Problematic Development of Implementation of WTE Projects in Slovakia

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The purpose of this article is to complete and confirm data about all projects of waste to energy (WtE) which successfully passed EIA phase for Slovakia as a whole. Because of missing centralized register of such facilities, there aren't available and confirmed data about which ones from all planned and announced projects were finalized to operational status, as well as what kind of environmental and technical problems they are facing. This article is focusing only on pyrolysis, gasification and plasma based technologies and do not include any kind of direct incineration or co-incineration technologies. For the last ten years, there is steadily increasing interest in various forms of WtE projects in Slovakia. Before the year 2006, the only existing types of WtE facilities were standard waste incinerators and co-incinerators in form of rotary kilns for cement production. Starting with the year 2006 there began to appear first WtE based on the pyrolysis and/or gasification processes of various kinds of wastes. By the year 2010 onward, there was as much as four new project in EIA phase each year, most of which finished this

process successfully. For the last two years, this number is growing even further. Concurrently, there are also increasing doubts concerning real environmental performance of these projects, as well as their overall long term feasibility and sustainability. The main part of the work was data collection from publicly accessible sources, concerning EIA, IPPC permits, metainformations about environmental permits issued by district authorities, air pollution data and financial indicators of operators followed by their verification with competent district authorities and operators of facilities in question (where it was possible).

1. Introduction

According to official EUROSTAT statistic, EU produces approximately 2.5 billion tonnes of waste every year. Significant portion of this amount still ends up at a landfills (approximately 25 percent for EU-28 and 51 percent for Slovakia in 2014, excluding major mineral wastes) [4].

Official European waste policies have been guided by Environment Action program programs for over 30 years. These Programs aim to set up a framework for broader perspectives on EU environmental policies, including waste legislation and waste strategies in general.

According to the 7th Environment Action Program (2012 to 2020), there is potential for improving waste management in the EU to make better use of resources, reduce the dependency on raw materials and lower the impacts on the environment by fully implementing EU waste legislation. Furthermore, it states that *existing prevention, re-use, recycling, recovery and landfill diversion targets should be reviewed, so as to move towards a lifecycle-driven 'circular' economy, with a cascading use of resources and residual waste that is close to zero [3].*

Planned shift to circular economy incorporates two steps, which could have opposite effects on energy recovery and waste-to-energy investments in near future. Whereas land filling elimination may imply a push towards increased waste-to-energy investments, the limiting of energy recovery to non-recyclable materials may reduce future developments within this field [3].

Waste-to-energy is a broad term that encompasses various waste treatment processes generating energy (e.g. in the form of electricity/or heat or the waste-derived fuel), each of which has different environmental impacts and circular economy potential.

Taking into account main objectives of the circular economy, recovery of energy from waste in any form should fit the EU waste hierarchy and it should not undermine this hierarchy by discouraging waste management options with higher circular economy potential.

In light of these facts, one of the crucial information which each member state (and Slovakia especially) unconditionally needs for creating waste management strategies that are in compliance with *circular economy rules* is actual state of its waste-to energy sector.

In compliance with the recommendations contained in the communication of the Commission to the European Parliament, the European Council, the European Economic and Social Committee and the Committee of the Regions from January 26, 2017 [1], Member States with low or non-existent dedicated incineration capacity and high reliance on landfill should take long-term perspective and carefully assess the following factors, when reviewing national waste management plans and assessing the need for additional waste-to-energy capacity for the treatment of non-recyclable waste:

- the impact of existing and proposed separate collection obligations and recycling targets on the availability of feedstock to sustain the operation of new incineration plants over their lifespan (20 to 30 years);
- the available capacity for co-incineration in combustion plants and in cement and lime kilns or in other suitable industrial processes; and
- planned or existing capacity in neighboring countries.

However, taking into account long-term problems with decrease of deposited waste in Slovakia (as there is continuous and rather steady stream of MSW into landfills, with 79 percent in 2005 and 69 percent in 2015), it should be noted, that according to principles of EU waste hierarchy, recovery of energy from waste (either in form of direct incineration or in form of fuel produced from waste), is still far better solution than actual situation.

Whereas actual state of *standard* waste-to-energy facilities in Slovakia is well known and precisely officially documented (as of 2015 there are two large-scale incineration plants for non-hazardous municipal waste, five incineration plants for hazardous waste from industry sector, five incineration facilities for hazardous waste from medical sector and four co-incineration facilities in forms of rotary kilns for cement and lime industry), situation in so called alternative thermal treatment methods is quite opposite [6].

For the purpose of this article, the term alternative thermal treatment methods cover all facilities that use substechiometric (concerning oxygen input) processes in form of pyrolysis or gasification, as well as any form of plasma-based waste treatment.

For the last ten years, there is steadily increasing interest in various forms of alternative thermal treatment methods in Slovakia. Before the year 2006, the only existing types of WtE facilities were standard waste incinerators and co-incinerators in form of rotary kilns for cement and lime production. Starting with the year 2006 there began to appear first alternative thermal treatment facilities based on the pyrolysis and/or gasification processes of various kinds of wastes. By the year 2010 onward, there were as much as ten new projects in EIA phase each year, approximately half of which finished this process successfully. For the last two years, this number is growing even further. Concurrently, there are also increasing doubts concerning real environmental performance of these projects, as well as their overall long term feasibility and sustainability. Because of missing centralized register of such facilities, there aren't available and confirmed data about which ones from all planned and announced projects were finalized to operational status, as well as what kind of environmental problems they are facing [5].

In Slovakia from among various types of wastes/resources the biggest interest is in pyrolysis of plastic. From different products of pyrolysis (pyrolysis gas, pyrolysis oil and pyrolysis char) the effort is to produce the highest rate of pyrolysis oil and pyrolysis gas is needed for heating pyrolysis unit [6]. So far, less attention has been paid to pyrolysis char, although in case of bigger capacity of pyrolysis plants, it could be an interesting product [2,7].

The purpose of this article is to complete and confirm such data about all projects which successfully passed EIA phase in Slovakia starting with year 2006.

Environmental legislative framework for alternative thermal treatment methods in Slovakia

By the Decree of the Ministry of Environment of the Slovak Republic No 367/2015 Coll. which changes and amends the Decree of the Ministry of Environment of the Slovak Republic No 228/2014 Coll., stating the requirements for the quality of fuel and the maintenance of fuel operation records, there was introduced new legal regulations for fuel derived from waste and stated the precise criteria for end-of-waste status of such fuels with special emphasis on protection of the atmosphere. Air protection requirements for the waste incineration do not apply for subsequent use of waste-derived fuels which meets these criteria.

Taking into account this Decree, there are now two possible modes of operation for alternative thermal treatment facility in Slovakia:

- Facility produce waste-derived fuel (solid, liquid or gas), which is in full compliance with defined end-of-waste status and is either used for energy production on-site or is placed on the market as a common fuel. In both cases emission limits and requirements for *standard fuel* burning applies.
- Facility produce waste-derived fuel (solid, liquid or gas), which fails to meet any one criterion from the set of criteria stated in cited Decree. In this case, requirements for waste incineration apply for use of such fuel (which retains its waste status).

2. Methodology

As mentioned in the first part of this article, there is no centralized register regarding facilities which uses alternative thermal treatment methods of waste. In respect of this, we were conducted following steps in the process of collection of data about alternative thermal treatment facilities (abbreviated as ATT in the rest of the article):

2.1. collection of data from publicly accessible sources regarding environmental permits compulsory to such facilities,

2.2. verifying the stage of realization of the individual projects indentified in the previous step,

2.3. collection of contact data of representatives of operators of the individual identified projects,

2.4. confirmation of the stage of implementation with the representatives of the operators and brief environmental screening of facility (where it was made possible by the operator's representative),

2.5. collection and analysis of information on the operators' financial results and the actual level of premiums claimed for the production of electricity from renewable sources (only for relevant installations).

The following sections detail the methodologies and sources of information for each of the above-mentioned steps.

2.1. Collection of data from publicly accessible sources

ATT facilities are subject, under Slovak environmental law, to several mandatory authorization processes and operational obligations which include the following permits and obligations (its not an exclusive list, only those authorizations, permits and obligations which are fully or partially accessible to the public are included):

- EIA permit,
- air pollution source operational permit,
- waste recovery facility operational permit,
- IPPC permit,
- obligation to report annually on the amount of pollutants discharged into the atmosphere in the past year.

As part of the data collection, we have analyzed and grouped all relevant permits for the last ten years from the following publicly accessible sources:

- http://www.enviroportal.sk/sk/eia
  (information system of all EIA processes carried out in the Slovak Republic, the information system is fully publicly accessible),
- http://charon.sazp.sk/zhodnocovanie_odpadov/zariadenie_zo.aspx
  (information system of waste recovery facilities operational permits, the information system is fully publicly accessible, but incomplete),
- http://mis.enviroportal.sk/
  (a meta-information system for the environmental district authorities, partly publicly accessible, it does not allow direct searching),
- www.air.sk/neis.php
  (information system containing annual reports of the amount of pollutants discharged into the atmosphere, the system is partially publicly available).

2.2.Verifying the stage of realization

Since the EIA permits, as the main source of information on individual identified projects in the previous step, is only the first in a series of subsequent permits

required before the start of actual operation, the next logical step was to verify whether the identified projects reached the operational stage.

This step includes following:

- inquiry of contact persons in EIA documents (under the condition that the contact details were given, they were functional and directed to the relevant person who had knowledge regarding further stages of the project),
- inquiry of relevant environmental district authorities,
- http://mis.enviroportal.sk/,
- www.air.sk/neis.php,
- cross-check with operators of other confirmed ATT devices.

2.3. Collection of contact data of representatives of operators

Set of contact details on the representatives of the operator, resulted directly from the first two steps. This set was augmented with contact details on legal representatives of operators (in cases where contact details for direct representatives of operator were not available).

2.4. Confirmation of the stage of implementation and brief environmental screening of facility

For each facility, for which the operational phase has been validated and for which valid contact data of the representatives of the operators has been obtained, a representative of the operator has been contacted with request for brief environmental screening of the facility in concern. Environmental screening covers following topics:

- stage of operation,
- real extent of granted permissions and authorizations,
- real extent to which the relevant environmental permits are fulfilled in accordance with environmental laws.

2.5. Collection and interpretation of financial data

As a complementary step, a collection of publicly available data on the financial results of the operators was made.

In addition, in the case of an installation that uses waste-derived fuel to on-site production of electricity, delivered directly into the grid, it is possible to verify the actual level of production of such electricity for each year from the publicly available database of Regulatory Office for Network Industries (www.urso.gov.sk) (latest available data are from 2015).

3. Results and discussion

3.1. EIA stage

Table 1: EIA processes started and successfully finished

Year	No. of started EIA processes	No. of successfully finished EIA processes
2005	1	1
2006	0	0
2007	2	2
2008	3	3
2009	3	3
2010	5	5
2011	2	1
2012	3	0
2013	9	8
2014	4	3
2015	3	3
Total	**35**	**29**

As mentioned, there was no ATT facility in Slovakia before year 2005. In 2005 started continuing and steadily increasing flow of ATT projects undergoing EIA phase as a first step in development process.

In following Table 1 are summarized numbers of such EIA processes started in each year together with number of those successfully finished (not necessarily in the same year, as process EIA for this kind of technologies often takes longer than one year). By successfully finished we mean EIA processes where positive final record was issued by competent authority.

3.2. Operational stage

Due to the fact, that positive final record as a mandatory outcome of EIA process is necessary condition for next steps in development process, only projects with such positive final records were further examine.

Next Table no. 2 shows which ones from the set of identified projects with positive final record reached operational status (either permanent operational status or trial operational status with the time limit constraint). For projects that reached operation stage, exact type of WtE process is also included in the Table 2.

Data used to complete this table was as follows:

- information from identified representatives of operators about current status of project (including whether construction permit, operational permit, final (operational) approval, air pollution source operational permit were issued),
- information whether annual reports on the amount of pollutants discharged into the atmosphere were filed and if yes what levels of pollutant's emissions were reported,
- information about annual levels of production of electricity from waste/derived fuels (these data are relevant only for installations that uses waste-derived fuel to on-site production of electricity and it's delivering directly into the grid).

As can be seen, from 29 projects that successfully finished EIA stage (from 2005 to end of 2016) only seven reach permanent operational or trial operational status. From the rest of the 22 projects total, 7 are in some kind of progress toward operational stage and 15 are stopped, either definitely or for indefinite time.

Table 2: Projects with successfully finished EIA stage – further development

Township	District	Year (first positive final record issued)	Actual stage of project development	Type of WtE process
Dunajská Streda - Mliečany	Dunajská Streda	2005	operational stage (permanent)	pyrolysis (thermal degradation without catalyst)
Lučenec	Lučenec	2008	operational stage (permanent)	pyrolysis (catalytic depolymerization)
Banská Bystrica	Banská Bystrica	2008	stopped	
Dubnica nad Váhom	Ilava	2008	project in progress (not yet operational)	
Mokrance	Košice - okolie	2009	operational stage (permanent)	pyrolysis (catalytic depolymerization)
Lieskovec	Zvolen	2009	operational stage (permanent)	pyrolysis (catalytic depolymerization)
Oborín	Michalovce	2009	project in progress (not yet operational)	
Stropkov	Stropkov	2010	stopped	
Senica	Senica	2010	stopped	
Sládkovičovo	Galanta	2010	stopped	
Senica	Senica	2010	stopped	
Bardejov	Bardejov	2012	stopped	
Mojšova Lúčka	Žilina	2012	stopped	
Sered'	Galanta	2012	operational stage (permanent)	pyrolysis (catalytic depolymerization)
Bardejov	Bardejov	2013	stopped	
Čierny Brod	Galanta	2013	operational stage (trial)	pyrolysis (catalytic depolymerization)
Lipany	Sabinov	2013	stopped	
Lieskovec	Zvolen	2014	operational stage (trial)	pyrolysis (thermal degradation without catalyst)
Rožňava	Rožňava	2014	stopped	
Malacky	Malacky	2014	stopped	
Zacharovce	Rimavská Sobota	2014	project in progress (not yet operational)	
Štúrovo	Nové Zámky	2014	project in progress (not yet operational)	
Dolný Bar	Dunajská Streda	2015	stopped	
Janík	Košice - okolie	2015	stopped	
Spišská Nová Ves	Spišská Nová Ves	2015	project in progress (not yet operational)	
Šamorín	Dunajská Streda	2016	project in progress (not yet operational)	
Handlová	Prievidza	2016	project in progress (not yet operational)	
Selice	Šal'a	2016	stopped	
Vranov nad Topl'ou	Vranov nad Topl'ou	2016	stopped	

	No. of projects	%
Projects in permanent operational stage	5	17
Projects in trial operational stage	2	7
Projects in progress	7	24
Projects stopped	15	52

Table 3:

Projects with successfully finished EIA stage – summary

Table 4: Cumulative list of codes of wastes considered for use in ATT facilities in existing and intended projects

Code of waste	Description
020104	waste plastics except packaging (wastes from agriculture, horticulture, aquaculture, forestry, hunting and fishing)
070213	waste plastic (wastes from the manufacture, formulation, supply and use of plastics, synthetic rubber and man-made fibres)
120105	plastics shavings and turnings (wastes from shaping and physical and mechanical surface treatment of metals and plastics)
150101	paper and cardboard packaging (packaging including separately collected municipal packaging waste)
150102	plastic packaging (packaging including separately collected municipal packaging waste)
150105	composite packaging (packaging including separately collected municipal packaging waste)
150106	mixed packaging (packaging including separately collected municipal packaging waste)
160103	end-of-life tyres (end-of-life vehicles from different means of transport and wastes from dismantling of end-of-life vehicles and vehicle maintenance)
160119	plastic (end-of-life vehicles from different means of transport and wastes from dismantling of end-of-life vehicles and vehicle maintenance)
160216	components removed from discarded equipment other than those mentioned in 16 02 15 (wastes from electrical and electronic equipment)
170203	plastic (construction and demolition wastes)
180104	wastes whose collection and disposal is not subject to special requirements in order to prevent infection (wastes from natal care, diagnosis, treatment or prevention of disease in humans – waste from human or animal healt care and/or related research)
180203	wastes whose collection and disposal is not subject to special requirements in order to prevent infection (wastes from research, diagnosis, treatment or prevention of disease involving animals – waste from human or animal healt care and/or related research)
191204	plastic and rubber (wastes from the mechanical treatment of waste – waste from waste management facilities)
191210	combustible waste RDF (wastes from the mechanical treatment of waste – waste from waste management facilities)
191212	other wastes (wastes from the mechanical treatment of waste – waste from waste management facilities)
200139	plastics (separately collected fractions – municipal wastes)
200301	mixed municipal waste (other municipal wastes – municipal wastes)
200302	waste from markets (other municipal wastes – municipal wastes)
200303	street-cleaning residues (other municipal wastes – municipal wastes)
200304	septic tank sludge (other municipal wastes – municipal wastes)
200306	waste from sewage cleaning (other municipal wastes – municipal wastes)
200307	bulky waste (other municipal wastes – municipal wastes)

As of May 2017, there are seven new confirmed projects in EIA stage, which includes some form of ATT facilities. It means, that with the inclusion of seven projects with completed EIA stage and declared effort to reach operational phase, there are overall 14 projects in preparation, which, after their successful development, should solve similar (or rather more stringent) requirements and problems as the ATT facilities identified in this study.

If we express these projects in terms of codes of wastes, we gets following Table 4.

Because these projects doesn't states exact intended amount for each code of waste separately, it's not possible to assess the availability of each code separately. However, taking into account the total capacity considered for all these projects and comparing it with the available cumulative capacity of the list of wastes mentioned above (where only waste disposed of by landfilling is considered to be available), we get relatively positive numbers, as can be seen in following Table 5.

Table 5: Projected capacity of waste intended for use in all ATT facilities (existing and upcoming) in comparison with available amounts of such type of waste

Projected capacity of all codes of wastes landfilled for all ATT projects t/year	Available capacity of these codes of wastes (only landfilled waste is included) t/year	Portion of landfilled waste %
about 250,000	about 1,140,000	22

There is one issue, stemming from these numbers that deserve further attention. As far as existing and upcoming projects are regarded, there is only one from them all, that actually consider recovery of municipal waste (and it's the one, whose implementation is unlikely in the near future). Taking into consideration fact that in Slovakia, there is major problem with the unfulfilled targets of the circular economy precisely for municipal waste, importance of proposed projects in relation to solving the problem of municipal waste (declared in many cases by investors) is questionable at best.

3.3. Main reasons for not reaching operational status

Because of relatively high rate of projects which successfully implements EIA stage but failed to reach operational status, decision was made to look into main reasons for such failure.

Among most common reasons are:

- technical reasons
  (the technology planned for use in the EIA stage has proven to be inadequate – supplier of technology fails to meet parameters declared in the EIA stage),
- financial reasons
  (inability to secure the financing of the project),
- administrative reasons
  (development of project was stopped due to the problems and delays in administrative authorization process).

Most important of these are technical reasons. Based on inquiries made among contact persons cited in EIA documents, at least sixty percent of failed or unfinished EIA processes has or still have serious problems with proving of adequacy of technology in consideration.

3.4. Environmental and financial performance of ATT facilities with operational status

For facilities confirmed as operational, were conducted environmental screening aimed at overall environmental performance. Finally, financial results in recent years for each operator were checked.

Main controlled topics were:

- scope of operating conditions defined in air pollution source operational permit with the emphasis on mode of gas phase combustion and emission limits thereof (Inquiry was made whether facility has emissions limits sets as waste incinerator or as facilities for *standard* waste-derived fuel. In the first case compliance with these limits was further checked. In the second case compliance with end-of-waste criteria for gas phase secondary fuel was checked),
- compliance of produced liquid phase (as the main output product) with end-of-waste criteria for liquid secondary fuel (inquiry was made whether facility performs analyzes of liquid phase to confirm compliance with these end-of-waste criteria and whether such compliance is actually reached.),
- statement of finances published as part of the tax returns for the last three years (profit or loss of operator in each of the last three years were checked).

In Table 6 are summarized these results for all facilities with confirmed operational status.

Table 6: Compliance with controlled set of environmental requirements

	No. of projects	Projects with available data %
Confirmed compliance with controlled environmental requirements	3	43
Confirmed violation of controlled environmental requirements	2	29
Compliance not yet tested	1	14
Data not-available	1	14

There are several important facts, regarding the previous Table:

- According to the values of the parameters for the end-of-waste status of liquid secondary fuel, valid at the time of the writing of this article (April 2017), there is one parameter (content of polycyclic aromatic hydrocarbons), whose value is virtually impossible to achieve. Due to this fact, facilities which proved compliance with all parameters for end-of-waste status of liquid secondary fuel except this one were classified as *Confirmed compliance*.

- The facility was classified as *Confirmed compliance* only if it verifiably met the requirements for scope of operating conditions (i.e. set emission limits for waste incineration or end-of-waste parameters for gas-phase secondary fuel used for reactor heating), as well as the end-of-waste parameters for liquid secondary fuel (with the exception mentioned in previous point).
- In case of partially available data, that showed non compliance with some of the controlled requirements, the facility was classified as *Confirmed violation*.
- In case of partially available data, that showed compliance with some of the controlled requirements, the facility was classified as *Data not-available*.

The operator's financial result was determined as the last indicator to check. The following Table 7 shows the numbers of operators with reported profit or reported loss (in both cases for the last publicly available reported yearly financial results in 2015). However, only operators in permanent operational regime were included in this case.

Table 7: Financial results of operators

	No. of operators	Operators in permanent operational regime %	Average value of reported loss/profit EUR
Operators with reported loss	2	40	about 1,800,000
Operators with reported profit	3	60	about 240,000

4. Conclusions

Following facts can be stated about the results in the previous chapter:

- The majority of existing ATT facilities can meet the end-of-waste requirements for liquid-phase secondary fuel produced from waste (with the mentioned exception of PAH parameter. However, as far as PAH content is concerned, there is current legislative effort to change this parameter to an acceptable level).
- As all identified ATT facilities entered the operation stage before actual validity of end-of-waste parameters for secondary fuels, there is not one ATT facility with operational status, which would be obliged to prove end-of-waste status of gas phase used for reactor heating. Instead, for all of these facilities, some kind of waste incineration emission limits variation has been set. Because of *natural gas level of pollution* rule, it is considerably easier to meet these emission limits than to meet end-of-waste criteria for produced gas phase.
- More than half of all identified ATT facilities, in permanent operation, consistently reported loss in yearly financial results.

From the environmental point of view, one of the major factor, which should play key role in selection of appropriate technology is ability to meet end-of-waste criteria for

liquid phase (produced as fuel) as well as for gas phase (if used for reactor heating). Such ability should be adequately demonstrated on an appropriate reference/testing facility, before starting of EIA process, or during this process at the latest.

From the economical point of view, major topics (or rather the most important of them all) are significant financial problem of more than half of ATT project realized to date. Although the financial side of ATT projects is not a subject of this study, it is so crucial for every other aspect of these projects (including compliance with environmental requirements) that it's not possible to ignore it. Based on information obtained in process of data collection, but unconfirmed by any hard experimental data, among main reasons of financial problems are:

- high maintenance requirements for each ATT project in operation,
- necessity of further (and in most cases unexpected) modifications of technology to reach satisfactory and sustainable operating mode,
- relatively poor quality of produced liquid fuel, which in turn causes lowering of it's market prices (compared to the initial expectations).

Inevitable conclusion, valid for potential operators as well as for competent authorities, is that strong emphasis should be placed on information about predicted abilities of proposed technologies and their confirmation by hard experimental data from testing/experimental pilot facilities at the EIA stage at the latest. In case that technology vendor is unable (or unwilling) to supply such experimental data, the whole project need to be assessed with utmost caution.

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