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# Overview of the waste-to-energy sector in Latvia: driving forces for a cluster creation

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**Abstract.** Waste to energy (WTE) sector includes collecting and pre-treatment of various types of organic and recyclable waste that is used as feedstock for conversion technologies generating valuable outputs (i.e. power, heat, biomethane, syngas etc.). Consequentially, the WTE value chain includes stakeholders from waste management and energy production markets.
The development of Latvian WTE is governed by advancements and availability of technology and innovation, the national legislation and binding regulations, and cooperation between the involved stakeholders. To promote more efficient waste management techniques, increase the use of alternative energy sources and improve cooperation between different target groups within the WTE sector (i.e. policy makers, investors and researchers) the establishment of a WTE cluster in Latvia is proposed. The initial information about the state-of-the-art of the WTE sector in Latvia is vital for development of such cluster.
The aim of this paper is to characterize the WTE sector in Latvia and analyse its driving forces (technology push versus demand pull) in order to determine a strategy for WTE cluster development. To reach this objective an analytical framework based on the technology push and demand pull methodological approach is applied. To reach the aim of this study, an inventory of WTE related stakeholders in Latvia is developed and the push and pull factors driving the development of WTE field are defined. Various factors and their interactions are analysed to determine which are the most influential for Latvian WTE sector development, finally we provide our conclusions and discussion.

**Key words:** waste to energy (WTE), push factors, pull factors, industrial clusters.

## INTRODUCTION

Waste-to-energy (WTE) is an interdisciplinary sector; it includes collecting and pre-treatment of various types of organic and recyclable waste that is used as feedstock for conversion technologies generating valuable outputs (i.e. power, heat, biomethane, syngas etc.). Energy can be recovered from various types of waste, e.g. municipal solid waste (MSW), industrial and agricultural biomass waste etc. For each type of waste different energy recovery technologies are available. Energy recovery from solid waste is typically performed using incineration, pyrolysis, gasification or co-incineration technologies. After reviewing previous comparisons of WTE technologies Rentizelas et al. (2014) conclude that incineration is currently most dominant type of thermal treatment. On the other hand Münster & Lund (2010) stress the opportunity to produce transport fuels from waste for which case thermal gasification or anaerobic digestion

technologies are more appropriate. Anaerobic digestion, e.g. in biogas reactors or landfill gas recovery, is another widespread waste to energy transformation strategy. Anaerobic digestion in comparison with thermal treatment enables the processing waste with high water content (Appels et al. 2011).

Given the diversity of the input wastes and the desirable outputs the development of WTE sector is also strongly related to the development of new technologies and market innovations. Currently research on the new WTE technologies is widespread: Münster & Meibom (2011) have evaluated the feasibility of different WTE technologies, Di Gregorio & Zaccariello (2012) proposed an effective WTE system configuration for fluidized bed gasification. Research on gasification of packaging scrap in fluidized bed reactor (Di Gregorio & Zaccariello, 2012) reveals that environmental load reduction can be achieved by cleaning syngas prior to combustion. Rentizelas et al. (2014) suggest that developing countries could benefit from implementing alternative MSW management technologies that have already been approbated in developed countries. On the other hand, direct technology transfer is typically unfeasible for countries where total amounts of generated waste are lower and the capacity of these technologies is too high to be used without adjustments.

WTE is both a waste management strategy and a means of energy production. Therefore WTE sector is governed by the policy and regulations of both waste management and energy production sectors. Waste management is regulated by requirements on waste collection, storage, treatment and disposal operations. The energy production sector is regulated by requirements on allowed technologies, production safety, allowed emission limits, feed-in quotas etc. This dualism complicates the constitutional and organisational subjection of WTE sector. The development of the WTE sector is therefore dependent on government's ability to coordinate the management of these spheres in order to provide the nurturing and interrelated framework for WTE related fields.

Overall, the development WTE sector is driven by various aspects, most important being amounts and types of generated waste that needs to be managed, availability of appropriate technologies, capacities and innovation, the regulation framework for waste handling and energy production. Given the broad extension of involved operations, the development of this sector is strongly affected by cooperation and communication possibilities between various actors along the WTE value chain.

Regarding the business perspectives and market analysis there are two different approaches that typically are used to characterize the dual drivers of economic and innovation development: technology push and demand pull (Di Stefano et al., 2012, Peters et al., 2012). Technology push strategy emphasizes that science, e.g., in the form of research and development of new technologies and innovation, stimulates market development, whereas, demand pull strategy is based on the notion that market features, particularly user demand, drives the innovation and market development. (Di Stefano et al., 2012). The discussion over which of the two strategies is predominant has been on-going for decades. Nowadays it has been widely recognized that both these perspectives and, most importantly, their interaction is the driver of innovation.

To characterize WTE sector in Latvia we adopt the two way oriented – technology push and demand pull - research methodology. In specific the aim of this paper is to characterize the waste to energy sector in Latvia and analyse its driving

forces (technology push versus demand pull) in order to determine a strategy for WTE cluster development.

In order to reach this objective the article is organized in following way: in next chapter the applied methodology is described, then the generated initial inventory of WTE related stakeholders in Latvia is described, the push and pull factors driving the development of WTE field in Latvia are defined and the various factors and their interactions are analysed to determine which have the largest influence on WTE sector development in Latvia, finally we provide our conclusions and discussion.

## MATERIALS AND METHODS

Activities in waste-to-energy are typically perceived as cooperation and interaction between waste management and energy sectors. Though both these sectors have been analysed independently, there have been no previous researches in Latvia describing the whole waste-to-energy sector. One way to promote more efficient waste management techniques, increased use of alternative energy sources and cooperation between different target groups within the WTE sector (i.e. policy makers, investors and researchers, technology providers) is to develop a WTE cluster in Latvia. Clusters are cooperation networks between companies in the same or similar industrial field or related to products chain of value. The aim of the cluster development is to improve the skill and knowledge exchange between the cluster participants and to promote innovation and smart specialization. Detailed analysis of WTE sector in Latvia allows identifying the main stakeholders involved in waste related activities and proposing various ways of cooperation between waste-to-energy stakeholders and potential cluster participants.

To establish cluster development strategy, firstly, the WTE stakeholders have to be identified. An inventory of main combustible and fermentable wastes and their treatment was generated to determine the stakeholders in WTE sector in Latvia. Data for 2008–2012 was collected. All stakeholders were grouped into related categories. Waste to energy sector is characterized by different crucial aspects and economic indicators such as: number of involved companies, number of employees, and characteristics of the value chain, as amounts of waste generation and energy recovery from wastes.

To evaluate the influence of ‘technology push’ and ‘demand pull’ further analysis of waste-to-energy sector in Latvia was done. The main driving forces were grouped into push and pull factors (see Table 1). The push factors are mainly identified as those internal trends of the industrial sector development that enhance the WTE sector development. The push factors incorporate information about the actual situation in Latvia and various aspects that facilitate introduction of WTE technologies and innovation that can stimulate the market development. The pull factors represent the national side attractiveness that facilitates the implementation of WTE technology and installations. These groups of factors include national regulations of waste management and energy supply utilities, as well as, public procurement initiatives and novel business model incorporation can facilitate further development of WTE field.

**Table 1.** Considered push and pull factors that influence WTE sector in Latvia

| Push factors | Pull factors |
|---|---|
| Available amounts of waste | Governmental regulations |
| Availability of WTE education | Taxes and subsidies |
| Availability of appropriate technologies | National infrastructure for technology development |
| Availability of capital | Cooperation of research institutions and private business |
| Promotion of entrepreneurship at national level | |

## RESULTS AND DISCUSSION

Statistical data form Central Statistics Bureau of Latvia (2013) was used to identify the structure of waste management sector. Within waste management sector 50% of 166 companies related to management of non-hazardous wastes are providing waste collection services, with a smaller part of companies performing recovery of sorted materials (39%) and waste treatment and disposal (11%) (see Table 2). Regarding economic performance of the waste management industry (including hazardous and non-hazardous waste management) – 61% of total added value in the sector is generated by waste collection, 20% by recovery and 19% by waste disposal. Sequentially, waste recovery and treatment subsector that has high potential of resource and energy recovery is underdeveloped. Only overall data can be provided for energy supply industry (see Table 2). A detailed distribution of energy suppliers by used resources or technology is not available due to structure of statistical database.

**Table 2.** Characterization of WTE related industry branches in 2011

| Industry | Number of companies | Turnover (thsd €) | Value added at factor cost (thsd €) | Number of employees |
|---|---|---|---|---|
| Energy supply | 383 | 2566,455 | 609,121 | 10,667 |
| Production of electricity | 222 | n.d. | n.d. | 1,944 |
| Steam and heat supply | 121 | n.d. | n.d. | 4,191 |
| Waste management | 178 | 204,528 | 56,023 | 3,609 |
| Collection, treatment and disposal and recovery of non-hazardous waste | 166 | n.d. | n.d. | 3,499 |
| Collection of non-hazardous waste | 83 | 71,188 | 32,254 | 2,564 |
| Treatment and disposal of non-hazardous waste | 19 | n.d. | n.d. | 300 |
| Materials recovery | 64 | 102,077 | 11,235 | 635 |

n.d. – no data available

Historical data on waste generation was gathered to analyse WTE development tendencies in Latvia. Table 3 presents data on the amount of generated waste for various European Waste Catalogue waste classification chapters which include wastes that could be used for energy recovery. A reduction tendency can be seen for municipal wastes, whereas the amount of wastes from waste treatment plants has increased in

recent years. This is due to increased sorting and recovery of wastes at treatment plants and management facilities.

**Table 3.** Amounts of generated waste in Latvia from 2008 to 2012

| | Amount of waste, tonnes | | | | |
|---|---|---|---|---|---|
| Waste chapter, description | 2008 | 2009 | 2010 | 2011 | 2012 |
| 02.Wastes from agriculture, forestry | 140,231 | 185,668 | 247,400 | 265,456 | 288,201 |
| 03.Wastes from wood processing, pulp, paper and cardboard | 72,586 | 75,588 | 86,067 | 97,993 | 43,573 |
| 15.Waste packaging (specifically wooden packaging 150103) | 19,141 | 1,437 | 1,060 | 7,785 | 807 |
| 16.Wastes not otherwise specified in the list (specifically end-of-life tires 160103) | 648 | 467 | 837 | 1102 | 484 |
| 17.Construction and demolition wastes (specifically wood 170201)) | 35 | 15 | 24 | 855 | 8417 |
| 19.Wastes from waste management facilities, waste water treatment plants | 60,781 | 58,913 | 111,853 | 163,437 | 327,854 |
| 20.Municipal wastes including separately collected fractions (municipal solid waste) | 260,741 | 189,629 | 179,593 | 229,940 | 171,731 |

A summary of data about amounts of waste treated for energy recovery for period from 2008 to 2012 is given in Table 4.

**Table 4.** Amounts of waste treated for energy recovery in Latvia from 2008 to 2012

| | Amount of waste, tonnes | | | | |
|---|---|---|---|---|---|
| Waste chapter, description | 2008 | 2009 | 2010 | 2011 | 2012 |
| 02.Wastes from agriculture, forestry | 0 | 0 | 0 | 27,226 | 96,598 |
| 03.Wastes from wood processing, pulp, paper and cardboard | 840 | 862 | 1,290 | 2,235 | 3,397 |
| 15.Waste packaging (specifically wooden packaging 150103) | 291 | 521 | 2,318 | 1,420 | 1,124 |
| 16.Wastes not otherwise specified in the list (specifically end-of-life tires 160103) | 3,077 | 782 | 4077 | 16,171 | 10,825 |
| 17.Construction and demolition wastes (specifically wood 170201)) | 0 | 0 | 12 | 216 | 18 |
| 19.Wastes from waste management facilities, waste water treatment plants | 7,215 | 3,035 | 52,254 | 102,540 | 129,378 |
| 20.Municipal wastes including separately collected fractions (municipal solid waste) | 171 | 5,549 | 36 | 36 | 376 |

The total number of companies performing energy recovery for described waste chapters varies annually. As can be seen from Table 4, largest amounts of treated waste in 2012 were agricultural wastes, wastes from waste management facilities, and end of life tyres. The rapid increase in treatment of agricultural wastes was due to favourable regulation initiated in 2009 (Cabinet of Ministers, 2009a) which introduced guaranteed

feed-in tariff policy for biogas plants. The noticeable increase in energy recovery from waste tires and wastes from waste treatment plants (mainly refuse derived fuels (RDF)) is due to increased use as fuel in cement industry. Since production of RDF in Latvia is still developing, 95% of wastes within waste chapter 19 are the imported RDF. Similarly the import of waste tires s twice larger than is annually collected state-wide.

The identified WTE stakeholders include organisations within waste management, waste-to-energy conversion and technology providers, public stakeholders as the government and research facilities and universities.

Most commonly used WTE technologies in Latvia are anaerobic digestion and thermal treatment, mostly combustion. Combustion of wood and wood wastes is common energy recovery technology in Latvia. Therefore most local WTE technology providers are specialized in this area. There are local technology providers for technologies of small (12–500 kW) and large (1–10 MW) capacity. Pyrolysis or gasification technology is gradually being introduced in Latvia. Few plants have been installed for waste tire pyrolysis and waste wood gasification.

Apart from waste generation, collection, treatment and energy production another important part of WTE value chain is research and innovation. WTE research in Latvia is a small but developing sector. It is mainly driven by research at universities, e.g. research on organisation of waste management and the potential of organic wastes to be used as energy resource (Bendere & Āriņa, 2011) and research on the potential of alternative feedstock for biogas production and combustion (Beloborodko et al., 2013; Ruģele et al., 2013). The main shortcoming is the lack of research oriented towards the WTE companies.

**Driving forces of waste-to-energy sector: Push factors**

The identified push factors characterize the capital and technology availability, availability of WTE specialists, entrepreneurship opportunities and introduction of new innovation that advance the development of WTE sector. Push factors incorporate information about the actual situation in Latvia and various aspects that facilitate introduction of waste-to-energy technologies and innovation. These aspects include the data on waste generation; possibilities for investments in WTE, related research and transfer of knowledge to industry, as well as WTE related education programs.

Analysis of statistical data on available amounts of waste suggests large potential for energy production of municipal solid wastes (MSW), wastes form waste management facilities and agriculture wastes. The use of agricultural wastes for energy recovery has been advanced by installation of more than 30 new biogas plants in recent years, still in 2012 only 33% of agricultural wastes were treated for energy recovery. Regarding data for wastes from waste treatment plants (chapter 19) 95% of the amount of wastes used for energy production is imported wastes. Therefore regarding nationally generated wastes from treatment plants (excluding RDF import) in 2012 only 2.35% were recovered as fuel or other means for energy production.

Installation of new waste treatment technologies provide new jobs, but also requires qualified specialists. Therefore coherent development of sector also requires availability of WTE education. As waste-to-energy field is related to various areas of knowledge, including among others waste management, energy production, environmental impact, different programs were explored that provide waste-to-energy related education. There are six higher education institutions that provide bachelor and

master level programmes in fields related to energy production, waste management and environmental engineering. There are also two colleges providing professional education and several vocational education institutions that provide training in WTE related programs.

WTE sector strongly depends on the availability of appropriate technologies. The main technology related issue in Latvia is that the capacity of existing technologies, typically adopted from other countries, is too high in regard to the amount of produced waste. Therefore technology is not used at its optimal capacity, which leads to various limitations regarding use of equipment, emissions, quality of source waste and economic considerations. Although such limitations influence the development of WTE sector in Latvia, they also provide good opportunities for research and technological improvements. In Latvia research and development of innovative WTE technologies that are adjusted to local conditions has been underdeveloped. One of indicators of innovation situation is the patent activity. Four national patents directly related to waste to energy have been applied for by Latvian authors from 2008 till 2013; six national patents have been granted for biomass incineration related technologies, two of which are in the process of being granted as worldwide patents. Three patents have been granted for anaerobic fermentation, biomass fermentation and biogas related technologies from 2010 till 2014. Overall a good tendency of increased patent activity can be seen in past five year period showing the increasing national interest in innovation related to waste-to-energy sector. Strengthening of Technology availability, research and innovation should be one of the main objectives of WTE cluster and further development of WTE sector in Latvia.

The recent rapid development of WTE sector in Latvia has been promoted by availability of capital though national funding schemes as Climate Change Financial Instrument and European Union and European Economic area funding schemes.

The development of new technologies can also be promoted by business incubators and sector associations. Although there are several business incubators in Latvia, they are mostly directed towards creation and aiding new small and medium size businesses, most of them producing consumer goods. Only few of companies involved in business incubators in Latvia are related to engineering sector. As WTE sector has not been fully established as a separate sector in Latvia, the sector associations are mostly related to either waste or energy sector. As there is no unifying WTE association in Latvia yet, the development of WTE cluster would provide better communication of all stakeholders and would also allow to address the interdisciplinary issues of WTE sector.

**Driving forces of waste-to-energy sector: Pull factors**

Pull factors represent national side attractiveness that facilitates the implementation of waste-to-energy technology and installations. National regulations of waste management and energy supply utilities, as well as, public procurement initiatives and novel business model incorporation can facilitate further development of waste-to-energy field.

Governmental regulations, taxes and subsidies are important pull factors that drive the demand for new technologies and sector development. As WTE sector in Latvia is connected to both waste management and energy production sectors, an important restrictions for WTE sector development in Latvia is the division of policy

and regulation of these sectors. Main limitations are related to complicated organisation of WTE sector and communication of WTE stakeholders. Nevertheless WTE regulations have promoted sector development. Regulations regarding the production of electricity using renewable energy sources (Cabinet of Ministers, 2010) and regarding electricity production and price determination upon production of electricity in cogeneration (Cabinet of Ministers, 2009b) have been instrumental to ensure increase of use of renewable energy resources and energy recovery form biomass.

From demand pull point of view the production of RDF should be stressed in Latvia. Yearly around 100,000 tonnes RDF is imported, therefore, the use and local production of RDF is currently a topic of interest in Latvia. Many industries are using natural gas as energy resource due to its advantage of higher combustion temperatures in comparison with wood biofuels. In 2008 a cement producer started to import and use RDF as additional energy source for production process. In response to such demand, there have been attempts to introduce RDF sorting plants in Latvia. Since 2012 RDF is being produced and sold to the cement producer by close located waste management organisation, in 2013 the another producer started to sell RDF produced in their waste sorting and treatment station to the cement producer (Waste statistical database, 2014)

Another pull factor is the national infrastructure for technology development and research. A nationwide long-term cooperation platform has been implemented in Latvia using public and European Union funding (Ministry of Education and Science). With the aim of aiding cooperation between research institutions, technology providers and users this platform is a good example of consolidated approach to innovation and technology development. The cooperation of research institutions and private business is currently intensively promoted in Latvia. Several research institute spin-offs have been developed, though there are few information sources about the actual firms as they are typically only start-ups. There are no significant spin-offs directly related to waste-to-energy.

Overall the main demand pull factors for WTE sector in Latvia as national regulation, innovation infrastructure, and technology demand from infrastructure are favouring the development of this sector.

## CONCLUSIONS

The analysis of historic data on energy recovery from different types of wastes shows a growing demand of RDF, waste tyres and agricultural wastes in previous years. As the national production of such high calorific wastes has been hindering, this demand has been covered by imported materials. Improved communication between involved stakeholders and awareness of national potential, e.g. through cluster collaborations, could promote efficient use of locally available energetic wastes.

Current development of WTE sector in Latvia has been mostly guided by push factors as capital availability and pull factors as governmental regulations, taxes and available subsidies. This is clearly demonstrated by the rapid development of agricultural biogas stations and utilization of agricultural wastes for energy production due to guaranteed feed-in tariff policy. An influential push factor for installation of these plants has been the availability of capital and appropriate technology. The development of WTE for other wastes (as mixed municipal wastes) in Latvia is limited

by availability of appropriate technology. Specifically the capacity of existing technologies is too high in regard to the amount of produced waste. Although such limitations provide large opportunities for research and technological improvements, in Latvia there is a lack of research and development of innovative WTE technologies that are adjusted to local conditions. This restriction may be offset by improving the cooperation of stakeholders in this sector through development of efficient WTE cluster.

Although many of push and pull factors in Latvia are well developed, currently the main shortcoming is lack of coordination and cooperation between stakeholders in the WTE sector. Therefore creation of a cluster that connects WTE stakeholders would be a significant driving force for strengthening of WTE sector. The main objective of WTE cluster should include ensuring the cooperation between researchers and technology provider and technology users in order to develop innovative and locally appropriate WTE technologies.

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