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1. Project background

1.1. Existing waste management situation in Albania and Tirana

The production of Urban Waste in Albania, due to a number of various economic and social factors, has undergone major changes in recent years and the total amount has continued to grow until it reached a level slightly lower than the European average.

In the most developed countries the entire waste management system is being treated as a profitable venture by private companies, by non-governmental and governmental organizations with a fee for waste treatment. Different technologies such as waste to energy plants are being adopted. The purpose of these technologies is the reduction of the amount of waste and environmental pollution and the production of a significant amount of renewable energy.

Figure 1:

Quantity of municipal waste generated in Western Balkan area, 2011 and 2016

Source: Eurostat: https://ec.europa.eu/eurostat
Integrated Waste-to-Energy in Albania – The Municipal Solid Waste Project in Tirana

In Albania the collection and centralized management of urban waste is not at an advanced stage and it is coupled with infrastructure problems and a lack of financial and technical capacities. This situation gives rise to serious problem to the environment and human health.

The most used method for the disposal of waste are still landfills which are not compliant to EU standards or are located in sensitive areas leading to potential environment pollution: that landfills are the main source of CH₄ emissions in the waste management cycle due to the high percentage of organic waste.

It's important to note that no biodegradable composting plant or incineration plant of municipal (not recyclable) and industrial waste exists to utilize their chemical energy content for the conversion to thermal and electrical energy. The only exception is the Waste to energy plant built in Elbasan in 2017.

1.2. Tirana district

In Albania, the district of Tirana has the highest MSW production, followed by the district of Fier, Gjirokastra and Vlora. Also in the district of Tirana, as in other most urban areas of the country, waste is collected and transported by private companies of waste collection.

The district of Tirana lies in the central part of Albania, occupying a part of the Coastal and Kavaja Plain, the surrounding hilly areas and the Tirana highlands. It has an area of 1,586 km² with a population of 749,365 [4] and the center is located in Tirana.

The Tirana district population represents about 26.76 % of the country population and the average population density is 472.49 inhabitants/km², compared with 97.4 inhabitants/km² nationwide. The density mainly reflects the concentration of the population in local units within a rather small area.

Figure 2: District of Tirana
1.3. Short description of the whole project

The project which involves Tirana district foresees the construction of various main facilities.

The different technologies and installations foreseen are dimensioned to address the management and treatment of the Inert and Urban Waste (MSW) produced in the province of Tirana. The Tirana Waste Treatment Area (T.W.T.A.) is designed to receive and treat or dispose 800 ton/day of waste at the beginning of the operation (Year 1) and 950/1,060 ton/day by year 30 of the concession, equal to a 0.5/1 % increase per year of the MSW production.

The project foresees:

- the construction of the urban waste processing plant with energy recovery (Waste to Energy plant – WTE) by producing electricity,
- the construction of urban waste landfill, a landfill for the waste after thermovalorization processing, and an inert waste landfill,
- the construction of an urban waste recycling and stabilization plant,
- the construction of the wastewater processing plant,
- in addition to the above constructions the project will include the final closure of the existing landfill.

1.4. Geographical location

The area for the construction of the new WTE plant and landfill will stretch south and east of the existing landfill area.

The proposed area for the realization of the plant covers about 120 hectares (1,200,000 m²). This area is necessary for the installment of the infrastructures provided in the project.

This area consists of planar and hilly areas partially unused and partially cultivated.

The access to the site is through a rural road which will require expansion and reconstruction. New roads will be designed and constructed to make the site more accessible.

1.5. Legal framework

Albanian Government is undergoing the process of transposing to Albanian Law the EU directives on Environmental themes and on waste management.
Between the EU directives on waste management, the Directive 2008/98/EC (Waste Framework Directive) sets the basic concepts and definitions related to waste management, such as definitions of waste, recycling, recovery. It explains when waste ceases to be waste and becomes a secondary raw material (so called end-of-waste criteria), and how to distinguish between waste and by-products.

The Directive lays down some basic waste management principles: it requires that waste be managed without endangering human health and harming the environment, and in particular without risk to water, air, soil, plants or animals, without causing a nuisance through noise or odours, and without adversely affecting the countryside or places of special interest. [2]

1.6. Project originator and purpose

The initiator and proposer of the construction of the Tirana Waste Treatment Area is the company Integrated Energy B.V. The direct beneficiary of the project is the District of Tirana that by this project can find a solution for urban solid waste management.

Integrated Energy B.V. is implementing the proposed project for the district of Tirana, based on the operating form BOT (Built, Operate, and Transfer), according to the Public-Private partnership scheme.

The main project participants at a national level are the Ministry of Environment, the Ministry of Energy and Industry and the Ministry of Finance.

The realization of the Waste to Energy plant, from the design to all services related to its operation have been contracted to Paul Wurth Energy Srl which belongs to the International Paul Wurth Group.

2. Project description of WTE plant

2.1. Technological choice

The technological choice is based on the purpose to provide a Waste to Energy plant for the production of electric power by means of Municipal Solid Waste (MSW) as is and/or waste similar/assimilable to MSW, available in the area covered by the plant.
Figure 5: WTE plant project Tirana – Process scheme
The plant consists of No. 4 Incineration Lines combined in two couples with common turbogenerator and auxiliaries.

The selected technology is that of thermal destruction by grate furnaces. The plant will generate electric power through a steam thermal cycle (Rankine cycle).

By the method of thermal treatment (thermo-destruction), the complete combustion (i.e. a total and fast oxidation) of combustible fraction is accomplished.

The MSW is combusted on the moving grate and the heat contained in the flue gas is recovered through a boiler with water pipes, capable of producing the superheated steam necessary to the turbine.

The superheated steam, coming from two boilers, feeds a common steam turbine which, by driving an alternator, is able to generate approximately 10.35 gross MW.

The electric power produced, net of the system own consumption, is put into the electrical grid.

The main equipment of a couple of incineration lines are:

- 2 Incinerator lines complete with flue gas emission abatement system,
- 1 Thermal cycle (common for two incineration lines),
- 1 Steam turbine (common for two incineration lines),
- 1 Air condenser (common for two incineration lines),
- 1 Compress air system,
- 1 Demi water production,
- 1 Emergency electric generator,
- 1 Waste collecting pit with approximately 2 days storage capacity,
- 2 Crane for waste feeding (one in stand-by),
- 2 Chimneys (placed in a common casing).

2.2. Design data

2.2.1. Characteristics of MSW

MSW and similar/assimilate are general terms to indicate the domestic/urban waste. Residues which at the original state (or as aggregate final product) exceed the maximum size of 70 cm cannot be fed to the furnace.

The following special and/or hazardous wastes must be never put into the incineration furnace:

- Ammunition and explosives,
- Radioactive waste,
- Pressure vessel,
- Laboratory waste,
- Infected waste and anatomic parts,
- Carcass of animals,
- Meat and bone meal,
- Asbestos residues,
- Sludge from decontamination and neutralization of steelworks,
- Pressurized gas in cylinders,
- Toxic and carcinogenic materials,
- Acids,
- Caustic solutions,
- Chemical product with high exothermic reaction.

The respect of the previous list is mandatory: the WTE plant is not authorized to burn special and/or hazardous wastes but only Municipal Solid Wastes.

Following, we indicate a EWC (European Waste Catalogue) codes list for the waste admissible to the Incineration Lines.

Table 1: Wastes admissible to the incineration lines

<table>
<thead>
<tr>
<th>02 Wastes from agriculture, horticulture, aquaculture, forestry, hunting and fishing, food preparation and processing</th>
<th>17 Construction and demolition wastes (including excavated soil from contaminated sites)</th>
</tr>
</thead>
<tbody>
<tr>
<td>02 01 Wastes from agriculture, horticulture, aquaculture, forestry, hunting and fishing</td>
<td>17 02 Wood, glass and plastic</td>
</tr>
<tr>
<td>02 01 03 Plant-tissue waste</td>
<td>17 02 01 Wood</td>
</tr>
<tr>
<td>02 01 04 Waste plastics (except packaging)</td>
<td>18 Wastes from human or animal health care and/or related research (except kitchen and restaurant wastes not arising from immediate health care)</td>
</tr>
<tr>
<td>02 01 07 Wastes from forestry</td>
<td>18 01 Wastes from natal care, diagnosis, treatment or prevention of disease in humans</td>
</tr>
<tr>
<td>02 02 Wastes from the preparation and processing of meat, fish and other foods of animal origin</td>
<td>18 01 04 Wastes whose collection and disposal is not subject to special requirements in order to prevent infection (for example dressings, plaster casts, linen, disposable clothing, diapers)</td>
</tr>
<tr>
<td>02 02 03 Materials unsuitable for consumption or processing</td>
<td>19 Wastes from waste management facilities, off-site waste water treatment plants and preparation of water intended for human consumption and water for industrial use</td>
</tr>
<tr>
<td>02 03 Wastes from fruit, vegetables, cereals, edible oils, cocoa, coffee, tea and tobacco preparation and processing; conserve production; yeast and yeast extract production, molasses preparation and fermentation</td>
<td>19 03 Stabilised/solidified wastes</td>
</tr>
<tr>
<td>02 03 04 Materials unsuitable for consumption or processing</td>
<td>19 03 05 Stabilised wastes other than those mentioned in 19 03 04</td>
</tr>
<tr>
<td>02 05 Wastes from the dairy products industry</td>
<td>19 05 Wastes from aerobic treatment of solid wastes</td>
</tr>
<tr>
<td>02 05 01 Materials unsuitable for consumption or processing</td>
<td>19 05 01 Non-composted fraction of municipal and similar wastes</td>
</tr>
<tr>
<td>02 06 Wastes from the baking and confectionery industry</td>
<td>19 05 03 Off-specification compost</td>
</tr>
<tr>
<td>02 06 01 Materials unsuitable for consumption or processing</td>
<td>19 08 Wastes from waste water treatment plants not otherwise specified</td>
</tr>
<tr>
<td>02 07 Wastes from the production of alcoholic and non-alcoholic beverages (except coffee, tea and cocoa)</td>
<td>19 08 01 Screenings</td>
</tr>
<tr>
<td></td>
<td>19 08 05 Sludges from treatment of urban waste water</td>
</tr>
</tbody>
</table>
The waste to be incinerated consists essentially of MSW and/or similar, as is and/or preselected, having a Lower Heating Value (LHV) from 1,600 kcal/kg to 2,500 kcal/kg, and Nominal value of 1,800 kcal/kg, water content 40%.

2.2.2. Nominal conditions of the project
The waste is intended as *non-hazardous waste / non-special waste* and shall have suitable size for the combustion process and compatible with the furnace supply system.

In correspondence with the nominal LHV 1,800 kcal/kg, the mass flow (QN) to be incinerated is equal to 240 t/d for each Incineration Line.

Under Nominal conditions the Net Electric power produced by two Incinerator Lines working at nominal load (net of the system own consumption) and deliverable to the National grid is equal to 8.55 MWₑ. The Nominal Thermal Load (NTL), in nominal conditions (LHV = 1,800 kcal/kg) is equal to 20.93 MWₜ for each Incineration Line.

From the combustion chart in Figure 6 we can deduce the very high degree of flexibility that characterises the system and this, both in terms of thermal load and waste capacity. The Combustion diagram represents, inside the red polygonal, the admissible field of operation for the plant.

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**Figure 6:** Combustion diagram of the project in Tirana
3. Overall concept of the waste to energy plant

The waste trucks carry the MSW in a platform in the weighting station for the appropriate operations of load weighting.

After the protocol of acceptance, the trucks proceed and unload the materials inside the building of the pre-sorting where the separation of the coarse and non-combustible materials (metals, inert, glass, etc.) takes place. The treated waste is transported to the waste bunker but only if it complies with pre-established EWC codes.

The two waste bunkers are designed with inner insulation or chemical additives for concrete in order to avoid any liquid leakage and are in slight depression to ensure no air leakages toward the outside and avoid bad smell.

The upper part of each waste bunker is provided with two cranes that mix the accumulated waste and introduce it into the loading hoppers of the combustion grates.

In the combustion chamber, the chemical energy contained in the MSW is transformed into heat through a complete combustion process in an oxidizing atmosphere.

The heat is conveyed from the flue gas through the heat-recovery boiler, where the gas transfers its energy directly to the water flowing inside the boiler tubes, which is transformed by heating first into saturated steam and then into superheated steam.

The superheated steam from the two boilers is sent to a common steam turbine in which the energy of the steam is converted into mechanical energy and then transformed into electric power by means of an alternator.

4. Description of the system units

4.1. Combustion chamber

4.1.1. Configuration and dimensions

Every waste incineration line is equipped with a combustion chamber and a steam generation system.

The combustion chamber is configured in its lower surface, by the grate, parallel side walls and sub-horizontal vaults rising toward the centre, up to the outlet section of the flue gas (Venturi).

Dimensions of the combustion chamber: approximately 4.57 m wide and 163 m³ volume.

The temperature of the flue gas entering Post-Combustion (at Venturi) is 950 °C ± 25 °C.

Specific thermal load at NTL is equal to 20,930 kW/163 m³ = 128.4 kW/m³ which is much lower of permissible value equal to 300 kW/m³.

In the initial part of the grate the material in the combustion is dried; in the subsequent sectors the combustion of less volatile and more carbonaceous components takes place.
4.1.2. Characteristic of the combustion chamber

The combustion chamber is semi-adiabatic, meaning that it does not participate entirely to the heat exchange for the generation of steam (but only partially).

It is constituted by a metal supporting structure with inside masonry in refractory material of suitable thickness. The semi-adiabatic combustion chamber has sub-horizontal pipes (with inconel cladding) in correspondence of grid lateral sides in order to avoid sticking of waste slags on refractory shoulders. In addition, in the middle section of lateral walls of the combustion chamber, there are some cooling pipes between refractory bricks. They are very useful because they serve to maintain a relatively stable temperature on refractory even if waste has a high LHV.

4.1.3. Control of combustion

The combustion control system is fully automated by DCS, being also provided with a partially/fully manual system from local keypad.

The furnace complex loop has the objective of implementing a control strategy that allows the furnace/grate system to react to changes in the load on the heat cycle (steam request) and to changes of the MSW, by automatically varying the flow rates of the waste/combustion air/recirculation flue gas around the operating point set by the operator.

The combustion control system processes a signal corresponding to the entity of Thermal Load entered in the combustion chamber and provides to automatically enter the correct amount of waste and the correct flow of combustion air (primary and secondary) and recirculating flue gas for the main purpose of maintaining the production of steam as constant as possible.

4.2. Air-cooled grate

Description and main characteristics

The grate is concerned by a nominal thermal load equal to 20.93 MW, coming from waste combustion.

Dimensions of the grate:
- width of 4.20 m,
- length of approximately 10.3 m,
- overall surface of approximately 43 m².

In the longitudinal direction, the grate is constituted by a set of 4 sectors, independent and consecutive one to another to form the bed supporting the waste during the combustion.

Each sector is characterised by having the upper surface composed of alternated stationary and movable bars rows, plus 1 stationary bar at the edge of the grate on each row.

The waste deposited on the fixed rows, is folded back and moved forward by the translation of the movable row placed above them.
The residence time of the waste on the grate (for the phases of drying, distillation, combustion, completion of combustion) depends on the Thermal Load, the waste composition, the humidity and LHV of the waste, the type of movement set and can last from a minimum of 30 to a maximum of 60 minutes.

In any case and condition, the length of the designed grate and the combustion time set guarantee the completeness of the combustion and an extremely low content of unburned matter in the slag.

4.3. Flue gas treatment system

4.3.1. General description

The flue gas treatment system is designed in order to reduce the dust, the acid pollutants and the inorganic/organic micro pollutants concentration in the flue gas coming from the boiler before the stack emission.

The flue gas treatment plant is mainly composed by:

- reactor,
- bag filter,
- ash and salts transport and storage system,
- reagents storage and injection system,
- flue gas extraction system and evacuation (final IDF),
- flue gas recirculation before the ID FAN into the furnace just before the post-combustion.

The flue gas coming from the economiser enters the reactor where hydrated lime and activated carbon are injected. The mixing of the reagents with the flue gas in the reactor and then in the bag filter provides the required contact time to start the chemical reactions and reduce the pollutants concentration in the flue gas.

The reaction salts and the dust are separated by the bag filter and conveyed by a dedicated transport system to a storage silo.

Here below a reference diagram of the flue gas treatment system.

![Flue gas treatment system diagram](image-url)
4.3.2. Main characteristics

- Low environmental impact on air,
- full respect of the European norms for flue gas emission at the stack (2010/75/EC),
- dry flue gas cleaning line (no wastewater),
- acid gases reduction and heavy metals removal by injection of hydrated lime and activated carbon into a reactor,
- bag filter installation to remove dust,
- continuous Emission Monitoring System in real time, recording and public availability.

4.4. Electric power generation – Steam turbine

4.4.1. General description

The Turbogenerator unit is placed on a supporting structure in reinforced concrete, insulated from the rest of the civil works to prevent the transmission of vibrations toward the outside.

The gross electric power at the terminals of the generator is approximately 10,350 kW (condition of nominal electric power), produced with 2 incineration lines at nominal power and no thermal power produced (design environmental temperature of 25 °C).

The gross electric power at the terminals of the generator will be affected by the steam eventually extracted on the steam turbine and used for local heating (e.g. greenhouse).

The maximum gross electric power at the terminals of the generator is approximately 4,800 kW (condition of nominal electric power and design environmental temperature of 25 °C), produced with 1 Incineration line at nominal power and no thermal power produced.

The condensation turbine, suitable for installation in a covered place, is a single casing, multistage with action and reaction stages.

The steam to the turbine inlet is superheated steam under the following conditions: 51.0 bar(a) / 415.0 °C and with a flow rate = 45.62 t/h.

The condensation is carried out with an air condenser at a nominal pressure of 0.120 bar(a) (T.sat. = 49.40 °C).

The turbine consists of two bodies, one of high pressure and one of low pressure, which process the complete expansion.

The turbine is equipped with No. 1 steam intake valve and an extraction/bleed of live steam at 3.5 bar(a) to supply:

- primary air preheating,
- deaerator,
- other thermal use (i.e. greenhouses).
The hot start-up, parallel setting with the mains and unit stop are automated. In case of black-out on the electric transmission network, the stand-alone operation is also provided.

### 4.4.2. Main characteristics

- High efficiency electrical power production to the National grid,
- steam turbine power generation and cogeneration for greenhouses,
- low electric power for self-consumption,
- air condensation (no water consumption),
- no waste water production.

![Diagram of WTE Plant – Power production and process](image)

**Figure 8:** WTE Plant – Power production and process

### 4.5. Summary of produced residual waste and related storage

The process of waste thermo-destruction produces three types of residuals products:

- slag and heavy ash from combustion,
- fly ash from the boiler,
- calcium product residues (CPR) by the bag filter.

#### 4.5.1. Slag and heavy ash from combustion

Slags are collected at the discharge point of the combustion grates.

Slag-heavy ash means that classified with the European EWC-code 19.01.12, heavy ash and slag, other than those referred to in item 19.01.11*, i.e. that do not contain any dangerous substances.
The maximum production of slag and heavy ash occurs in correspondence to the lowest LHV, when, generally, to the maximum waste flow rates corresponds the higher content of inert and not combustible materials.

Content of total unburned matters in the slag-heavy ash, expressed as total organic carbon (TOC) ≤ 3.0 % by weight. Final destination of the slag-heavy ash are landfill or disposal by specialized and authorised companies.

The wet slag is removed with a plate conveyor, type APRON or equivalent, to be discharged into special containers or in a suitable slag compartment of adequate size.

4.5.2. Fly ash from the boiler

The lighter part of ashes is dragged by the flue gas to be separated in the boiler.

Fly ash means that classified with the European EWC-code 19.01.13*, light ash containing dangerous substances.

This is essentially the lighter combustion ash sent, by mechanical transport, to their storage silo.

Dust/light acid ash is disposed by specialized and authorised companies.

4.5.3. Calcium product residues (CPR)

CPR means that classified with three different European EWC-code:

- 19.01.07*, solid waste produced by the flue gas treatment,
- 19.01.05*, filtration residues by flue gas treatment,
- 19.01.10*, spent activated carbon used for flue gas treatment.

This is represented essentially by the residual combustion ashes, reaction salts of the neutralization process and the spent activated carbon, that are sent, by mechanical transport, to the storage silo.

The recirculation of the Calcium Product Residues (CPR) does not have high effect on the production of residues and the storages.

CPR is disposed by specialized and authorised companies.

5. Summary

Considering the current conditions of Albania in the waste management field and the important economic growth that is affecting this country, we believe that this project fits perfectly into the ongoing modernization process.

The road taken can only bring Albania closer to Europe’s standards, helping to create the conditions to become a member of the European Union in the next future.

The flexibility and modularity of this technology has been chosen precisely for this evolving country because:
Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. [1]

6. References


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