

Current State of Waste Management in Tajikistan and Potential for a Waste-to-Energy Plant in Khujand City

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EXECUTIVE SUMMARY

The objectives of this study were:

- Examine the current state of waste management in Tajikistan, in particular in Khujand city.
- On the basis of the obtained information propose methods for increasing recycling and composting in Khujand.
- Conduct a very preliminary feasibility study of the potential for implementing a waste-to-energy plant in Khujand for recovering electricity and heat, by combusting the post-recycling fraction of the Khujand municipal solid wastes.

Waste management is one of the main environmental problems in Tajikistan and it includes waste from industry, mining, households, medical, and other wastes. The average waste generation per capita is 0.89 kg per day. [1] Annually, about 1,7-2 million tons of municipal solid waste (MSW) is generated nationwide. [5]

The current waste management system in Tajikistan relies heavily on landfilling and it faces several problems, such as lack of landfill space, small amount of recycling and composting measures, and other related environmental problems.

Municipal solid waste is neither sorted nor treated in the country. Because of trucks and fuels shortage, the collection of municipal solid waste is poor in urban areas, where there is almost no municipal waste service.

There are 70 official MSW landfills in Tajikistan, which hold about 12 million tons of waste and cover 296 ha. [5] None of the landfills meet current international standards.

Systems providing municipal services in Tajikistan:

- National state enterprises, that are part of the State Unitary Enterprise (SUE; Khojagii Manziliyu Kommunalii (KMK)).
- Public and private enterprises subjected to local administrations of state executive power.

Khujand is the second largest city of Tajikistan and is located in the northern part of the country in the province of Sughd. It has a population of 160,000 inhabitants (2011). [5] The total registered solid waste disposal in Khujand is 51,974 tons per year and it is expected to increase up to 103,000 tons by 2026.[5]

Systems providing municipal services in Khujand:

- State Enterprise “Motor Pool” – solid waste collection and disposal services
- State Enterprise “Roads Operation” – municipal roads maintenance and repair
- State Enterprise “Housing Facilities Maintenance” at the left and right banks – maintenance and operation of multi apartment buildings, which are located in the city
- Landscape gardening trust company – green planting in public places
- Municipal lighting enterprise
- Main department for “Repair and maintenance services of fountains”
- State Communal Unitary Enterprise “Khujandvodokanal” – urban sewerage and water services in the City

The Motor Pool was established in Khujand City in 1975 and it has the following main tasks:

- Solid waste disposal
- Liquid waste disposal
- Snow cleaning from central streets of the
- Watering of public places
- Capturing/shooting of homeless animals
- Household waste utilization and disinfection

No health and safety training is taking place at Motor Pool. At the waste management utility, no recruitment policy is in place and no real contracts are in place. Waste collection efficiency is low, due to the time consuming manual loading and inefficient load volume of the most trucks and tractors.

Collected waste by Motor Pool is usually transported to the city dumpsite, which is located in the North of the town. The dumpsite is situated 4 km Northeast of town and 17 km away from Motor Pool. The area of the dumpsite is 20 hectares. ^[5] Waste disposal at landfill is taking place about 20 years. ^[5]

In Khujand city there is an essential potential for sorting out of recyclables. Waste composition of the city shows essential potentials in separate treatment of recyclables, such as plastic waste, green waste, paper and textile waste, metal waste and rubber waste (truck tires).

Currently, official waste collection and disposal practice does not include any waste separation. But there is a running informal system, which is organized by the City and Waste Management Enterprise.

Usually, solid waste is not separated in town and informal waste pickers pick out plastic and metal components at the dumpsite. They sell plastic waste to

plastic collection points in the city. Further, these points sell it to plastic producing companies.

In order to reduce landfilling, Khujand city should be provided with a waste management system that is based primarily on source separation. Households in Khujand city should be provided with four bins:

- Garden and kitchen waste
- Paper and cardboard
- Hazardous materials, batteries, paint, oil etc.
- Residual waste

The second main step of waste reduction and saving the landfills areas is realization of a waste-to-energy plant in Khujand. The waste generation in Khujand is 51,974 tons per year and 142 tons per day. ^[5] Based on this information, it is possible to build in Khujand a WTE plant based on the Energos grate combustion and gasification technology.

By using the Energos technology, we can provide Khujand city with an economically efficient alternative to conventional grate combustion with equally low emissions to the atmosphere and flexibility in feedstock. The Energos technology ranges in capacity from 30 tons/day per unit to 118 tons/day per unit. These low capacity facilities can be build at a capital cost per ton, which is lower than large mass burn WTE facilities and require a small footprint of less than one hectare. ^[21] The construction of small scale WTE plant is beneficial, because it avoids the environmental and economic impacts connected with the long waste transfer distance. Using the Energos grate combustion and gasification technology, we can build a plant with combined heat and power (CHP) system. During periods of low heat demand, steam can be used to produce electricity and then this produced electricity can be sold to the grid and used by local consumers.

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1 INTRODUCTION

Municipal solid waste (MSW) consists of all types of wastes discarded by citizens and collected and disposed in some way by municipalities. It covers waste from households, office buildings, small businesses and institutions, yard and garden, street sweeping, markets, and litter containers.

Solid waste management is one of the most important municipal services that every city government provides for its residents. The generation of municipal solid waste is a by-product of urban life and is growing even faster than the rate of urbanization, because it is also related to economic development and increase of the gross domestic product (GDP) of a nation. According to the World Bank's "Global Review of solid waste management - What a waste", ten years ago there were 2.9 billion urban residents worldwide who generated about 0.64 kg of MSW per person per day, i.e., 0.68 billion tons per year. Today, there is an urban population of about 3 billion generating 1.2 kg per person per day (1.3 billion tons per year). The urban MSW generation is expected to increase to 2.2 billion tons per year by 2025. ^[1]

In lower income countries, the rates of waste generation will be more than double over the next twenty years. Globally, the costs of solid waste management will increase from today's annual \$205 billion to \$376 billion in 2025. ^[1] The predominant method of MSW disposal globally is landfilling which is a large source of methane emissions to the atmosphere. Uncollected solid waste contributes to air pollution, occasional flooding, and public health impacts such as diarrhea, dengue fever and respiratory ailments. Solid waste management is a city's single largest budgetary item, in lower income countries.

As global solid waste quantities are growing rapidly, it is necessary for all nations to protect the Earth from pollution and to manage their MSW so as to ensure a safe and healthy environment. Figure 1 shows the preferred hierarchy of different ways for managing MSW:

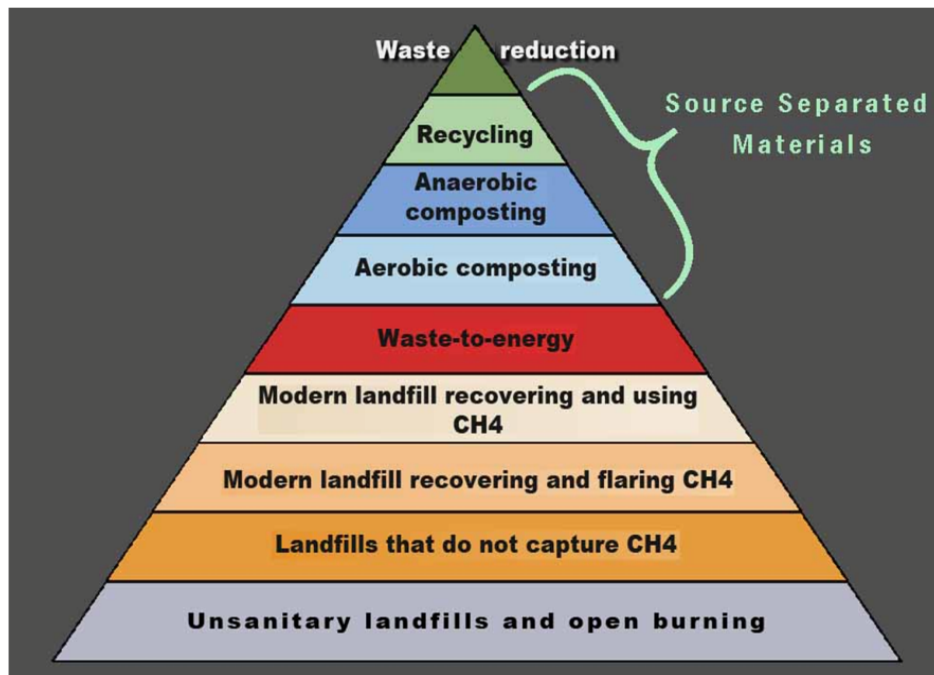


Figure 1: The Waste Management Hierarchy ^[2]

- **Waste reduction:** Initiatives of waste reduction seek to reduce the quantity of waste at generation points by redesigning products. It includes prevention, minimization, and reuse
- **Recycling and materials recovery:** Return of materials to the economy and reduced quantities of disposed waste are the key advantages of recycling and recovery. Informal waste pickers at disposal sites and collection points recover a significant portion of discards in many developing countries. There are five categories of recyclable waste in Tajikistan: paper, plastics, metal, glass and fabrics
- **Aerobic and anaerobic composting:** Composting of organic waste, either aerobically or anaerobically
- **Waste-to-energy:** Incineration of waste with energy recovery can reduce the disposed waste volume by up to 90%. Incineration without energy recovery is not preferred option because of its costs and pollution. Open-burning of waste is discouraged, because of severe air pollution. Waste-to-energy facilities have a number of environmental benefits such as its net GHG emissions are usually low and comparable to those from biomass energy systems. Another advantage of the WTE over landfilling is it reduces the waste volume and its mass and recovers the energy and heat from wastes. Also, WTE plant continuously serves future generations for many years, while sanitary landfill is filled in 10-20 years ^[3]

- **Landfill:** Landfills are a final disposal site for waste and should be operated to protect the public health and environment. Usually, landfilling progresses from the worst type of open dumping controlled dumping, controlled landfilling, to sanitary landfilling.

The main landfill disadvantages are:

- Greenfields are forever converted to garbage cemeteries
- The methane generated from uncontrolled landfills makes an important contribution to GHG and climate change
- Burying a ton of MSW is equivalent to wasting a barrel of oil, which is equivalent to 600 kWh of electricity per ton of landfilled MSW ^[3]

Tajikistan is a landlocked and mostly agricultural country in Central Asia. Ninety-three percent of Tajikistan's territory is mountainous. Tajikistan has energy sources and minerals, such as oil and coal, gold, silver, aluminum, uranium, and others. The capital and largest city of Tajikistan is Dushanbe (679,400 pop. in 2008) ^[4] and the second largest Khujand (160,000 pop. in 2011). ^[5]

The main important indicators of Tajikistan are shown in Table 1.

Table 1: Land Area, Population, and Economic Indicators of Tajikistan ^[6]

Total area (sq. km)	Population (millions)	Population growth rate (%)	GDP (PPP/billion \$)	GDP Per capita/\$	Gross national saving, %	Population below poverty line, %
143,100	8	1.75	19.2	2,300	12.4	35.6

2 COUNTRY PROFILE

2.1 Geography, Climate and Sources of GDP

Tajikistan is a mountainous country with 72 peaks over 6000 meters high. [7] Ninety-three percent of Tajikistan's land area is mountainous. The country borders Afghanistan to the south (1,206 km), Uzbekistan to the west (1,161), Kyrgyzstan to the north (870 km), and China to the east (414 km). [8] Its population is 8 million (July 2014 est.), and the average population density 51.6 persons per km². [9] Tajikistan's primary sources of revenue are aluminum production (216,400 tons in 2013), [10] electricity (17.1 billion kWh in 2013) [11] and cotton (392,000 tons in 2013). [12] About 80% of Tajikistan's total export earnings are derived from cotton and aluminum. [7] The state-owned Tajik Aluminum Company operates the largest aluminum plant in Central Asia and one of the largest in the world (plant capacity: 517,000 tons). [13] Hydropower provides 50% of the country's energy needs and 95% of its electricity consumption. [7] Tajikistan has energy sources and minerals such as oil and coal, gold, silver, aluminum, uranium, lead, zinc, copper, bismuth, molybdenum, iron, spat, salt and others. The capital and largest city of Tajikistan is Dushanbe (679,400 people, 2008) [14] and the second largest city is Khujand (160,000 people, 2011). [5]



Figure 2: Map of Tajikistan

Over 400 deposits of mineral resources have been found in Tajikistan. [15] Zerafshan, Tajik-British joint venture extracts gold at deposits Taror, Jilau and others in the Soghd region. Darvoz, another Tajik-British joint venture extracts gold in Khatlon region. According information of Academy of Science of Republic of Tajikistan 28 deposits of gold have been discovered in territory of Tajikistan, with total volume 429.3 tons of gold. [15] The world's second large deposit of silver is the Bolshoi Konimansur is situated in the north of Tajikistan. The

deposit will last for 50 years with annual extraction of 50 tons of silver. [15] In the north of Tajikistan there are many deposits of construction and decorative materials such as marble, limestone, granite, volcanic tuff and mineral springs. The coal extraction of important deposits of coal at Kshtut-Zauran and Fan-Yagnob would last for 200 years. [15] Deposits of strontium have been found in Khatlon region. The south of the republic – the Khoja Mumin, Tanabchi, Khoja-Sartez and Samanchi deposits contain billion tons of salt. The largest rivers of Tajikistan are the Syr Darya (2,400 km), the Amy Darya, the Vakhsh, the Zeravshan, and the Kofarnihon. [7] Vakhsh is the most important source of hydropower. Tajikistan has over 1,000 lakes, 80% of which are more than 3,000 m above the sea level. [7] Most of them are in the eastern Pamir region. The largest lake is the salt water Lake Karakul (380 km²), in the north-east of the country and the deepest freshwater lake is Sarez (490 m deep), in the western Pamirs. [7]

Climate and the Average Weather of Tajikistan

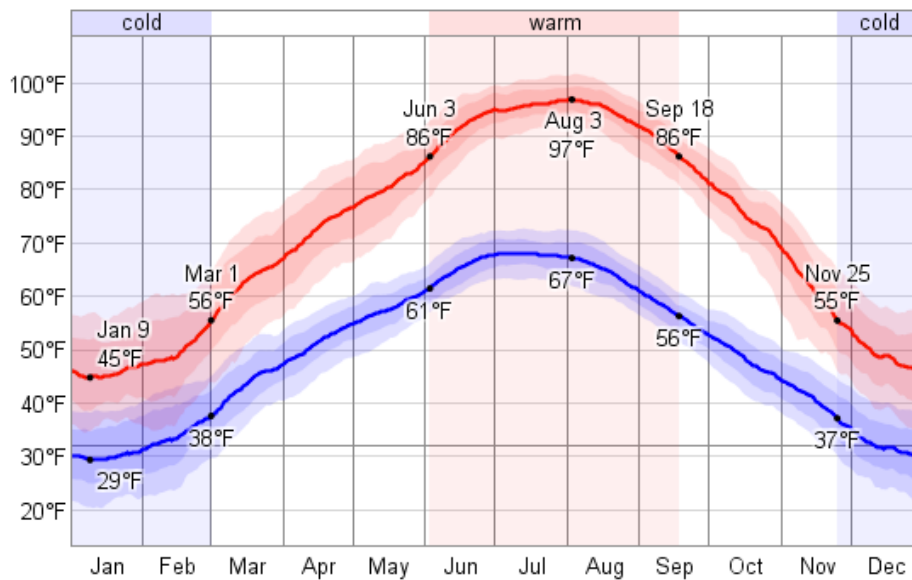


Figure 3: Daily High and Low Temperatures During the Year [16]

— High temperature — Low temperature

Figure 3 shows that the warm season in Tajikistan is from June 3 to September 18. The average daily high temperature is 86°F. August 3 is the hottest day of the year with the average high temperature of 97°F and low temperature of 67°F. The cold season in our country is from November 25 to March 1. The average daily high temperature is 55°F. January 10 is the coldest day of the year with the average high temperature of 45°F and low temperature of 29°F. The lowest air temperature of -81°F is observed in the Eastern Pamirs, and the highest air temperature of 116°F. [17]

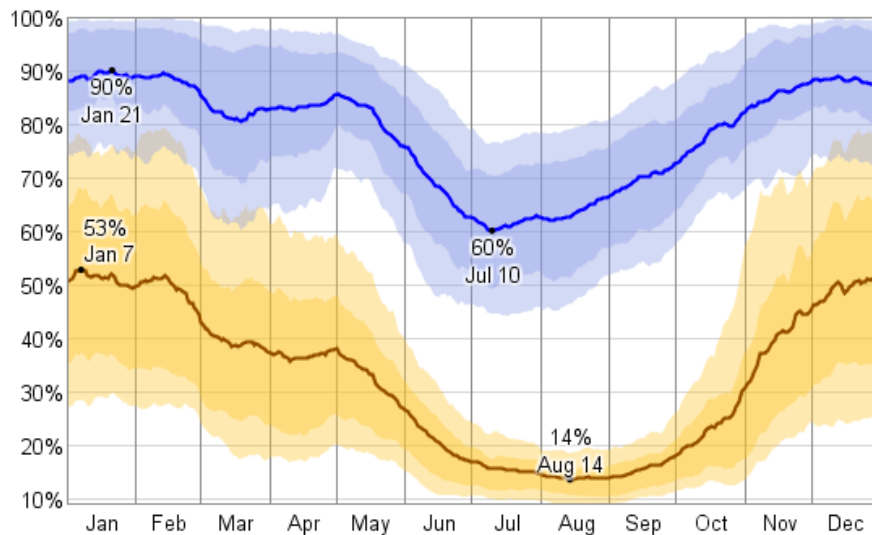


Figure 4: Relative Humidity ^[16]

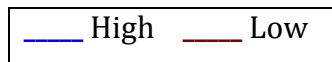


Figure 4 shows that, over the year, the relative humidity in Tajikistan ranges from 14% (very dry) to 90% (very humid), rarely dropping below 9% (very dry) and reaching 100% (very humid). Around August 14 the air is driest. The relative humidity drops below 16 (dry) three days. Around January 21 the air is most humid. The relative humidity reaches above 85% (very humid) three days.

In general, the Tajikistan climate is continental, subtropical, and semi-arid, with some desert areas. The average annual numbers of sunshine hours are 2,097 to 3,166 hours. ^[18] The average precipitation ranges between 700 and 1,600 millimeters (27.5 and 63 inches). ^[19] The heaviest precipitation falls are at the Fedchenko Glacier. The average precipitation over there is 2,236 millimeters (88 inches) per year. ^[19] The lightest precipitation is in the eastern Pamirs, which average less than 100 millimeters (3.9 inches) per year. ^[19] Precipitation occurs mostly in the winter and spring.

The major environmental problems of the country are high air pollution caused by industry and motor vehicles, water pollution from untreated industrial waste and agricultural runoff, concentration of agricultural chemicals and salts in the soil, soil erosion, poor management of water resources and poor solid waste management. Dust and sand from the deserts of Uzbekistan and Turkmenistan cause air pollution across southwestern region in summer. Climate change like in the whole world is observed in Tajikistan. For the last 65 years, the average annual air temperature has increased by 3.2-3.3°F in the mountainous areas, by 33-34°F in the broad valleys, and by 34-35°F in cities. Tajikistan has enormous reserves of hydropower resources (527 billion kWh per year). ^[17]

Table 2: GDP Composition by Sector in 2012 and 2013 (Percent of Total GDP)

Sector	Year	
	2012, (%) ^[6]	2013, (%) ^[20]
Industry	25	23.2
Agriculture	25.6	21.1
Services	49.3	55.7

2.2 Air Quality Management

Over the past decade, air quality has improved, both in urban and rural areas. In 2003 approximately 119,000 tons of harmful substances were emitted into the atmosphere. ^[7] Energy and industry were responsible for 34,000 tons and mobile sources for 85,000 tons. ^[7] The main stationary sources of air pollution in Tajikistan are chemical industries, building, light industries, heat and power plants, agriculture, mining metallurgy, and mechanical processing.

- **Industry** is the biggest stationary polluter. Tajik aluminum plant, Tajik cement plant, Isfara metallurgical plant, Vakhsh nitrogen-fertilizer plant, Yavan chemical plant, mining enterprises, Dushanbe refrigerator plant, and Dushanbe steel factory are the large stationary sources of atmospheric air pollution. The Tajik aluminum plant accounts for 60-70% of all emissions from stationary sources. ^[7]
- **Power generation** is the second largest polluter. The number of thermal power stations, including diesel stations fell from 568 in 1990 to 49 in 2000. ^[7] Tajikistan has two thermal power plants: one in Dushanbe with capacity of 198 MW and the other in Yavan with capacity of 120 MW, which is closed since 1988. ^[7]
- **Transport** is the main mobile source of air pollution in Tajikistan. Transport's share in air pollution has increased, because the number of cars has grown rapidly. Because of poor fuel quality, the average fuel consumption and emissions are high.

The Tajik railways, the Tajik aluminum plant, and the Dushanbe "Pamir" refrigerator plant are the main generators of ozone-depleting substances. They use methyl chloroform (CH₃CCl₃), chlorofluorocarbons (CFCs), methyl bromide (CH₃Br), and hydrochlorofluorocarbons (HCFCs). ^[7] The storms that bring dust,

salt and sand from the drained Aral Sea are another source of pollution. The country also suffers from desert storms that carry sand from Afghanistan.

Currently, there are only four monitoring stations measuring pollutants in Tajikistan. Three stations are in Dushanbe and one station is in Kurgan-Tyube. They measure air pollution three times a day during peak hours except on Sunday. Stations in Dushanbe measure concentrations of sulphur dioxide, nitrogen dioxide, formaldehyde, carbon monoxide, sulphate, ammonia, and hydrogen sulphide (H₂S). Station in Kurgan-Tyube measures only concentrations of ammonia, sulphur dioxide, nitrogen dioxide, and carbon monoxide. [7] Polluting industries, enterprises, organizations, and other legal entities report annually their emissions to State committees.

2.3 Waste Management

Municipal solid waste consists of food waste, green waste, cardboard and paper, textiles, wood, rubber and leather, nappies, metal, plastics, glass and others. The management of MSW is the responsibility of local government and is often the largest budget item. Uncollected solid waste is the main contributor to local flooding, soil, and water pollution. Municipal solid waste requires a strong social contract between the citizens and the municipality.

The per capita generation of MSW varies from city to city. Waste generation rates are higher in urban areas. Rural areas have lower waste generation rates, because on average, rural area residents are less affluent, have higher levels of recycling and reuse, compost, and purchase fewer items from stores.

Waste management is one of the main environmental problems in Tajikistan and includes waste from industry, mining, households, medicine, and other municipal sources.

3 WASTE GENERATION AND DISPOSAL

Annually, about 3.5-4 million m³ of municipal solid waste (MSW) is generated nationwide, corresponding to an estimated 1,7-2 million tons. [7] In Dushanbe about 1,200,000 m³ of municipal waste is generated annually, which is about 218,000 tons and only about 50% of that is dumped at official, regulated landfills. [7] The rest of waste goes to illegal landfills. MSW in Tajikistan consists of components, such as kitchen waste and food scraps, leather and resins, plastics, metals, paper and cardboard, glass and ceramics, leaves and ash. Municipal solid waste is neither sorted nor treated in the country. Because of trucks and fuels shortage, the collection of municipal solid waste is poor in urban areas, where there is almost no municipal waste service. Waste is disposed

illegally in the countryside and in parts of the cities. There are 70 official MSW landfills nationwide, which hold about 12 million tons of waste and cover 296 ha. Therefore the average current deposition in these landfills is calculated to be 4 tons MSW per square meter. [7]

None of the landfills meet current international standards. Their current regulations need to be revised in order to improve the existing landfills. In Dushanbe, there are some small facilities for recycling waste paper to produce tissue paper. Reuse or recycle of industrial waste is one way to save natural resources and to protect the environment. However, at the present time, it is less costly for enterprises to pay for disposing their wastes rather than fund the development of new-low waste processes, thus reducing the amount of industrial waste.

Medical waste accounts for 5-7% of municipal waste [7] and in contrast to the practice in developed nations it is dumped together with municipal waste in municipal landfills. There is not any environmentally appropriate disposal for medical waste or any facilities for its incineration.

3.1 Integrated Waste Management

Integrated waste management is a strategic approach that covers all sources of waste generation, segregation, transfer, sorting, treatment, recovery and disposal in a comprehensive manner, with an emphasis on maximizing resource use efficiency.

Components of an integrated solid waste management plan are:

- Data on waste quantification and characterization with future trends and data on prevailing waste management systems and gaps therein.
- Monitoring and feedback mechanism.
- A list of goals to be achieved through integrated solid waste management system.
- Implementation aspects as institutional requirements, time schedules, costs, and etc.
- All municipal policies, objectives, initiatives, and aims related to waste management.
- The scale and character of the city, climate, development and natural conditions.
- Waste generation data for recent years and projections for 15-25 years. [7]
- The role of municipal solid waste in the city's urban metabolism and GHG emissions assessment.

The waste management plan encompasses:

- **Stakeholders:** individuals or groups, who have roles or an interest in proposed project. All stakeholders should be involved in creating a solid waste management program.
- **Process elements:** technical aspects of solid wastes management. All stakeholders impact one or more of the elements. When creating a solid waste management program the elements need to be considered in order to have an efficient system.
- **Policies and impacts:** regulatory, financial and environmental realities where the waste management system operates.

There are three key system elements in integrated sustainable waste management:

- **Public health:** public health concerns are the basis for solid waste management programs. Not properly collected and disposed solid waste can be a breeding ground for vermin and insects, and can pass on water and air-borne diseases.
- **Environmental protection:** improperly disposed or poorly collected waste can have a harmful impact on the environment. In low and middle-income countries municipal solid waste is mostly dumped in low-lying areas.
- **Resource management:** municipal solid waste can represent significant potential resource. Nowadays, the global market for recyclables has increased significantly. Producing new products with secondary materials can save considerable energy. For instance, in order to produce aluminum from recycled aluminum 95% less energy requires than producing it from virgin materials. ^[1]

3.2 Policy, Legal and Institutional Framework

The Tajikistan law on Waste Production and Consumption Management was adopted in 2002. ^[7] This law defines types of waste and technological processes for its disposal and use. It also promotes recycling, separation of valuable components from waste and waste minimization. The State Committee for Environmental Protection and Forestry is responsible for overall waste management of the country. The State Land and Waste Inspectorate develops

regulations, standards and norms, spends inspections for the Law implementation on Waste Production and Consumption. [7] In each city, the municipal and housing services are responsible for waste collection and disposal.

3.3 Regulatory Framework of Tajikistan

In Tajikistan there are two main systems of providing municipal services:

- National state enterprises, that are part of the State Unitary Enterprise (SUE; Khojagii Manziliyu Kommunalii (KMK))
- Public and private enterprises subjected to local administrations of state executive power

The majority of enterprises that provide municipal services in districts and cities of Tajikistan are part of the State Unitary Enterprise Khojagii Manziliyu Kommunalii with more than 180 utilities in total. [5] Only eight cities (Dushanbe, Khujand, Chkalovsk, Kayrokkum, Rogun, Sarband, Nurek and Varzob) have service providers under municipal administrations. However, the solid waste management of the city of Khujand is managed through the Khujand City Administration, not through the State Unitary Enterprise Khojagii Manziliyu Kommunalii.

- **Law “On privatization of state property in the Republic of Tajikistan”, March 2009, 497;** [5] The law dictates that enterprises on disposal of radioactive waste cannot be privatized while other types of waste management activities can be privatized.
- **Law “On licensing of separate types of activities”, December 2010, 662;** [5] – article 17 regulates, that activities such as management of hazardous waste, radioactive waste and wastes, that destroy the ozone layer should be licensed by authorized state structure, which is responsible for environmental protection under certain circumstances.
- **Law “On Environmental Protection”, July 2004, “LEP”** [5] – this law regulates that solid waste disposal requires a license and sets out the local authorities competencies. Article 53 regulates, that local organizations, private industries, local authorities, institutions and citizens are obliged to observe sanitary and ecological rules in the waste handling.
- **Law “On Ecological Expertise”, January 2010, 589** [5] – this law regulates conducting and organization of ecological expertise as part of the license, defines concrete obligation and rights for concerned sites. It

also establishes the citizens' rights on receiving of information about potential harm of different types of activities on the environment.

- **Law “On Population Sanitary-Epidemiological Safety Organization”, December 2008, 48** ^[5] – the law determines the regulatory role of the government in providing sanitary-epidemiological safety and it also determines structure and organization of sanitary-epidemiological monitoring and requires that waste management activities, such as industrial waste collection and disposal are subject to sanitary-epidemiological monitoring.

4 CASE STUDY: THE CITY OF KHUJAND

Khujand is the second largest city of Tajikistan and is located in the northern part of the country in the province of Sughd. It has a population of 160,000 inhabitants (2011). ^[5] Chkalovsk, Kayrakkum and Gafurov are towns and surrounding districts. Khujand is an important transportation hub. It is also scientific, cultural, economic and political center of the country. It is located on the banks of Syr Darya river.

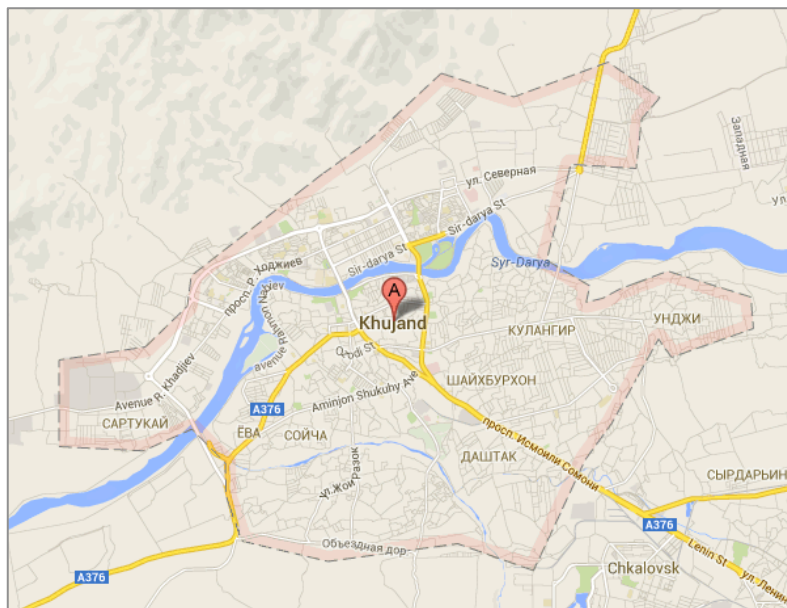


Figure 5: Khujand, Tajikistan

4.1 Land Use and Settlement Patterns

Khujand city's land use and settlement patterns in different colors are shown at the map below. There are many multi-story buildings on the right bank of Sir Darya river and multi-story buildings are located along the main roads on the left river bank. The North area of the city is bordered with mountains, while agricultural lands can be found in South, West and East sides of town.



Figure 6: Existing Land Use and Settlement in Khujand City [5]

4.2 Air Quality

The success of pollution reduction depends on monitoring system and an efficient registration. According to the information provided by the Department for Environmental Protection of Khujand city and the Environmental Protection Administration of Sughd province, no samples of atmospheric air for the identification of atmospheric air quality are taken in Khujand city.

The main sources of atmospheric air pollution stated by the Environmental Protection Department are:

- Transportation
- Industry
- Electricity
- Manufactures, increasing environmental temperature
- Waste disposal
- Radioactive disposal landfill
- Noise
- Unauthorized Solid Waste disposal

The main pollutants of atmospheric air stated by the Environmental Protection Department are:

- Carbon monoxide
- Sulphure oxides
- Hydrocarbons
- Particles
- Nitrogen oxides
- Other gases and vapors

The main air pollution sources are transportation and industry. From the information provided by the DEP: in Khujand City, the total amount of vehicles is 15,501 and per year they emit 5409.8 tons of emissions per year (only Carbon Dioxide Emissions).^[5]

There are 39 major enterprises in Khujand city, which produce 149.12 tons of emissions per year.^[5]

Table 3: Emissions and Chemical Composition^[5]

Particulates	58.235 ton
Anhydride	32.368 ton
Oxide carbonate	47.86 ton
Nitric oxide	9.801 ton
Organic carbohydrates	0.5041 ton
Other gases and vapors	0.3604 ton

4.3 Socio-Economic Conditions

As noted earlier, the population of Khujand city is 160.000 (2011). [5] The following are some socioeconomic data about Khujand:

- The unemployment rate is estimated at 30% [5]
- Although there are some industries in Khujand, currently job opportunities are limited
- In 2010, the budget of the city was 44,573,400 Somoni (8.2 million U.S. dollars) [5]
- Job opportunities in waste collection and waste to energy plant construction will be created, which would be beneficial to the city

4.4 Present Organization of the Solid Waste Management in Khujand

The following diagram indicates general solid waste management system in Khujand City and mainly involved institutions and organizations:

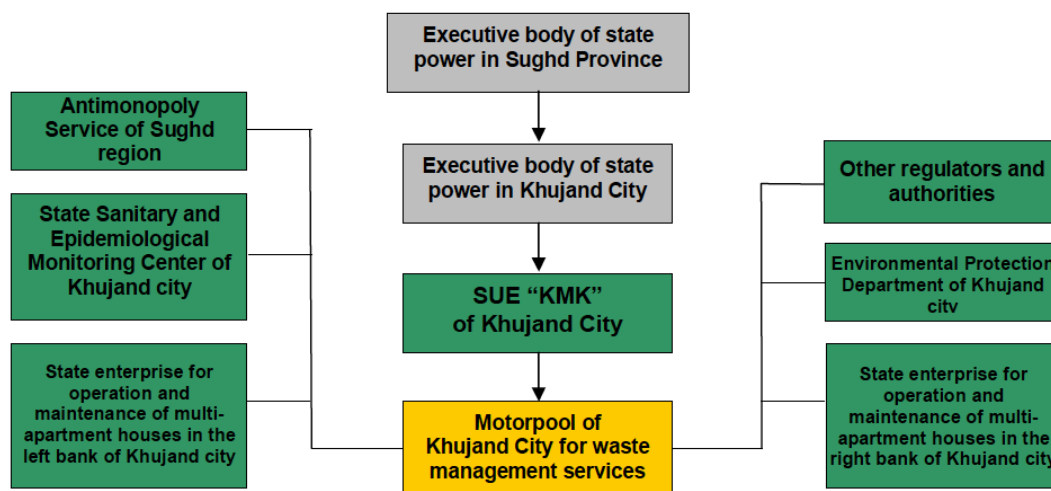


Figure 7: Present Organization of Solid Waste Management in Khujand [5]

Services, such as solid waste collection and disposal are organized at the Executive Body level of the state power of Khujand City (later on referred to as “Khukumat”). It has created Communal State Unitary Enterprise “Head Department for Communal Housing Services and Municipal Improvement” of Khujand City (later on referred to as SUE “KMK”) for coordinating and managing of operational activities of the following communal enterprises, which are located in the city:

- State Enterprise “Motor Pool” – solid waste collection and disposal services
- State Enterprise “Roads Operation” – municipal roads maintenance and repair
- State Enterprise “Housing Facilities Maintenance” at the left and right banks – maintenance and operation of multi apartment buildings, which are located in the city
- Landscape gardening trust company – green planting in public places
- Municipal lighting enterprise
- Main department for “Repair and maintenance services of fountains”
- State Communal Unitary Enterprise “Khujandvodokanal” – urban sewerage and water services in the City

4.5 Regulatory Framework at National and City Levels

The following institutions, at the municipal and national levels are involved in the Khujand solid waste management system:

- Khujand City Department of the Environmental Protection under the Government of Tajikistan Republic
- Center of Khujand City State Sanitary and Epidemiological Supervision of the Ministry of Tajikistan Republic
- Sughd Province Antimonopoly service under the Government of Tajikistan Republic
- Khujand City Fire Emergency Service of the Internal Affairs Ministry of Tajikistan Republic
- SUE “KMK” on the behalf of Khukumat of Khujand City
- SE “Housing Facilities Maintenance” at the right and left banks of Khujand City

5 ORGANIZATION OF WASTE MANAGEMENT IN KHUJAND

5.1 Organizational Structure of Motor Pool

The Motor Pool was established in Khujand City in 1975 based on the decree issued by the Ministry of Communal Services of Tajik USSR. [5] Based on the decree issued by Khujand City as of January 2005 the Motor Pool has become a self-financed enterprise. [5] City does not have any other alternative provider of services on municipal waste collection and disposal.

Organizational Structure of the Khujand Solid Waste Management Company

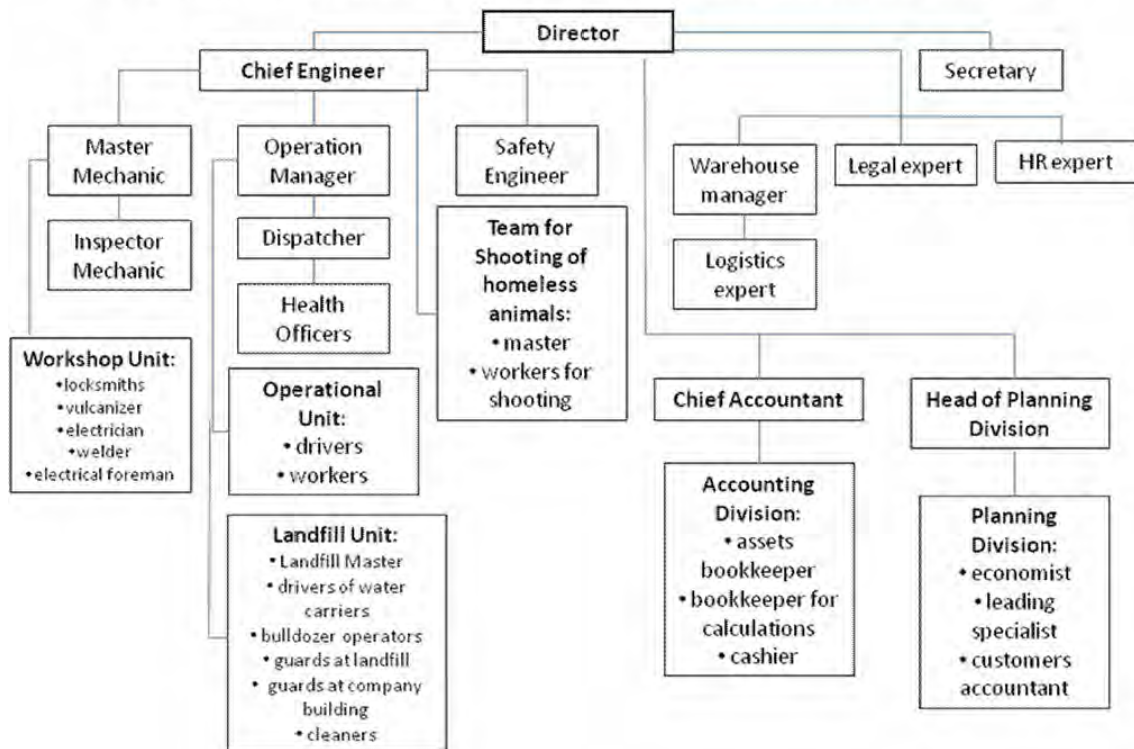


Figure 8: Organizational Structure of Khujand Solid Waste Management Company ^[5]

The Motor Pool consists of management, waste collectors, staff at landfill and administrative staff (bill collectors).

The enterprise has the following issues:

- Lack of staff motivation. Generally, staff feels underpaid for their services. Especially, women are underpaid and they are not recruited to management positions.
- Discrimination and gender inequality. Uzbeks are not recruited to administrative tasks. Women salaries are less than men salaries.

Potential customers of Motor Pool, which form its income basis:

- **Household customers** (apartment blocks and individual houses)
 - Low income
 - Medium income
 - High income

Issues:

- As waste collecting containers are placed away, customers living in individual houses have to be present when the Motor Pool waste collectors pass their houses with waste collection trucks.
- Issues of the customers living in multi-apartment buildings are lack of emptying containers and waste collection points in time and health risks because of this issue.
- **Public institutions** (large-scale customers for Motor Pool)
 - Hospitals
 - Schools, universities and other institutions

Issues:

- Not all public institutions have contract with Motor Pool (e.g. Khujand State University)
- Knowledge about hospital waste is limited at Motor Pool
- **Private enterprises**
 - Large scale enterprises (industries)
 - Small and medium size enterprises (SMEs)

Issues:

- Approximately, 50% of all private enterprises and public institutions have contract with Motor Pool. There are private institutions and enterprises, which still do not have contractual agreement with Motor Pool [5]

5.2 Main Tasks and Responsibilities of Motor Pool

Motor Pool is a self-managed legal entity, implementing its activities in the capacity of State Enterprise, pursuing commercial benefits on self-sufficiency and self-financing base.

The main current enterprise task is to maintain sanitation condition of the City, such as:

- Solid waste disposal from households, commercial and public entities
- Liquid waste disposal from households, commercial and public entities, which are not connected to urban sewage network
- Snow cleaning from central streets of the city and watering of public places
- Capturing/shooting of homeless animals
- Household waste utilization and disinfection

Besides providing above-mentioned services, the enterprise provides city improvement services, such as cleaning of trays, irrigation ditches, city streets, main roads and pavements.

In order to implement its activities the enterprise has its special disposal vehicles and other operational facilities, including the landfill site for waste disposal. The enterprise independently approves and develops the annual plans for financial and operational activities, concludes service agreements, contractors and suppliers.

The enterprise is managed by Director, whom Khujand SUE “KMK” appoints and dismisses on contractual basis under agreement with Khujand City Chairman. The director organizes all enterprise activities and bears responsibility for its performances and condition. Also, he is responsible for hiring and firing of employees, takes actions for staff incentives and compensation damage in accordance with labor legislation of Tajikistan.

In order to organize services the enterprise resolves the following issues:

- Staffing and hiring employees based on employment contract conditions
- Establishes salary levels and conditions
- Defines workers hiring and firing order and salary system
- Defines work shifts, routine working hours
- Determines the volume and types of providing services

5.3 Staff of Motor Pool

Currently, 137 people are working at Motor Pool. From the total number, only 22 employees are working at the administration and 115 employees are working as operational personnel. Besides full-time employees, the enterprise hires 22 part-time workers under temporary employment contract, in order to implement specific functions and tasks. ^[5]

According to the Collective Agreement as of 03.02.2010, time-rate bonus system was applied at the enterprise. The level of salary is defined based on position held and individual employment contract. According to the enterprise internal work regulations, six days working week, 40 hours per week and 7 hours per day (from 8:00 am to 4:00 pm) is established. On Saturday employees work 5 hours and they have day off on Sunday. Standard working time for workers at the age of 16-18 is 35 hours per week, 6 hours per day and 5 hours on Saturday. ^[5]

5.4 Workers' Health, Safety and Security at Motor Pool

No health and safety training is taking place at Motor Pool. In general, mechanics, guards, administrative staff, cleaners, drivers and loaders, which are working at the Motor Pool enterprise are unaware of health and safety.

The enterprise consists of these shortcomings:

- Personal protective equipment, such as special clothing is usually worn out and dirty.
- Fire equipment outdated and non-functioning
- First aid tool kits exist, but they are without content
- No possibilities to shower or change clothes; Lack of hygienic measures, such as water and soap.
- Lack of ventilation, lifting equipment, proper light and heating. Electrical installations are unsafe.
- No registration of accidents is made.

5.5 Labor Conditions and Rights

Lack of knowledge contributes to the general poor awareness of worker's rights. Motor Pool has five representatives, who are all workers and the head of the trade union group is elected for a five-year period.

5.6 Recruitment and Contracts

At the waste management utility, no recruitment policy is in place. Top management positions are formally decided by KMK (SUE – State Unitary Enterprise). The director directly hires necessary staff for all other positions. No real contracts are in place.

5.7 Waste Picking

Mainly, plastic bottles, metals, electronic devices and bones are picked and sold at the landfill. In the center of the city, besides aforementioned components, old medicine and food wastes are picked and sold. Usually, around 25-50 people are involved in waste picking at the dumpsite and they support approximately 20-30 families. ^[5]

Waste pickers can be divided into two subgroups:

- Waste pickers, who are working in town and picking out recyclables at public collection points
- Waste pickers, who are working at the dumpsite and picking out recyclables from the dumpsite – they are relatively well organized. They have regular contact with the firms or trucks, which buy the gathered waste. They often work together in groups (e.g. friends or family members).

Alternative solutions for waste pickers, which have been discussed with Motor Pool:

- Informal waste picking transformation into official employment in landfill and Motor Pool facility
- Waste pickers also can be offered with a work in the Municipality (green yards cleaning, street cleaning, storm water ditches and sewers cleaning)
- Recyclable material and green waste informal collection will be tolerated in the future in urban areas. In this regard, urban waste pickers will have income possibilities

5.8 Stakeholders

- KMK (SUE – State Unitary Enterprise) communal services of Khujand (e.g. gets paid by 8% of Motor Pool's income, and recommends staff to Motor Pool and decides top management position) ^[5]
- The Municipality, including the Department for Environmental Protection
- State Epidemiological Control Center (SES)
- Household customers
- Housing associations/head of Mahallas (streets with private houses) and Djamoats
- Private enterprises and public institutions (especially hospitals)
- Waste pickers
- Companies buying waste (mainly Kyrgyz and Chinese companies)
- Youth Environmental organization
- General public
- Consumer protection organization

5.9 Tariff Regulation and Methodology

The Motor Pool of Khujand City is a “dominant provider”, which provides more than 65% of services on the market, in accordance with actual legislation of Tajikistan Republic “On natural Monopolies and restriction of Monopolistic Activity”. [5] Tariffs for waste collection and disposal services and other enterprise services are subject to State regulation.

The State authority regulating the enterprise services prices and is the Antimonopoly Service under the Government of Tajikistan Republic of Sughd Province, which periodically approves and reviews tariffs of the enterprises. Thus, present State authority plays an important role in solid waste management system.

Figure 9 illustrates the review, approval and introduction process of the enterprise tariffs:

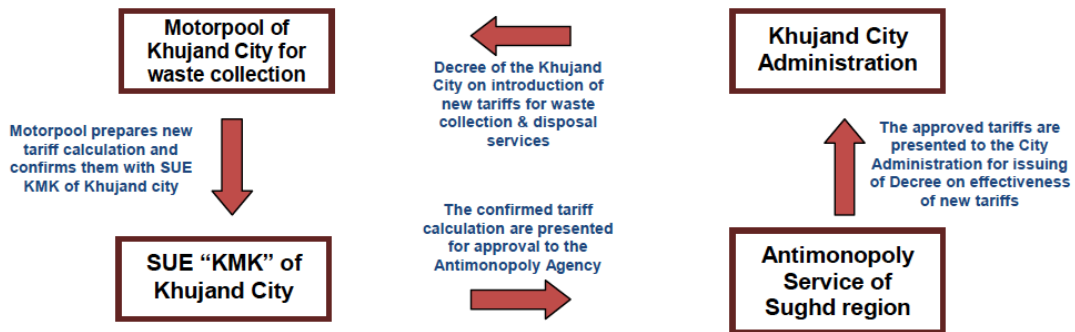


Figure 9: The Process of Review, Approval and Introduction of Tariffs of the Motor Pool Enterprise [5]

The tariffs have been reviewed irregularly. The last tariff adjustments took place in 2007 and 2010. The main factor for tariffs revision is an increase in prices for lubricants and fuel, which are the essential part of the enterprise expenses.

The tariffs are defined based on operational costs estimate related to the financial year (“Financial plan”), which gets approved by the SUE “KMK” on annual basis. Tariffs do not get approved annually. Annual costs estimate includes the following:

- The enterprise overall costs
- Costs of solid waste collection and disposal
- Cost of liquid waste collection
- Costs for watering the streets and snow cleaning from municipal territories

- Costs for elimination of unproductive animals (e.g. dogs without owners)
- Staff costs
- Concluded contracts with customers

The enterprise applies different tariff systems:

Table 4: Different Tariffs of the Enterprise ^[5]

Customer category	Type of tariff	Applied norms
Domestic customers	Uniform	Yes
Enterprises and institutions irrespective of their type of ownership	Volumetric	No

Tariffs for waste collection and disposal services are divided by customer, while tariffs for other services are divided by the type of works.

5.10 Waste Generation

There are several ways of waste classification in categories. The main waste classification is presented below.

Waste classification by waste generators:

- Solid waste and residues from agricultural production
- Solid waste from residential households and small commerce
- Solid waste from industry and big commerce
- Solid waste from public institutions
- Solid waste from street cleaning and drainage channels (municipal waste)
- Solid and liquid waste from sewage system cesspools (municipal service)

Classification of registered and unregistered waste:

- **Registered Waste** – those amounts of waste, which are taken over by Municipal or other authorized companies to collect solid waste. Waste can be taken over directly at waste collection points, at households or being delivered directly to the landfill.
- **Unregistered Waste** – waste, which is part of the following groups:
 - Recyclables - which are picked out of solid waste by informal waste pickers and being transferred to agents or directly to industry

- Unregistered household waste – which is being burned or composted at private premises and at the own house yard
- Unregistered institutional waste – which is being tipped at the institution premises (e.g. medical wastes at hospitals)
- Unregistered industrial and commercial waste – which is being tipped at the company premises
- Unregistered agricultural waste – which is being used in agricultural production or being tipped at the own premises
- Waste, which is tipped mostly by private customers at illegal dumps

Table 5: Waste Management Classification Scheme ^[5]

Waste Type	Minimum Way of Disposal/Treatment	Treatment before dumping required	Recommended advanced treatment (based on economic feasibility)
Household Waste without hazardous waste components Household similar waste from Institutions With components similar to household waste and without hazardous waste	Collection in containers and disposal at a controlled landfill with baseline sealing system with leachate and gas collection	Not obligatory, extraction of recyclables (paper, plastic, metals) would be optimal	- Utilization of landfill gas - Energy production by waste incineration (Waste to Energy) - Biological treatment (anaerobic digestion, composting, catalytic oxidation)
Mono component Industrial Waste (from big industry productions), which consists of only one type of waste	According to chemical contents and environmental risk assessment; normally the dumping capability can be ensured by physical or chemical methods	In most of the cases, yes	According to chemical contents and volumes
Hazardous Waste	Intermediate storage separated from other waste	No disposal at landfills allowed	Treatment obligatory by physical or chemical methods
Green Waste grass and wood sticks from public and private green areas (separately collected) or kitchen waste from households and restaurants (separately collected)	Treatment obligatory Treatment at Simple controlled composting yards which enable natural composting (separated from other solid waste) Disposal at landfills not obligatory	Dumping at landfills is possible, but considered as not necessary and sub-optimal economic solution	Biological treatment (anaerobic digestion, composting, catalytic oxidation)

5.11 Collection of Waste

According to the information provided by Motor Pool the total registered solid waste disposal in Khujand in 2010 was **51974 tons**.^[5]

According to the information mentioned above and based on **0.89 kg** of per capita waste generation per day,^[1] Table 6 shows the waste quantities were collected in 2010:

Table 6: The Total Registered Solid Waste Disposal in Khujand in 2010^[5]

Waste sources	Waste amount, m ³	Assumed density, ton/m ³	Waste amount, tons	% of total weight of waste
S.W. from private households	120040	0.2	24008	55.1
S.W. from institutions and enterprises	31881	0.25	7970.25	14.6
S.W. from cleaning public yards and streets	65104	0.3	19531.2	29.9
L.W. from enterprises and population	369	0.61	225.09	0.2
L.S. from public properties	393	0.61	239.73	0.2
Total waste	217787		51974.27	100

- Solid waste collected from private households: **24008 tons**
- Solid waste from institutions and enterprises: **7970 tons**
- Solid waste from cleaning public yards and streets: **19531 tons**

In addition to MSW collection and disposal, the Motor Pool is also responsible for liquid waste disposal after street scavenging cleaning of irrigation ditches from mud. Liquid waste quantities, which have been disposed to the wastewater treatment plant by Motor Pool are mentioned below:

- Liquid waste disposal from enterprises and population: **225 tons**
- Liquid sewage from public properties (city service): **239 tons**

5.12 Waste Disposed at the Landfill

The Khujand landfill does not have a weighbridge and all quantities of delivered waste have to be estimated on the basis of trucks unloaded and volume of MSW in truck. Based on the information provided by the landfill manager, waste delivered to the landfill includes:

- Household waste
- Medical waste from hospitals (Only bottles and packages. Other type of waste, such as blood conserves, injection needles and etc. are collected and disposed off at the hospital)
- Construction waste
- Waste from textile and other industry (food, glass production)
- Animal carcasses

Per day, 40-50 trucks of solid waste from commerce and households (waste delivered from Motor Pool) arrive to the landfill. Motor Pool collects waste with 27 waste trucks with different load capacity. Per month around 1250 round trips are being made for waste collection and transport, which means that the average trip amount per day is 40-50 round trips. The average volume capacity of a truck is 12 m³. The average weight of waste, which is loaded and compacted in the truck is 0.3 tons. It means the monthly tonnage of collected and transported waste to the landfill is approximately 3.6 tons. ^[5]

Some industry and commerce have their own agreement and dispose their waste at the landfill using their own trucks.

Small quantities of electronic waste are delivered to the landfill. Usually, waste pickers sort it out, immediately.

5.13 Waste Collection and Sorting Campaign

After waste collection, waste trucks would be weighted at the weighbridge. Then, waste sorting and its weighing would be provided by waste pickers. During sorting, attention would be given to purify material by sorting manually. The most common waste contaminations are humidity, dust and organic kitchen waste.



Figure 10: Truck Weighing



Figure 11: Waste Sorting and Weighing

Municipal Waste Components (from the right and left river sides of Khujand):

- Paper or cardboard (newspaper, magazines, books, printed paper, copy paper, postcards, envelopes and etc.)
- Metals (food tins, metallic tubes and etc.)
- Aluminum cans
- Plastic (toys, bags, plastic packaging for liquid detergents, bleaches, softeners, motor oils, shampoos and etc.)
- Rubber (rubber gloves, bicycle tires and etc.)
- PET packaging (plastic bottles for mineral waters, juices, milk, vinegar)
- Organic kitchen waste
- Wood (furniture parts, wooden items and etc.)
- Textile (cotton, woolen rags and etc.)
- Glass
- Construction waste (rocks, bricks, soil and etc.)
- Animal waste (dried meat with bones and skin and etc.)
- Electronic waste (irons, cell phones, radio devices and etc.)
- Inert waste (glass, porcelain and etc.)
- Hygiene products
- Hazardous wastes (batteries, oil, chemicals, fluorescent lamps, paint, pesticides and herbicides and etc.)
- Other residual waste

5.14 Waste Weighing and Sorting

Figure 11 shows the locations of the Waste Weighing and Sorting Campaign in Khujand. [5] Based on information given by Motor Pool, waste composition in Khujand looks as it is shown below: [5]

- Food waste: 4.5%
- Plastic items: 10%
- Paper waste: 25%
- Construction waste: 24%
- Metallic waste: 5%
- Dung: 20%
- Packages: 10%
- Liquid waste: 1%
- Shooting and utilization of homeless animals: 0.5%

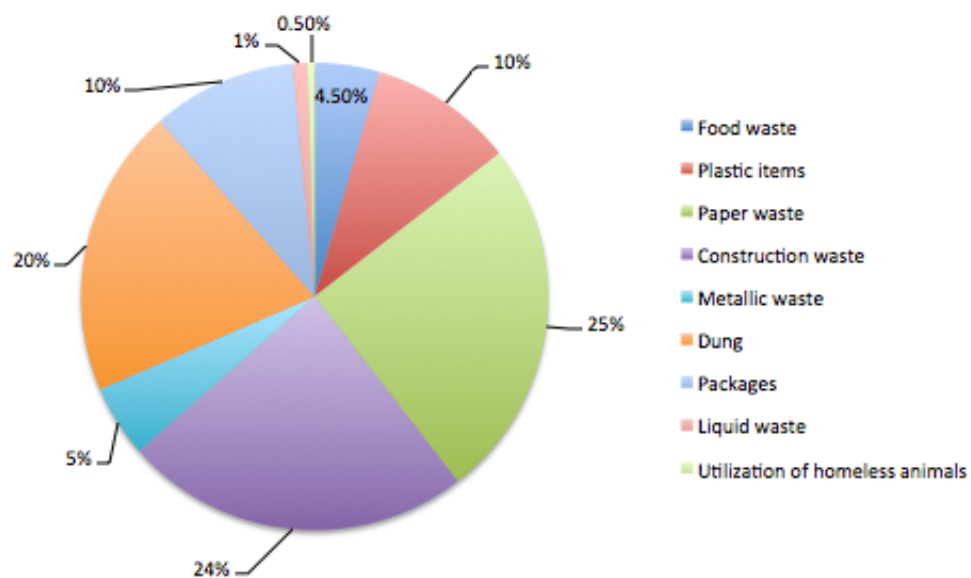


Figure 12: Waste Composition in Khujand [5]

The lower heating value (LHV) for Khujand MSW is estimated at 10 MJ/kg. [2]

5.15 Waste Generation Balance

In general, the waste flow in Khujand takes place as shown in Figure 13.

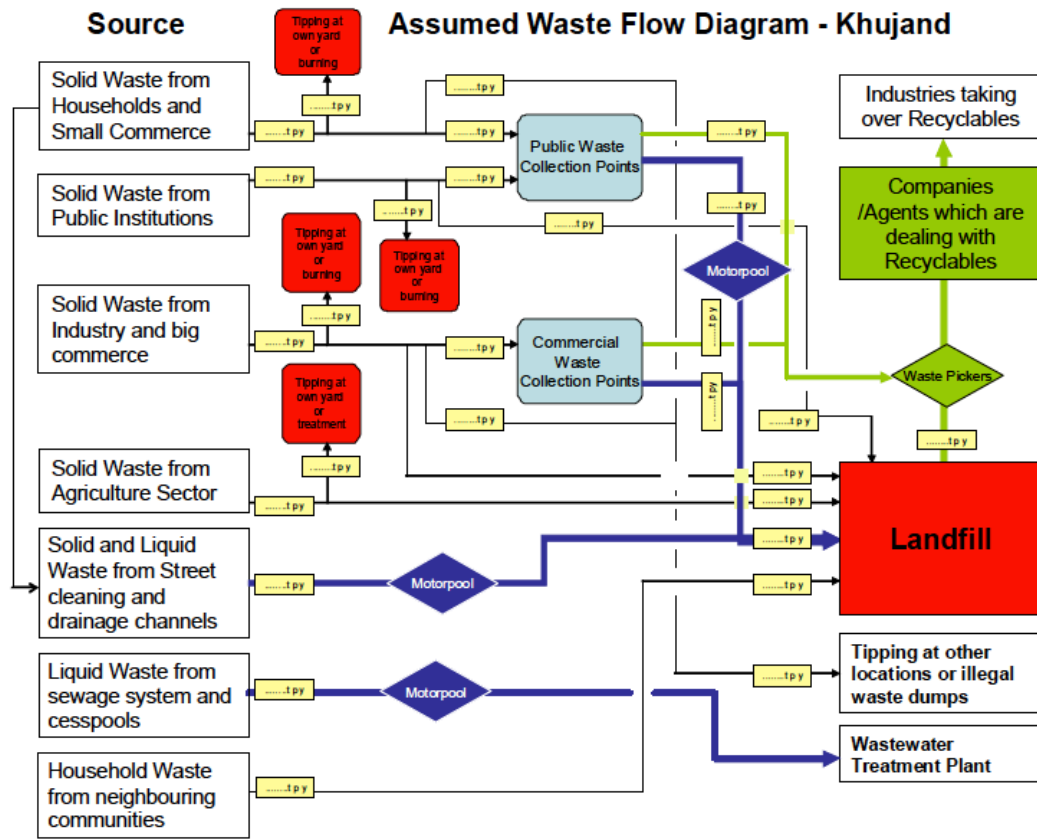


Figure 13: Khujand Waste Flow Diagram [5]

Waste generation is mainly affected by a high level of informal waste collection, without registration and control.

5.16 Assumptions Made in Estimating Waste Generation in Khujand

The following main assumptions were made in calculating the waste generation in Khujand: [5]

- Solid waste from households living in multi storey buildings/flats: 300 kg per capita/year
- Solid waste from households living in houses: 350 kg per capita/year
- Solid waste generated at workplace: 30 kg per work place/year
- Solid waste generated in schools and kindergartens: 40 kg per student/year

6 WASTE GENERATION PROJECTION FROM PRESENT TO 2026

Assumptions and Scenarios

In general, the Khujand region is very stable and the economic indicators in terms of business activities and employment rate are considered slightly better than the national macro-economic prognosis.

Demographic Development:

Demographic development is considered with 2% per year. [5]

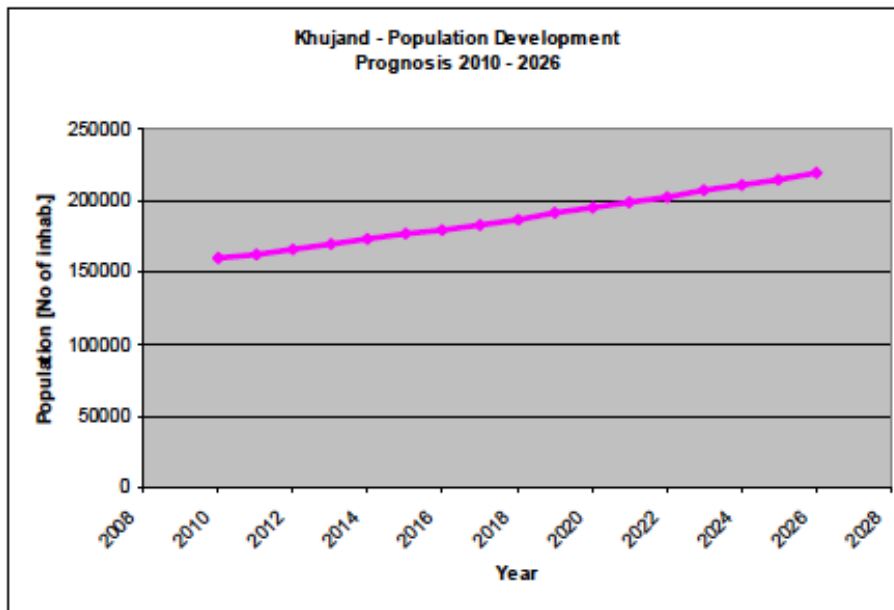


Figure 14: Khujand Demographic Development Prognosis [5]

Figure 14 illustrates, that the population of Khujand will be over 220 thousand people in 2026.

Waste Composition:

Future waste generation scenarios reflect on a stable composition of household waste as it is illustrated below:

Table 7: Waste Composition [5]

Waste Composition [% of weight]		
Green Waste	%	23
Plastic	%	15
Paper	%	5
Metals	%	1
Textile Waste	%	6
Construction Waste	%	22
Other Residual Waste	%	28

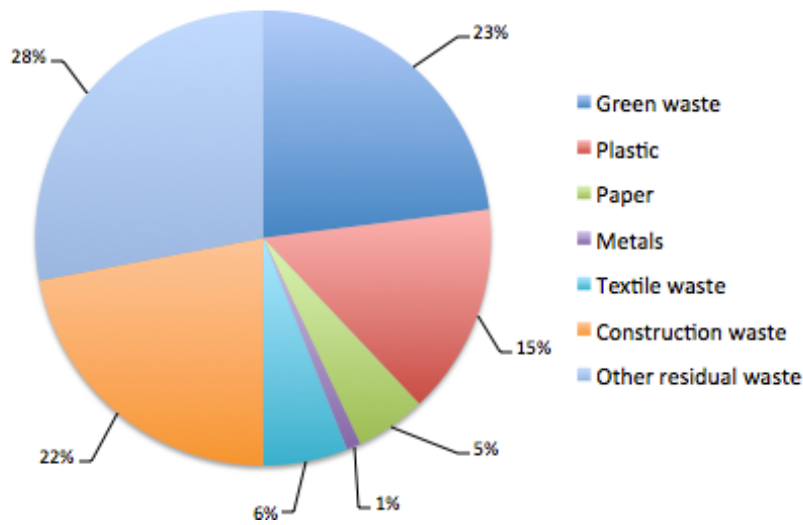


Figure 15: Waste Composition [5]

6.1 Waste Generation Projection Until 2026 – Low-Level Scenario:

This scenario is reflecting on a per capita waste generation (0.42 ton per year) and a steady demographic development. [5] In 2015 waste collection rate reached to 90%, which means that a small percentage of solid waste is being treated or disposed (burning of waste at private premises, composting at private yards). [5]

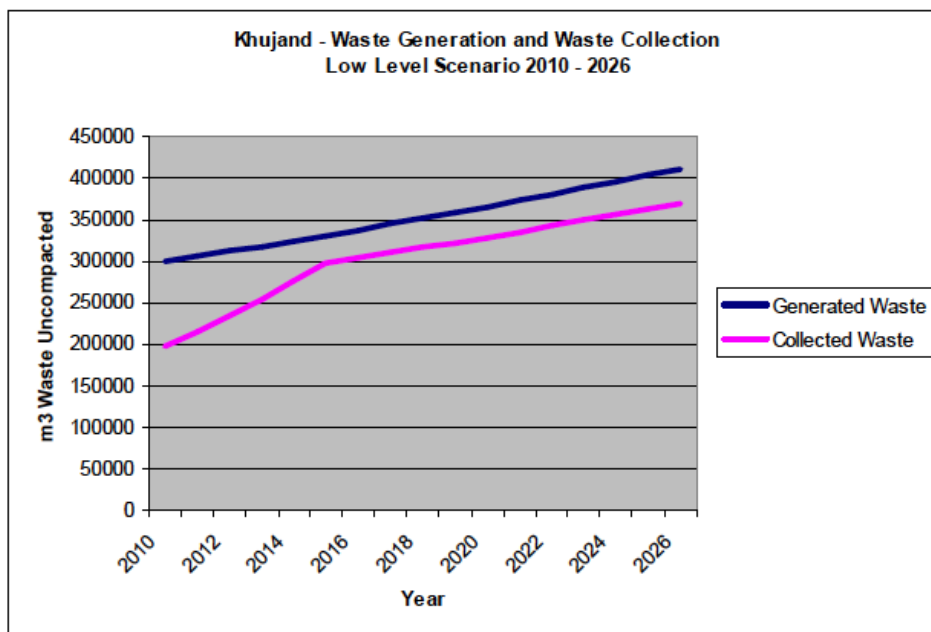


Figure 16: Khujand Waste Generation and Waste Collection [5]

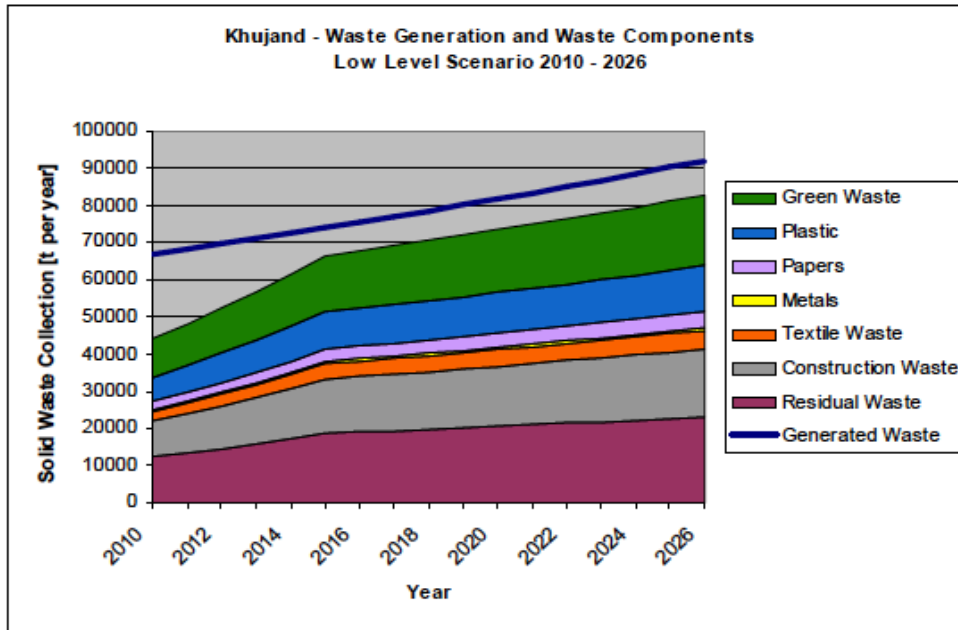


Figure 17: Khujand Waste Generation and Waste Components Low Level Scenario 2010-2026 [5]

6.2 Waste Generation Preview Until 2026 – Medium-Level Scenario:

This scenario is reflecting on a progressive waste generation, which is higher than population increase. Per capita waste generation is growing progressively up to 0.59 ton per year. [5] From 2022 and further, because of the good socio-economic conditions, slight reduction of per capita waste generation is considered.

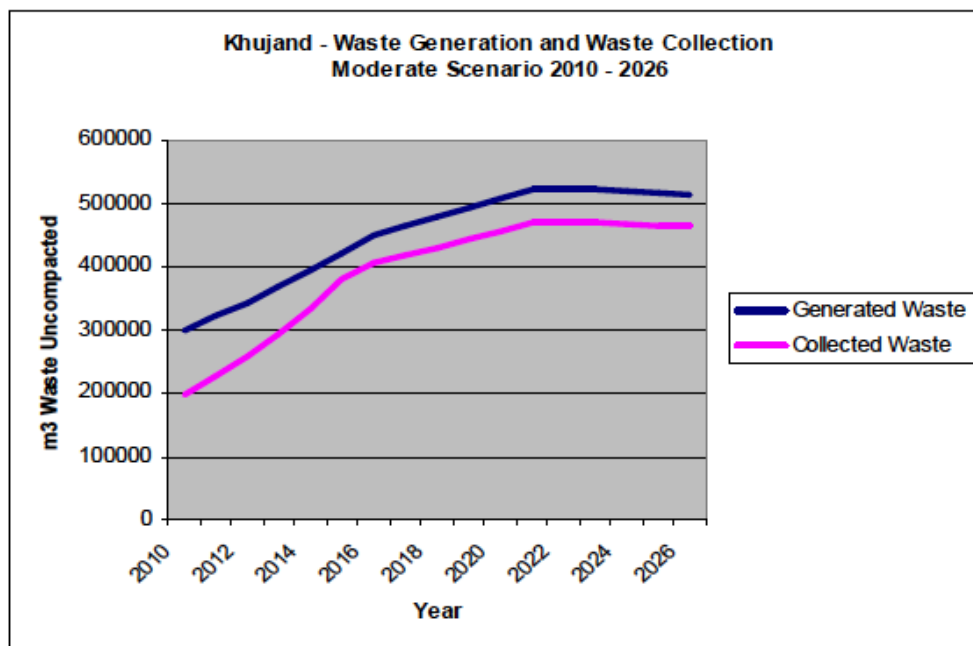


Figure 18: Khujand Waste Generation and Waste Collection [5]

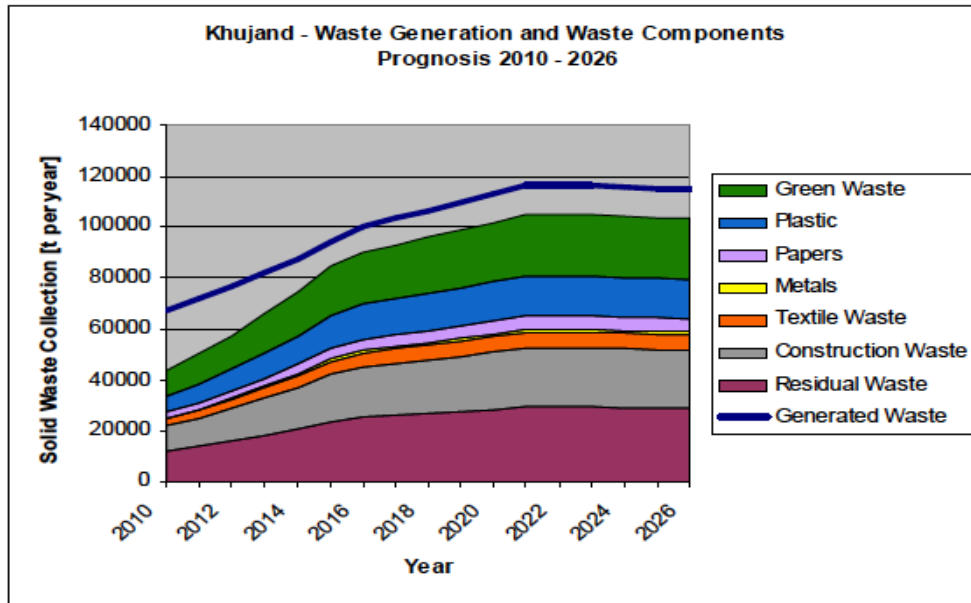


Figure 19: Khujand Waste Generation and Waste Components Medium Level Scenario 2010-2026 [5]

6.3 Waste Generation Preview Until 2026 – High-Level Scenario:

The high level scenario is based on assumption of a very high per capita waste generation up to 0.85 ton per year, without implementation of reduction strategies. [5]

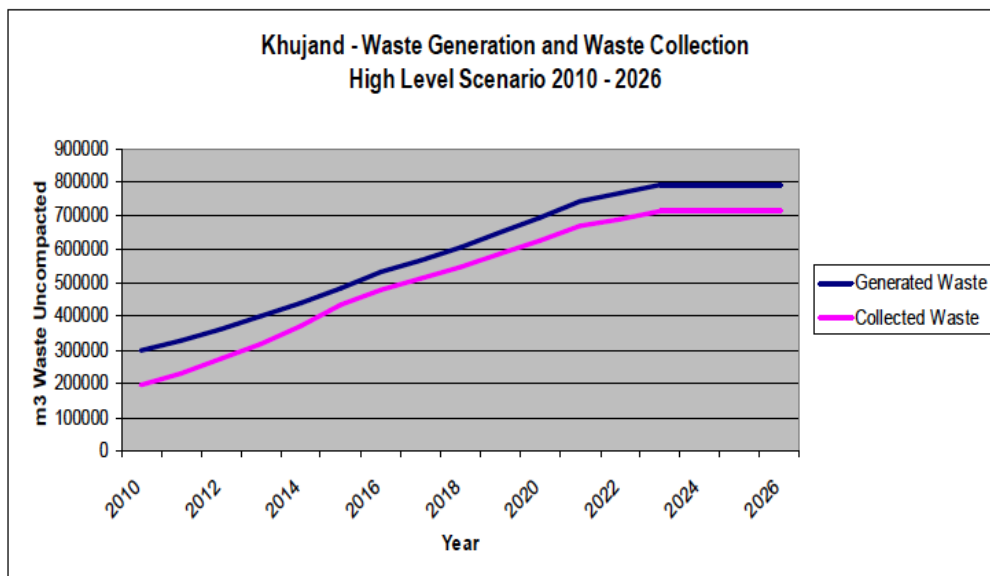


Figure 20: Khujand Waste Generation and Waste Collection High Level Scenario 2010-2026 [5]

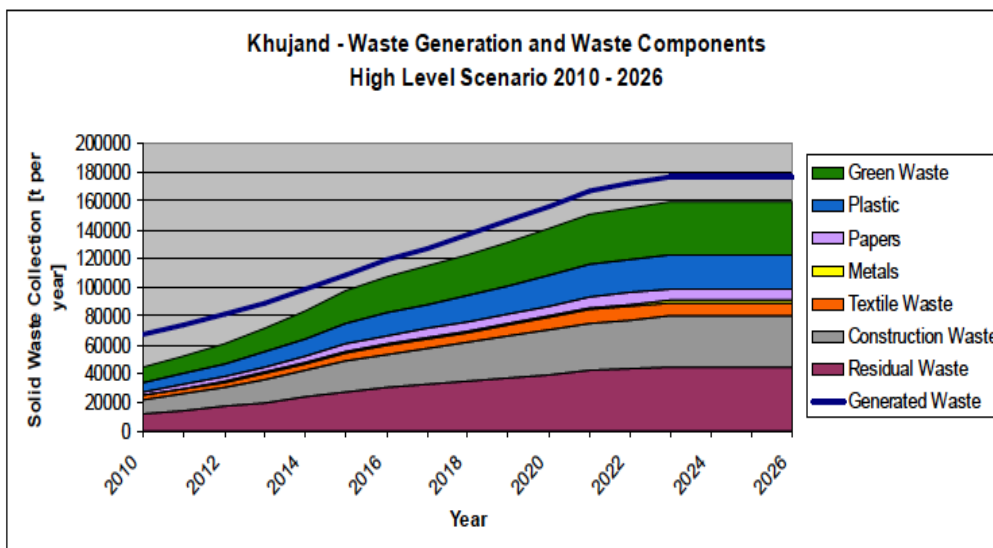


Figure 21: Khujand Waste Generation and Waste Components High Level Scenario 2010-2026 ^[5]

6.4 Summary Conclusion About Waste Generation

Different waste generation forecasts illustrate a steady growth of per capita waste generation per year. Based on the scenario, amount of the collected waste is expected to increase up to **83,000 tons** until 2026 (low-level scenario) and to **159,000 tons** (high-level scenario). ^[5] Based on medium-level scenario, amount of the collected waste will increase up to **103,000 tons**. ^[5]

The low-level scenario is unrealistic in the long term, because Khujand as a district capital will have certain progressive development, which will cause the waste generation progression.

The high-level scenario is also unrealistic in the long term, because it can be expected, that waste reduction strategies will take place while reaching a certain socio-economic level.

The medium-level scenario is considered as the most realistic. Region will follow up waste collection and reduction strategies and a pro-environmental policy, which are being implemented in order to reduce the progressive increase level of waste generation, which is to be seen in direct proportion with macro-economic development. ^[5]

Waste composition analysis shows an essential potential for waste to energy and recycling technologies, which will be discussed further.

7 POTENTIAL FOR SEPARATION OF RECYCLABLES

7.1 General Definition

Every regional waste management system has to consider waste not only as a material, which is tipped somewhere at low cost, but it should consider, that communal waste consists of different kinds of components with a certain value. It should not be forgotten, that the construction and operation of landfills with high-developed technical and environmental standards is expensive. The usage of landfill volume at “ecological landfills” should be used very effectively.

We have to separate the following components, which are not recommended for landfilling:

- Recyclables – solid waste material, which can be recycled and similar kind of material can be produced again. For instance, plastic bottles and bags, different kinds of metal, cardboard, paper and expanded polystyrene
- Components, which should be used for thermal and other technological processes – wood waste, used oil and lubricants
- Green waste – should be composted
- Hazardous waste components – tipping at landfills is not allowed

7.2 Existing Practice in Separation of Recyclables and Other Components

Currently, official waste collection and disposal practice does not include any waste separation. But there is a running informal system, which is organized by the City and Waste Management Enterprise.

The following recyclables are subjects of picking by informal waste pickers:

Table 8: Waste Pickers’ Recyclables Subjects ^[5]

Waste Component	Location of Picking out	Assumed further treatment
Plastic Waste, mainly plastic bottles	At the dumpsite	Handover to agents and transfer to China via Kirgistan
Electronic waste	At the collection points or at the dumpsite	No information, handover to intermediate agent assumed
Metal Waste	At the collection points or at the dumpsite	Handover to agents, which are delivering to metal industry

7.3 Identified Potential for Separate Collection of Recyclables and Other Usable Components

In Khujand city there is an essential potential for sorting out of recyclables. Waste composition of the city shows essential potentials in separate treatment of recyclables, which are shown below:

- **Plastic waste** – actual collected weight approximately 6 tons per year with potential to increase up to 14 tons per year based on the medium-level scenario ^[5]
- **Green waste** – actual collected weight around 10 tons per year with potential to increase up to 24 tons per year. ^[5] The main quantity of green waste is usually generated by public green yards maintenance
- **Paper and textile waste** – the quantities are not high, but it plays a certain role in waste composition
- **Metal waste** – being generated in minor quantities, which are immediately picked out by waste pickers
- **Rubber waste (truck tires)** – almost does not exist in Khujand solid waste. These components are being reused by companies and being burned at the end of life-cycle

While taking into account reuse or recycling, the following aspects have to be considered:

- Recyclables need a market, where the components can be sold
- The price for selling of recyclables has to be equal or higher than the cost for sorting out of recyclable and disposal cost
- The cheapest method for the waste enterprise to receive recycling material is to separate waste at the consumers' level. It will require some efforts for public awareness campaigns and training of local population, in order to accept container points for separate collection

The following potential for recycling and treatment are shown by a rough analysis:

- **Plastic waste** – currently, separation and selling of plastic waste at the local market is feasible. Mostly foreign traders are buying plastic waste. Most of the plastic waste is being used as heating material in some

industrial production technologies, such as cement factories in China. There is also an economic potential to use plastic waste in future local industry of the plastic productions. The waste-to-energy option could also be considered in the future, in order to produce heat and electricity by using plastic waste in district waste-to-energy plants

- **Green waste** – there are two green waste treatment technologies:
- **Composting** – using plants producing compost, which is similar to fertilizer for agriculture and green yards
- **Waste-to-energy at biomass treatment plants** – biomass factories use the energy potential of green waste. A project for establishment of a biomass factory is just at the beginning and would require a certain time period for realization

The most preferable solution would be combined strategy:

- Composting plan with a production capacity enough for the demand of the City for green yards maintenance
- Excessive green waste transport to the biomass factory (energetic use)
- Paper, cardboards and textile waste – potential receiver of this type of recyclables are paper factories
- Metal waste – there is a regular demand on specific metal components. Selling prices for this material are dependent on the World Stock Market for Metal. Prices for the electronic waste and all sorts of cable waste (copper) are high at the market and all other discarded metal receives lower price per ton. Population should be motivated to bring their metal waste to specific collection points, where metals would be taken

7.4 Hazardous Waste

Hazardous wastes generate greater risk to the environment and human health than non-hazardous wastes, which is why it requires stricter control. Hazardous wastes have following characteristics:

- Toxicity
- Corrosivity
- Reactivity
- Inflammability

7.5 Household Hazardous Wastes

Many people are unaware of the hazardous nature of products they purchase, even if the product packaging has hazardous symbols and describes how to use the product correctly. Household hazardous wastes from products, such as oils, paints and cleaning products can be explosive, flammable or oxidizing. Wastes from other products can be more hazardous to human health and may have mutagenic, carcinogenic, corrosive, toxic, irritant or harmful characteristics. By using or disposing incorrectly, some products used in household are hazardous to the environment and can harm water sources, the ozone layer and contaminate soil. Hazardous waste must be handled carefully, because in very small quantity it can harm public health and the environment. Amount of the hazardous household waste in Khujand is less than 0.25% by weight. [5]

Household hazardous waste are motor oil, fuel, paint, fluorescent lamps, antifreeze, electronics, such as televisions, cell phones, batteries, computers, pesticides, herbicides, cleaning chemicals, medical wastes and others. In Khujand, the most frequent hazardous household wastes are needles, medicines, batteries, aerosol cans, some electronics and fluorescent lamps.

7.6 Medical Waste

The World Health Organization (WHO) classifies medical waste into following categories:

- Infectious – waste from surgery and autopsies on patients with infectious diseases
- Sharps – disposable saws, syringes, needles, nails, blades, broken glasses and other items, that could cause a cut
- Pathological – human flesh, fetuses, blood, body fluids, body parts, organs and tissues
- Pharmaceuticals – chemicals and drugs, that are returned from chambers, outdated, spilled, no longer required and contaminated
- Radioactive – liquids, solids and gaseous waste contaminated with radioactive substances used in treatment of diseases and diagnosis
- Other wastes – waste from kitchens, offices, tools and attachments, paper, etc.

In Khujand, hospitals have a huge lack of a proper waste collection, treatment and disposal system. No proper containers are available for medical waste collection. Usually, it dumped at open collection points nearby insufficient oven, where syringes are burnt. The remaining needles from syringes are disposed within solid waste at city dumpsite. The wastes, such as empty bottles

and packages are usually dumped at nearby collection point. Hospital areas and collection points are mostly not properly fenced. Pictures below illustrate solid waste collection point at the regional hospital in Khujand:



Figure 22: Solid Waste Collection Point at the Regional Hospital in Khujand



Figure 23: Oven for Burning Syringes at the Regional Hospital in Khujand



Figure 24: Leftovers From Burning Process

The hospital collects around 5000-6000 syringes/needles per week. The birth station collects approximately 500 up to 700 needles per week. [5]

7.7 Radioactive Waste

Usually, hospitals and other health care and diagnosis institutions generate radioactive wastes. In Khujand hospitals no radioactive waste is accumulated. Other sources for radioactive pollution are uranium tailings, which were established during uranium production in Soviet times. Large uranium tailings do exist only several kilometers away from town.

8 THE MAIN MUNICIPAL SOLID WASTE REDUCTION STEPS

Prevention – in Khujand, especially at schools awareness programs about environmental issues are exist. These programs mainly carry out by NGOs. However, these programs are usually at a small scale and do not reach the whole population of the city. Plastic waste has a high potential for waste prevention in Khujand.

Re-use – in Khujand, re-use of the high-value waste products, such as electronic waste, glass, bones, plastic are already carry out informally. For instance, electronic wastes are rarely brought to the collection points or dumpsite. Usually, people sell their electronic waste to small companies, which re-use different components of electronic waste. Also, people re-use clean and not

broken bottles at home and re-use animal bones for feeding cattle. Plastic is picked at the dumpsite and collection points of the city informally. Plastic bottles usually are sold to Chinese companies, where they are expected to be re-used.

Recycling – currently, there is no indication for recycling processes in Khujand. Raw materials, such as aluminum and other metals are extracted at the waste collection facilities and dumpsite or directly from people at their houses. Above mentioned raw materials usually are sold to a company in Kyrgyzstan or China. In Khujand, there are no companies, which could recycle plastic, metal and other waste components.

Energy recovery from waste – in Khujand, there is no waste-to-energy plant. Due to relatively high amount of paper, textiles and plastic (more than 25% by weight) there would be a potential for building of the waste-to-energy plant, in order to produce heat and electricity in Khujand city and Sogd Region. ^[5]

Disposal – as in Khujand there are just small activities for waste re-use or recycling, majority amount of the generated waste is deposited at the dumpsite.

9 WASTE COLLECTION AND TRANSPORTATION

For waste collection, a system with public collection points and stationary container system are adopted in Khujand. These systems require residents to bring their wastes to collection points. These collection points are located at open spaces along the streets. Collection points consist of waste bins, which are not fixed on the ground and are movable. There is no house-to-house service for public waste collection.

In Khujand, different kinds of vehicles, such as compactor trucks, side loaders and open back trucks are being used for solid waste collection. In general, waste collection trucks are in poor condition and some of them are out of service. Usually, people who do not have an access to waste collection service, dump their waste at public area, river or burn it in their backyards polluting the air. Open dumps provide sources for diseases, because of bacteria, insects and rodents.

Because of the limited budgets, local agencies do not have an adequate capacity to handle the solid waste. Transfer stations, which could connect surrounding parts and areas to the city waste collection and disposal service, are not common in Khujand.

The Special Sanitary Cleaning Motor Pool is responsible for solid waste collection from the street collection points.

10 SERVICE AREA OF MOTOR POOL

The population of Khujand is 160,000 people. [5]

Amount of buildings and organizations of Khujand within the service area of Motor Pool: [5]

- 10726 private houses in 18 mahallas (streets with private houses) with 57450 population
- 575 houses in residential sectors
- 404 organizations and enterprises
- 557 public organizations

Khujand city is divided into two parts: [5]

- Left bank of Sirdaryo river – consists of 12 micro-districts, 3 mahalla committees, 336 multi-storey buildings and 1980 private houses
- Right bank of Sirdaryo river – consists of 2 micro-districts, 15 mahalla committees, 197 multi-storey buildings and 8746 private houses

Motor Pool service area for waste collection and disposal includes an area with following amount of buildings:

Table 9: Number of Buildings and Apartments in Service Area in Khujand [5]

Number of storeys	Quantity of houses (pcs)	Quantity of apartments
Right bank		
Private houses	1980	-
2-floors	11	120
3-floors	13	243
4-floors	164	10611
5-floors	112	7367
9-floors	36	1836
Left bank		
Private houses	8746	-
2 floors	37	392
3 floors	40	1301
4 floors	60	2632
5 floors	41	2261
6 floors	1	10
7 floors	3	192
8 floors	0	0
9 floors	15	565

In Khujand all waste collection points are belong to JEUs (house associations). There are 338 containers in the whole city. Motor Pool owns 245 containers and JEU owns only 93 containers.

Streets of the private houses (Mahallas) do not have containers and collection points. Usually, families of Mahallas collect their waste at home and bring it to the Motor Pool tractors and waste trucks, when they arrive in Mahallas streets for carrying out their waste collection services.

There are more than 300 waste collection points in town, which belong to the JEUs (housing associations).^[5] Not all waste collection points are equipped with containers. Waste collection points that have containers are mainly equipped with containers without lids. Most containers are in bad condition. There are 32 illegal waste collection points in Khujand. In central streets solid waste disposal is performed everyday from 5 a.m. to 1 p.m.^[5]

The 9-floor buildings have waste chutes, however the chutes are functioning only in 2 buildings.^[5] The waste chutes consist of asbestos cement pipe. Waste manholes are in the front door of the buildings. Not functioning chutes are welded.



Figure 25: Waste Chutes in Multi-Storey Building

11 EQUIPMENT OF MOTOR POOL

11.1 Types of Waste Collection Trucks

Motor Pool uses rear loaders, side loaders and tractors with trailers for waste collection.



Figure 26: Waste Collection Truck – KAMAZ KO-415A



Figure 27: Waste Collection Truck – ZIL KO 449-12



Figure 28: Waste Collection Truck – GAZ-53 KO-413



Figure 29: Waste Collection Truck – Tractor Tojiron With Trailer

11.2 Truck and Vehicle Fleet

Currently, solid waste collection and disposal in Khujand is performing by using side and rear loader, truck and tractor. Working group often loads manually solid waste to the trucks. However, manually loading is very time consuming and costly process. Motor Pool has a station with special vessels for fuel and lubricants storing. Also, it has a fuel station for refueling of company cars and trucks.

Usually, during the night solid waste collection and disposal trucks stay at the drivers' houses, who are responsible for the truck. Drivers park trucks at their houses, because of economic fuel usage and transport absence for employees.

11.3 Types of Waste Collection Points



Figure 30: Open Waste Collection Point Without Fence or Concrete Structure



Figure 31: Waste Collection Point With Fence



Figure 32: Waste Collection Point in Multi-Storey Building/Waste Chutes

11.4 Types of the Waste Collection Containers



Figure 33: Metal Containers Without Wheels and Lid



Figure 34: Big Metal Container (bunker) Without Wheels and Partly With Lid

12 DISPOSAL INTERVAL AND ROUTE PLANNING

In Khujand, solid waste collection and disposal is performed in three shifts by Motor Pool: ^[5]

- First shift is from 5:00 a.m. to 1:00 p.m.
- Second shift is from 8:00 a.m. to 4:00 p.m.
- Third shift is from 5:00 p.m. to 12:00 a.m.

Usually, two people work for every waste collection schedule. Sometimes, when the workload is big three people work for every waste collection schedule.

Waste collection points, which are along the main roads, usually are served by Kamaz and Gaz trucks, which have higher loading capacity. Tractors with trailers usually serve areas with narrow streets.

13 WASTE TREATMENT AND EXISTING DUMPSITE

Collected waste by Motor Pool is usually transported to the city dumpsite, which is located in the North of the town. The dumpsite is situated 4 km Northeast of town and 17 km away from Motor Pool. The area of the dumpsite is 20 hectares.

^[5] The access road to the dumpsite is in an adequate condition.



Figure 35: City Landfill in Khujand

13.1 Description of the Landfill Site

Waste disposal at landfill is taking place about 20 years. [5] The operator of the landfill and several other workers are daily at the landfill site. The landfill has access roads from two sides of the valley, from the west and south sides. Some agricultural plants can be found in the east of the landfill valley.

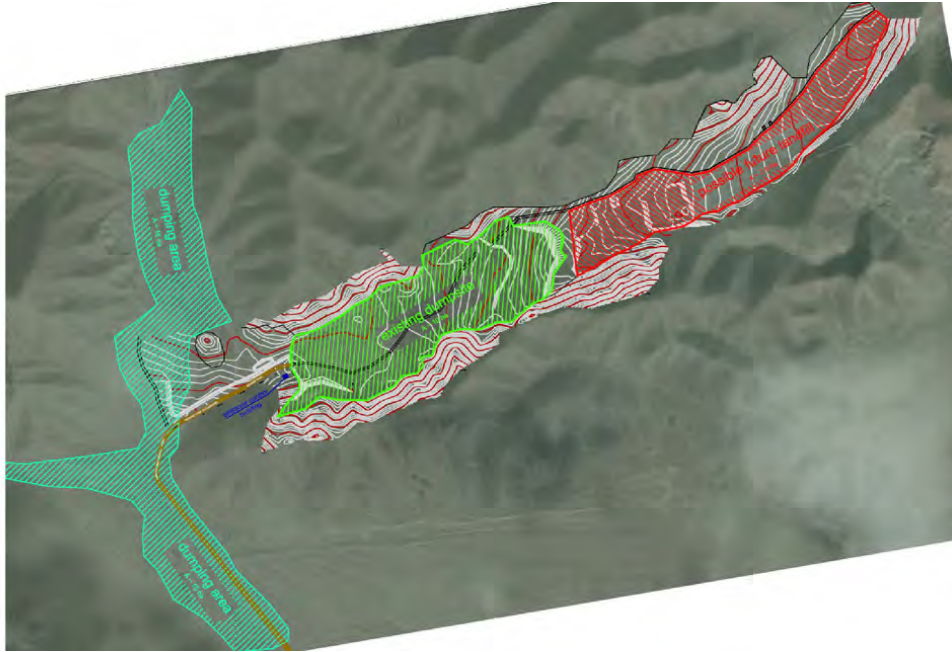


Figure 36: Landfill Area Map [5]

The main tipping area is marked in bright green color. Secondary tipping area is in the Northwest, which is marked in blue-green color. This area is being used during rainy/winter season, when due to the slope of the road the access to the main tipping area is not possible. The red area is the future landfill area.

13.2 Waste Tipping at the Existing Dumpsite

The waste delivered to the landfill includes:

- Household waste
- Medical waste from hospitals (only bottles and packages)
- Waste from industry
- Construction waste

Everyday, 40-50 trucks of solid waste from the households and commerce, every week 1-2 trucks of solid waste from textile industry, 1-2 trucks from hospitals and 3-4 trucks of construction waste arrive to the landfill. [5] As there is no chemical industry in town, there is no chemical waste at the landfill. Usually, solid waste is not separated in town and informal waste pickers pick out plastic

and metal components at the dumpsite. They sell plastic waste to plastic collection points in the city. Further, these points sell it to plastic producing companies.



Figure 37: City Dumpsite for Municipal Waste in Khujand

13.3 Evaluation of the Existing Landfill Facilities

The landfill is located in reasonable distance from the next settlements and the city. Wind blowing from the landfill does not reach population centers and mountains restrict the visibility of the landfill site.

Several deficiencies, which restrict a proper landfill operation:

- Landfill does not have clearly defined borders
- It lacks of a proper source of drinking water supply and power supply
- There are no storage and workshops rooms at the landfill
- There is no truck disinfecting and washing system

- Tipped waste is not covered, which causes to permanent wind blowing and light waste deposition to the surrounding lands
- Waste disposal sanitary and hygienic norms are not followed
- No weighbridge is installed, which makes delivered waste documentation difficult
- The operation roads at the landfill are in poor condition

There is no leachate collection system at the bottom of the dumpsite. Also, there is no gas extraction system installed at the dumpsite. The landfill gas is emitted directly to the atmosphere. No soil, air and water monitoring is carried out at the landfill. The landfill is not well equipped and waste is dumped without any transformation, such as packing or soil layering.

The guard house, which is located at the entrance of the landfill is in very poor condition and it is not equipped with running water. Usually, general director of Motor Pool appoints personnel for the landfill. The head of the landfill controls landfill stuff daily operations. Not only Motor Pool, but also some other companies transfer their waste to the landfill based on separate contracts with the landfill.

14 PAYMENTS FOR WASTE COLLECTION AND DISPOSAL

City services of Motor Pool are paid from financial body of Khujand City Administration through Khujand City KMK account, which transfers funds further to the Motor Pool account. According to cooperation agreement, Motor Pool repays to Khujand KMK 8% of the fund for its services. ^[5]

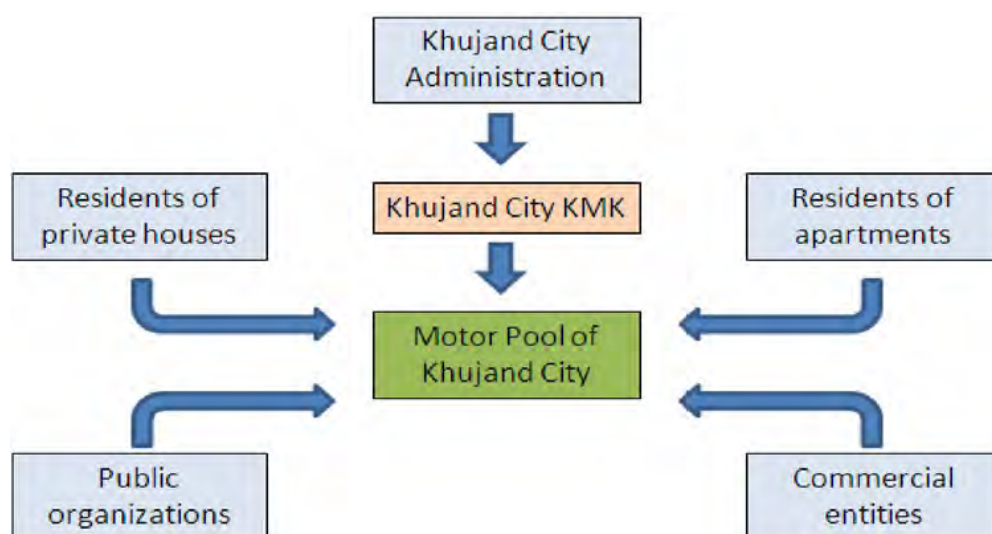


Figure 38: Flow Chart of Payments Received by Motor Pool ^[5]

14.1 Tariff Setting Procedure

Motor Pool tariffs for different group of consumers, such as:

- Household consumers – even tariffs. The payment amount is not affected to the real solid waste disposal volume. It is calculated based on normative standards of solid waste accumulation per person. Tariffs for household consumers are set for one person per month, depending on accommodation type:
 - Population of multi-storey buildings (flats)
 - Population of private houses
- Organizations and enterprises, regardless of the ownership form – payment is calculated based on waste volume. For instance, for kindergartens and schools waste volume is calculated based on the number of children and students; for hospitals based on the number of beds. For commercial enterprises waste volume is calculated based on the enterprise area.

Population payment amount formula:

Amount of payment = number of family members x monthly tariff per person

Organizations and industrial enterprises payment amount formula:

Amount of payment = monthly tariff x waste volume

15 CURRENT WASTE MANAGEMENT QUALITY AND EFFICIENCY

City Administration and Motor Pool are doing their best in providing regular cleaning of public areas and waste collection points of Khujand city. Current waste management system has some weaknesses and deficiencies, which are limiting and restricting its modernization. The strategic objectives for waste management improvement are illustrated in the following figure:

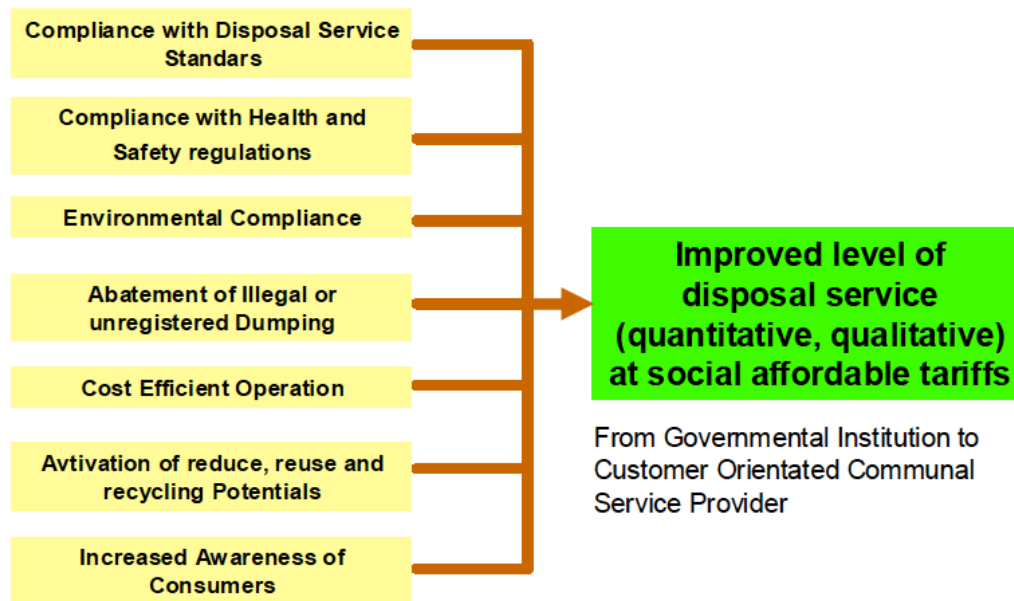


Figure 39: Targets of Modern Urban Solid Waste Management System ^[5]

15.1 Quality of the Waste Management Service for Households

In general, waste collection points density is low in Mahalla (streets with private houses) areas. Most of collection points do not have containers, which it is creating certain environmental problems and hygienic risks for residents. Waste disposal intervals are ranging from daily disposal to weekly disposal. There are some waste disposal interval restrictions, which are mentioned below:

- Most of waste collection points do not have containers, which require time consuming waste loading process. Because of that, waste disposal procedure can be done only once per week in certain areas
- Number of functioning trucks is limited, which does not allow more intensive waste disposal intervals
- In the narrow street of Mahallas waste disposal can be performed only by small trucks, which is very time consuming process

15.2 Service Quality for Institutions, Industry and Commerce

All institutions and enterprises within Motor Pool service area are being provided with its waste collection services. Only few institutions and enterprises directly deliver their waste to the landfill using their own trucks.

In the center of Khujand most of waste collection points are located nearby institutions, which are being used also by residents. There is a lack of containers,

which results in open waste tipping under doubtful environmental and hygienic conditions.

It is almost impossible to determine and quantify illegal waste dumping in Khujand due to the following reasons:

- The legal directives are not accurate and control measures are not being fulfilled properly by city authorities
- In some cases (e.g. hospitals) legal directives for waste disposal are existing, but not being performed due to the lack of budget to organize regular waste disposal
- Almost all big enterprises are not disposing their waste based on environmental directives and standards
- Residents are tipping often their waste in public areas, which it leads to high expenses for street and public yard cleaning
- Residents of Mahallas (streets with private houses) often burn their waste at their backyards, especially in winter

Huge number of small illegal dumpsites are still existing and being used in Khujand.

15.3 Organization of the Waste Management Services

Current organization weaknesses of the waste management services in Khujand:

- Lack of the waste management appropriate planning instruments
- Suboptimal use of resources, due to a weak management and lack of planning
- Inappropriate payment system by domestic customers
- Inadequate reporting and accounting system
- Lack of subscriber contracts with domestic customers

15.4 Staffing

Following conclusions and comments can be summarized according existing organization and staff capacity of Motor Pool:

- Due to a limited motivation, caused by low payment and harmful working conditions, the enterprise is always lack of workers and administrative staff
- Staff qualification and capacity is limited, which needs to be developed
- Professional and training development programs for staff are not designed and not conducted

- Staff of the enterprise should develop its computer knowledge and work with some office applications
- There is no regular system to take corrective actions for efficiency improvement

16 TASKS AND PROCEDURES

16.1 Waste Collection

Waste collection procedure are restricted mainly by a lack of sufficient number of containers, which require time consuming manual loading at most collection points. Additional restricting component to organize waste collection in efficient way is a weak technical condition of the truck fleet.

Currently, waste collection is fulfilled by 20 trucks with compressing unit and 7 tractors for disposal in narrow streets of mahallas (streets with private houses), which do not have waste collection points. All tractors and trucks deliver waste directly to the landfill. Approximate trip number of trucks to the landfill is 1250-3000 per month, which is around 2 trips per day. ^[5]

- Waste collection working hours:
 - 5-5.5 hours per day
 - 15-17 hours per month
 - 180-190 hours per year
 - Around 5 working hours per ton of waste

Waste collection efficiency is low, due to the time consuming manual loading and inefficient load volume of the most trucks and tractors.

16.2 Landfill Operation

Current landfill operation organization level is very basic, which cannot fulfill the environmental, health and safety standards. Main development measures, which landfill needs are mentioned below:

- Measures against fly tipping in western landfill area
- Clean up of the fly tipping areas and tipping the waste to the landfill
- Measures against wind blowing of waste (e.g. temporary coverage of tipped waste)
- Entrance control of delivered waste by weighbridge and visual inspection

- Obtaining of basic machinery, such as wheel loader, bulldozer and compactor for landfill operation
- Establishment of temporary access roads, instructions for waste deliverers and a tipping plan with tipping areas identification
- Waste technical compaction after tipping
- Measures for leachate, surface water collection and drainage

Currently, several informal waste pickers are working at the landfill. They are picking recyclables, such as plastics and metals. They are working under doubtful hygienic and safety conditions. This informal waste picking process should be transformed into official task of landfill operations. Waste pickers should be contracted by the waste management enterprise and should receive clear work instructions and safety equipment for waste inspection and sorting out of recyclables. Only waste management enterprise should be authorized to sell the recyclables. In addition, measures for composting of the green waste should be considered at the landfill.

17 Economic Efficiency

17.1 Tariff Structure

Tariffs are low and do not cover the actual operation costs. Only 65% of population is being charged with waste collection tariffs, while the whole population of Khujand is generating waste and disposing it at public areas. ^[5]

17.2 Billing Efficiency

During the last years billing efficiency could be improved, but still 35% of the population is not being charged with waste tariffs. ^[5]

17.3 Operation Costs

The operation costs are mostly affected by salaries and high fuel costs. Approximately 50% of the operation costs are for fuel, lubricants, material and spare parts and another 50% of it is for salaries and social contribution. The major part of the costs is being spent for waste collection and transport activities. ^[5]

17.4 Revenues

Motor Pool provides services on solid and fluid waste disposal, watering and snow removal to the city, population, commercial entities and public organizations. Around 99% of services are related to solid waste disposal and 1% to fluid waste disposal, watering and snow removal and other services. [5]

Due to the following facts the revenue of the enterprise has steadily increased over the past years:

- Tariff increases
- Increased waste volume for private customers
- Increased waste collection rates

18 IMPACTS FROM INADEQUATE WASTE MANAGEMENT FACILITIES

Waste collection and disposal facilities pose a risk to the environment and to the health of population and workers, because they are not operating according to the international standards. The environment and the public will benefit, because of the installation of an improved waste collection system with additional collection points, containers and equipment.

In order to improve the waste collection system, not only technical investments are necessary, but additional complementary measures have to be carried out. Minimization of negative impacts to the public health and environment is additionally achieved through maintenance of waste disposal facilities and respective safety measures, such as cleaning and maintenance of collection points and trucks, containers, minimization of illegal waste dumping. These measures include also health and safety training for workers, public awareness campaigns, implementation of an environmental and health and safety monitoring system.

My research of the waste management in Khujand has shown the following situation and urgent development needs:

- The ratio between generated and collected waste is low; only 75% of generated solid waste is being collected. [5] Storm water ditches, waste tipping at streets, informal dumps and burning or dumping at the private yards has to be assumed
- Most solid waste is being tipped along streets and at collection points without containers. Open waste tipping increased health risks for the

population, the necessity of time consuming and inefficient methodology for solid waste collection

- The available human resources and machinery capacity for waste collection are limited and cannot cover an increased waste collection volume. Most of the trucks do not provide sufficient load volume, which would allow efficient waste collection. The result is an increased work time for manual loading and relatively high specific fuel consumption per ton of collected waste
- The landfill site does not comply with basic health and environmental standards and is being operated almost without technical equipment
- Due to a lack of safety equipment, safety and health standards of the workers, fulfilling landfill operation and waste collection are not applied
- Currently, basic workers rights are not fulfilled (e.g. discrimination, lack of compliance with Tajik legislation)
- Lack of organizational performance and structure (but they have clear interest for improvements)
- Due to combination with other services, present institutional waste management structure does not allow a transparent economic management
- Tariffs are low and they do not cover the operation costs. The costs difference has to be covered out of City budget

The analysis of the future waste generation in Khujand until 2026 has assumed a steady increase of the solid waste collection from 2011 to 2021 and from this year onwards a slight decrease, because advanced waste reduction strategies would be effective. ^[5] This prognosis is based on the assumption of economical development of the region and steady population increase.

The long-term development strategy of the waste management in Khujand will address on the following institutional measures and investments:

- Estimated total cost of the investments is approximately 17.1 million USD between 2012 and 2026 ^[5]
- Waste tipping improvement at collection points by minimization of open waste tipping (waste tipping in containers) and increase waste collection points' technical and density standard

Effects:

- Population health risks minimization caused by open waste tipping
 - Waste collection operation costs reduction (fuel consumption)
 - Bad environmental effects reduction caused by illegal waste dumping, burning at private premises and open waste tipping
 - Relevant climate emissions reduction caused by private waste burning and inefficient waste collection
- Waste collection truck modernization by obtaining additional modern waste collection trucks with sufficient load volume

Effects:

- Workers health risks minimization caused by waste loading
 - Waste collection operation costs reduction (especially, fuel consumption)
 - Relevant climate emissions reduction caused by transport and inefficient waste collection
- Waste management enterprise operational center modernization

Effects:

- Operational staff health risks minimization by supplying of suitable working equipment and sanitary rooms
 - Enterprise operational efficiency improvement
 - Equipment and facilities supplying with a proper maintenance of the equipment and machinery, which will increase equipment's life-cycle
- Upgrading of the existing landfill site to an ecological landfill, which will support a safe operation with minimized health risks for the operational staff

Effects:

- Environmental risks minimization caused by gas emissions, generation of dust and uncontrolled leachate outflows
- Relevant climate emissions reduction, especially CH₄ and CO₂ emissions
- Operational staff health risks minimization caused by handling waste without protection

19 INSTITUTIONAL DEVELOPMENT

Transformation of the existing communal enterprise “Motor Pool” into a modern Waste Management Enterprise under the ownership of the City Administration and two separate operational units for landfill operations and waste collection.

Effects:

- More transparency in accounting
- Improved communication culture with population, political and other stakeholders
- Better follow up capability of sustainable tariff strategy
- Increased enterprise managerial capacity
- Long-term enabled investment planning

20 ORGANIZATIONAL DEVELOPMENT OF THE WASTE MANAGEMENT ENTERPRISE

In order to be prepared for the advanced waste management operations in the future, re-organization of the enterprise structure by the public awareness planning and managing, separate operational units establishment for landfill operations and waste collection, labor staff conditions improvement, increasing of the capacity to schedule daily operations should be performed.

Effects:

- Improved managerial structure
- Investments can be maintained and operated
- The enterprise works on stable cost conditions and revenue
- Improved staff labor conditions (especially, health and safety standards)

Public Awareness Activities:

Effects:

- Illegal waste tipping reduction
- Population motivation in following up the waste reduction strategies
- Acceptance of higher level waste tariffs
- Waste management enterprise branding as a modern urban infrastructure service provider

21 SUGGESTIONS AND RECOMMENDATIONS

Priority Issues and Solutions

Issues	Solutions
Problem of making contracts with organizations and enterprises	To make contracts with all organizations and enterprises as soon as possible
New containers	To provide all collecting points with new containers
Old transport means (trucks)	Purchase of new transport means
Contracts with population and enterprises	To make strict contracts and to fine customers in case of breaking the contract
Outdated auto park	To renovate the auto park
Social services for Motor Pool employees	To protect employees by law
Employees safety at work place	To organize additional courses for truck drivers on using of special techniques

Suggestion of Solutions for the Following Issues:

Environmental issues:

- To define optimal work schedule
- To register temporary waste collection points
- To hold monitoring on keeping distance between collection points and multi-story houses
- To hold monitoring on technical condition of trucks
- To disinfect trucks

Staff recruitment issues:

- Salary system should be based on education level, work experience, without any discrimination
- Recruitment policy should be based on level of education, work experience and without any discrimination
- Employees should be promoted to a different position based on their communication skills, professional knowledge and performance indicator

- Financial incentives (rewards) should be organized for active Motor Pool employees

EHS issues:

- Quarterly conduction of trainings and seminars involving psychologists
- Program designing involving the environmental protection department
- Building crematorium and purchasing special transport for sick and dead animals transportation

Consumer relation issues:

- Making contracts with consumers
- To establish consulting centers for consumers
- Waste sorting organization. Explaining to the population necessity of sorting. Population training
- Qualification and skills improving of Motor Pool staff (conducting seminars and workshops for Motor Pool employees)

In order to reduce landfilling, Khujand city should be provided with a waste management system that is based primarily on source separation. Households in Khujand city should be provided with four bins:

- Garden and kitchen waste
- Paper and cardboard
- Hazardous materials, batteries, paint, oil etc.
- Residual waste

22 WASTE-TO-ENERGY FUNDAMENTALS

Rapid growth of urban population and economic development have resulted in the generation of enormous quantities of municipal solid waste that cannot any longer be disposed in landfills. This has led to the U.S., E.U. and other developed countries to adopt the “hierarchy of waste management” that gives priority to composting, recycling, waste reduction and waste-to-energy (WTE) over sanitary landfilling. Sanitary landfills protect groundwater and surface and reduce greenhouse gas emissions to the atmosphere. However, it has been estimated that globally, over 80% of the total urban post-recycling MSW is landfilled (1 billion tons per year), and only 20% of the waste is disposed in sanitary landfills. [2]

Waste-to-Energy is the energy generating process in electricity or heat form through a variety of processes, such as combustion, gasification, pyrolyzation, anaerobic digestion and landfill gas recovery using non-recyclable waste materials. Energy recovery from waste is part of the non-hazardous waste management hierarchy. Through converting of non-recyclable materials into heat and electricity we produce clean, renewable energy and reduce greenhouse gas emission and support recycling through the recovery of metals. Worldwide, there are more than 800 thermal treatment plants and most of them are in the U.S., E.U., Japan and China. [2]

The integrated solid waste management framework of analysis consists of three dimensions:

- The stakeholders
- The physical Waste System Elements (generation, storage, collection, etc.)
- The aspects (technical, environmental, etc.)

22.1 Thermal Treatment Technologies

Effect of the inert and moisture materials on MSW heating value.

From Figure 41 we can see, that non-combustion materials and the moisture contained in MSW decrease its calorific value.

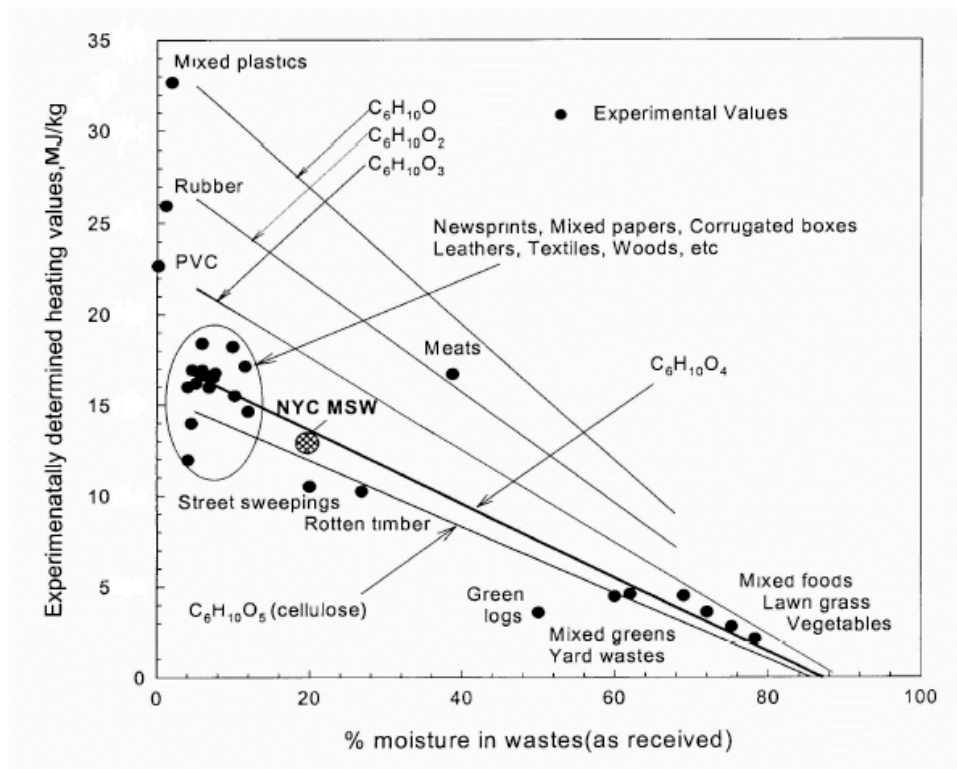


Figure 40: Effect of Components and Moisture on Calorific Value of MSW [2]

22.1.1 Grate Combustion

In grate combustion WTE, the MSW bags are discharged from the collection vehicles into the waste bunker, which is located in a fully enclosed building. A crane loads solid wastes into the feed hopper of the WTE furnace and a ram feeder pushes the wastes onto the moving grate. The mechanical motion of the grate moves the bed of solid wastes through the combustion chamber. The high temperature turns the wastes into the ash that is discharged at the lower end of the grate.

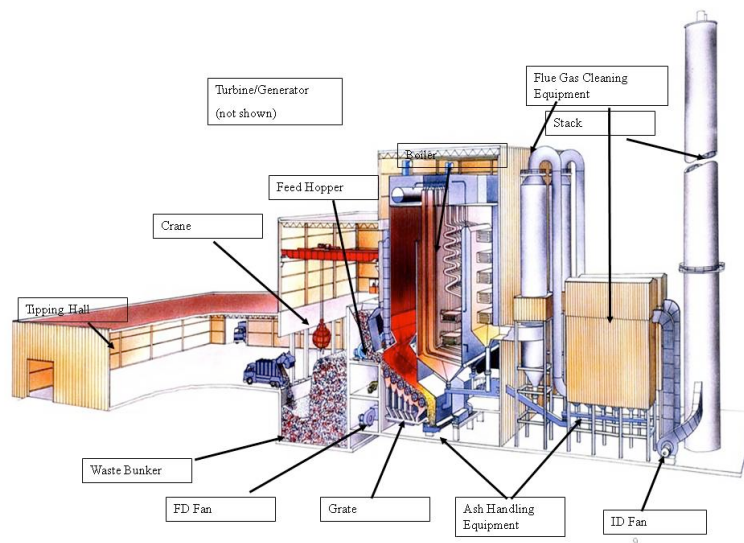


Figure 41: Parts of a WTE Grate Combustion Plant [2]

22.1.2 Combustion of Refuse-Derived Fuel (RDF)

This process consists of single shredding of the MSW, sorting out of the recyclable materials, and then combusting the resulting RDF. There are 12 RDF WTE facilities in the U.S. Their capacity is ranging from 360 to 2,700 tons per day. [2]

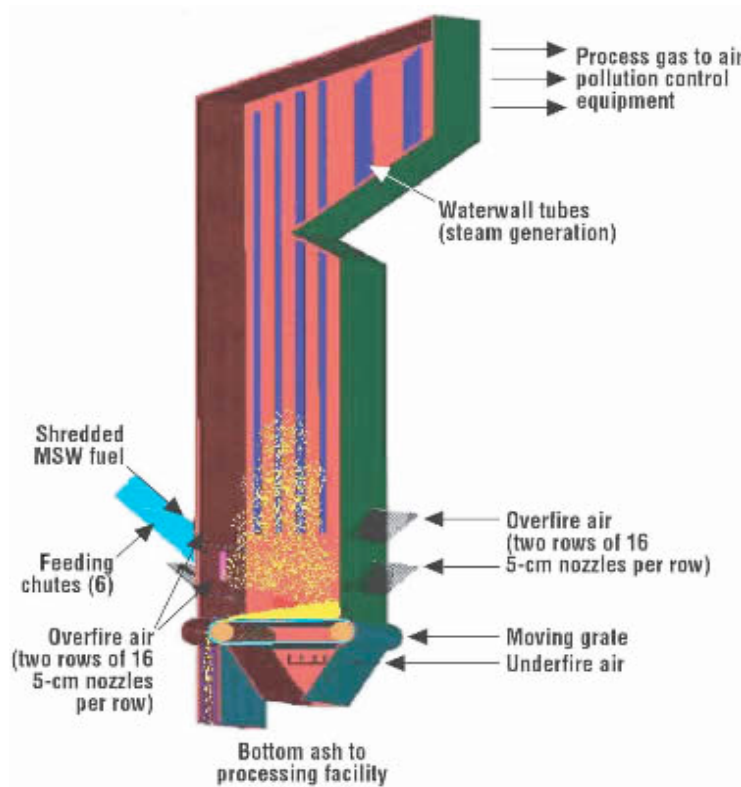


Figure 42: Schematic Diagram of the SEMASS Combustion Unit [2]

22.1.3 Fluidized Bed Combustion

By introducing a gas flow through the bottom of the waste bed, the fluidization process converts solid wastes into a fluid.

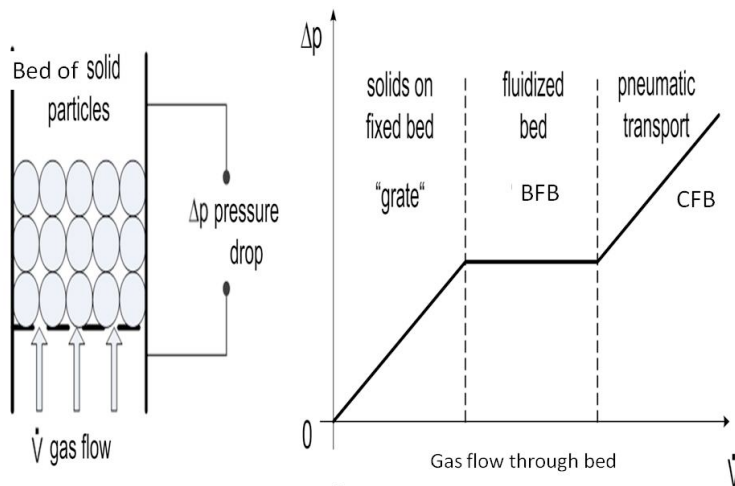


Figure 43: Change in Behavior of Bed Solids with Increasing Gas Flow and Pressure Drop Through the Bed [2]

Figure 44 illustrates a bed of solid particles placed on a perforated plate in a vertical cylinder. As a gas is injected through the plate and as its flow increases the bed of solids starts behaving as a boiling liquid. If the gas flow rate is increased further, the particles from the fluid bed can be carried out of the reactor by gas.

22.2 Gasification Technologies

These processes have low emissions as the conventional WTE combustion process and produce a vitrified ash that can be used favorably outside landfills. The largest user of MSW gasification in the world is Japan.

22.2.1 The JFE Direct Melting Process

The JFE Direct Smelting reactor looks like a small iron furnace, where the waste particles are fed through the top of a vertical shaft. In this process the MSW is shredded and converted to RDF, drying the organic fraction in a rotary kiln and then extruding it under pressure into 15-mm diameter by 20-mm long cylindrical particles. [2] The material produced in several RDF facilities is then transported to a regional Direct Smelting facility in order to combust it and to recover the energy.

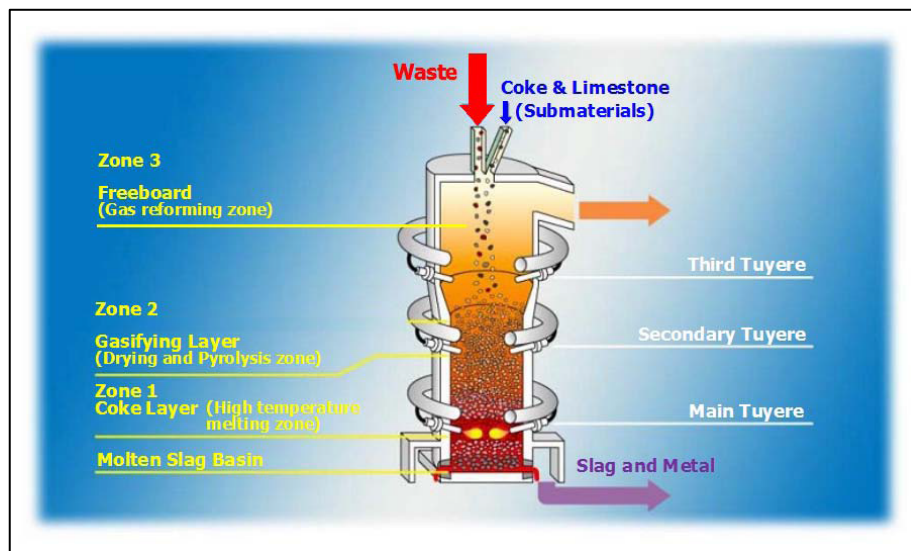


Figure 44: The JFE Direct Smelting Process [2]

22.2.2 The Energos Grate Combustion and Gasification Process

Currently, six plants in Norway, one in the U.K., one in Germany use the Energos grate combustion and gasification technology. Energos is part of the ENER-G group and its headquarter is located near Manchester, U.K. In order to

provide an economic alternative to grate combustion WTE, this technology was developed in Norway in 1990s. [2] This technology has low emissions to the atmosphere and flexibility in feedstock. Capacity of current operating plants range from 10,000 to 78,000 tons per year. [2]

The Energos plant feedstock is post-recycling MSW mixed with a smaller amount of other waste streams, such as industrial waste and wastes from materials recovery facilities. Prior to thermal treatment, the materials are shredded in a shredder and then metals are removed magnetically. In Figure 46 is shown a schematic diagram of the combustion and gasifier chamber.

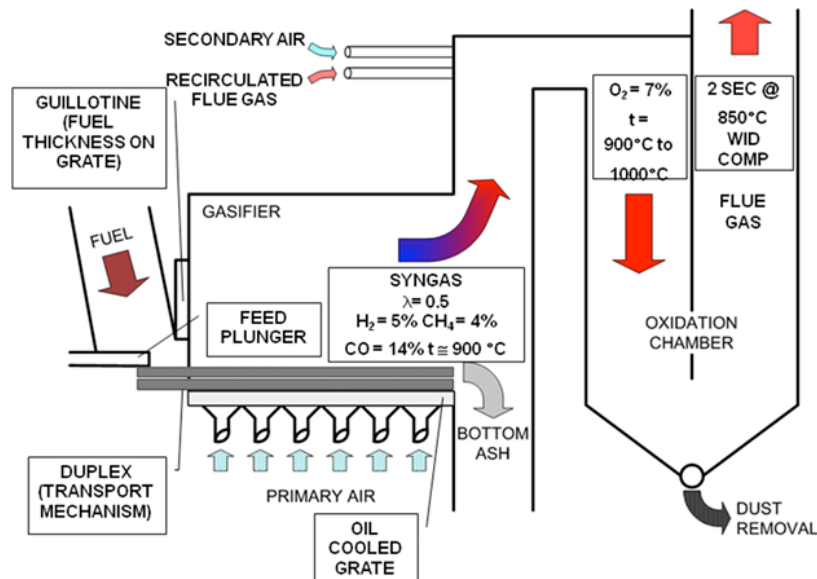


Figure 45: The Energos Gasifier and Combustion Units [2]

Heat recovery steam generation unit is shown in figure 47.

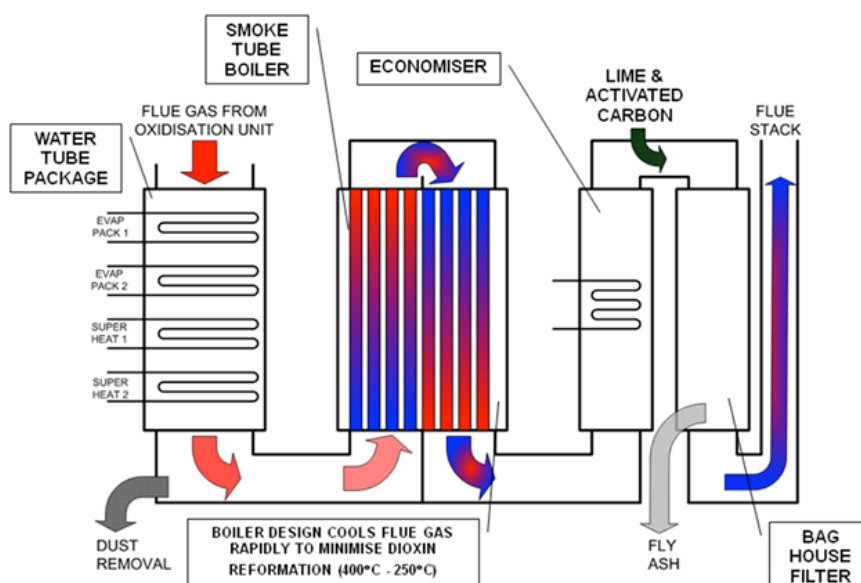


Figure 46: Energos Recovery Steam Generation [2]

The availability of the Energos plants is about 90% (8,000 hours per year). [2] Over the years, the Energos plants have treated over 1.8 million tons of post-recycling wastes and produced 3,800 GWh of both thermal and electric energy. [2] It has reduced the greenhouse gas emissions over landfilling by 990,000 tons of equivalent carbon dioxide emissions. [2] These plants provide district heating to the host communities and local industries.

22.3 Major parts of a WTE plant

- Civil engineering works (site preparation, services, building, landscaping)
- Furnace
- Boiler
- Air pollution control system
- Steam turbine

22.4 Selecting the site for the WTE plant

The factors that should be considered for the WTE plant site selection:

- Proximity to waste generation center
- Proximity to district heating and cooling
- Proximity to water
- Proximity to electricity connection lines
- Proximity to landfill (for ash disposal)
- Proximity to industrial steam consumers
- Utilities
- Traffic
- Access roads

23 POTENTIAL FOR THE WASTE-TO-ENERGY PLANT IN KHUJAND

As from previous analysis we know, that the waste generation in Khujand is 51,974 tons per year and 142 tons per day, then based on this information we can predict, that we can build in Khujand the WTE plant with the Energos grate combustion and gasification technology.

By using the Energos technology, we can provide Khujand city with an economically efficient alternative to conventional grate combustion with equally low emissions to the atmosphere and flexibility in feedstock. The Energos

technology ranges in capacity from 30 tons/day per unit to 118 tons/day per unit. These low capacity facilities can be built at a capital cost per ton, which is lower than large mass burn WTE facilities and require a small footprint of less than one hectare. [21] The construction of small scale WTE plant is beneficial, because it avoids the environmental and economic impacts connected with the long waste transfer distance.

Using the Energos grate combustion and gasification technology we can build a plant with combined heat and power (CHP) system. During periods of low heat demand, steam can be used to produce electricity and then this produced electricity can be sold to the grid and used by local consumers. Below, Table 10 shows the existing Energos plants, which are operating in Norway.

Table 10: Operating Energos Plants [21]

Plant Location (start up year)	Waste Input Streams	Total Annual Capacity, tons (no. of lines)	Approximate Site Area (m ²) ¹	Thermal Energy Produced (MWh/year)	MWh, th per ton	Investment per ton of annual capacity ²	Investment per MWh, th produced
Ranheim, Norway (1997)	Paper mill rejects + various commercial wastes	10,000 (1)	N.A.	25,000	2.5	\$1,350	\$540
Averoy, Norway-Nordmore Region (2000)	Mixed MSW + various commercial wastes	30000 (1)	6,000	69,000	2.3	\$1,033	\$450
Hurum, Norway (2001)	Mixed MSW + commercial waste from airport + paper rejects	39000 (1)	6,000	105,000	2.7	\$657	\$238
Minden, Germany (2001)	50% Residual MSW + RDF (paper and plastic waste)	39000 (1)	6,000	105,000	2.7	\$673	\$243
Forus, Norway-Stavanger Region (2002)	Residual MSW + commercial wastes	39000 (1)	6,000	105,000	2.7	\$825	\$314
Sarpsborg 1, Norway (2002)	MSW + commercial wastes	78000 (2)	9,000	210,000	2.7	\$525	\$195
Sarpsborg 2, Norway (2010)	MSW + commercial wastes	78000 (2)	9,000	256,000	3.3	\$525	\$195

¹ Since site area is project specific, approximate site area has been estimated by use of the following data provided by Energos: Single Line site area is 6,000 sq meters and double line site area is 9,000 sq meters. The data shown in this Table will be further refined during continuing thesis research.

² Assuming Investment per ton for Sarpsborg 2 Plant is the same as Sarpsborg 1.

24 Economics

The following five tables indicate the summary of two case studies: one of them is the projected plant in Khujand and another one is the existing Sarpsborg - Energos plant in Norway.

Table 11: Summary of Two Case Studies in Norway and Khujand – Part 1

Case Study	Sarpsborg 1, Norway (2002)	Plant in Khujand
Total MSW (tons/year)	78,000 ^[21]	52,000 ^[5]
MSW LHV (MJ/kg)	10 ^[2]	10 ^[2]
WTE plant hourly capacity (tons/hour)	9.75	6.5
WTE plant capacity (tons/day)	214	142
WTE plant annual capacity (tons/year)	78,000	52,000
Waste Input Streams	Mixed MSW+ commercial waste	MSW (paper and plastic waste)
Approximate Site Area (m ²)	10,000 ^[21]	10,000 ^[21]
Number of lines	1 ^[21]	1 ^[21]
Hours of operation (per year)	8,000 ^[2]	8,000 ^[2]
Number of employees (person)	60 ^[2]	60 ^[2]

Table 12: Summary of Two Case Studies in Norway and Khujand – Part 2

Case Study	Sarpsborg 1, Norway (2002)	Plant in Khujand
Thermal Energy Produced (MWh/year)	210,000 ^[21]	140,400 ^[21]
Electricity production (kWh/ton MSW)	673	675
Electricity to the grid (at 25% thermal efficiency MWh/year)	52,500	35,100
Electricity price (US\$/MWh)	100 ^[24]	40 ^[23]

Table 13: Summary of Two Case Studies in Norway and Khujand – Part 3

Case Study	Sarpsborg 1, Norway (2002)	Plant in Khujand
CAPEX (US\$ million)	41	15.6
CAPEX (US\$/ton MSW)	525 ^[21]	300 ^[21]
OPEX (US\$ million)	1.2 ^[25]	0.09 ^[6]
OPEX (US\$/ton MSW)	15	1.73

Table 14: Summary of Two Case Studies in Norway and Khujand – Part 4

Case Study	Sarpsborg 1, Norway (2002)	Plant in Khujand
Current gate fee (US\$/ton MSW)	37 [26]	15
Current gate fee (US million \$/year)	2.9	0.78
Recovered metal (US\$/ton MSW)	23	21
Recovered metal (US million \$/year)	1.8 [28]	1.1 [27]
Electricity revenue (US\$/ton MSW)	94	41
Electricity revenue (US million \$/year)	7.3 [29]	2.1

Table 15: Summary of Two Case Studies in Norway and Khujand – Part 5

Case Study	Sarpsborg 1, Norway (2002)	Plant in Khujand
Total revenue (US million \$/year)	12	4
Total expenses (US million \$)	42	16
Payback period (year)	4	4
Household electricity consumption (MWh/year)	8.2 [30]	5.8 [22]
Number of homes which could be supplied with electricity (per year)	6,402	6,052

From the last five tables above we can see that the estimated capital cost of the projected plant in Khujand is about \$16 million. Currently, in Khujand, there are very small unofficial recycling and composting measures. Because of that, we cannot find the amount of recycled and composted MSW. Based on the following formula, I calculated that the payback period of the capital investment of the plant in Khujand is about four years:

$$\text{Payback period} = \frac{\text{CAPEX}}{\text{Revenue} - \text{OPEX}}$$

$$\text{Payback period} = \frac{\$15,600,000}{\$4,032,461 - \$90,000} = 4 \text{ years}$$

It means, that after 4 years we can get revenue, which is equal to \$3,942,461 annually, by operating the WTE plant in Khujand. The operating period of the plant is usually 20 years, but with proper maintenance it can be operated over forty years for current generation and can be a patrimony gift to the following generations. [2]

Realization of this WTE plant in Khujand is feasible, if the government would help for its investment through a grant from international and national organizations. The prospective owners of the facility provide another part of the capital cost and the remainder is obtained from a national or international bank in the form of a long-term loan.

The total annual revenue of the plant is equal to \$4,032,461, which includes revenues from gate fee, recovery of metals and sale of electricity.

24.1 Proposed Capacity and Energy Generation Potential

The WTE plant size in Khujand case is a single line of 6.5 tons/hour capacity, i.e., 6.5 tons x 8,000 hours of operation per year = 52,000 tons per year. The current generation of MSW in Khujand is 52,000 tons per year and based on medium-level scenario is projected to increase to 103,000 tons by 2026. A second line may be added to the plant in the future, thereby doubling capacity to 103,000 tons per year.

As the annual electricity production in Khujand is 35,100 MWh and the average household electricity consumption is 5.8 kWh/year [22], the WTE in Khujand would provide enough electricity for about 6,052 households per year.

The WTE plant with Energos grate combustion and gasification technology in Khujand would be look as it shown in the following figures.

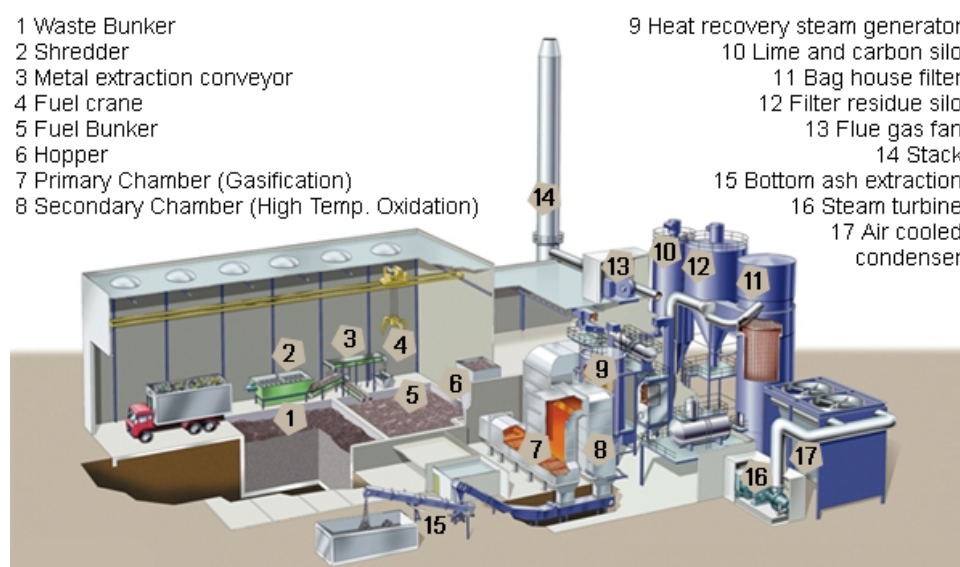


Figure 47: WTE Plant with the Energos Grate Combustion and Gasification Technology



Figure 48: WTE Plant using the Energos Grate Combustion and Gasification Technology

24.2 Typical Timetable for Completion of Project ^[2]

- Prefeasibility study, including the WTE plans siting – 12 months
- Feasibility and cost benefit analysis, including design of the WTE plant – 4 months
- Preparation and launching of the tender documents – 6 months
- Contract award – 15 months
- Environmental permitting of the facility – 10 months
- Completion of design according to the environmental permit – 1 month
- Construction phase – 24 months

Total – 72 months

25 ADVANTAGES AND OF THE WASTE-TO-ENERGY PLANT IN KHUJAND

25.1 Advantages

- It requires a small footprint of less than one hectare
- People will have 24/7/365 power and heat, especially during the winter
- The areas of Khujand city would be cleaner
- Reduction of air emissions (mainly CO₂); GHG emission reduction
- Current landfill sites can be mined out and the landfill material used as fuel
- Land saving - from the closing/elimination of landfills
- Urban mining: treatment- extraction of metals from combustion residues
- From the worldwide experience, WTE goes hand in hand with recycling
- The fuel is obtainable cheaply
- There will always be a reliable source of fuel as people will always have waste
- Plant can be built at a capital cost per ton that is low than that of a large mass burn WTE facilities
- The significant amount of energy produced
- The low level of uncertainty following its implementation
- Minimization of waste that end up in landfills
- Energy generation from non-fossil fuels; generation of clean and green energy
- New job opportunities and capacity building in energy and waste sector
- Reduction on fossil fuel dependence
- Energy production increase from renewable resources and preservation of natural resources, fossil fuels

25.2 Disadvantages

- The public is still unconvinced that emissions from waste-to-energy plants are clean and free from harmful chemicals
- Waste-to-energy facilities are expensive to construct
- High cost of combustion residues disposal
- Realization of the projected WTE plant in Khujand is feasible, if the government would help for its investment

CONCLUSION

Rapid growth of urban population and economic development have resulted in the generation of enormous quantities of municipal solid waste that cannot any longer be disposed in landfills.

Municipal solid waste in Tajikistan consists of food waste, green waste, cardboard and paper, textiles, wood, rubber and leather, nappies, metal, plastics, glass and others. Annually, about 1,7-2 million tons ^[7] of municipal solid waste (MSW) is generated in Tajikistan. In Dushanbe about 218,000 tons of municipal waste is generated annually and only about 50% of that is dumped at official, regulated landfills. ^[7] The rest of waste goes to illegal landfills. Municipal solid waste is neither sorted nor treated in the country. Because of trucks and fuels shortage, the collection of municipal solid waste is poor in urban areas. None of the landfills meet current international standards. Reuse, recycle and composting of waste are the one way to save natural resources and to protect the environment. Another important way of saving natural resources and protecting the environment is waste-to energy.

Waste-to-Energy is the energy generating process in electricity or heat form through a variety of processes, such as combustion, gasification, pyrolyzation, anaerobic digestion and landfill gas recovery using non-recyclable waste materials. Energy recovery from waste is part of the non-hazardous waste management hierarchy. Through converting of non-recyclable materials into heat and electricity we produce clean, renewable energy and reduce greenhouse gas emission and support recycling through the recovery of metals.

The waste generation in Khujand is 51,974 tons per year and 142 tons per day. Based on this information, we can predict, that we can build in Khujand the WTE plant with the Energos grate combustion and gasification technology.

By using the Energos technology, we can provide Khujand city with an economically efficient alternative to conventional grate combustion with equally low emissions to the atmosphere and flexibility in feedstock. The construction of small scale WTE plant is beneficial, because it avoids the environmental and economic impacts connected with the long waste transfer distance.

Using the Energos grate combustion and gasification technology we can build a plant with combined heat and power (CHP) system. During periods of low heat demand, steam can be used to produce electricity and then this produced electricity can be sold to the grid and used by local consumers.

The estimated capital cost of the projected plant in Khujand is about \$16 million. The estimated land area for the plant is 10,000 m² and the estimated lower heating value (LHV) for Khujand MSW is 10 MJ/kg.

The payback period of the capital investment of the plant in Khujand is about four years. It means, that after 4 years we can get revenue, which is equal to \$3,942,461 annually, by operating the WTE plant in Khujand. The operating period of the plant is usually 20 years, but with proper maintenance it can be operated over forty years for current generation and can be a patrimony gift to the following generations. [2]

Realization of this WTE plant in Khujand is feasible, if the government would help for its investment through a grant from international and national organizations. The prospective owners of the facility provide another part of the capital cost and the remainder is obtained from a national or international bank in the form of a long-term loan.

The total annual revenue of the plant is equal to \$4,032,461, which includes revenues from gate fee, recovery of metals and sale of electricity.

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As the annual electricity production in Khujand is 35,100 MWh and the average household electricity consumption is 5.8 kWh/year [22], the WTE in Khujand would provide enough electricity for about 6,052 households per year.

Typical duration for completion of project is 72 months. [2]

The main advantages of the WTE plant in Khujand:

- People will have 24/7/365 power and heat, especially during the winter
- WTE plant continuously serves future generations for many years, while sanitary landfill is filled in 10-20 years
- Incineration of waste with energy recovery can reduce the disposed waste volume by up to 90%.
- It requires a small footprint of less than one hectare
- The areas of Khujand city would be cleaner
- Land saving - from the closing/elimination of landfills

- New job opportunities and capacity building in energy and waste sector
- Reduction of air emissions (mainly CO₂); GHG emission reduction
- Reduction on fossil fuel dependence

The main disadvantages of the WTE plant in Khujand:

- The public is still unconvinced that emissions from waste-to-energy plants are clean and free from harmful chemicals
- Waste-to-energy facilities are expensive to construct
- Realization of the projected WTE plant in Khujand is feasible, if the government would help for its investment

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APPENDICES

Appendix 1. The Waste Management Hierarchy in Tajik language (by Shahnoza Boboeva)

