

WASTE TO ENERGY (W2E) AS THE MODERN CONCEPT OF WASTE MANAGEMENT

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Abstract

Nowadays, besides the classical energy sources, as for example coal, there are also several other energetic resources that might be seen as alternatives. During last decade the global energy market was searching for new solutions possible to be used for energy production. Under the research many factors have been taken into account, but mainly the concentration was made on environment protection issues. With such base, now, we are able to confirm the efficiency of alternative energy sources, among which we can differentiate: water, wind, geothermal, solar, wastes, etc., but also there are still undertaken research for energy sources improvement regarding environmental policies, and here there are opportunities such as resources from shale gas, nuclear, volcanos, hurricanes, etc.

All these energy sources contain positive and negative features, so it is important to balance them. However, not always it is possible. In this paper is made the investigation for the most popular alternative energy sources. There is a presentation of their strengths and weaknesses, and discussion the opportunities to use them with benefits. For the research it is taken the stand-point of management, as the first decisions in case of energy production come from this scientific area.

Key words: waste to energy, waste management, W2E technology, W2E plant

1. INTRODUCTION

Currently, there is an increasingly visible problem of waste management, both municipal and other than municipal (industrial, hazardous, medical, etc.). In 2011, in Poland were produced nearly 136 million tons of waste, of which 12 million tons were municipal waste and nearly 124 million tons were other than municipal waste. In addition, more and more are also embossed issues of filled landfills and the lack of space for this type new objects creation. Currently, the landfill is cumulated with 1654.1 million tons of waste, and the total area of the landfills in Poland is more than 9,000 hectares (GUS, 2014). Widely promoted solution by both, the government and the media, is the process of recycling. This is firstly adopted by the European Union as a strategy for dealing with waste, as well as the benefits of recycling, manifested mainly by opportunities to obtain secondary raw materials for production. However, it should be noted that not all recycling is so advantageous solution as it might seem. The fact that through these processes there is an access to affordable and nutritious recyclables is undeniable.

However, controversial issues are connected with the demand for given type of raw materials, or rather absence of this demand, then bigger usage of energy and harmful gases emission into atmosphere in recycling processes than in the raw materials production processes, or incorrect classification as a recycling the processes of waste collection and sorting, which further as unchanged are under further disposition, but without any control for managing them. In view of the above considered issue, on the other hand there are additional, global energy-related issues, and more specifically to a real increase in the prices of energy fuels and thereby increasing prices of electrical energy, there is a need to find a solution to the sustainability and slow down the use of energy sources using appropriate modern technology.

In addition, a very important aspects are: environmental pollution and climate change, for which there is a need to prevent them, or minimize, what is associated with the adaptation of material and energy needs to strive the emissions reduction of pollutants and harmful gases (Energy, 2015). At the same time environmental aspects along with the equally important economic and social aspects are the pillars of sustainable development.

2. THE IDEA OF WASTE TO ENERGY (W2E) TECHNOLOGY

Technology of producing energy from waste = W2E (Waste-to-Energy) is the waste heat treatment and the electricity and heat production from waste. In recent years, this technology is becoming more and more popular in the world, especially in developed countries, where there are many companies, even large power plants that generate energy by burning waste and received heat is used in industry or sold to individual customers. Waste, despite the seeming futility, have very valuable potential - especially energy. Therefore, they should not be seen in terms of the problem, but as an important source of obtaining recycled materials and energy, together with the possibility of environmental protection and waste disposal methods should be established and implemented in accordance with the strategy for sustainable waste management. It is widely understood that the combination of the principles of sustainable development of proper waste management, waste have to get the status of objects consisting of different types of raw materials and energy.

The most common process of W2E is to burn waste, firstly because it is not complicated, and the second that it generates a relatively low cost (Themelis, 2003). Waste which are burned for energy need to possess combustible and compost properties (WTERT, 2012).

The energy obtained from waste is seen as a clean, renewable energy. This is due to the fact that the source of this energy in the form of waste, is a reliable and renewable source. Of course, given that the waste streams are very diverse they should be also used as the source in different ways. Examples include metal waste to be collected, stored, and then subjected to processes to produce secondary raw material, and in this case they are not a source of energy. However, in the case of many other types of waste recovery of these values in the form of electricity, heat or fuel is relatively simple, cost-effective and is often more effective alternative for the environment than recycling or landfill (Energy, 2015).

3. EUROPEAN USAGE OF W2E TECHNOLOGY

Globally, many countries for more than a decade are using the Waste-to-Energy technology, but in Poland this kind of disposal is still not popular. The very important aspect that should be emphasized analyzing W2E technology is the perception of the business entities implementing this technology. It is incorrect to categorize them as companies carrying out waste management processes, as it is the intermediate target, but the main objective of the activity is to generate energy from the waste. Therefore, they should be classified as plants. From this point of view emerges a waste classification in the above-mentioned manner - as an energy source, which is the raw material coal and other fuels in conventional power plants. Unfortunately, both, the law and society, focused on waste management and not on their energy use, by what the discussed business entities are received more in the context of waste incineration plants than the power plants. In countries with a higher level of development, where has been running many of such plants (Figure 1), the potential of plants with W2E technology is used in the maximum way, resulting the landfills have been reduced to a minimum (Energy, 2015).

Data presented above can be further supplemented by information on waste management strategies in selected countries (Figure 2).

The graphical presentation in Figure 2 indicates that in most EU countries the main method of waste management is still their landfilling (the EU average is 40%), then the waste is subjected to recycling processes, and usually only a small percentage of waste is incinerated.

4. DIFFERENT KINDS OF W2E BENEFITS

Considering the various aspects of the W2E technology use, the economic benefits cannot be ignored, among which the most important include (WTERT, 2012):

- The value of the electricity,
- The value of heat and fuel,

- Fees charged for waste management,
- The value of non-energy waste, selected in the recycling segregation for secondary raw materials.

Of course, the benefits for W2E technology, and not just economic there are much more to achieve. Here it should be mentioned first of all about relieving the environment by reducing the adverse impacts of waste, reducing the amount of waste in landfills defaulting and thus reducing storage space, the production of "green" energy, which, being an alternative to traditional energy produced will help to reduce consumption of non-renewable natural energy resources, and may be cheaper energy.

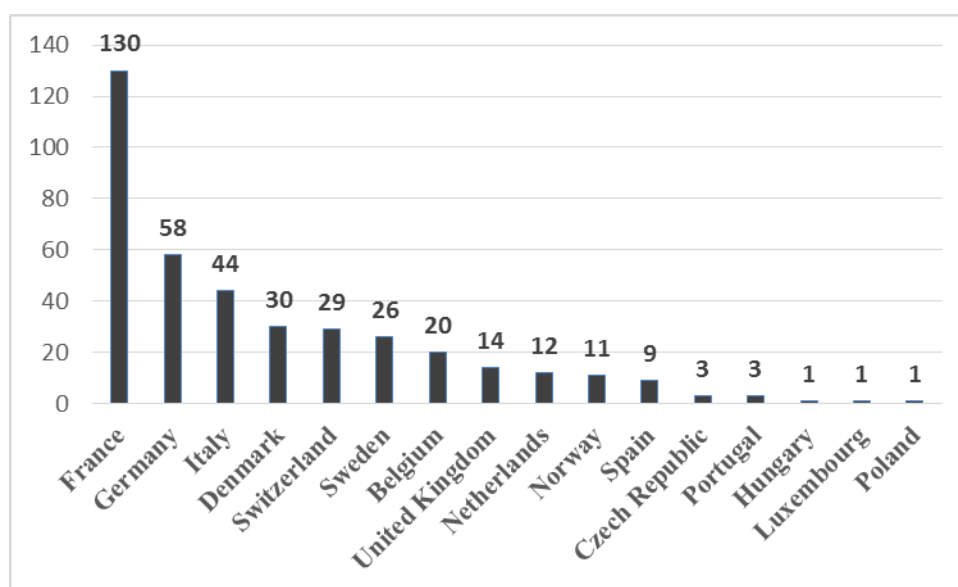


Figure 1. Number of W2E plants in chosen countries of Europe (Authors own elaboration based on WTER, 2012).

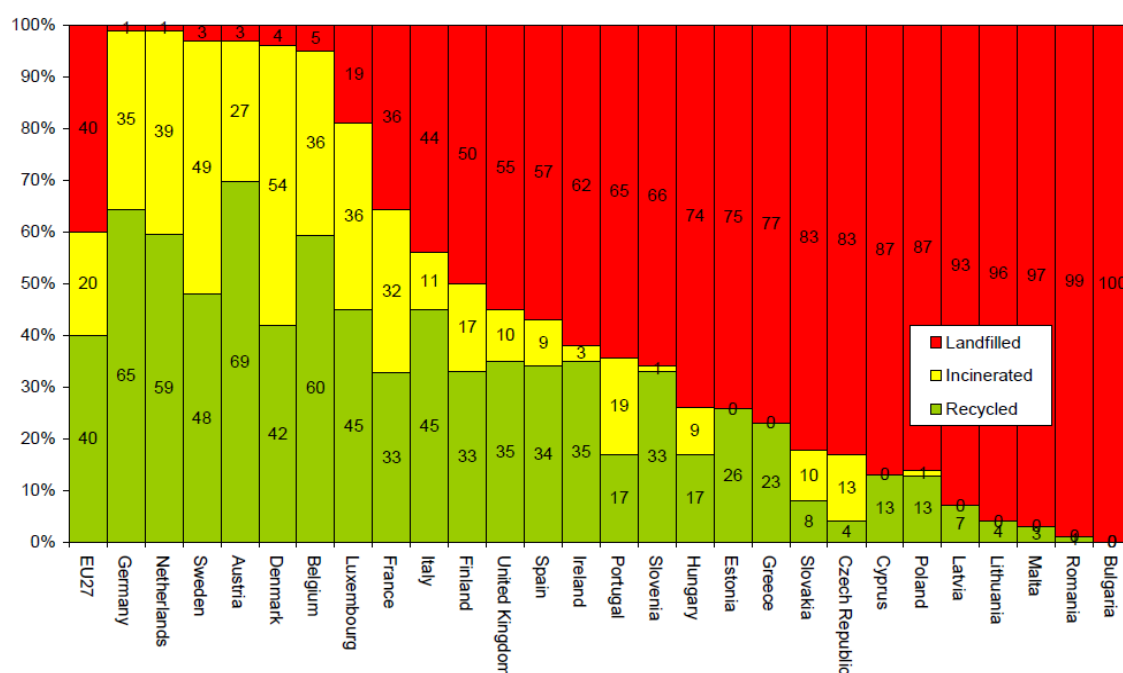


Figure 2. Waste management (mainly municipal solid waste) in EU27 countries in 2008 (Eurostat, 2015).

The use of W2E technology allows in environmental aspect to reduce greenhouse gas emissions into the atmosphere. This is possible by the action of three mechanisms operating in this technology (Michaels, 2012):

- generating electricity or steam in W2E technology avoids emitting carbon dioxide, which has the place in the traditional power plants that use fossil fuels for energy production;
- incineration process prevents them from being stored and landfilling, which in turn translates into a smaller amount of methane emitted into the atmosphere from landfills;
- recovery of ferrous and non-ferrous metals from waste in W2E technology is more energy efficient than the original production of these materials.

Thus, the W2E technology seems to be sustainable technology, allowing to produce the maximum amount of energy with minimal impact on the environment. This technology is seen as the best waste management option just because of the energy and environmental performance and, in particular, the low greenhouse gas emissions (Schroeder, 2012).

5. BRIEF PRESENTATION OF W2E TECHNOLOGY

Waste to energy (W2E) plants recover thermal energy contained in the waste using a highly efficient boilers that produce steam, which then can be sold directly to other industries, or further used to drive turbines to produce electricity (Michaels, 2012).

Schematic operations of the facility recovering energy from waste are illustrated in the following Figure 3.

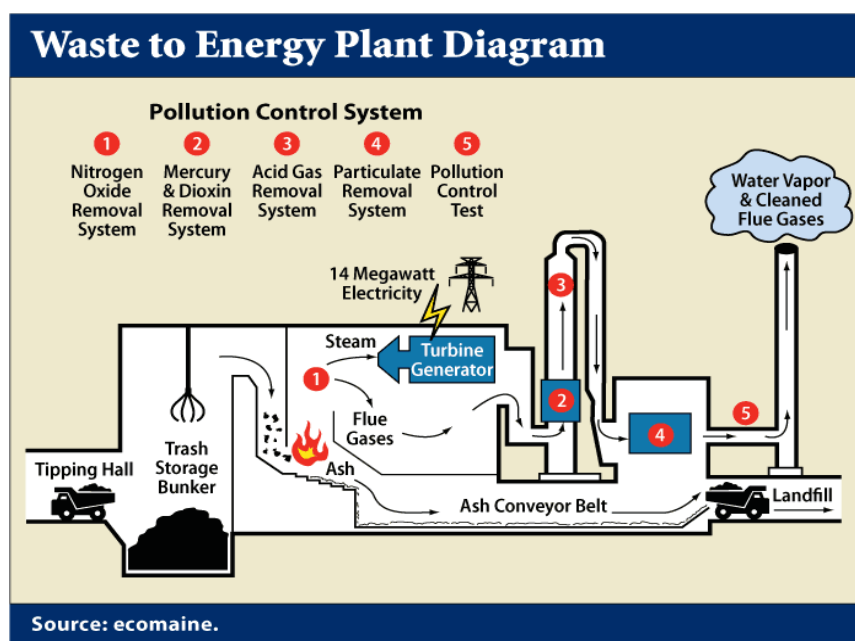


Figure 3. Schematic operations of the facility recovering energy from waste (Ecomaine, 2015).

Technology of waste treatment to energy, shown in Figure 3, is a very modern one and from technical point of view seems to be quite complicated due to the fact that the waste is combusted in the parameters that are varied. They may have very different sizes, can be dry or wet, and can drastically differ with energy potential. These wastes must be completely burned and the residue of this process are removed by a number of advanced treatment systems that are continuously monitored and controlled in terms of environmental (Thorneloe et al., 2006).

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graph TD; A[WASTE LOADING, WEIGHING] --> B[Tipping floor, charging bucket]; B --> C[Pre-grinder Ø < 30 cm]; C --> D[Belt conveyor]; D --> E[2-stage Iron Separation]; E --> B; E --> F[Plate conveyor]; F --> G[Pit]; G --> H[Grinder Ø < 10 cm]; H --> I[Belt conveyor]; I --> J[Plate conveyor]; J --> K[Plate distributor]; K --> L[Silos]; L --> M[Comb extractor]; M --> N[Dosing screw]; N --> O[Plate conveyor]; O --> P[Distribution system]; P --> Q[Feeding screw]; Q --> R[COMBUSTION CHAMBER];
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The flowchart illustrates the waste management process, starting with 'WASTE LOADING, WEIGHING' (indicated by a large arrow). The process then moves to 'Tipping floor, charging bucket', which feeds into a 'Pre-grinder Ø < 30 cm'. The output of the pre-grinder goes to a 'Belt conveyor', which then leads to '2-stage Iron Separation'. From '2-stage Iron Separation', the material can return to the 'Tipping floor, charging bucket' or proceed to a 'Plate conveyor'. The 'Plate conveyor' leads to a 'Pit', which then feeds into a 'Grinder Ø < 10 cm'. The output of the grinder goes to a 'Belt conveyor', which then leads to another 'Plate conveyor'. This 'Plate conveyor' feeds into a 'Plate distributor', which then leads to 'Silos'. The 'Silos' are connected to 'Comb extractor' units. The 'Comb extractor' units feed into 'Dosing screw' units. The 'Dosing screw' units feed into a 'Plate conveyor', which then leads to a 'Distribution system'. The 'Distribution system' feeds into two 'Feeding screw' units, which finally lead to the 'COMBUSTION CHAMBER' (indicated by a large arrow).

The diagram illustrates a complex industrial process involving a gas turbine and a steam cycle. Key components and their interactions include:

- Gas Turbine Section:**
 - High Pressure turbine** and **Low pressure turbine** are connected to a common shaft.
 - Emergency by-pass** valve allows steam to bypass the turbines.
 - Condenser** is cooled by water from **Cooling towers**.
 - De-aerator** and **pump** maintain the water level and pressure in the steam cycle.
- Steam Cycle Section:**
 - Super-heater** and **evaporator** are part of the main heat exchanger.
 - Condenser** is cooled by water from **Cooling towers**.
 - De-aerator** and **pump** maintain the water level and pressure in the steam cycle.
- Process Flow:**
 - Combustion air** is heated in the **furnace**.
 - The hot air then passes through the **grate cooling unit**, **super-heater**, **evaporator**, and **economizer**.
 - The steam generated in the **evaporator** is sent to the **condenser**.
 - The **condenser** is cooled by water from the **Cooling towers**.
 - The **de-aerator** and **pump** maintain the water level and pressure in the steam cycle.

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Usually, they come from the local administrative units to which they belong and which operates the plant has signed an agreement to receive such waste. Since these units usually have a waste management program, before it enters the combustion plant are subjected to a process of segregation, during which the separated waste is recyclable. The rest is transported to the plant, where the loading of waste into the furnace. There combustion temperature is so high that it completely destroyed all kinds of viruses, bacteria, tanks and other compounds that could affect human life or the environment (Figure 5).

Heat from the heated incineration boiler circulating water in the pipe, causing it to boil, leading to the formation of steam. This steam can be used directly in the heating system or plant. Usually, however, the steam is used to drive a turbine that generates electricity. At the end, once the combustion process has been completed, the ashes are removed with metals using magnets and other mechanical devices, which are passed on for recycling (Kaplan et al., 2009).

Above shows a typical plant producing energy from waste in the process of combustion. Incineration is the most common process used in the technology of W2E, but it is one of the four. The other three processes are: gasification and pyrolysis (thermal processes) and anaerobic digestion (a biological process) (Energy, 2015). Probably, along with the growing importance of obtaining energy from waste soon as these three processes will gain more popularity and will be used on a large scale as well as the combustion process.

6. THE EXAMPLE OF W2E PLANT IN POLAND

In Poland there are plans to build several plants using waste as a source of energy, and with the aim to generate energy in the process of combustion. Currently, there is only one object like that, and it is the Permanent Municipal Waste Disposal Plant in Warsaw (ZUSOK). Construction of a heating block at ZUSOK began in October 2006 Investment projects completed in July 2007, the building block cost about 5 million PLN. Supply district heating to ZUSOK investment was financed by SPEC and the plant accepts municipal waste only from Warsaw. The plant installed a turbo-generator with a capacity of 2.4 MW. Inclusion in a heating block system changed slightly turbine operating conditions. In view of increasing the steam pressure downstream of the turbine, decreased efficiency of the machine and hence the production of electricity. In 2008, ZUSOK converted into heat 39 729 tonnes of waste. The amount of waste incinerated depends on the calorific value of the work, that is, the higher heating value waste is incinerated, the less they can be burned to produce a nominal amount of energy, which is designed for the boiler. In a functioning installation can be converted to heat a larger amount of waste, provided that they would have a slightly lower calorific value. The second way to use a larger amount of waste is the expansion of the plant with additional lines for the incineration of waste. In the same year in ZUSOK produced and sold approximately 243 000 GJ of thermal energy from a profit of around 3.5 million PLN. In addition, it is the cheapest source of thermal energy in Warsaw, because it has a lower price at a level of several percent from other suppliers. In addition, the plant produced in 2008 10 545 MW of electricity, of which 2 430 MW were sold, and the remainder was consumed for their own needs. ZUSOK revenue from the sale of electricity in 2008 amounted to approximately 0.29 million PLN (Egospodarka, 2015).

The above example shows that power plants processing waste to energy can be effective with selling energy and heat, and also can minimize the usage of natural resources through utilizing waste instead of coal, oil or gas. This means that plants use this type of waste and recover their value, while they are generally perceived as worthless.

7. SUMMARY AND CONCLUSIONS

This article justifies the need to promote energy production from waste treatment by usage of W2E technology.

Presentation of the fundamental aspects of the concept and technology of generating energy from waste has to justify the need to promote it. Due to the favorable aspects of energy, environmental, and economic will be in the coming years, there will be a trend propagating this kind of activity. Government and administrative units should be seen in this technology a chance to develop the energy market, reduce environmental pollution and gained from both sources economic benefits. They should therefore seek to change the strategy and determine W2E technology as a key element in the production of energy and the energy from waste should be promoted socially, because it is often the local people blocking beneficial investment associated with waste disposal, which is primarily due to the lack of information about the absence of negative the effects of such investments for the environment. It is also taking active steps to encourage this type of investment, rather than focus solely on recycling processes, seeing them as the sole way to correct waste management and acquisition of raw materials. For this purpose, it becomes the change in the definition of waste, to which must be added the information that they are secondary, renewable source of clean energy. If there will be taken although some possibilities presented above, it is very possible that in the future almost disappear landfill and will be strategically significant competition to traditional power in the form of plants producing energy from waste.

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