Problems and prospects of creating an environmentally friendly WtE plant

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Abstract. The main stages in choosing the optimal technology for thermal treatment of MSW (municipal solid wastes) at the stage of feasibility study are discussed. The analysis of the influence of the fuel component on the structure of the WTE plant is carried out. Recommendations have been developed for choosing the optimal energy structure of a WTE plant, ash and slag management schemes, and thermal utilization technologies that are most suitable for the location of the facility. A study was conducted on the influence of the selected structure of the energy complex on the decision to choose a gas treatment system. A comparison of criteria for choosing the structure of the energy complex at the MSW in comparison with the energy thermal power plant (TPP) is made.

Due to the economic and environmental problems that appear during the construction of WTE plants, when it comes to waste scheme for cities and regions, it is recommended to use a scheme with the maximum use of secondary raw materials from waste and thermal treatment only of residues that are not subject to recycling, from which the fractions containing the largest amount of pollutants (RDF fuel) are extracted. The technology using deep recovery of secondary raw materials will simplify the structure of WTE plant, reduce capital and operating costs, and most importantly reduce emissions of harmful substances into the atmosphere with flue gases, ash and slag.

Keywords. Thermal power plant on municipal solid waste (WTE plant), thermal treatment of municipal waste; engineering in thermal energy field.

1. Introduction

The use of municipal solid waste (MSW) as a resource for obtaining secondary raw materials and energy has long been an attractive option for commercial structures and local authorities in many countries (unfortunately, except Russia). Thermal treatment helps to reduce the disposal of unsorted MSW in landfills, allows to process waste that can not be effectively used for obtaining secondary raw materials or recovery by biological treatment.

Russia is still making its first steps in the issue of energy treatment of MSW. In 2001, after reconstruction, the Moscow WTE № 2 was put into operation, where three turbine units with an electric capacity of 1.2 MW were installed - the first thermal power plant in Russia, the main fuel of which is MSW. Later, several other facilities installed in Moscow. Currently, a large-capacity TPP is in construction in Moscow and Kazan [1].

Energy production companies perform engineering and design work for thermal waste management companies abroad and in Russia. The interest of power engineers in this source of energy continues to grow, orders for the implementation of feasibility studies for the
construction of WTE plants from major energy companies (PJSC Mosenergo, LLC AGK-1) appear. Today, Russia, in comparison with the EU and Japan, has very little experience in the construction of WTE plants. The main suppliers of equipment are companies from the EU, Japan, such as CNIM (France), Babcock Environment GmbH, Hitachi Zosen Inova AG, Mitsubishi Heavy Industry, etc. Unfortunately, due to the high cost of equipment, the main criterion for choosing a production line is often to reduce capital costs. The methodology for selecting the best available technology, given in [2], is often not applicable to real objects, which leads to the need for each project to search for new methods, select criteria for selecting the best technology.

As the main performers of the feasibility study in the field of thermal waste disposal are energy companies operating on the Russian market. The criteria for selecting Technical specifications for WTE plants and the methods of selecting best available techniques (BAT) are often made by analogy with the energy of thermal power plants that burn fuel to produce electric and thermal energy. The lack of a methodology for analyzing the structure of WTE plants, elements included in the scheme, and their impact on technical and environmental indicators, leads to the risk that when comparing structures, the choice may not be made in favor of the optimal solution.

Creating a methodology and defining criteria for evaluating various technologies for thermal treatment of MSW is an urgent task in the development of the industry. As it was noted earlier, Russia currently has only a few large WTE plants, which means that it is impossible to analyze the impact of elements of the structure WTE plants only on the basis of domestic experience in operating such installations. Conducting a comparative analysis of various structural schemes of WTE plants, common in the EU and Japan, will help to identify their main advantages and disadvantages, determine the scope of application.

The purpose of the work carried out by the authors is to develop a General methodology for selecting a WTE plants structure that meets the requirements of legislation and the conditions of the customer. The research objectives include:

- study of the main elements included in the structure of TPP on MSW (including environmental and technical-economic aspects);
- research of the main technologies used at each stage of the technological process of thermal treatment of MSW.
- identification of factors affecting the efficiency and selection of criteria for evaluating the effectiveness of the WTE plants structure.
- conducting a criteria analysis of various structures of WTE plants to create a highly efficient energy complex that meets the requirements of high efficiency and environmental friendliness.

In this article, the authors propose a sequence of stages for selecting the WTE plants structure, and describe the main problems that arise at each stage.

2. Comparison of criteria for selecting the structure of an TPP and WTE plant

Methodology of analysis of the structure of the technological scheme of the WTE plant in its composition is similar to the analysis of the structure of schemes of thermal power plant with solid fuel (a common type of diagram shown in figure 1, are given in brackets the same steps for the energy of the plant to solid fuel).
Despite the fact that the structure of WTE plant and a TPP on solid fuel includes the same elements, there are significant differences that determine the difference in approaches to the analysis and selection of characteristics of the main elements of the structure. Thus, it can be concluded that the choice of the WTE plant structure should be made according to other criteria, and the criteria for choosing the optimal technology for TPP on solid fuel are not applicable for WTE plant.

The authors propose a method for decomposing the plant structure into separate elements in accordance with figure 1, for analyzing the properties of each element separately, as well as analyzing the effect of the element on the key performance indicators of the object: environmental friendliness, efficiency.

The stages for selecting the WTE plant structure is shown in figure 2.

3. The evaluation phase of the fuel component

The morphological composition of incoming MSW for thermal treatment varies in a wide range depending on the season and geography and has a strong impact on the economic, environmental and reliability indicators of the EC.

At the level of the subjects of the Russian Federation, in accordance with the Recommendations for the development of a regional program in the field of waste management, a scheme for the treatment of MSW is approved. Since January 1, 2017, recommendations for the development of territorial waste management schemes have been introduced [4], which provide for thermal treatment only sorted MSW, and from January 1, 2020, thermal treatment of unsorted waste will be prohibited by law. The recommendations consider five schemes for handling MSW, two of which involve thermal waste treatment:

1. Mixed waste collection with subsequent sorting and thermal treatment;
2. Separate collection with subsequent sorting and thermal treatment.
With the introduction of separate collection, waste coming to the WTE plant is pre-prepared at the collection stage, and some of the fractions containing potential pollutants are removed. In Russia, there is no established collection of hazardous waste, so when collecting separately, the probability of getting substances containing pollutants is quite high.

When using the scheme without separate collection, the use of a waste sorting complex in the scheme for handling MSW will allow, on the one hand, to meet the targets [5] for waste treatment and recovery of secondary raw materials, on the other - to improve the environmental and economic performance of WTE plant.

When it comes to thermal treatment of unsorted MSW or waste with a low calorific value, achieving the goal of reducing the content of harmful substances in flue gases and ash and slag waste is a complex and expensive process. Strong fluctuation in the morphological composition of MSW leads to the risk of non-project regimes and exceeding the maximum permissible emissions. Foreign experience shows that the achievement of high WTE environmental indicators is possible only when preliminary preparation of MSW is carried out together with the introduction of effective integrated flue gas cleaning, ash and slag neutralization and a suitable organization of the combustion process.

Structure of an energy complex for thermal treatment of MSW requires large capital expenditures: the estimated cost of an WTE for generating heat and electricity can be 6-10 times higher than the cost of an energy complex of the same capacity that burns organic fuel [6]. It is advisable to minimize the amount of waste entering thermal disposal and increase the level of preparation. Thermal treatment of sorting waste, on the one hand, requires the installation of a waste sorting complex or the introduction of a waste pre-treatment system in the region, which increases the specific cost of waste disposal, but at the same time allows to use less complex technologies of thermal treatment and gas treatment to achieve high environmental performance of the object, reduces the size of the object. Removing heavy metals, chlorine (PVC), and mercury-containing waste (thermometers, batteries, lamps) from the waste stream will reduce the load on the gas treatment system, reducing the operating costs of the thermal recycling process and emissions of harmful substances into the atmosphere.

When assessing the capacity of the WTE plant, the estimated amount of waste that can enter the enterprise from industrial and municipal enterprises is estimated, taking into account the transport shoulder (which usually should not exceed 25 km. The planned morphological composition of waste is evaluated. The main problem at this stage is that statistics on the morphological composition of waste in municipal enterprises are often absent. At the stage of the feasibility study, data on the morphological composition of waste can be accepted for preliminary assessment in accordance with the data [3], [7] however, in order to evaluate the accepted result, field studies must be performed.

Depending on pre-treatment scheme, the number and percentage of fractions that will be removed from the total flow of MSW, and the percentage of extraction of each fraction are specified. The total amount of MSW that is planned to be sent for thermal waste treatment line is determined. The assessment of the amount of waste that will be delivered to the WTE plant and the planned methods for waste preparation is an integral part of the engineering study before the construction of the WTE plant.

An important process at this stage is the assessment of the lowest calorific value of the prepared waste, which is planned to be sent for thermal disposal. In work [7] the method of estimation of the lowest heat of combustion of waste, approved at special plants of Moscow, is given. This method can be applied for preliminary assessment of waste, laboratory testing at this stage is mandatory.

The most difficult from a technical point of view is the process of determining the chemical composition of waste (content of heavy metals, chlorine, sulfur, fluorine), due to the lack of guidelines for conducting work, a small number of accredited laboratories. Data on the forecast composition of flue gases can be taken from data [8], [7], but also require laboratory confirmation.

The lack of confirmed methodological data on the morphological composition of municipal solid waste, the lack of data on the statistics of industrial waste sorting complexes leads to the
need for laboratory experiments at the stage of feasibility study. Carrying out scientific analytical and experimental works devoted to the evaluation of the chemical composition of flue gases at combustion of different waste fractions in order to determine the flue gas composition most accurately, will also allow to assess the impact of extraction of various fractions of MSW the composition of the flue gases and, accordingly, the choice of technology for thermal utilization, schemes of gas treatment.

4. Determination of the energy structure
WTE plant as an energy object has a number of features that must be taken into account when developing schemes for the release of heat and electricity. The main purpose of the object, the main criterion is the need for continuous thermal treatment of a certain volume of waste at the same time, seasonal or daily variations in heat or electrical energy should not lead to partial or complete unloading of a line, as it will lead to overflow of the warehouse, to partial burial or transportation to other enterprises. When determining the energy structure of an enterprise, it is necessary to consider various schemes for using energy obtained from TPP on MSW, the description of which is given in table 1, the options are arranged in ascending order of the object’s CAPEX.

| №   | Structure of the energy complex                                                                 | Scope/ Features                                                                 |
|-----|-------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------|
| 1   | Hot water boiler house for WTE plant (separate / in the structure of the boiler house)        | Replacement of the existing boiler house. Seasonal changes in heat consumption must be taken into account. |
| 2   | Steam boiler house, steam release to the Collector of organic fuel. (in the structure of TPP)  | Savings due to the availability of the necessary infrastructure at the TPP; Applicable if there are steam consumers with parameters up to 40 bar. |
| 3   | Steam boiler room, steam release on prom. the company (a separate company)                    | Large cities rarely have large steam consumers; In case of planned shutdowns of the enterprise, the line is stopped. |
| 4   | Condensing WTE plant (as part of an existing TPP)                                             | Savings due to the availability of infrastructure at the TPP; There is a continuing possibility of supply of electricity. |
| 5   | WTE plant with heat water heating (as part of an existing TPP)                                 | Savings due to the availability of infrastructure at the TPP; Availability of a constant possibility of heat/ electricity supply; Reduction of the payback period due to the possibility of heat release for heat treatment. |
| 6   | Condensing WTE plant (individual enterprise)                                                   | The need to build new infrastructure; For objects of low power the application is not rational; |
| 7   | WTE plant with heat water heating (individual enterprise)                                      | The need to build new infrastructure; For objects of low power the application is not rational; It is difficult to organize the sale of heat in the existing market of thermal energy. |
| 8   | WTE plant with gasification and use of heat engines                                            | High efficiency of electric power generation; High CAPEX (not discussed in the article); |

Thus, when determining the structure of heat and electricity supply, it is important to evaluate the scheme of consumption of heat (in the form of steam or hot water) and electric energy, which is implemented in the region.
It seems reasonable to build a hot water boiler house that burns MSW, this solution is characterized by the lowest CAPEX, but in conditions of seasonal and daily fluctuations in heat consumption, line downtime is possible. This solution can be considered when building in the Northern regions, with the duration of the heating season of 9-10 months. If there is a constant consumption of heat energy (industrial enterprise), the problem of underloading the heat capacity of the WTE plant is less noticeable than when the WTE plant is working for the utility sector.

Placing an WTE plant in an existing CHP plant has a number of advantages related to the availability of infrastructure, personnel, and, most importantly, the ability to supply heat and electricity to existing networks. Restrictions associated with the use of this option are related to the presence or absence of space at the CHP, the need for strict control of incoming waste to maintain safety at the facility, the inability to organize the entrance of transport. Often existing facilities are located in close proximity to residential buildings.

The construction of thermal power plants for MSW thermal treatment in the form of a separate enterprise has a number of advantages associated with the possibility of the entrance road, the possibility of accommodation outside residential areas, this greatly increases CAPEX, is a scheme of heat and electrical energy to existing networks. Heat supply may not be possible due to the network's balance sheet belonging to the heat generating company. The construction of a low-power WTE plant may not pay for itself in this case.

For each specific case, depending on the structure of heat and electric energy consumption, the choice of the optimal power equipment for WTE plant should be made during the feasibility study.

It is necessary to pay attention to the fact that the steam produced at the WTE plant has quite low parameters, which is associated with the processes of chlorine corrosion of metal superheaters and is usually no more than 40-60 bar, 400-420 °C [7]. Depending on the composition of waste, the size of WTE plant, the chosen technology, thermal treatment of one ton of MSW can produce from 360-580 kW of electric energy (in the condensation cycle) or 1.3-1.9 Gcal of thermal energy [3]. At this stage, the proposed site is also selected and external factors that may affect the EC structure are evaluated.

5. Determination of the ash and slag handling scheme

During the operation of the WTE plant, solid waste is formed in the form of slag and ash, as well as gas cleaning products, depending on the technology of thermal utilization adopted at the enterprise, the ratio of the amount of ash and slag may differ. The amount of gas cleaning products produced is affected by the adopted gas cleaning system. Ash and gas cleaning products are usually disposed of together.

Slag is usually removed from the boiler furnace, ash silo, and flue gas treatment system. Ash and gas cleaning products are removed from the final stages of gas cleaning, including the bag filter.

According to the research carried out in [9] at the Moscow WTE plant, the slag of the waste heat recovery boiler belongs to the 4th hazard class (low-hazard), and the gas cleaning products selected from the bag filter belong to the 3rd class (moderately dangerous). As a rule, waste of the 4th hazard class can be buried in landfills, while waste of the 3rd hazard class should be buried in specially equipped landfills and require neutralization [7].

Depending on the waste management scheme adopted in the region three main scenarios for ash and slag waste management can be considered at the stage of selecting the TPP structure for MSW:

- Landfills for waste disposal of the 3rd and 4th hazard class are located within transport accessibility in the region where the EC is located;
- Landfill for waste disposal of hazard class 4 is located within the construction region, waste of hazard class 3 must be transported a long distance;
- In the region of EC construction and in the surrounding regions, there are only landfills that accept waste of the 4th hazard class.
While in most regions it is possible to organize the disposal of waste of the 4th hazard class, the determining factor will be the presence of a landfill for the disposal of waste of the 3rd hazard class and its remoteness. If it is necessary to transport ash over long distances, there are additional advantages of thermal waste disposal technologies, which produce the least amount of ash. It is preferable to use gas cleaning systems that allow efficient cleaning of flue gases with minimal reagent consumption.

If it is not possible to dispose of waste of the 3rd hazard class, it is advisable to consider gasification systems with slag melting or remote devices for slag melting. It is possible to use technologies that reduce the hazard class of gas cleaning products.

6. Selection of thermal recycling technology for MSW

Thermal recovery processes can be divided into three categories (combustion, gasification and pyrolysis), which differ depending on the value of the excess air coefficient in the combustion chamber, combustion occurs in an environment with excess air, gasification is a partial oxidation process that requires an excess of air slightly below the stoichiometric level, and pyrolysis occurs in the absence of air supply.

Technologies for thermal utilization of MSW can be divided into the following types: layer combustion and fluidized bed combustion (combustion category), as well as gasification and pyrolysis. Combustion of synth gas in the recovery boiler in the scheme with gasification at high temperatures allows you to organize the melting of the ash residue in order to bind pollutants. The use of plasma gasification also allows for the melting of the ash residue.

Grate combustion technology is, according to [2], the best available technology. In General, the technologies of layer combustion and fluidized bed combustion are comparable the advantage of grate combustion technology is a lower cost of equipment and a lower volume of formation of fly ash.

In contrast to combustion on a grate, when burning in a vortex fluidized bed, 1.5-2.5 times more ash is carried away [9], the disadvantage of the technology is the need for input control of MSW supplied for thermal utilization (control of the fractional composition, glass and metal intake). The use of the vortex fluidized bed technology allows for rapid changes in the load of the boiler unit. With significant fluctuations in fuel humidity, VCS technology allows Gorenje to maintain the combustion process without reducing the efficiency of primary flue gas cleaning systems.

The experience of operation of MSZ No. 4 in Moscow has shown that for unsorted municipal solid waste, the use of VCS is impractical, and the technology of combustion in a vortex fluidized bed should be used for burning prepared MSW (for example, after sorting, crushing, or RDF) [7].

The disadvantage of the grate combustion technology in installations operating on unsorted MSW, for all its advantages, is relatively low environmental friendliness. The daily fluctuations of the composition of the unsorted MSW can lead to change of parameters of combustion in the boiler of the plant to MSW, which in turn becomes the cause of significant fluctuations of concentrations of toxic components in the DG, as a consequence, insufficient stable operation of the gas cleaning system [8]. If there are significant fluctuations in humidity, fuel underburning increases, the temperature regime of the layer is violated, and the reliability of primary flue gas cleaning systems decreases.

Pyrolysis technology is well developed, but is rarely used for economic reasons: due to the significant content of fuels in solid residues during pyrolysis, the fuel heat utilization factor is about 1.6 times lower than for conventional layer combustion [6], and due to the need for careful fuel preparation.

The technology of gasification with ash residue melting has a number of advantages associated with a low yield of waste of hazard class 3 (ash residues of combustion after the melting process are removed in the form of non-leachable glassy slag, when burning RDF, the contribution of heavy metals to the composition of ash and DG is significantly reduced). At the same time, gasification technology is expensive, and currently there are no operating industrial installations in Russia. Table 2 compares the characteristics of thermal recycling technologies for MSW.
7. Choosing a gas cleaning system

After selecting the thermal recovery technology, determining the fuel composition and the estimated composition of flue gases, taking into account the external factors of the object location, the choice of a flue gas cleaning system is made. Methods for cleaning flue gases are divided into primary and secondary. Primary methods include a number of measures aimed at reducing the formation of harmful substances in the volume of DG, secondary methods are aimed directly at removing pollutants from the DG stream. Depending on the selected structure, the flue gas treatment technology may include various methods for primary and secondary removal of harmful substances, each of which performs the function of removing a specific substance or group of substances. In General, the list of the main harmful substances in the DG and cleaning technologies is given in table 3.

**Table 3. List of main DG pollutants and gas treatment technologies**

| №  | Pollutant                  | Gas cleaning technology                                                                 |
|----|----------------------------|----------------------------------------------------------------------------------------|
| 1  | Solid particle             | Bag filters, electric filters, cyclones                                                  |
| 2  | Nitrogen oxides (NOx)      | Primary reduction methods, SNCR and SCR                                                  |
| 3  | Acid gases (SOx, HCl, HF)  | Wet, semi-dry or dry scrubbers, bag filters                                               |
| 4  | Heavy metals               | The primary methods to reduce injection of activated carbon, the removal of solid particles |
| 5  | Dioxins and furans         | Primary reduction methods, activated carbon injection, SCR, solid particle removal         |

At the stage of choosing a gas treatment technology for EC on MSW, it is required to perform a multi-factor analysis of the technological scheme of the enterprise as a whole. The concentration of DG pollutants is largely influenced by primary methods for preventing flue gas pollution, such as the selected technology for thermal waste disposal, organization of combustion processes, preliminary preparation, etc. The main risks of exceeding the MPC in various modes of operation of the EC on MSW are associated with the installation going beyond the limits of design indicators, violation of processes related to the primary prevention of harmful emissions. During dry treatment of flue gases, gaseous acidic components (HF, HCl) are adsorbed by an alkaline chemical (usually sodium carbonate, less often lime), and heavy metals, PCDD/F are removed using activated carbon. For mixing, a dry reactor is used, which ensures a uniform distribution of the adsorbent in the flue gas flow and a sufficient reaction time. Due to the
presence of reagents in dry form, the efficiency of the adsorbent reaction is quite low. To increase efficiency, adsorbent recirculation is used, however, the adsorbent consumption in general exceeds the stoichiometric ratio with a coefficient of about 2 [8], which leads to a large consumption of adsorbent and, as a result, a large ash consumption on bag filters (RF). The system is characterized by the complexity of regulating the flow of reagent to maintain the set values of concentrations of pollutants.

The main principle of the DG treatment technology by semi-dry method does not differ from the DG dry cleaning technology, the main difference is that the adsorbent is dissolved in water to produce a liquid solution. The solution is sprayed in the flue gas stream at a temperature of 200-240°C, using nozzles in a semi-dry reactor. Spraying of the reagent leads to an increase in the contact area of the adsorbent with chemicals in the composition of the DG, as well as when water evaporates, the flue gases are cooled to a temperature of 130-180 °C. In the process of semi-dry cleaning, the bag filter ash containing a large amount of reagent is recirculated, the stoichiometric ratio is usually about 1.5, and the formation of ash on the RF is reduced. The efficiency of the system for removing harmful substances from the flue gases is higher.

There is a wide variety of elements and designs for wet flue gas cleaning systems. The main principle is intensive contact between flue gases and water. The flue gases come into contact with drops of the reagent solution, the polluting components are absorbed and removed with an aqueous solution. Typically, a two-stage DG treatment is used, in which the first stage flue gases pass through a scrubber, in which water is sprayed to remove hydrogen chloride and fluoride, and the second stage is sprayed with water with alkaline additives to neutralize sulfur dioxide. During the operation of this system, lime does not enter the RF with ash, significantly reducing its volume. Wet gas cleaning system is characterized by the highest efficiency and at the same time the greatest SAREH. In a wet gas treatment system, waste water is generated that requires neutralization and additional treatment.

Bag filters are used for dedusting almost all modern thermal power plants on MSW, which is due to their high efficiency, in combination with other cleaning systems, bag filters are also used to neutralize acid gases and remove heavy metals. Cyclones and EFS are mainly used as pre-dusting units due to their relatively low efficiency (this article is not considered).

Increasing requirements for the degree of flue gas purification, reducing the level of fuel preparation lead to an increase in the cost of the technological line of the gas treatment system. A comparative analysis of the most common in the world practice of construction of thermal power plants on MSW structural schemes of gas treatment, which will be carried out in the future, will determine the optimal structure in terms of minimizing the negative impact on the environment, minimizing capital and operating costs.

### Table 4. Comparison of the most common gas cleaning technologies

| №  | Composition of the gas cleaning system                                      | Applicability                                          |
|----|--------------------------------------------------------------------------|--------------------------------------------------------|
| 1  | SNCR+Dry sorbent injection+ Bag filter                                   | RDF, industrial waste (wood, paper production).        |
| 2  | SNCR+Semi Wet System+ Bag filter                                         | RDF, prepared municipal waste, unsorted waste.         |
| 3  | Wet system+ BF + SCR                                                    | RDF, prepared municipal waste, unsorted waste.         |
| 4  | Electrostatic precipitator + Wet system + Bag filter + SCR               | RDF, prepared municipal waste, unsorted waste.         |

8. **Conclusions**

Thermal waste disposal is a technically complex and expensive process (specific capital costs are about 300-800 euros / ton of waste per year [10]). Meeting the high environmental
requirements for ECS that utilize MSW in a constantly changing fuel composition is a difficult task. In the conditions of the modern Russian market of heat and electric energy, without attracting subsidies from the state, or complex schemes for returning investment to investors, the use of EC on MSW can not be competitive and payback. The cost of construction of condensing power units for MSW reaches 5500-6500 $/kW.

When drawing up a waste management scheme for cities and regions, it is recommended to use a scheme with the maximum use of secondary raw materials from waste and thermal utilization only of residues that are not subject to recycling, from which the fractions containing the largest amount of pollutants (RDF fuel) are extracted. The scheme with the use of deep recovery of secondary raw materials will simplify the structure of TPP on MSW, reduce capital and operating costs, and most importantly reduce emissions of harmful substances into the atmosphere with flue gases, ash and slag.

Due to the peculiarities of EC operation at MSW and the low power of the facility for energy release (400-700 kW of EE/ton or 2000-2800 kW of heat/ton), at the feasibility study stage, it is advisable to consider the option of placing a complex for thermal waste disposal in the structure of an existing energy enterprise, which will ensure a reduction in capital costs, the necessary equipment loading during operation.

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