Construction of waste incineration thermal power plants for a comprehensive solution to the problems of solid waste disposal in the Irkutsk region

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Abstract. Proposed is a method of processing and recycling solid household wastes (SHW) by combustion in boiler furnaces together with irring - Borodin coal. The technology of preliminary sorting with the list of necessary equipment and works is presented. Thermal calculations of the boiler were performed BBP-420-140-6 on combined combustion of SHW and coal in different ratios. Technological solution is proposed, which allows to dispose of sorted solid household wastes during combustion in furnaces together with coal in different ratios.

1. Introduction
In the age of industrialization and mass consumption of raw materials, one of the major problems is the issue of generation and accumulation of garbage, as well as the search for methods of its disposal. The situation in the Russian Federation and the Irkutsk region in the field of education, use, decontamination, storage and disposal of waste leads to negative pollution of the environment, unsustainable use of natural resources, significant economic damage and poses a real threat to the health of the population of the Russian Federation.

According to statistics, the Irkutsk region is ranked ninth in the Russian Federation and third in the Siberian Federal District by the number of SHW formed. The volume of waste is 2.5% of the same indicator for the Russian Federation. In terms of the volume of processing and disposal of garbage the region occupies one of the last revenge. If in the country this indicator is 60%, in the Irkutsk region so far 27.7%. Some of the waste can be processed to produce secondary products. However, solid household waste (SHW) is also generated, with no applications that can be an affordable and cost-effective renewable energy resource. Unlike natural fossil resources, whose location is independent of man, solid household wastes are formed where electrical and thermal energy are most needed, i.e. in large cities. Also important is the fact that SHW is independent of different climatic and geographical factors, unlike other secondary and renewable sources of energy.

Given the characteristics of our region and the world experience in the field of processing and recycling of SHW, one of the directions today is the joint burning of SHW and fossil fuels in powerful energy boilers. It should be noted that in the construction and operation of thermal electric stations (TES), SHW not only generates and usefully uses electric and thermal energy, but also solves an important social task - waste landfills are eliminated, polluting the environment and removing huge areas from the sphere of useful use.
2. Materials and methods
The existing SHW disposal system in the Russian Federation is based on the disposal of the vast majority of waste (about 98%) at landfills and unorganized landfills. This situation has a negative impact on the state of the natural environment and the sanitary and epidemiological situation both in the country as a whole and in the vicinity of major cities in particular. Existing polygons built decades ago are almost completely filled. Therefore, many large cities, megacities and agglomeration systems of settlements face a "garbage collapse" with a projected social explosion. The Irkutsk region is no exception. Figure 1 shows a map of landfills in the Irkutsk district.

![Map of landfills in the Irkutsk region](image)

**Figure 1.** Map of landfills in the Irkutsk region

The paper offers a comprehensive solution to the problem of solid waste disposal, which consists of several stages: preliminary sorting of solid waste with the selection of secondary raw materials; drying, grinding of sorted solid waste; burning of solid waste together with coal in the furnace of an energy boiler. At the same time, the technology of direct combustion of solid waste, the implementation of thermal methods for burning 1000 kg of solid waste will allow you to get thermal energy equivalent to burning 250 kg of fuel oil. However, the real savings will be greater, since the fact of preserving primary raw materials and the costs of its production are not taken into account.

The proposed technological scheme for generating heat and electricity in combination with a thermal power plant (reconstruction of an existing thermal power plant) is shown in figure 2.
Figure 2. TES burning solid waste with a capacity of 150-380 thousand tons.

Pre-sorting involves separating solid waste into fractions at waste processing plants manually or using automated conveyors. This includes the process of reducing the size of garbage components by grinding and sifting them, as well as extracting larger or smaller metal items, such as cans. Selecting them as the most valuable secondary raw materials precedes further disposal of solid waste. To implement pre-sorting of garbage, the following equipment: sorting cabin area of 140 m², equipped with 20 work stations for sorting, 16 kinds of products [10]; frameless hangar, with an area of 427 m² (28.5x15 m), where the domestic premises on the basis of two sea containers with an area of 62 m², which houses changing rooms with showers and toilets, an office, recreation room workers; landscaping an area of 165 m² (137 road plates 6x2 m and the cage from the scattering of debris); construction of a frameless sorting building that does not require "serious" foundations on "standard" soils.

The estimated estimated cost, according to the calculations received, is about 30 million rubles. Of these, 10 million 404 400 rubles – the total price of the equipment (crane departures 9.7 m EPSILON100L97, specialized and/or KAMAZ-6520 with Multift bunker under cullet V=20 m³, feed conveyor and sorting conveyor, compactor and more), the rest of the cost of machinery and vehicles.

The paper calculates the main technical and economic indicators of a thermal power plant with a capacity of 380 thousand tons per year using solid waste operating independently (option 1) and in conjunction with an energy thermal power plant (option 2). The results are presented in table 1.

| №  | Name of the indicator                                      | Option 1 | Option 2 |
|----|-----------------------------------------------------------|----------|----------|
| 1  | Cost of equipment, mln. RUB.                             | 2600     | 2230     |
| 2  | Cost of construction and installation works, mln. RUB.    | 1000     | 860      |
| 3  | Cost of project work, mln. RUB.                          | 415      | 360      |
| 4  | Cost of commissioning, mln. RUB.                         | 215      | 175      |
| 5  | Total capital expenditures, mln. RUB.                    | 4230     | 3625     |
| 6  | Specific capital expenditures, million rubles per 1 Megawatt | 170     | 98       |
| 7  | The cost of disposal of solid household waste, RUB/tons   | 1200     | 1020     |
| 8  | Cost of electricity generation, RUB / kWh at:            |          |          |
|    | $Q_{h} = 1300$ kcal / kg                                  | 1.44     | 0.86     |
|    | $Q_{d} = 2000$ kcal / kg                                  | 0.89     | 0.48     |
The considered option of disposal of solid waste after sorting when burning in the furnaces of power boilers of TES, will reduce fuel costs and, consequently, the cost of energy produced [11].

3. Results

It should be noted that for reliable combustion of solid waste together with coal in boilers (in particular BBP-420-140-6), it is necessary to provide for their pre-drying and grinding separately from the fuel preparation path of the TES. BBP boiler layout-420-140-6 it is made according to the P-shaped scheme and designed for operation in seismic areas [12].

In order to choose the optimal ratio of Irsha-Borodinskiy brown coal and SHW, several variants of the composition of the solid fuel and SHW mixture were calculated. The main calculated parameters are shown in table 2.

| Name of the value | Irsha-Borodinskiy brown coal | 10% SHW and 90% of coal | 20% SHW and 80% of coal | 30% SYM and 70% of coal |
|-------------------|-----------------------------|------------------------|------------------------|------------------------|
| the efficiency of the boiler, % | 92,97 | 92,853 | 92,687 | 92,55 |
| Total fuel consumption, kg / s | 20,17 | 20,88 | 21,66 | 22,49 |
| Estimated fuel consumption, kg / s | 20,11 | 20,82 | 21,6 | 22,43 |
| Exhaust gas temperature, °C | 147 | 148 | 150 | 151 |
| Temperature of gases at the outlet of the furnace, °C | 1063 | 1063 | 1063 | 1062 |
| The quantity of exhaust gases, kg / h | 660612,3 | 668720,9 | 678711,4 | 688070,9 |

The optimal ratio is proposed: 10% of solid waste and 90% of Irsha-Borodinskiy coal.

To increase the efficiency of a thermal power plant using solid waste operating independently, it is necessary to provide for an increase in steam parameters (above 420 °C). This will be achieved by using corrosion-resistant steels and protective coatings; using intermediate superheated steam: the steam at the exit of the high-pressure stage of the turbine is sent back to the boiler, where it is heated to the initial temperature, then enters the pressure stage; using external superheating on heat exchange surfaces heated by the combustion products of organic fuel.

The combination of a Thermal power station using Solid household waste with traditional thermal power plants and CCGTs will allow:
- increase the efficiency of power generation, in relation to waste processing, from about 20 % to 30-35 % and thereby increase the installed capacity;
- to minimize the cost of construction and installation works;
- to save fossil fuels.

4 Discussions

Thermal utilization of sorted SHW with the release of heat and electricity to the urban consumer is a more preferable option than generating the same amount of energy at a conventional thermal power plant plus processing, and even more so, disposal, of an equivalent amount of waste [22]. That is why it will be more efficient to use sorted SHW as fuel together with coal. In addition, the analysis of the waste composition showed that 35 tons of 100 tons of solid waste will be recycled. During sorting, hazardous waste is also removed, which will be sent to recycling companies.
An important issue that requires a separate serious study is the issue of the formation of pollutants into the environment, as well as the development of technologies for their disposal. Table 3 shows the regulatory emissions of pollutants from outgoing gases of power plants that burn solid municipal waste and organic fuel.

Table 3. Some regulatory emissions of pollutants from outgoing gases of power plants that burn solid municipal waste and organic fuel

| Energy technology installations that burn solid waste (EU 94/67/EEC) | Power plants for burning solid fuels (GOST 50831-95) |
|---------------------------------------------------------------|--------------------------------------------------|
| Daily average | Average half-hours | α=1.4 | in recalculation on α=2 |
| Solid particle | 10 | 30 | 150-250 | 100-165 |
| Carbon monoxide, CO | 50 | 100 | 300-400 | 200-260 |
| Nitrogen oxides, NO2 | 200 | 400 | 300-640 | 200-420 |
| Sulfur oxides, SO2 | 50 | 200 | 1200-1400 | 800-920 |
| Hydrogen chloride, HCL | 10 | 60 | not normalized | not normalized |
| Hydrogen fluoride, HF | 1 | 4 | not normalized | not normalized |

Given that at the moment, most thermal power plants that use coal and solid waste as fuel have a negative impact on the environment, which is unacceptable in many cases today, and even more so in the future. Therefore, promising energy technologies and equipment should be developed in such a way that their impact is minimal and meets modern and planned sanitary standards. Meeting these requirements by economically justified means is very difficult. To overcome them, a balanced concept of creating large environmentally friendly power plants that run on low-grade coal is necessary.

In this paper, the calculation of harmful emissions into the environment is performed, the results of which are presented in table 4.

Table 4. Comparative calculation of emissions of pollutants into the atmosphere

| | Irsha-Borodinskiy brown coal | 10% SHW and 90% of coal |
|----------------|-----------------------------|-------------------------|
| Ash particles | 480,98 tons / year | 520,54 tons / year |
| Sulfur oxides | 1415,93 tons / year | 1465,78 tons / year |
| Nitrogen oxide | 1281,82 tons / year | 1274,38 tons / year |
| Benzo(a)pyrene | 0,56 tons / year | 0,546 tons / year |

From the calculations carried out, it can be seen that when solid waste is burned together with coal, emissions of Benzo(a)pyrene and nitrogen oxide into the atmosphere are reduced through the use of reagent technologies. However, this increases the number of emissions of ash particles and sulfur oxides.

5 Conclusions
In this work, we selected one of the most effective and appropriate methods for processing and disposing of SHW in our region – burning pre-sorted SHW together with Irsha-Borodinskiy coal. The paper presents a pre-sorting technology with a list of necessary equipment and works. Thermal calculations of the BBP boiler unit were made-420-140-6 on Irsha-Borodinskiy coal and on the joint combustion of solid waste and coal in different ratios. The optimal ratio is proposed: 10% of solid waste and 90% of Irsha-Borodinskiy coal. A comparative calculation was performed for various fuel combustion technologies.

Thus, the study showed that the development and implementation of this technological project requires significant capital investment at all stages of the life cycle of this type of production, and this, in turn, should be accompanied by a thorough technical and economic justification of innovations with the determination of the economic effect of the project, as well as competent environmental proposals.
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