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SWOT ANALYSIS OF TECHNOLOGIES APPLIED FOR THERMAL TREATMENT OF MUNICIPAL SOLID WASTE

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ЕВРОПЕЙСКИ СЪЮЗ
ЕВРОПЕЙСКИ ФОНД ЗА РЕГИОНАЛНО РАЗВИТИЕ
ОПЕРАТИВНА ПРОГРАМА НАУКА И ОБРАЗОВАНИЕ ЗА ИНТЕЛИГЕНТЕН РАСТЕЖ
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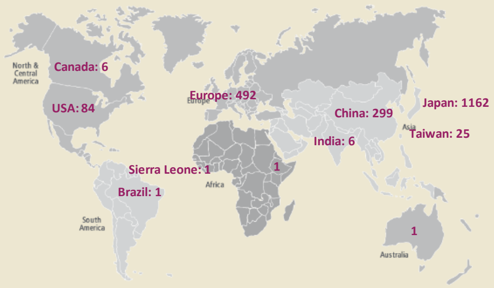
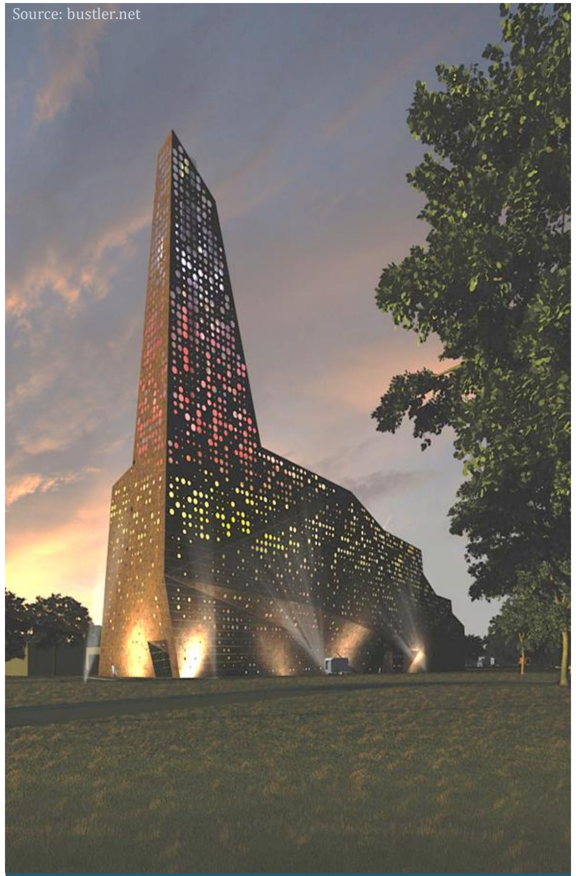
INTRODUCTION



Waste-to-Energy technologies have over the past decade received increased attention as part of the development of a more sustainable waste management practices.
Worldwide there are about 2170 WtE facilities. Asian countries have the largest number of facilities for thermal treatment of waste, some of theme because of limited open space issue for the siting of landfills and high urban population.

For example Japan has been taking out its solid waste issue by processing about an estimated 70% of MSW in WtE facilities. The number of facilities in Europe is above 450- the large number is primarily because of the EU Circular Economy Package and the EU aims for gradual reduction of municipal waste landfilled to 10% by 2030.
WtE technologies can be divided into different categories. The conventional approach for energy recovery of waste is direct combustion or incineration with direct generation of heat. Besides incineration more advanced thermochemical approaches, such as pyrolysis, gasification and plasma-based technologies, have been developed. Both pyrolysis and gasification differ from incineration in that they may be also used for recovering the chemical value from the waste. The chemical products derived may in some cases then be used as feedstock for other processes or as a secondary fuel. Incineration is by far the most widely applied- the degree of demonstration, as measured by overall throughput and operational hours of pyrolysis and gasification on the main European waste streams is low compared to incineration.
The following table provides summarized information for waste thermal treatment technologies.

Source: bustler.net



Waste incinerator and Power plant
Location: Roskilde, Denmark
Capacity: 350,000 tpa
Electricity: for 60,000 households each year

Source: www.power-technology.com

Project for WtE plant
Location: Abu Dhabi
Capacity: up to 900 000 tpa
Up to 90 MW of electricity

Source: www.energy-xprt.com

Plasma gasification facility
Location: Swindon, UK
Capacity: 100 000 tpa RDF
20 MW electrical power
Output: leach resistant vitrified slag

Summary of technologies for thermal treatment of MSW

DIRECT COMBUSTION: • Used as a treatment for a very wide range of wastes, often used for combustion of MSW and RDF. • main stages are drying and degassing, pyrolysis and gasification, oxidation; • oxygen supply is essential; •Traditional method is burning in combustion chamber and grate; • the temperature must usually be above 850°C to destroy chemicals such as dioxins but must not exceed 1300 °C as this can affect the way ash is formed and its content; • Hot combustion gases from the grate flow into a boiler where the heat is captured to generate steam; •The slag may be clean enough for road construction. Outputs are flue gas, heat and power, ash, slag

PYROLYSIS: • Often require waste pre-treatment; • used for wide range of wastes • degassing of wastes in the absence of oxygen, during which pyrolysis gas and a solid coke are formed.; • Conventional pyrolysis reactors have one of the following configurations: fixed bed, fluidized bed, entrained flow, moving bed, rotary kiln, ablative reactor. • temperature range - 250-900 °C. Outputs are pyrolysis gas, pyrolysis liquid and solid coke

GASIFICATION: • Often require waste pre-treatment; • used for wide range of wastes ; • partial combustion of organic substances to produce gases that can be used as feedstock (through some reforming processes) or as a fuel. • temperature range 500-1800 °C or higher. • The syngas can be used for efficient production of electricity and/or heat, or second generation liquid biofuels. Outputs are Syngas, slag, ash

PLASMA GASIFICATION: • Sustainable waste solution for all types of waste streams.; •The process uses extreme temperatures that can be in excess of 5000 °C.; • Under these conditions the products are clean syngas, a glass-like solid slag; •The plasma that is used to heat the waste material is created by passing an extremely high voltage through a gas in a special chamber • The gas can be air, oxygen, nitrogen, or an inert gas such as argon. •The high voltage ionizes the gas between the electrodes of the plasma torch, allowing it to conduct electricity and a current flows through the ionized gas. This current generates a very high energy zone where the temperature can approach that of the sun. When waste material is passed through this zone in the plasma, it is immediately volatilized and dissociated.

METHODS

The strength & weakness and opportunity & threats on the basis of different factors for direct combustion, pyrolysis, gasification and plasma-based gasification are determined.

The evaluation in SWOT is made with values from 1 to 2.

(2: higher importance)

Factors used in the assessments of SWOT analysis

Technological → **Environmental**

Social → **Financial & Economical**

RESULTS

Direct combustion

S
- Widely applied: 2
- Wide size ranging (t/day): 1
- Mixed, heterogeneous waste: 2
- Part of integrated waste management systems in Europe: 1
- Utilization of heat in district heating & cooling: 1
- Effect on reduction of GHG as replacement installation in TPP: 1

W
- Emissions into the atmosphere: 2
- Does not completely eliminate waste volume: 1
- Depending on the type of flue gas treatment technology- different amounts of hazardous waste and waste water : 2
- Social disapproval because of air pollution: 2
- Literature survey- the lowest net energy production to grid: 1

O
- Leaching of metals from slag and ash: 2
- Reducing the impact to the environment by utilization of the slag: 2
- Development of innovative biotechnological solutions for bioremediation and reduction of toxicity of hazardous ashes: 2
- Development of bioremediation complexes for minimization the impact of air polluters and GHG emissions : 2

T
- Development of competitive technologies with better environmental performance: 2
- Development of new technologies with lower O&M costs: 2
- Development of new technologies with higher net energy production to grid: 2
- Threat of suspension of EU grants for direct combustion plants with limited energy recovery : 1

Pyrolysis

S
- Wide range of wastes: 2
- Compact and modular plants: 1
- Reduced flue-gas volumes, which may reduce capital costs: 2
- Concentration of some pollutants in pyrolysis treatment is lower than their concentration after incinerators of similar waste: 2
- Literature survey- net energy production to grid is higher than incineration: 1
- The bulk of heavy metals pass into the solid residue: 1

W
- Require waste pre-treatment: 2
- Rarely used in Europe for treatment of MSW: 1
- Consistency in the chemical and physical composition of the waste or a slight change within narrow limits: 1
- Requirements for drying of waste: 1
- Energy production kWh/t is lower than gasification: 1

O
- Development of bioremediation complexes for minimization the impact of air polluters and GHG emissions : 2
- Possibility of recovering the material value of the organic fraction, e.g. as methanol: 2
- Possibility for external use of pyrolytic oil as a clean energy resource: 2
- Meeting specifications for external use of the produced char after treatment procedure (e.g. by washing chlorine content): 2

T
- Literature survey- net energy production to grid is lower than gasification and plasma-based technology: 2
- Development of syngas production technology without specific requirements for consistency in chemical and physical composition of waste : 2

Gasification

S
- Smaller waste water flows from synthesis gas cleaning: 2
- Smaller gas volume compared to the flue-gas volume in incineration): 2
- Predominant formation of CO rather than CO2: 2
- Wide size ranging (t/day): 1
- Small and compact aggregates: 1
- Literature survey- net energy production to grid is higher than pyrolysis: 1
- Treatment of wide range of waste:2
- Lower concentration of some pollutants than incinerators of similar waste: 2

W
- Require waste pre-treatment: 2
- Rarely used in Europe for treatment of MSW: 1
- Requirements for drying of waste: 1
- Energy production kWh/t is lower than plasma-based technology: 1

O
- Bioremediation and utilization of slag/ash residues: 2
- Transformation of syngas into ethanol: 2
- Production of Ammonia from Syngas via Chemical Synthesis Route: 2
- Production of Methanol (CH3OH) from Syngas via Chemical Synthesis Route: 2
- Production of Synthetic Natural Gas from Syngas via Chemical Synthesis Route: 2
- Production of ethanol from syngas via biochemical synthesis route *with Clostridium ljungdahlii* : 2

T
- Literature survey- net energy production to grid is lower than plasma-based technology: 2
- Development of syngas production technology without specific requirements for waste pre-treatment: 2

Plasma-based gasification

S
- variety of different wastes : 2
- Minimal pretreatment of waste: 2
- The solid by-product, vitrified slag, can be used as a construction material: 2
- the gas is created without generating any air emissions: 2
- Nonleaching slag: 2
- ability to minimize if not eliminate the need for a landfill: 2
- can be used to process wastes in an existing landfill and eliminate the old landfill: 2
- Destruction eff: >99,99%: 2
- Social approval – the most environmentally sound WtE technology: 2
- highest net energy production to grid: 1

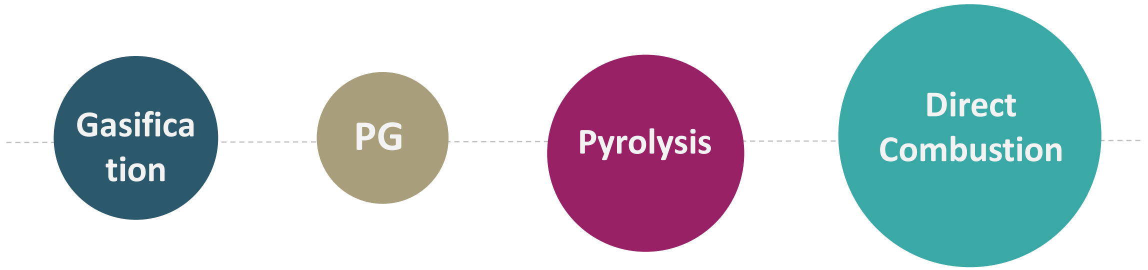
W
- Limited current operating experience 2
- It can be very complex, expensive and operator-intensive technology: 2

O
- Transformation of syngas into ethanol: 2
- The environmentally sound nonleaching slag can be use as a road material: 2
- The environmentally sound nonleaching slag can be use as a construction mat.: 2
- Production of Ammonia from Syngas via Chemical Synthesis Route: 2
- Production of Methanol (CH3OH) from Syngas via Chemical Synthesis Route: 2
- Production of Synthetic Natural Gas from Syngas via Chemical Synthesis Route: 2
- Production of ethanol from syngas via biochemical synthesis route : 2

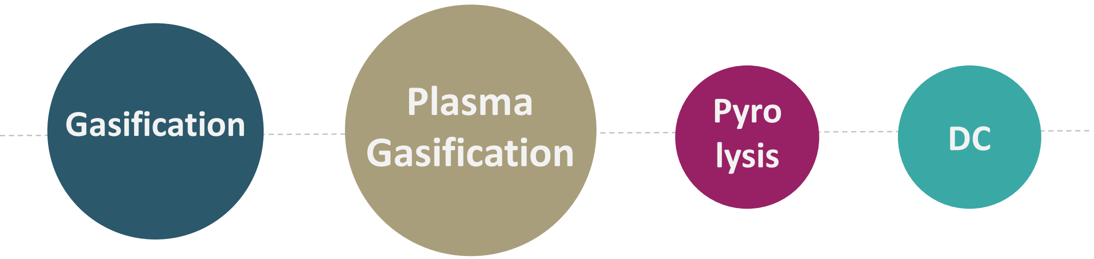
T
- Availability of lower in investments, O&M costs and easier for operation technologies for thermal treatment of MSW, covering the present requirements of environmental legislation : 2

1 Ratio between strengths

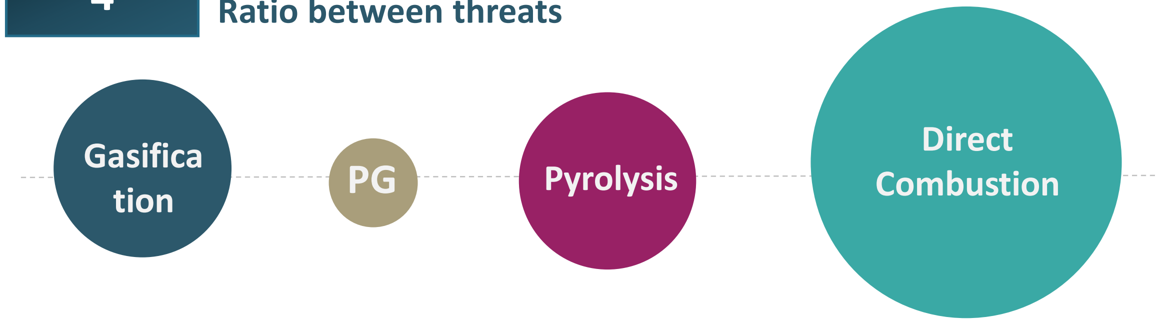
2 Ratio between weaknesses



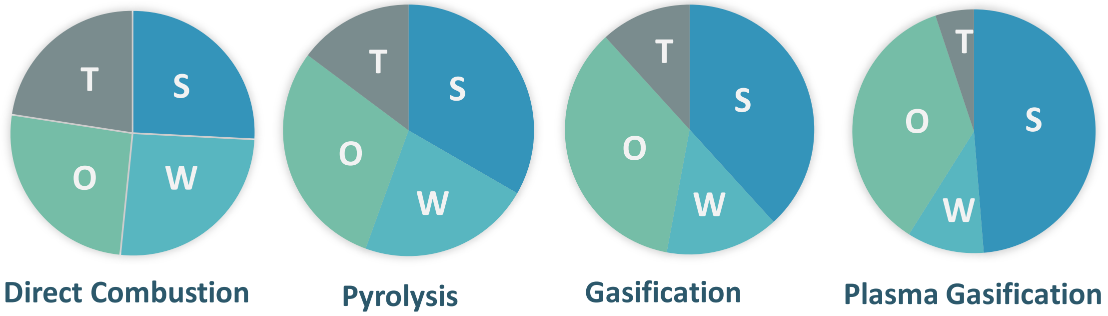
3 Ratio between opportunities



4 Ratio between threats



5 Ratio between S & W & O & T



CONCLUSIONS

A comparison of strengths, weaknesses, opportunities and threats of each technology have been made.

It is established that plasma gasification has the greatest strengths – in comparison with the other three technologies it is found that this one is the most environmentally sound, with the highest energy production to the grid. The weaknesses of this technology is the limited operating experience and high operating costs.

It is established that direct combustion has the most weaknesses, primarily because social disapproval, air emissions, hazardous residues. On the other hand direct combustion is widely applied and solution must be sought for mitigation of weaknesses. This can be achieved through development of innovative biotechnological solutions for bioremediation and reduction of toxicity of hazardous ashes, development of bioremediation complexes for minimization the impact of air polluters and GHG emissions, leaching of metals from slag and ash, which would lead to a cleaner environment.

Both pyrolysis and gasification may be used for recovering of chemical value of waste, e.g. as methanol. Pyrolytic oil may be used as clean energy source and pyrolytic char could meet the specification for external use after some treatment processes.

Plasma-based gasification has the most opportunities because of non-leaching vitrified slag, as well as opportunities for different types of chemical or biochemical utilizations of syngas into high value products, which is also strengths opportunities of gasification. Example of biochemical utilization of syngas is production of ethanol via biochemical synthesis route *with Clostridium ljungdahlii.*

Acknowledgements

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