



“Do not demand more from the Earth.
Rather do more with what the Earth provides.”
- Gunter Pauli, *The Blue Economy*

Opportunities of energy production and -usage in large-scale wastewater treatment

GABNAI Z. – NAGY D. – BAI A.

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Earth Overshoot Day



Importance of the topic

1. Population growth, economic development globally:

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- The quantity of waste and by-products
 - Pollution
 - Energy demand

2. Responsibilities:

- Environmental regulations, obligations
- Wastewater treatment, waste disposal
- CO₂ emission reduction, energy and material saving

3. Growing demand for similar technologies and solutions:

- Efficient, environmentally friendly by-products / waste management
- Efficient, environmentally responsible and material-saving operation
- Energy production is also conducted in

4. “Think globally, act locally” - approach



Characteristics of wastewater treatment

Main influencing factors:

- population
- living standards
- economic conditions of the country or area
- level of technology
- size of settlements, plants



Continent	Country	Number of plants	Total quantity (billion m ³)	Treated quantity (billion m ³)
Africa		2 000 pcs	13.0	7.0
Of which:	RSA	923 pcs	3.5	1.9
	Egypt	372 pcs	7.1	4.0
America		21 000 pcs	97.0	56.0
Of which:	USA	16 583 pcs	60.4	41.0
	Mexico	2 289 pcs	7.5	3.1
	Canada	1 265 pcs	6.6	5.6
Asia		8 000 pcs	130.0	62.0
Of which:	China	3 272 pcs	38.0	26.6
	Japan	2 148 pcs	16.9	11.6
Europe		47 000 pcs	52.0	37.0
Of which:	Germany	9 933 pcs	5.3	5.2
	United Kingdom	8 035 pcs	4.1	4.0
	Russia	7 836 pcs	12.3	n.a.
	Poland	4 253 pcs	2.3	1.4
	France	3 280 pcs	3.8	3.7
	...			
	Hungary	593 pcs	0.2	n.a.
Australia		580 pcs	2.1	2.0

The activated sludge process

~ 1910: A type of wastewater treatment process for treating sewage or industrial wastewaters using aeration and a biological floc composed of bacteria and protozoa.

The general arrangement of an activated sludge process for removing carbonaceous pollution includes the following items:

- **Aeration tank**, where air (or oxygen) is injected in the mixed liquor.
- **Settling tank** (usually referred to as "final clarifier" or "secondary settling tank") to allow the biological flocs to settle, thus separating the biological sludge from the clear treated water.

Treatment of nitrogenous matter or phosphate involves additional steps where the mixed liquor is left in anoxic condition.



Role of large-scale wastewater treatment plants

Most of the produced wastewater

- municipal treatment plants
- agricultural plants
- industrial plants

Important targets:

1. minimizing operating cost and/or
2. maximizing revenues



Energy production & utilization options

Most important biogas production-based methods:

81 biogas plant in Hungary, 20 based on wastewater treatment plant.
Average size: 1 MWe, biogas production: 1.2 PJ (PAN-LNG projekt, 2016).

1. minimizing operating costs: self-sufficiency (electricity and heat)
+ algae: micro and macro elements, CO₂ (2x yield)
2. maximizing revenues: biomethane production and usage



Energy utilization options

1. Minimizing operating costs: self-sufficiency

(electricity and heat, cogeneration)

- 1920: biogas plants based on wastewater treatment plants (Germany)
- operating plants in Hungary: 20 (in Debrecen as well)

Main problem: utilization of waste heat during summer

Opportunities: district heating, agricultural activities: dryer, greenhouse, technological heat?



Energy utilization options

2. Maximizing revenues: biomethane production from biogas

Recently 300 plants in 15 countries

In Hungary: 2 plants: Kaposvár and Zalaegerszeg



Feeding biomethane into
the natural gas pipeline



Fuel production from the
wastewater-based biogas

Main problem: investment cost

Energy utilization options

Feeding biomethane into the natural gas pipeline

- Hungary: Kaposvár

Details:

- Operation: 30.09.2015.
- Investment cost: ~ 1 billion Forints
- Annual biomethane production: 5 billion m³
- Raw material: waste sugar beet and sewage sludge
- Utilization: electricity and heat, dryer, natural gas pipeline of the city



Energy utilization options

Fuel production from the wastewater-based biogas

- 1941: biogas plants based on wastewater treatment plants (Finland):
- 100 biomethane-fueled vans and buses



Energy utilization options

Fuel production from the wastewater-based biogas

- Hungary: Zalaegerszeg

Details:

- Operation: 02.09.2011.
- Investment cost: ~ 140 million Forints
 - Biogas clarification: 120 million Forints
 - Filling station: 20 million Forints
- Daily biomethane production: 3 600 m³
- Production cost of biomethane: 0.52 EUR/m³
(0.8 l gasoline/m³ biomethane)
- Utilization: Own vehicle fleet: 12 vans, 3 buses
- Raw material: sewage sludge, wastes from meat industry, etc.



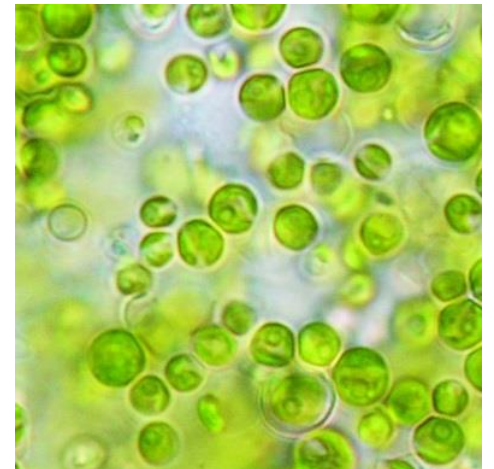
A further possible direction: algae

Based on the flue gas of a biogas plant:

- 30% CO₂-content (flue gas)
- Excellent carbon source for algae
- Algae breeding experiments
 - increasing yields (multiple effect)
 - multi-purpose utilization
(e.g, biofuel, fodder, industrial usage)

Post-treatment method (NPP):

- great outgoing water quality



Conclusions (1)

Importance and possibilities of waste and by-product utilization as raw material

- Rational, prudent and sustainable utilization is crucial
- Wastewater treatment combined with renewable energy production and waste management
- Importance of detailed economic calculations and feasibility



Conclusions (2)

Big cities & big wastewater treatment plants

- Cost-efficient biogas-cleaning technologies
- Public transport: bus or van fleet

Advantages and opportunities:

- Own biomethane filling stations
- Petrol-independence
- Emission reduction in the downtown
- Available cost savings: ~ 40 % + VAT



Conclusions (3)

In Hungary recently

- Little significance
- In the early stage of development (concurrence: electric, LPG)
- Continuous change: Price of fossil fuels, technological progress

Further research tasks

- Detailed economic calculations
(NPV, DPP, IRR, PI, CBA, sensitivity analysis, scenario analysis, energy balance, quantification of external effects)





Thank you for your attention!