Waste to energy: Nothing but the facts

K. V. Ladygin, S. I. Stompel, Y. L. Spektor, *IPEC,LLC.*

Waste-to-energy is a waste management sector, in which people more often speak of myths, not of facts. The experience of the company IPEC in manufacturing of environmental protection equipment and the conducted research and studies help us to clear up this complex issue.

Half of the world's population lives in the cities. If the current world economic model remains the same, this index will inevitably increase in the nearest future. The number of EU urban population exceeds 70% while in the Central Federal District of Russia this number is close to 90%. Modern city, with its developed technical infrastructure, is a massive consumer of the resources. At the same time, it is a powerful source of environmental pollution. MSW is a major problem in modern megalopolises because the amount of waste, generated by the urban population, is twice as big as the amount of annual world steel production (3 billion tons and 1.5 billion tones accordingly).

It is obvious that the rapid increase in waste amount requires constant monitoring, designing and actualizing of the new concepts in waste management field. The traditional approach to MSW disposal is to isolate it at the landfill sites in the most reliable way.

Thermal Decomposition Plant TDP-2-200

However, it is now obvious that to prevent the waste flow from entering its deposition place is easier than to manage it after the disposal is completed. Nowadays, the contemporary scientific research and developments are focused on the opportunities of processing the waste into valuable secondary resources. At the current stage, the concept of circular economy includes waste-to-resource base in the form of material and energy resources. However, the cost-effective material resources can only be derived from treated and sorted waste fractions of a high quality. On the contrary, there is no such high requirements for the energy resources.

Sweden is an absolute leader in waste-to-energy management field: waste percentage of 98.6% is forwarded for further processing. As a result, the amount of waste, deposited in the landfills, was reduced to 1.4% over the last 15 years. This percentage is also accounted for the ash, resulted from obtaining heat and electric power. The total amount of energy produced from waste increased to 48.4%.

Research and technology institutions made numerous efforts towards generating the energy from the most common and close-at-hand source, from waste. The proposed technological solutions in this area vary significantly.

For example, the project of using bacteria in waste-to-energy process promises energy generation in microbial fuel cells. The project is now being designed in Russia.

This technology, originated in NASA, attracts scholars from all over the world. Nevertheless, this process still relates more to the future, whilst solutions of power generation from waste are available today as well.

Industrial Complex of continuous pyrolysis Thermal Decomposition Plant (TDP-2) coupled with energy generation system is one of such solutions. The company IPEC has been producing environmental protection equipment and facility for two decades already. Two types of generation sets were tested: *Capstone* microturbine (the USA) and gas engine generator FAS (*Fasenergomash* Ltd, Russia).

Low temperature pyrolysis unit decomposes raw materials (high calorific hydrocarbon containing waste) into pyrolysis gas, fuel oil and dry residue. Boiler fuel or diesel oil is used for the plant startup. After the process stabilization, the additional energy sources are not needed anymore; this feature turns pyrolysis plant into a cost-effective facility. The derived pyrolysis gas is fed either to the gas turbine or to the gas-piston drive of the generating set for energy generation.

Capstone gas-turbine system includes compressor, gas-turbine engine and power generation unit. The specific *Capstone* feature is the air layer, which is formed around the turbine shaft and which ensures its high reliability: the manufacturer stated over 60 000 operating hours without overhaul and one of the highest turbine efficiency in its grade level (35%).

Capstone advantages also include low noise level and low emission of contaminants:
according to the manufacturing company, emissions of CO and NOx do not exceed 9 ppm. Considerable cost and rigid requirements for fuel gas preparation are the two main disadvantages of the *Capstone* turbine.

Gas-piston generating plant of Russian make (*FAS)* does not have such a long-term service, but it is capable of utilizing fuel gas, directly produced at *Thermal Decomposition Plant*. *FAS* has such advantages as simplicity and low maintenance cost: its price is much lower in comparison with *Capstone* products.

The Complexes *TDP-2-200* with *Capstone C30* turbine (30 kW of electric power consumption) and *TDP-2-200* with gas-piston generating plant *FAS* (12 kW of electric power consumption) were tested using different types of feedstock:

- chicken manure (waste from poultry farming);
- oil sludge (waste from oil refinery);
- automotive waste chips;
- oil soaked rubber chips (recycled rubber products, soaked with used oil for 12 hours).

Hydrocarbon wastes were loaded into *TDP-2* receiver tank manually (experimental conditions did not require automatic feeding). Raw materials were fed into pyrolysis reactor by screw conveyor. After drying, the thermal destruction started in oxygen deficient environment, generating pyrolysis gas (volatile hydrocarbons) and pyrolysis fuel (liquid hydrocarbons). Pyrolysis gas was directed to generator unit.

The tests were conducted at regular operation mode; the Complex, comprising both pyrolysis and generating plants, resulted the maximum possible value of electric energy allowable by design capacities.

The estimated consumption of pyrolysis gas (calorific value - 40 mJ/m3 (9600 kcal)) by *Capstone* microturbine was 0.28 m3 per 1 kW; the gas consumption by generating plant *FAS* was equal to 0.18 m3 per 1 kW.

Dry residue: a) dry subsoil (from oil sludge processing), b) carbon black (from waste rubber products processing)

Waste rubber, oil sludge and chicken manure are one of the most common secondary energy resources, whereas automotive waste chips are quite exceptional sources of energy.

Automotive waste chips contain 30–35% of metals and the main processing techniques are based on various methods of nonferrous metal extracting. Due to sufficiency of rubber, plastic and wood content, it is possible to generate electric power energy after the metal extraction. *TDP-2* pyrolysis unit, indeed, demonstrates high capability of processing of discarded computers (electronic scrap components, such as mainboards). Although the processing of e-waste in the course of the above test was not conducted, we are confident that the outputs would be the similar.

The equipment that took part in the tests, (TDP-2 *Capstone* turbines and *FAS* generating plant), could not be referred to as 'pilot' or 'experimental' since the units had already been used in producing and proved its high performance capabilities in waste management field.

TDP-2 plants successfully utilizes various types of waste: oil sludge, drilling sludge, rubber goods, e-waste, etc. *Fasenergomash* Company manufactures generating plants based on Japanese *Kubota* engines and Russian *VAZ*, since 1995. *Capstone* Company has more than 7000 installations in the world and more than 1100 of its units are present in Russia.

Test results confirmed that the innovative Complex demonstrated high productivity in the waste-to-energy field.

Speaking globally, the waste with potentially significant calorific value is an inexhaustible source. Unlike gas, coal or oil, this type of waste is not affected by geographic, climatic, political or economic conditions. Waste-to-energy technology would ultimately become the most common way of power generation.