above, meeting the established landfilling and recycling targets would still leave at least 25% of MSW available for energy recovery purposes. Indeed, WtE capacity gaps appear evident in many DSR countries.

In evaluating the future potential for WtE development, the individual DSR countries should adopt a long-term, holistic perspective. Factors such as planned waste prevention, improved recycling, sorting of biodegradable waste, and improvements in the recyclability of various high-calorific waste streams can have important impacts for the WtE sector. Newly built incineration plants planned without taking these factors into account face the risk of being underused or abandoned. On the other hand, waste management practise in most DSR countries is characterized by significant landfilling and lower levels of recycling. The shift away from landfilling presents opportunities for both recycling and WtE. Indeed, those states with more developed waste management systems indicate that the two are complementary.

Ultimately each country should conduct a careful assessment of its waste management practices using the most current and precise data available while also taking into account planned developments in MSW management practices, including already planned prevention schemes and additional recycling and recovery capacities. Such assessment will serve to identify the potential gap in capacity toward the 2035 targets. Forecasted developments in waste generation and waste intensity could also be taken into account in order to assess the long-term availability of the required feedstock. Before building new plants, the feasibility of improving the efficiency of D10 incineration facilities as well as possible synergies with existing co-incineration capacities (e.g. combustion plants, cement and lime kilns, other suitable industrial processes) should also be considered. With this information each individual country can then make a more informed decision regarding the potentially required capacities for individual waste management operations, including energy recovery.

If after such assessment, new WtE projects are indeed deemed appropriate, it is then crucial to carefully consider the possible longevity of any WtE project. Such issues as supporting legislation and economic incentives; the composition, characteristics and availability of the respective waste streams; desired energy output; implementation of the best available and most energy-efficient WtE technology; potential synergies with other industries and existing infrastructure; and the plant's size and location must all be assessed in order to achieve the best possible solution. In this context, the Zwentendorf case study offers valuable insights into dealing with these and other potential challenges that any WtE project may face. While the plant certainly benefited from a favourable legislative landscape, what was also crucial in this aspect was the carefully planned implementation which allowed for communities and industry to adapt. Management and ownership through a public–private partnership allowed for the combination of private industry knowhow with public support, both financially and legislatively. The plant's unique system of energetic interplay with neighbouring industries makes it possible to benefit from existing infrastructure while also achieving high levels of efficiency as well as positive environmental impacts through reduced emissions. All of these factors also contributed to the high level of public acceptance, though equally important was the transparent involvement of the local community throughout the process.

The changing landscape for waste management and waste to energy is certain to have long-term implications for their future development. As countries shift their waste management systems up the waste hierarchy, all WtE technologies are bound to be impacted, some positively and some negatively. Nevertheless, WtE development will certainly constitute a critical element in the transition to a circular economy. What will be crucial is for individual countries to carefully consider these potential impacts and to plan the development of their waste management systems accordingly while also promoting transnational cooperation in this area through the sharing of experience and best practices. The DSR has a unique capacity to do so as part of its Sustainable Energy Priority Area.

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Waste-to-Energy in the Danube Strategy Region: Challenges and Prospects

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This study presents the current state and main challenges for the development of the waste-to-energy (WtE) industry in the countries of the Danube Strategy Region (DSR). Waste-to-energy systems constitute a broad range of technologies for converting various types of waste either directly into electricity or heat or into a fuel for subsequent use. These technologies, furthermore, are dependent on complementary systems and services, in particular waste management. WtE is thus a complex topic overlapping with other prominent issues, such as sustainability, resource security, and the circular economy. The study provides a general overview of WtE technologies and associated systems, presents a cursory look at relevant EU legislation and statistics, details the main challenges facing the development of WtE projects, outlines the situation in the DSR countries, and, finally, presents a case study of a selected successful project.

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