Managing sludge from a country perspective – the case of Hungary

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Hungarian Water Infrastructure

- area: total 93 030 km^2
- population: 9 678 000 (2023)
- density: 105/km^2
- over 100 000 km long water and sewerage networks
- 97% piped drinking water supply, they drink tap water
- **87% sewerage, full wastewater treatment - all sewers are connected to a sewage treatment plant**

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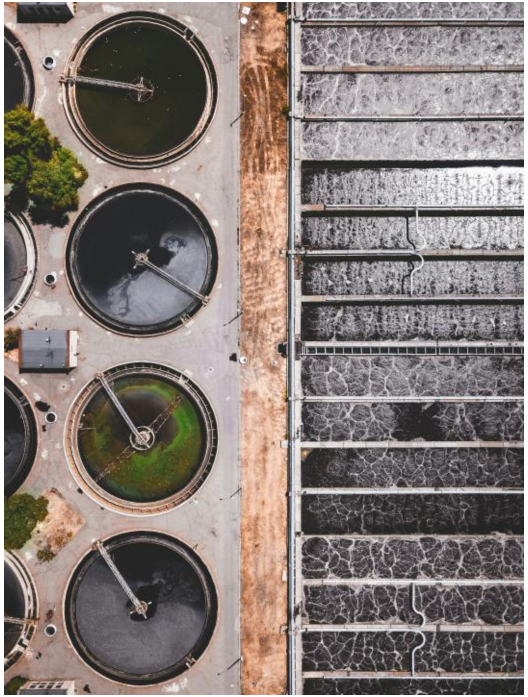
Hungarian Wastewater Infrastructure



- **Wastewater infrastructure: ~820 municipal wastewater treatment plants in operation.**
- **National wastewater treatment capacity: ~11.1 million population equivalent (PE).**
- Total national wastewater load: ~13.7 million PE.
- Sewer connection availability:~87% of households (2025 estimate).

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Hungarian Sludge Statistics

Annual sewage sludge generation expected to reach (2026):

~245–250 thousand tons dry solids/year (tDS/y).

Main sludge management routes in Hungary:

- anaerobic digestion,
- agricultural reuse,
- composting,
- solar drying,
- co-digestion,
- limited thermal utilization

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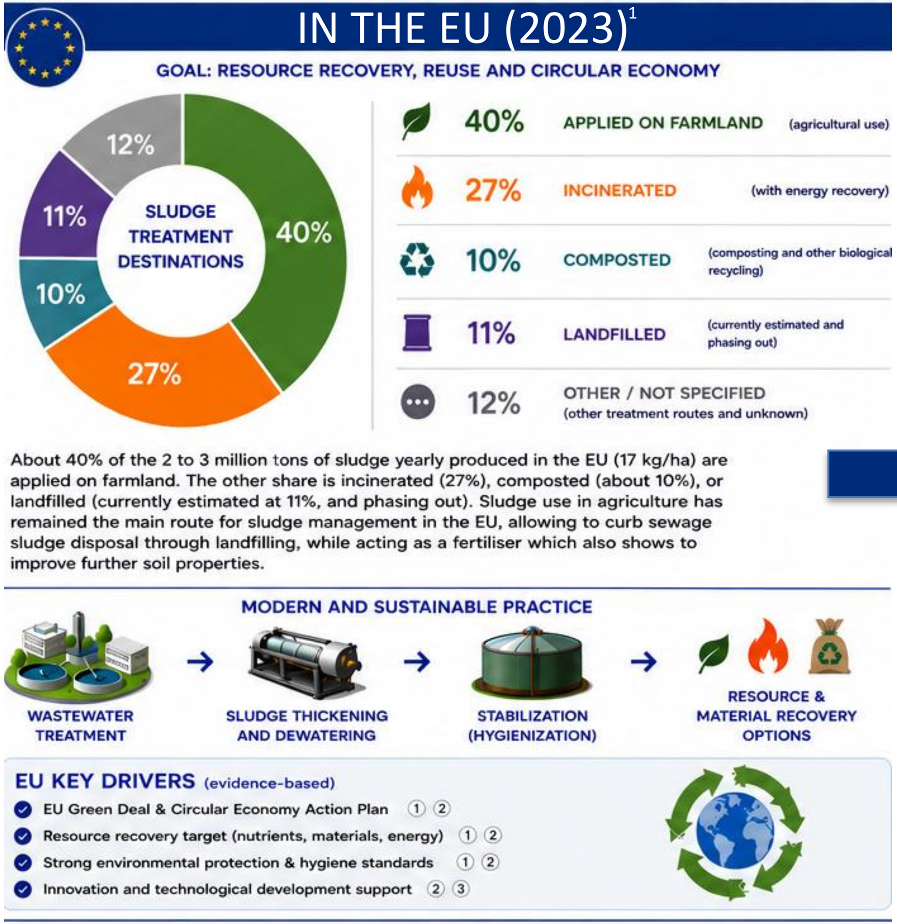
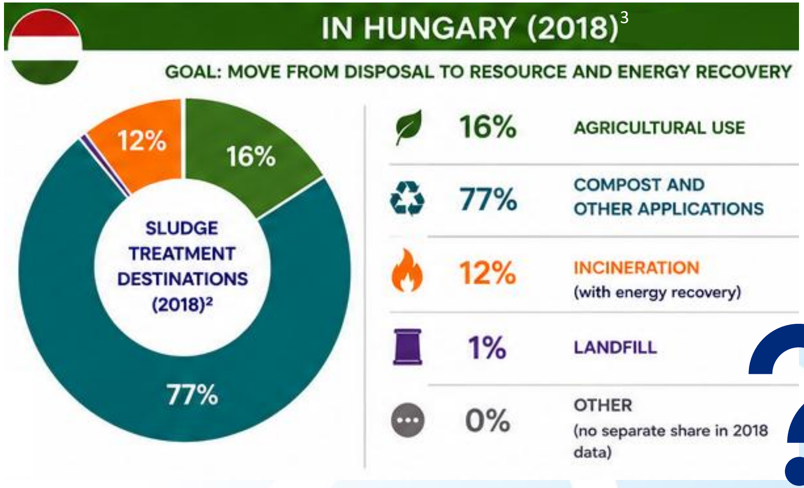
https://rcisd.eu/wp-content/uploads/2020/12/Country_report_on_sustainable_biomass_assessment.pdf?
Milyen anyagok fordulhatnak elő a szennyvíziszapban?/What materials can be found in the wastewater sludge? - Prof. Dr. Juhász Endre (2025)

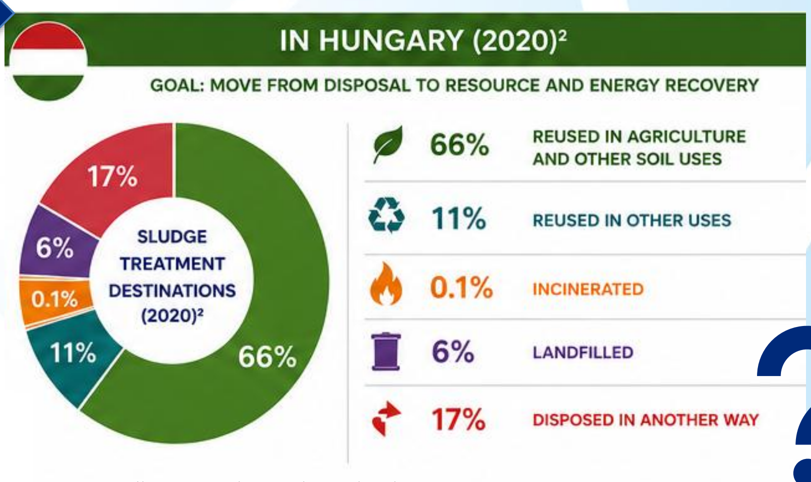


Reference 1: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=SWD%3A2023%3A158%3AFIN&qid=1684830815132

VS.



Reference 3: https://dunaregiostrategia.kormany.hu/download/a/cf/33000/EUSDR-PA4_Danube-Region-sewage-sludge_study_final_March2021.pdf



Reference 2: https://water.europa.eu/freshwater/countries/uwwt/hungary

Key Hungarian developments in recent years

Pressure on sludge handling capacity

e.g. gradual **reduction of possibility for recultivation** utilization, the decrease of the area available for recultivation

Traditional low – value sludge handling

Modern, resource recovering sludge utilisation

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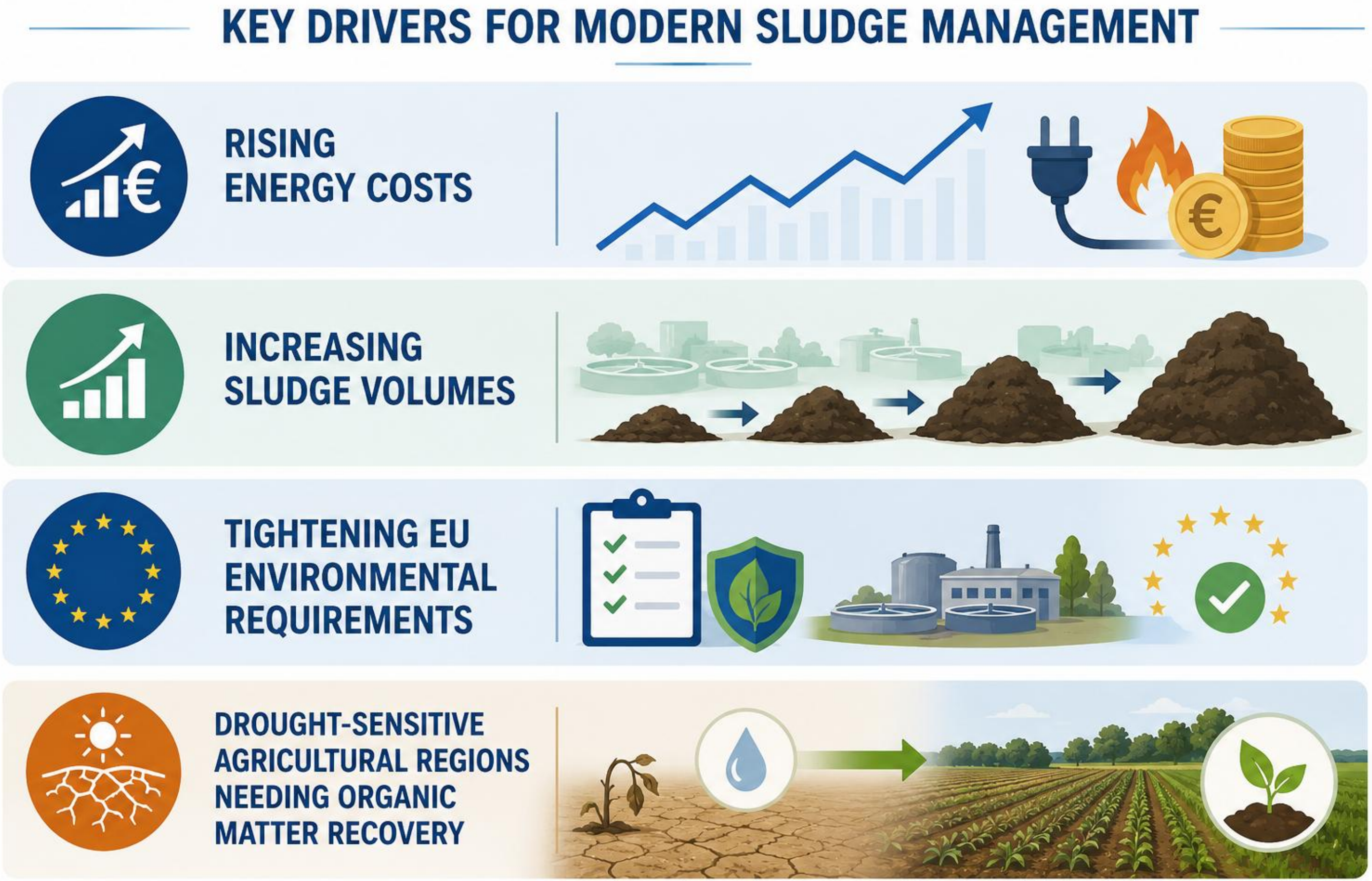
Hungary faces additional pressure



Key Hungarian developments in recent years

FROM: Traditional, low-value sludge handling
(Past / Previous practice)

AGRICULTURAL DISPOSAL
- Low treatment level
- Weather dependent
- Limited nutrient recovery
- Odor and transport impacts

LANDFILL-ORIENTED HANDLING
- Landfilling costs
- Loss of resources
- Regulatory pressure
- Not sustainable long-term

TO: Modern, resource-recovering sludge solutions
(Current trend / Future direction)

ANAEROBIC DIGESTION
- Stabilizes sludge
- Reduces odors and pathogens
- Produces biogas
- Improves dewaterability

CO-DIGESTION
- Higher biogas yield
- Utilizes organic co-substrates
- Shares costs and improves economics
- Enhances process stability

BIOGAS-TO-ENERGY SYSTEMS
- Converts biogas to heat and power
- Reduces energy costs
- Lowers greenhouse gas emissions
- Contributes to energy independence

THERMAL DRYING SOLUTIONS
- Produces high-quality, dry material
- Reduces transport and disposal costs
- Enables alternative uses
- Lower mass, lower emissions

KEY BENEFITS OF THE TRANSITION

Resource recovery	Cost savings	Lower emissions	Regulatory compliance	Energy production	Sustainable future

Hungarian utilities are embracing modern sludge management technologies to build a more sustainable, circular and energy-positive future.

Key EU Policy Drivers for strategic sludge management

Urban Wastewater Treatment Directive (UWWTD Recast)

This is probably the single most important policy anchor.

EU Taxonomy Regulation

This is extremely relevant for utilities seeking:

- EU funding // EIB financing // green bonds // sustainability-linked loans.

Corporate Sustainability Reporting Directive (CSRD)

This becomes important for: municipally owned utilities // large operators // infrastructure companies.

Utilities increasingly need to report: Scope 1 emissions, energy intensity, waste recovery, circularity metrics, climate adaptation.

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Key Policy EU Drivers

HUNGARIAN PRACTICES ALIGNED WITH EU DRIVERS & ESG CONTRIBUTIONS

HUNGARIAN PRACTICE	EU DRIVER	ESG CONTRIBUTION
Anaerobic digestion	UWWTD recast	Climate mitigation
CHP & biogas	EU Taxonomy	Renewable energy
Co-digestion	Circular Economy Action Plan	Resource efficiency
Thermal sludge treatment	Pollution prevention	Reduced environmental risk
Regional sludge hubs	CSRD / governance expectations	Operational resilience

Micropollutants, PFAS and the future of sludge utilization

Hungarian experts increasingly focus on:

- ➢ PFAS,
- ➢ pharmaceuticals,
- ➢ microplastics,
- ➢ endocrine disrupting compounds,
- ➢ heavy metals in sludge streams.

Important Hungarian debate

Hungary still values agricultural reuse because:

- ➢ soils — especially in the Great Plain (Alföld) — require organic matter replenishment,
- ➢ sludge remains an important nutrient source.

At the same time:

- ➢ EU regulation is becoming stricter,
- ➢ public acceptance risks are increasing,
- ➢ future contaminant limits may significantly reduce direct land application options.

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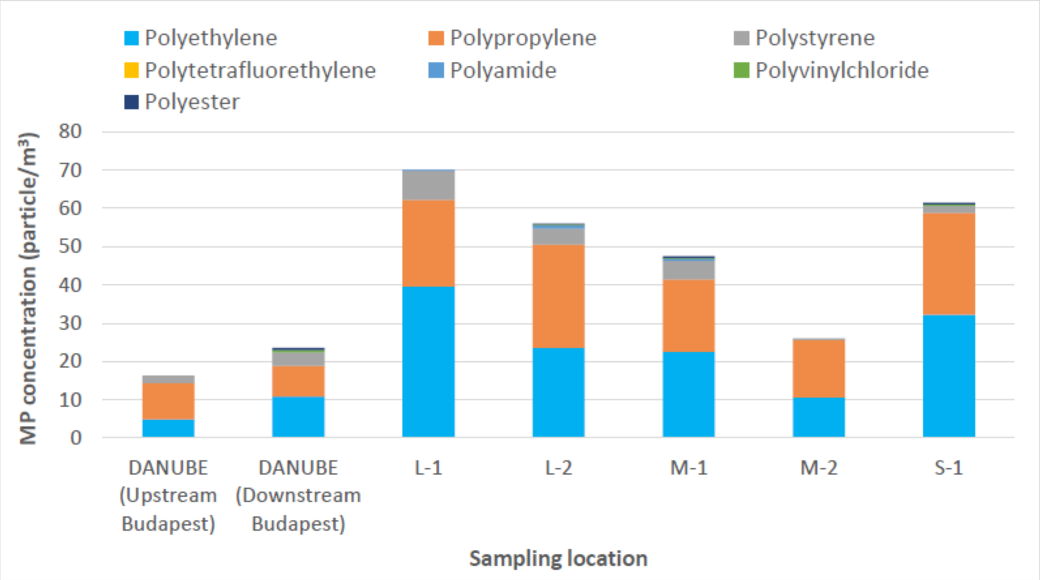
Microplastics in the effluent wastewater



11.7 - 84.6 particle/m3

Table 3: Details of the sampled wastewater treatment plants.

Sampling site	WWTP capacity		Size category	Collected samples		
	m³/day	EP		influent	effluent	sludge
L1	200 000	1 333 333	large	yes	yes	yes
L2	8 000	57 000	large	yes	yes	yes
M1	5 620	41 573	medium	yes	yes	no
M2	5 000*	20 000	medium	yes	yes	no
S1	1 400	8 048	small	yes	yes	no

*Running with 50% of the capacity.

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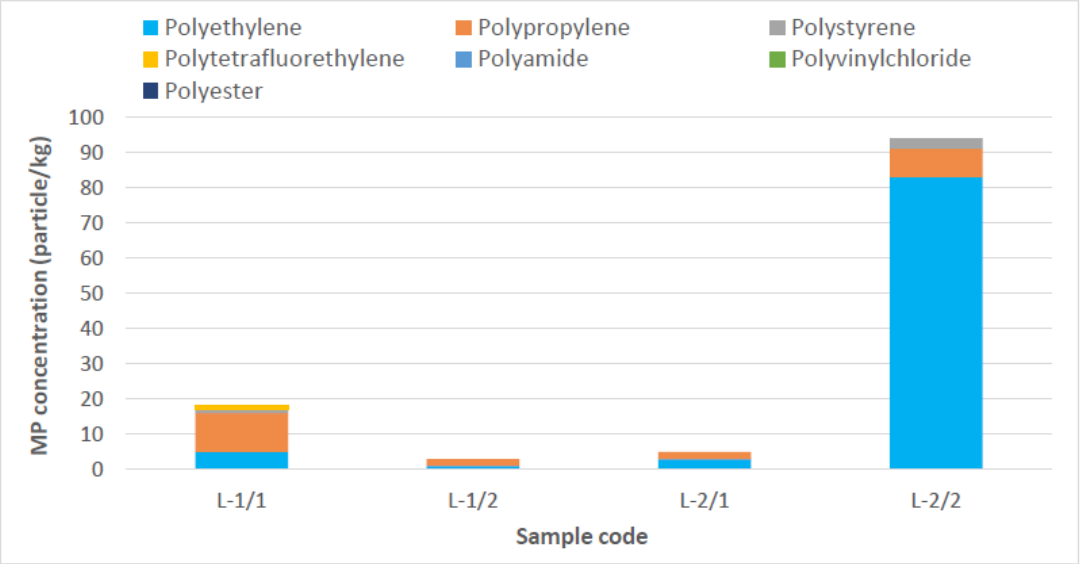
Reference: https://dunaregiostrategia.kormany.hu/akadalymentes/download/f/2e/d2000/Microplastics-in-wastewater_report_2021.pdf
Source: The Role of Micropollutants in the Environment Gerencsérné Dr. Renáta Berta Managing Director, Associate Professor University of Pannonia University Center for Circular Economy, Nagykanizsa

Microplastics in the wastewater sludge



1-3. sample: 3-11 particle/kg

4. sample: 94 particle/kg

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Reference: https://dunaregiostrategia.kormany.hu/akadalymentes/download/f/2e/d2000/Microplastics-in-wastewater_report_2021.pdf
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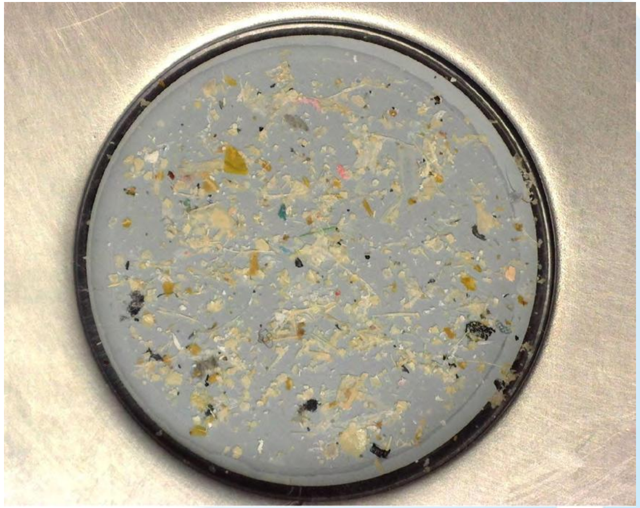
Wastewater treatment and Microplastics

- Only 0.1–3% of incoming microplastics end up in the receiving surface water body with the treated effluent.
- A significant proportion accumulates in sewage sludge → this must be carefully considered during subsequent sludge utilization and reuse.



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Micropollutants, PFAS and the future of sludge utilization

Current strategic directions include:

- thermophilic digestion,
- solar sludge drying,
- regional sludge hubs,
- pilot thermal utilization/incineration concepts,
- preparation or fourth treatment stage technologies.

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Regional Sludge Hubs / Shared Facilities

- Smaller (WWTPs) - > **regionalization and shared infrastructure to overcome the high capital and operational costs of advanced sludge treatment**.
- **Regional sludge hubs** = economies of scale that individual small plants cannot achieve.
- **Shared Dewatering and Thermal Treatment**
- **Inter-municipal Cooperation:** Collaborative management models allow smaller municipalities to pool resources and share the financial burden of compliance with strict EU environmental directives.

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Regional Sludge Hubs / Shared Facilities

- **Reduced Transportation Costs:** Regionalization hubs = optimized logistics
- **Sludge-to-Energy Focus:** Technological upgrades, focus on turning sludge into a resource by generating energy via Combined Heat and Power (CHP) units.
- **Challenges in Disposal:** Despite progress, finding reliable outlets for treated sludge (such as composting) remains a challenge, often leading to large quantities of compost accumulating at treatment sites.
- **Role of EU Support:** Investments in these centralized and regional systems have been heavily supported by EU accession funds and cooperative projects aimed at improving water quality in the Danube region

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Case Study: South Budapest WWTP as flagship example

Budapest Sewage Works Ltd. developed one of the most advanced sludge-energy systems in Hungary:

- mesophilic + thermophilic digestion,
- co-digestion with external organic waste,
- Combined Heat and Power (CHP) energy generation,
- major reduction of external energy demand.
- Future: Energy neutral WWTP?

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Case Study: Eger sludge treatment discussions

Sewage sludge incinerator in Eger burns wet sewage sludge right next to the sewage treatment plant

- Short transport distances -> reduce CO_2 emissions
- Waste heat enables low-emission, energy-efficient drying of sewage sludge.
- Thermal energy is utilised for both internal and external processes.
- CO_2-neutral heat and electricity replace fossil fuel-based energy sources.
- Thermal utilisation eliminates the need for sewage plant operators to invest in hygiene measures

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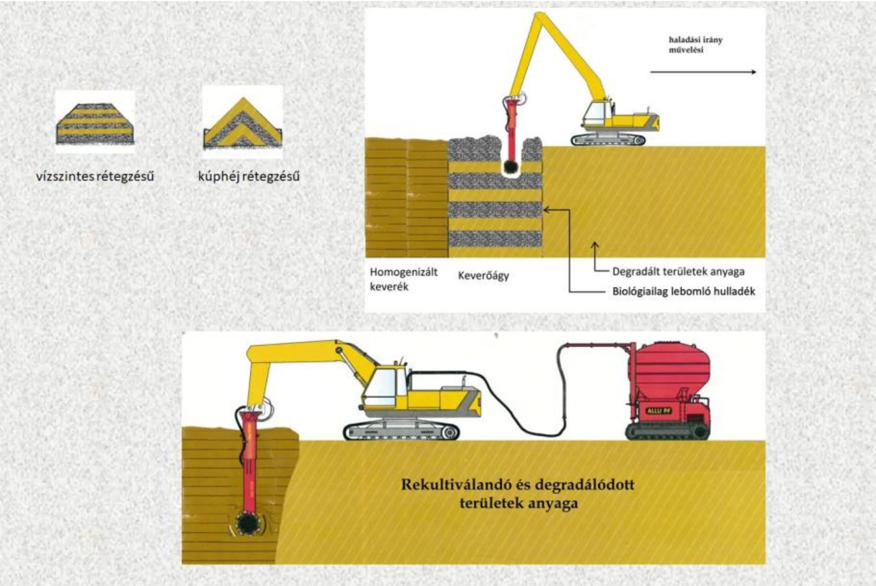
https://um.baden-wuerttemberg.de/en/international-cooperation/european-union/the-eu-strategy-for-the-danube-region/projects/sewage-sludge-incinerator-eger?

Case Study: Reculterra Technology



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Future outlook – it is increasing not about quantity but quality

Energy-neutral wastewater treatment plants

Under the revised UWWTD:

- larger WWTPs are expected to move toward energy neutrality.

Phosphorus recovery

Very important long-term issue.

- sewage sludge contains strategic nutrients,
- phosphorus is a critical raw material in the EU.

Mono-incineration

strategically important because it supports:

- **safer handling of micropollutants, PFAS, heavy metals, and microplastics**,
- **phosphorus recovery** from sludge ash,
- reduction of land application risks,
- and compliance with stricter future EU environmental and circular economy requirements.

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Future outlook – it is not about quantity but quality

Life-cycle costing (LCC) is becoming a key strategic tool
Attractive CAPEX can hide unsustainable operational costs

Future cost drivers are expected to include:

PFAS and micropollutant management,
stricter emission standards,
phosphorus recovery requirements,
energy price volatility.

It is a MUST be considered for

- EU compliance,
- affordability constraints,
- long-term operational resilience,
- and circular economy objectives.

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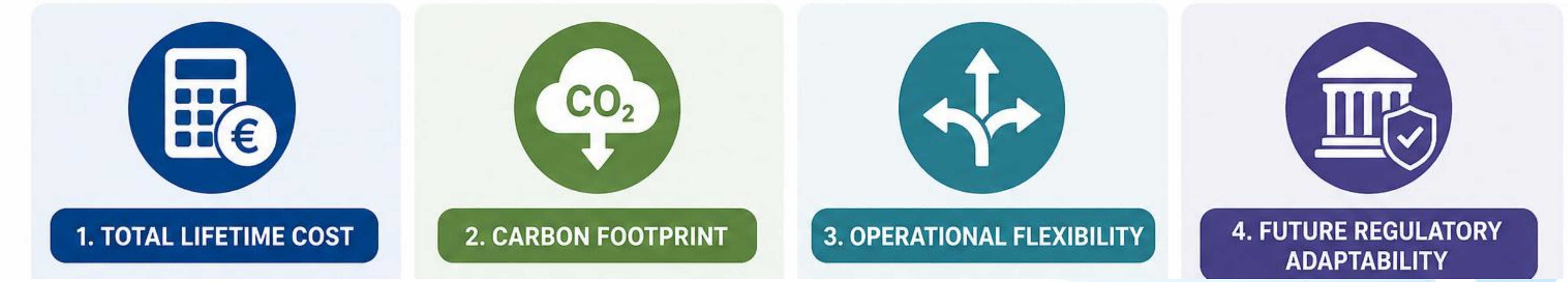
EU Joint Research Centre (JRC): Life-cycle and sustainability assessment of wastewater/sludge systems
https://publications.jrc.ec.europa.eu/repository/bitstream/JRC134591/JRC134591_01.pdf
ScienceDirect – Environmental and economic assessment of future sludge management pathways
https://www.sciencedirect.com/science/article/pii/S0301479724013252

Future outlook – it is not about quantity but quality

Strategic sludge investments should therefore evaluate:



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EU Joint Research Centre (JRC): Life-cycle and sustainability assessment of wastewater/sludge systems
https://publications.jrc.ec.europa.eu/repository/bitstream/JRC134591/JRC134591_01.pdf
ScienceDirect – Environmental and economic assessment of future sludge management pathways
https://www.sciencedirect.com/science/article/pii/S0301479724013252

Thank you for your attention!

See you at the Poster Presentation!

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