



AUTH



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Managing and recycling bio-waste in Greece through the implementation of a developed circular economy system

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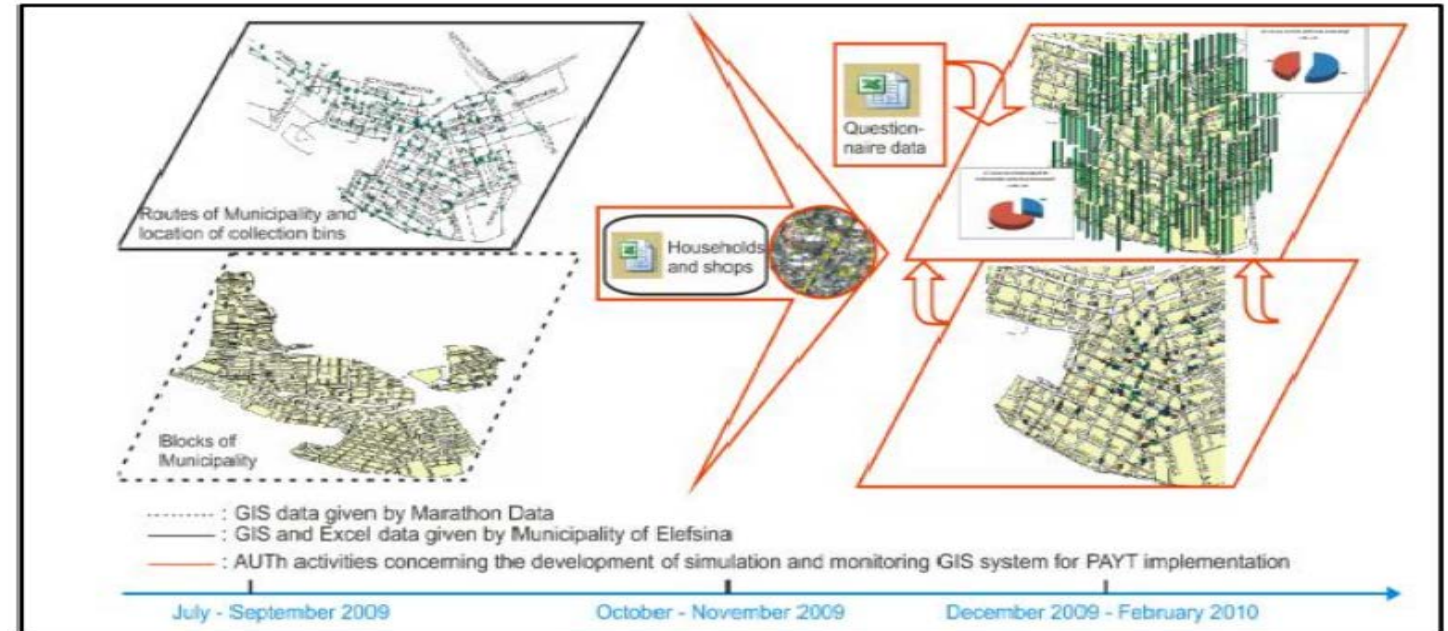
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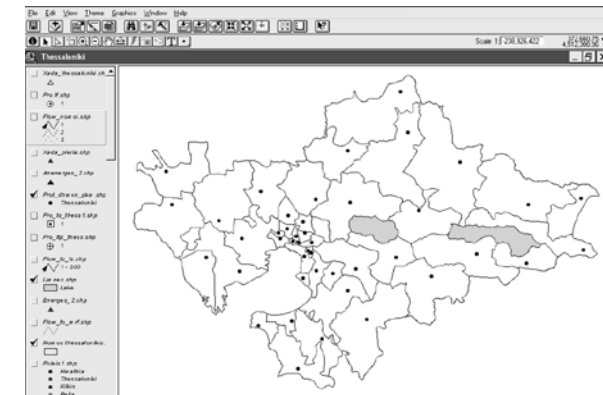
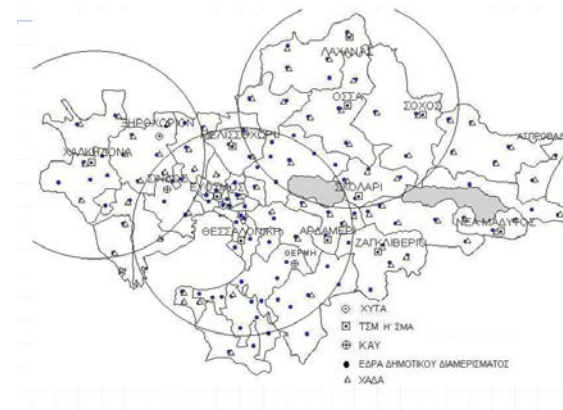
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Main Research Topics



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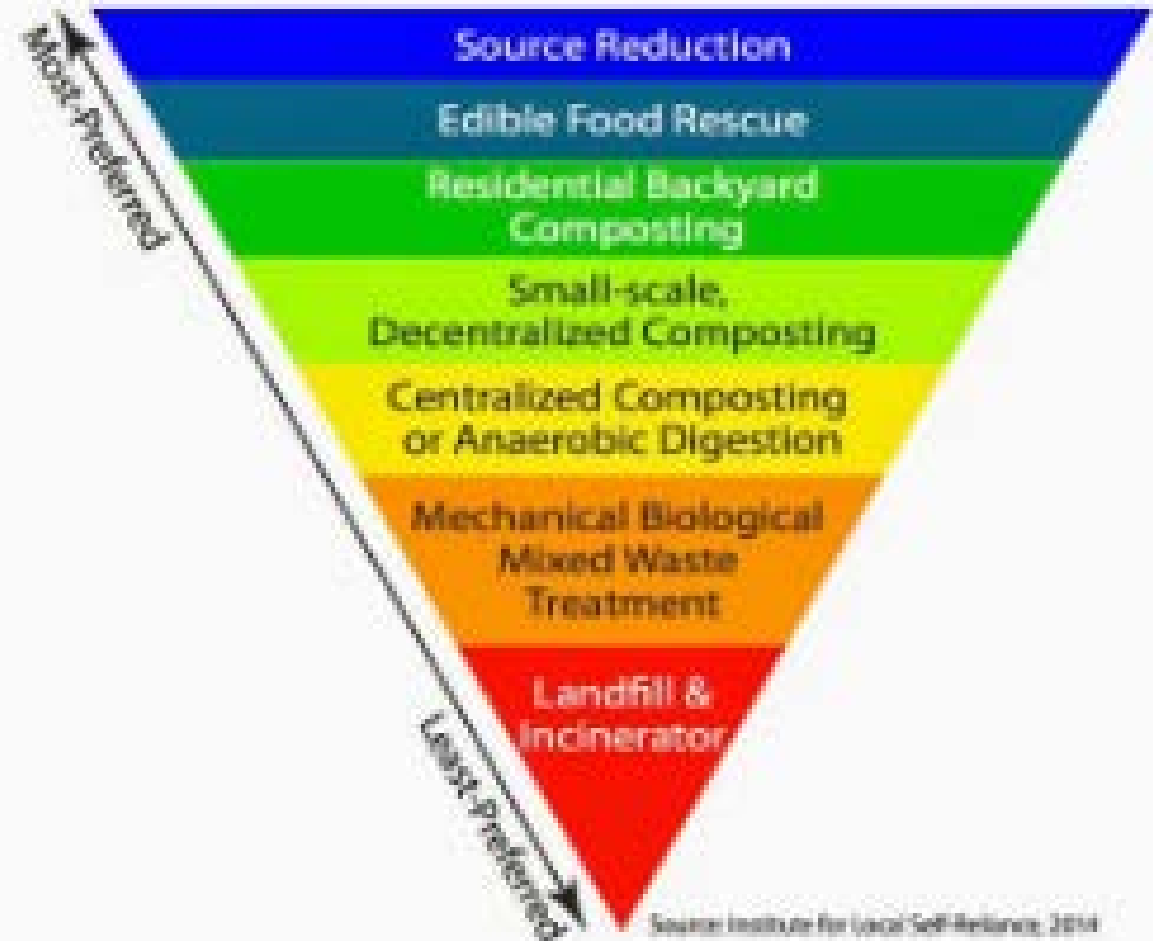




Bio-waste

- Organic waste is defined as biodegradable garden and park waste, food and kitchen waste from households, restaurants, caterers and retail premises, and comparable waste from food processing plants.

Hierarchy For Reducing & Recycling Food Scraps And Other Organic Discards



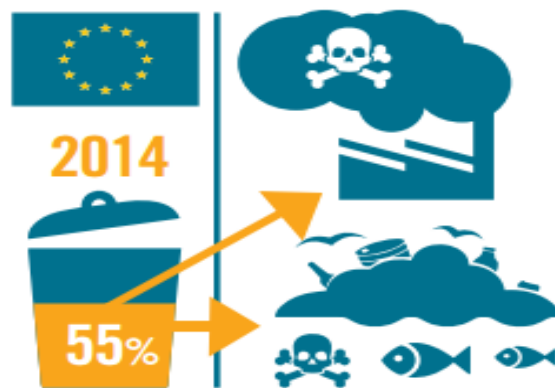


NGOs call the EP to get the Circular Economy Back on Track



EUROPE'S WASTE IS A PROBLEM...

IN 2014 EUROPE SENT OVER 55% OF ITS WASTE TO LANDFILL AND INCINERATORS, GENERATING TOXIC AND CLIMATE-DAMAGING EMISSIONS, POLLUTING EUROPE'S FRESH AND MARINE WATERS, DESTROYING VALUABLE RESOURCES AND RESULTING IN A HUGE MISSED OPPORTUNITY FOR JOB CREATION IN REPAIR AND RE-USE.



...AND IT'S TIME TO BRING IT FULL CIRCLE

MOVING TO A CIRCULAR ECONOMY COULD CREATE

870,000 NEW JOBS
ACROSS THE EU
BY 2030

CIRCULAR ECONOMY POLICIES
COULD SAVE
415 MEGA TONNES
OF CARBON EMISSIONS
BY 2030



10 KEY STEPS

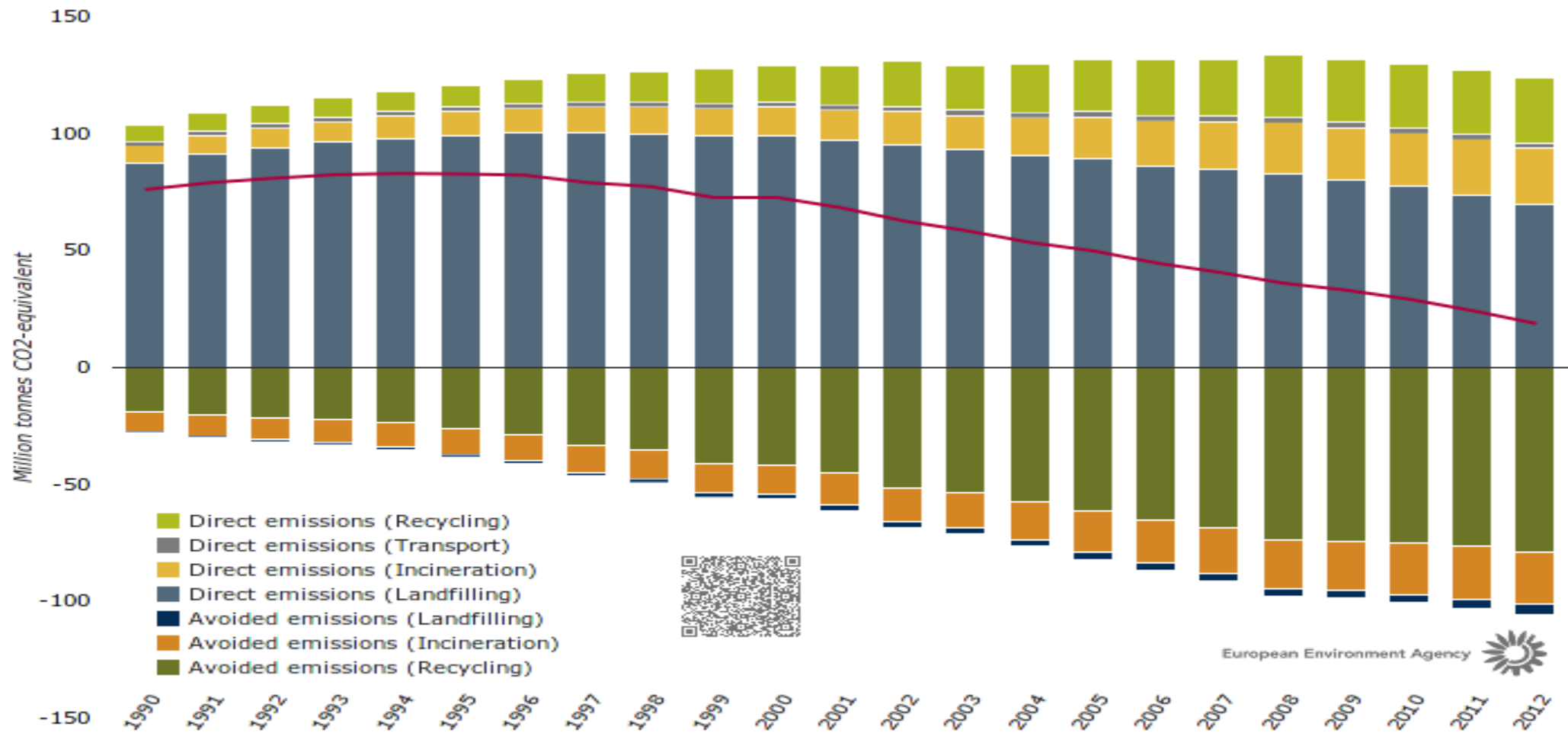
TO GET THE CIRCULAR ECONOMY BACK ON TRACK

- 1 ADDRESS WASTE PREVENTION DIRECTLY**, by including targets to reduce waste generation for 2030 compared with 2013 and on the maximum residual waste in kilograms per capita for 2030.
- 2 INTRODUCE A BINDING FOOD WASTE REDUCTION TARGET BY 2018 OF AT LEAST 30%**, and mandate the Commission to establish a common measurement methodology by 2017, ensuring food waste over the full supply chain is accounted for.
- 3 SET A BINDING MARINE LITTER REDUCTION TARGET OF 50% BY 2025**, to be reached in part by a phase out of unnecessary, non-reusable packaging, and single-use plastic items.
- 4 STRENGTHEN RECYCLING AND RE-USE TARGETS**: increase recycling targets to 70 percent overall and 80 percent for packaging by 2030 and include a separate target for preparing for re-use; similar targets exist in Flanders, France and Spain helping extend product lifetimes and creating thousands of local jobs.
- 5 GRANT DEROGATIONS ON THE RECYCLING TARGETS ONLY TO MEMBER STATES WHO MEET STAGED TARGETS CAPPING RESIDUAL WASTE PER CAPITA PER YEAR** in 2023 and 2028. Such an approach would incentivise waste prevention and separate collection while allowing for the different starting points of Member States, in terms of both recycling and waste generation.
- 6 CLARIFY THE DEFINITION OF 'PREPARATION FOR RE-USE'**; opening the preparing for re-use definition to re-use activities focusing on non-waste risks placing unnecessary burdens on many second-hand operators working outside of the waste regime. The definition provided in the current Waste Framework Directive should be retained to assure legal clarity.
- 7 DEFINE 'FINAL RECYCLING' AS THE POINT AT WHICH WASTE MATERIALS ARE EFFECTIVELY REPROCESSED INTO SECONDARY RAW MATERIAL** which can be directly reintegrated in new products, to reflect true recycling rates, and ensure comparability of statistics between Member States.
- 8 ENSURE EXTENDED PRODUCER RESPONSIBILITY (EPR) MINIMUM REQUIREMENTS SUPPORT WASTE PREVENTION AS A PRIORITY** and that fees are modulated based on the environmental impact of products, including durability, reparability, non-toxicity, recyclability, ensuring the higher levels of the waste hierarchy are prioritised. Producer fees should cover the full net costs of collection, treatment and related activities to prevent waste and littering of products covered by EPR schemes.
- 9 OBLIGE MEMBER STATES TO SEPARATELY COLLECT ALL RECYCLABLE WASTE AND ENSURE SEPARATION OF BIOWASTE AT SOURCE**, by eliminating wording on technical, economic and environmental practicality.
- 10 INTRODUCE A BAN ON THE INCINERATION OF UNTREATED WASTE**, as exists for landfill under the Malagrotta judgement, and strengthen enforcement of both bans.



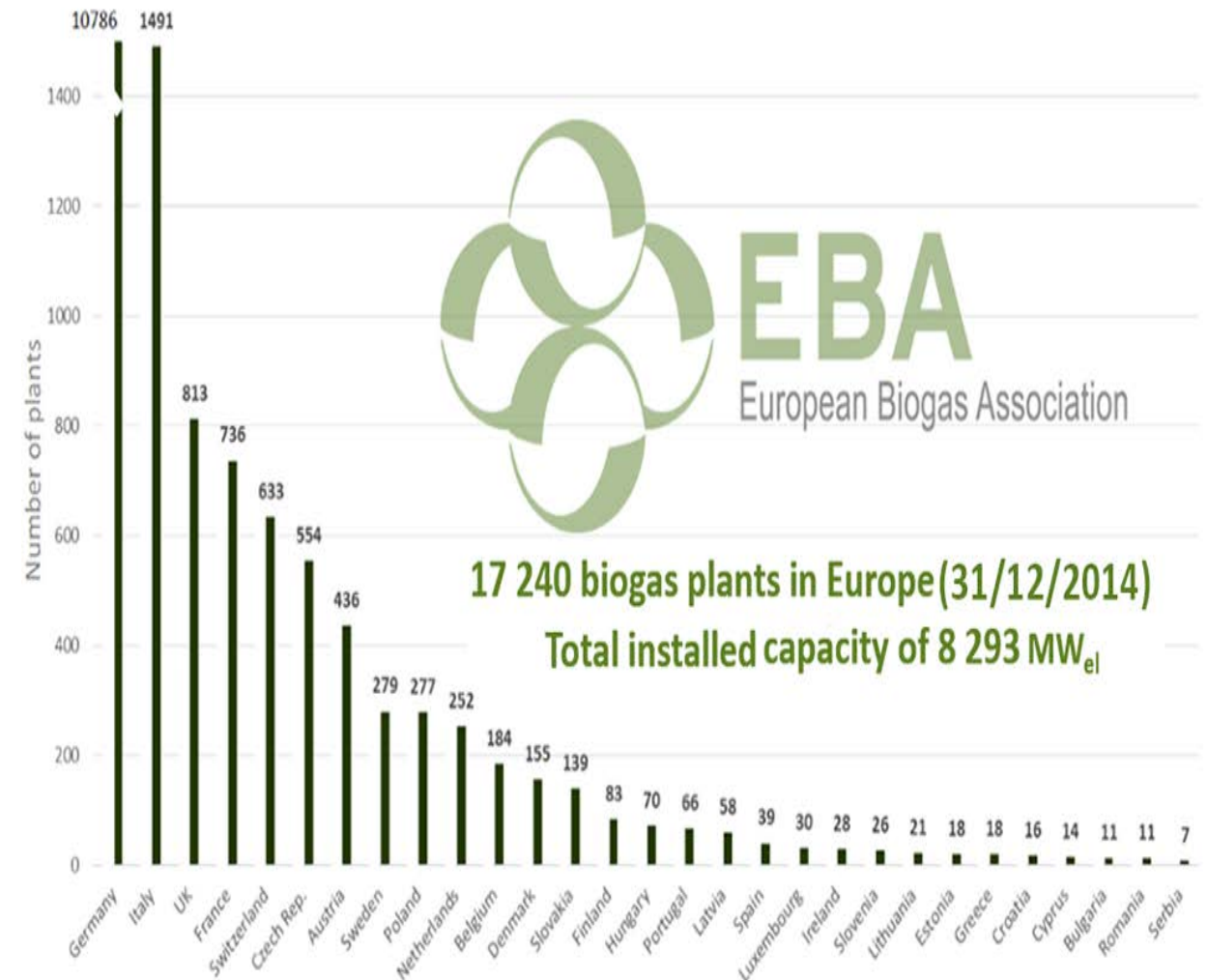
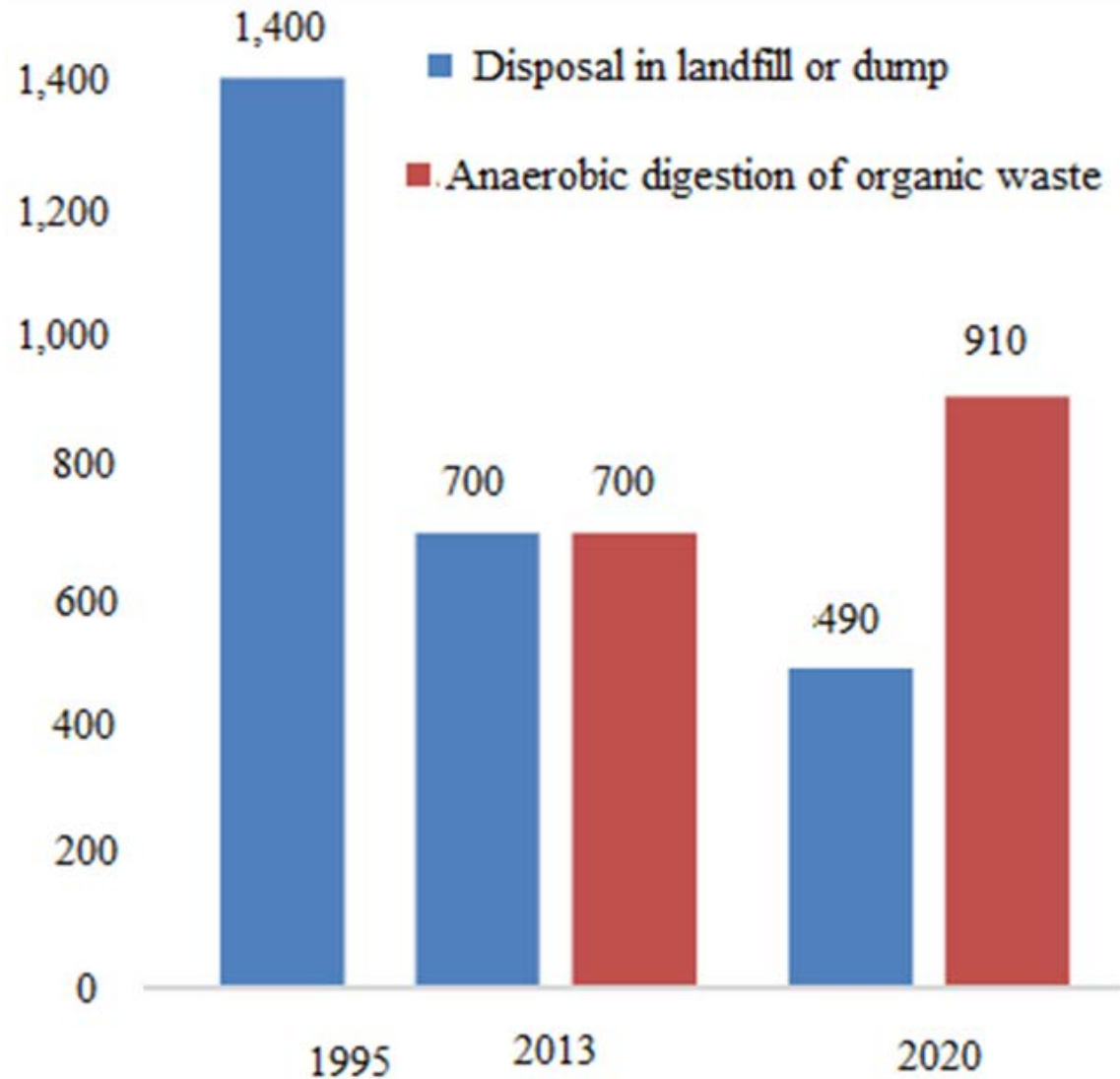


Greenhouse gas emissions from municipal waste management in the EU-27



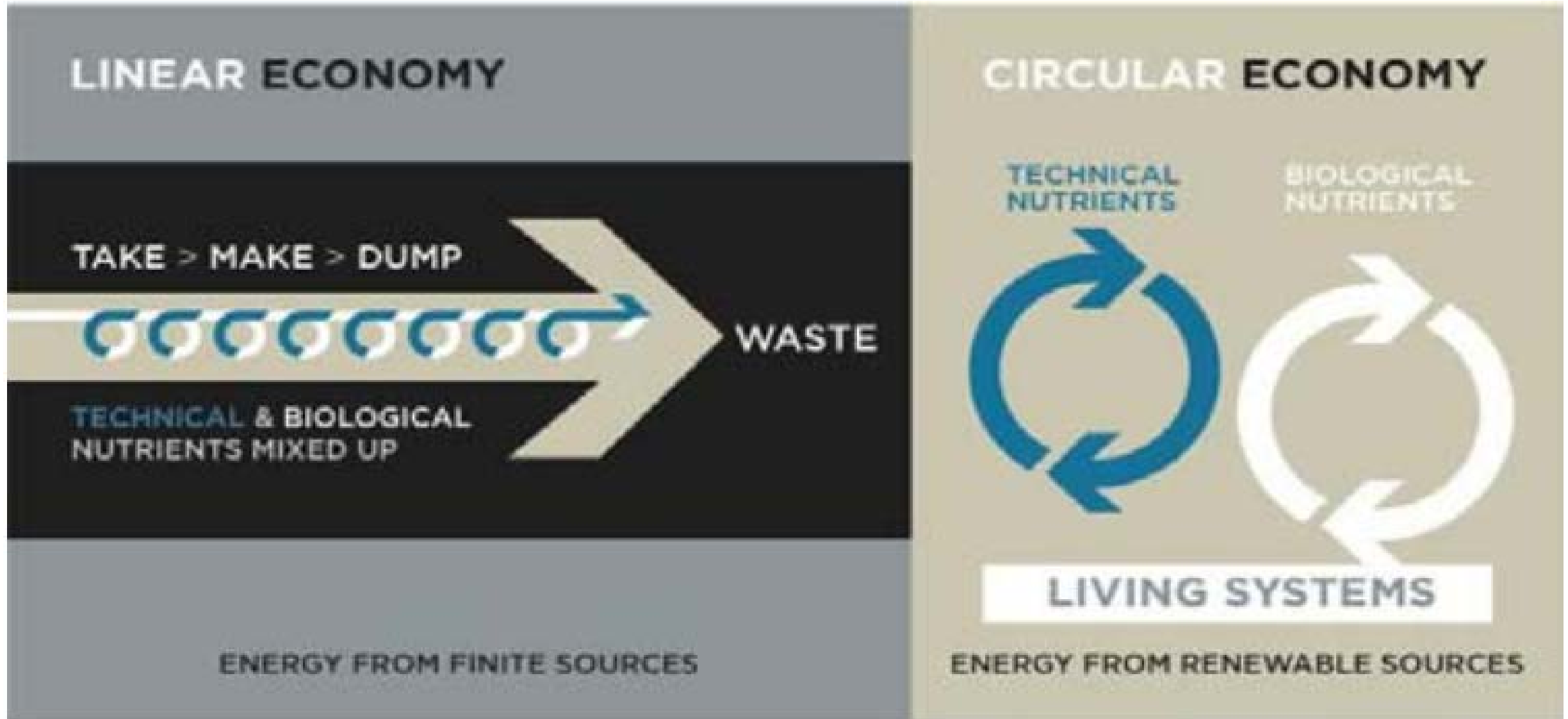


Intended quantity of biodegradable municipal waste to anaerobic digestion





From linear to circular economy





Multi-objective optimization problem?

$$\begin{aligned} \max ER_j = & \sum_v \sum_\rho (A_j^E \cdot c_\rho^v) \\ & + \sum_\xi \sum_\sigma (\Gamma_j^E \cdot d_\sigma^\xi) \\ & + \sum_o \sum_\tau (E_j^E \cdot e_\tau^o) \end{aligned}$$

$$\begin{aligned} \max FT = & \sum_\mu \sum_\pi [CF\Phi_\mu^\mu \cdot \phi_\pi^\mu + CFV_\mu^\mu \cdot b_\pi^\mu] \\ & + \sum_v \sum_\rho [CF\Phi_\rho^v \cdot \chi_\rho^v + CFV_\rho^v \cdot c_\rho^v] \\ & + \sum_\xi \sum_\sigma [CF\Phi_\sigma^\xi \cdot \psi_\sigma^\xi + CFV_\sigma^\xi \cdot d_\sigma^\xi] \\ & + \sum_o \sum_\tau [CF\Phi_\tau^o \cdot \omega_\tau^o + CFV_\tau^o \cdot e_\tau^o] \end{aligned}$$

Typology of existing/proposed facility (i)	Sub-typology of facility (i)	Capacity of facility [ΔE_i^i , (t/d)]	Wastes' input at facility (t/d)	Mass reduction at facility (%)	Residues output from facility (t/d)	Binary decision variables (0, 1)	Wastes' flows from producers to facilities and wastes'/residues' flows from facilities to other facilities/landfills
Transfer station	μ	k	b		t	φ_π^μ	
Material recovery	v	g	c	f_{MRF}	s	χ_ρ^v	
Energy recovery	ζ	h	d	f_{WTE}	q	ψ_σ^ζ	
Landfill	o	u	e			ω_τ^o	

$$\begin{aligned} \min GHE = & \sum_\xi \sum_\sigma (\Gamma_\xi^{GHE} \cdot d_\sigma^\xi) \\ & + \sum_o \sum_\tau (E_o^{GHE} \cdot e_\tau^o) \end{aligned}$$

$$\begin{aligned} \min FIDI = & \sum_o \sum_i \sum_\tau \eta_{i\tau}^o \cdot \omega_\tau^o \\ & + \sum_\mu \sum_o \sum_\pi \sum_\tau t_{\pi\tau}^{\mu o} \cdot \omega_\tau^o \\ & + \sum_\xi \sum_o \sum_\sigma \sum_\tau \delta_{\sigma\tau}^{\xi o} \cdot \omega_\tau^o \end{aligned}$$

$$\begin{aligned} \max MR_j = & \sum_v \sum_\rho (A_j^M \cdot c_\rho^v) \\ & + \sum_\xi \sum_\sigma (\Gamma_j^M \cdot d_\sigma^\xi) \end{aligned}$$



Mixed constraints problem?

- (a) Service demand, i.e. the produced amount of wastes is equal to the sum of capacities from the facilities of the system

$$a_i = \sum_{\mu} \sum_{\pi} \alpha_{i\pi}^{\mu} + \sum_{v} \sum_{\rho} \varepsilon_{i\rho}^v + \sum_{\xi} \sum_{\sigma} \zeta_{i\sigma}^{\xi} + \sum_{o} \sum_{\omega} \eta_{i\omega}^o$$

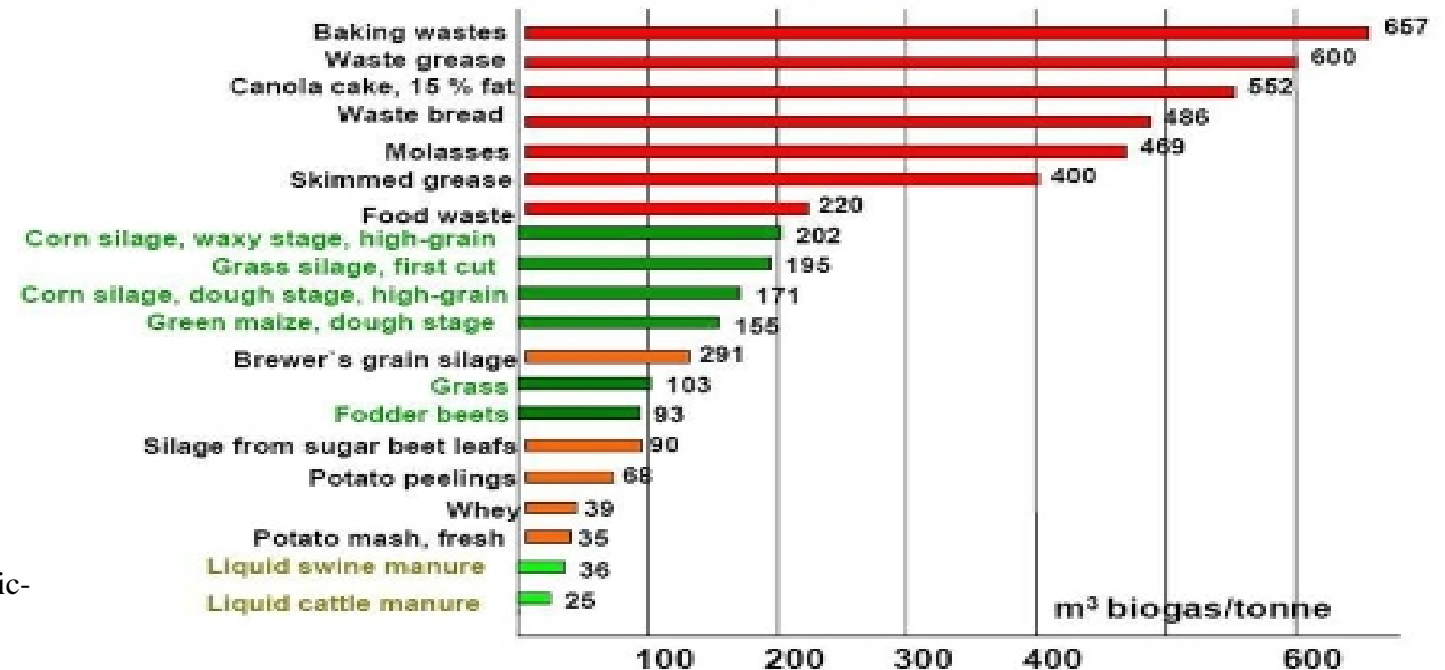
- (b) Facility capacity.

- (c) Mass input-output relation at facilities.

$$\min GHE = \sum_{\xi} \sum_{\sigma} (\Gamma_{\xi}^{GHE} \cdot d_{\sigma}^{\xi}) + \sum_{o} \sum_{\tau} (E_o^{GHE} \cdot e_{\tau}^o)$$

- (d) Compactor- and truck-capacity, maximum allowed gross truck weight and speed limits. Solid wastes were allowed to either leave transfer stations uncompressed (in the case that they are sent to material recovery facilities, by mostly open- containers), or compressed (in the cases they are sent to waste-to energy facilities or landfills).

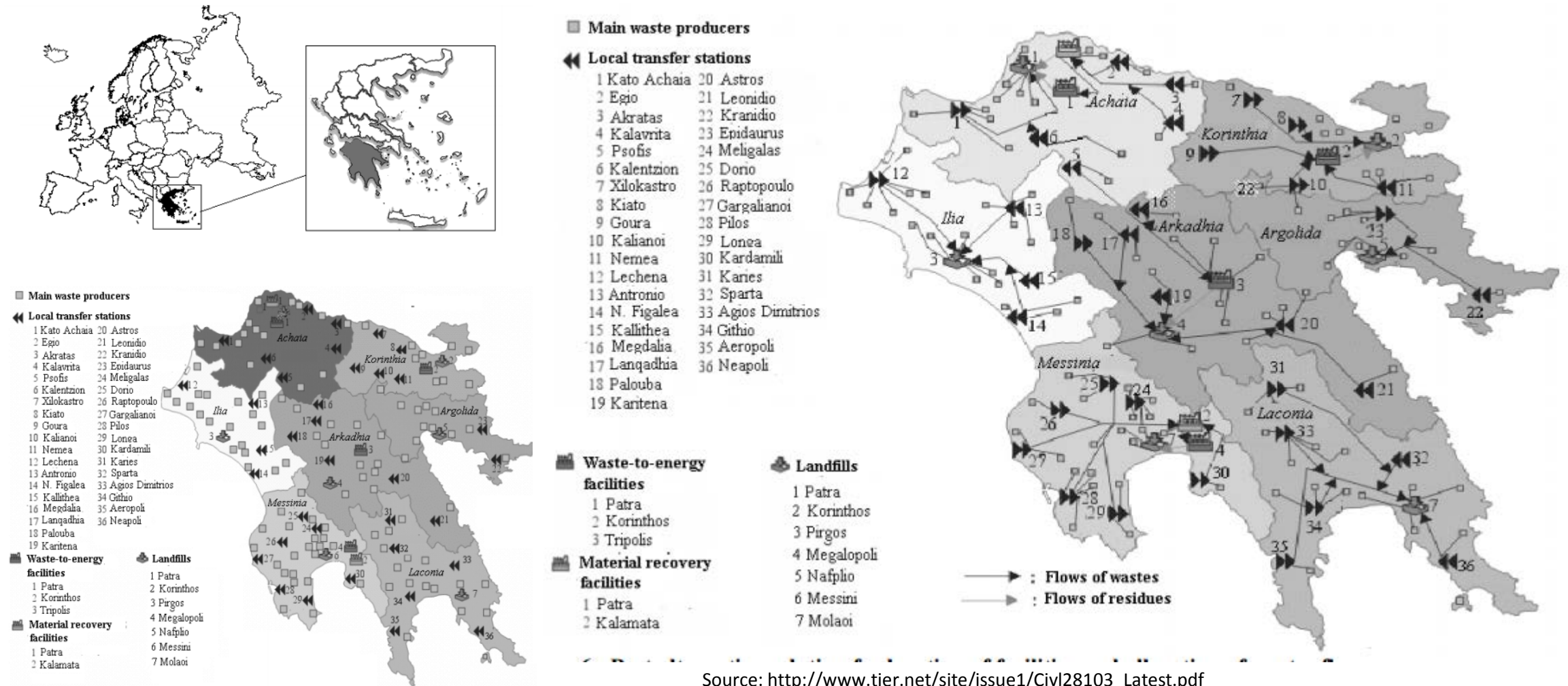
Potential Biogas Yields





Are there existing and candidate facilities?

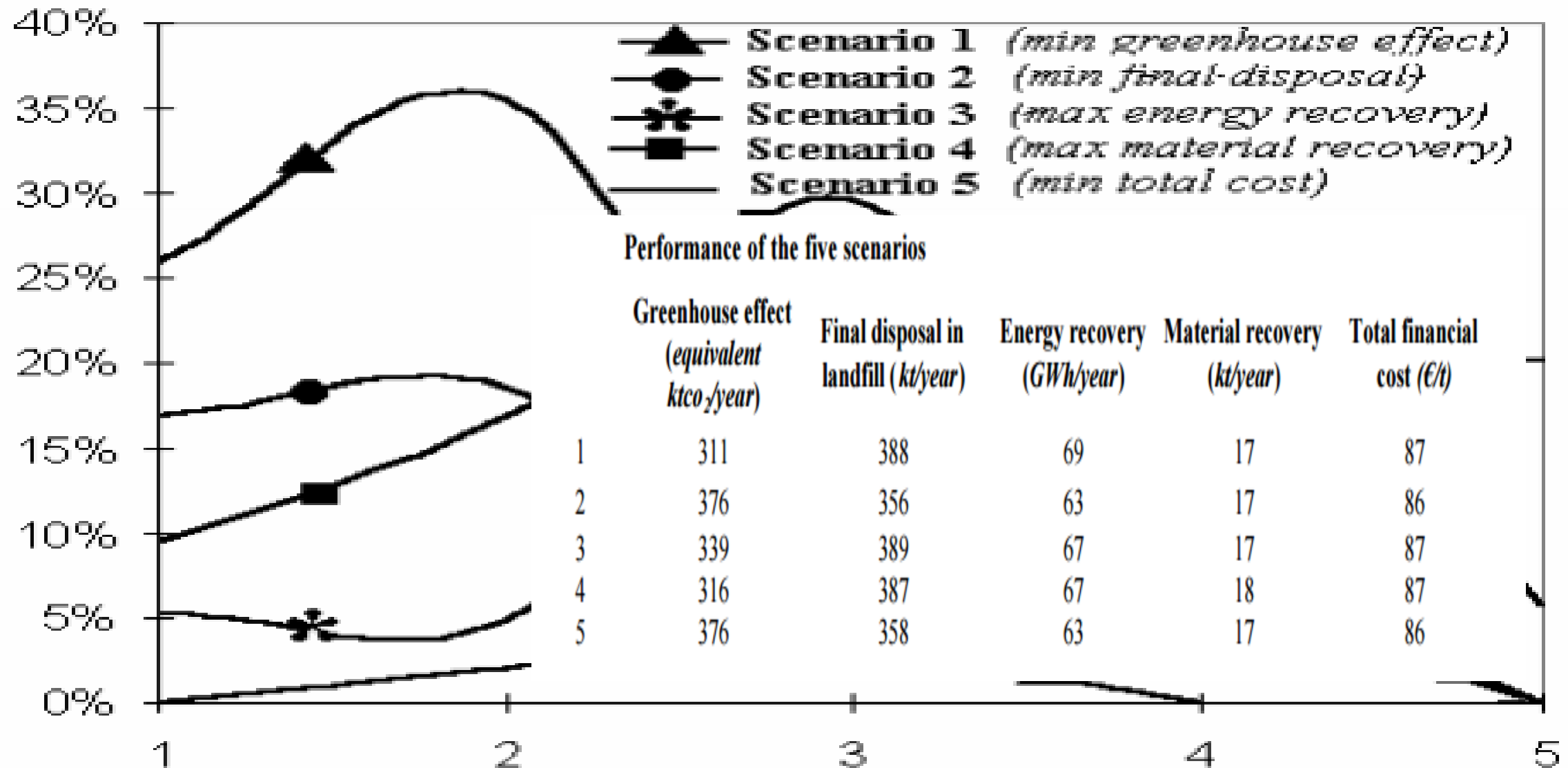
Which is the best alternative solution?



Source: http://www.tjer.net/site/issue1/Civil28103_Latest.pdf

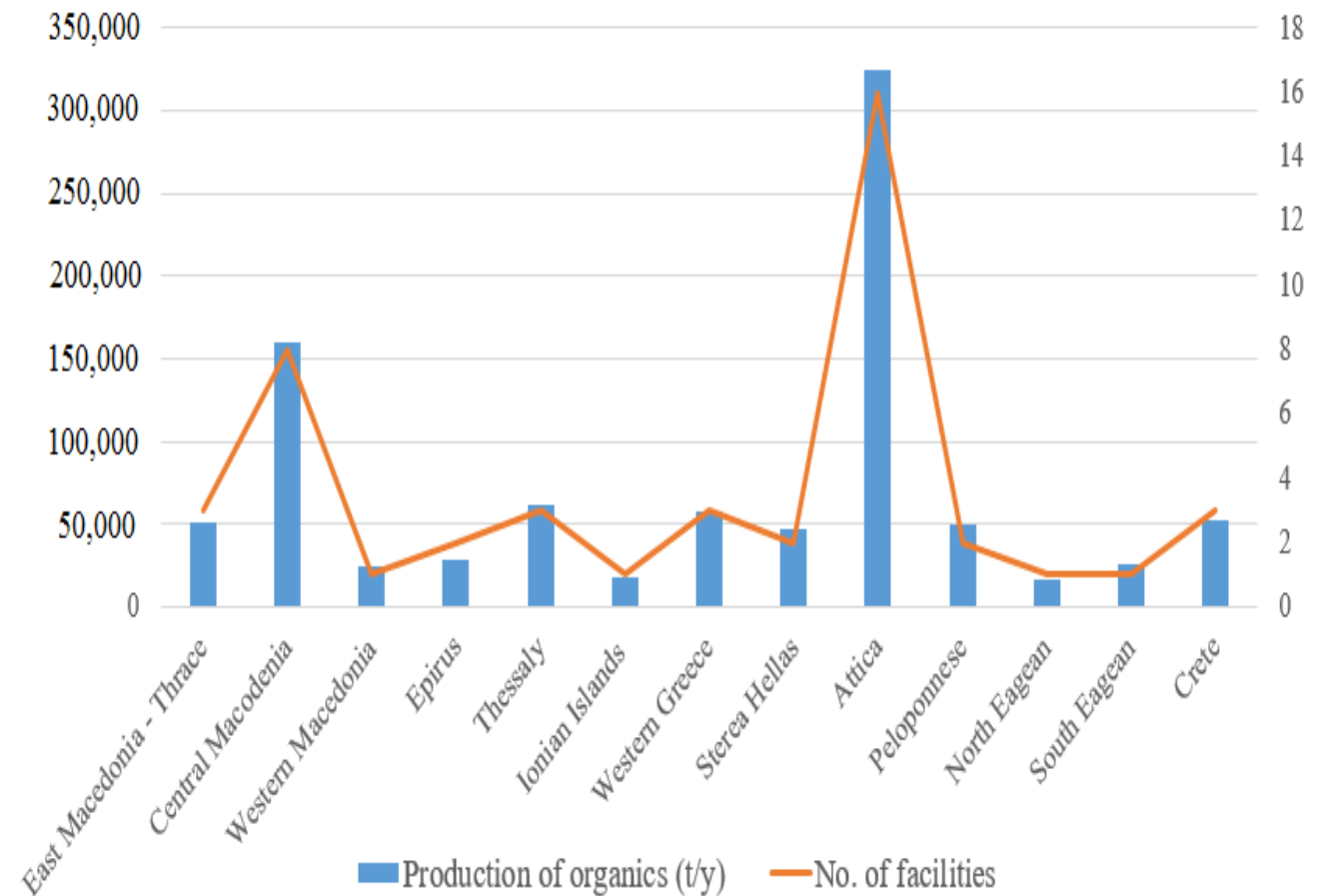
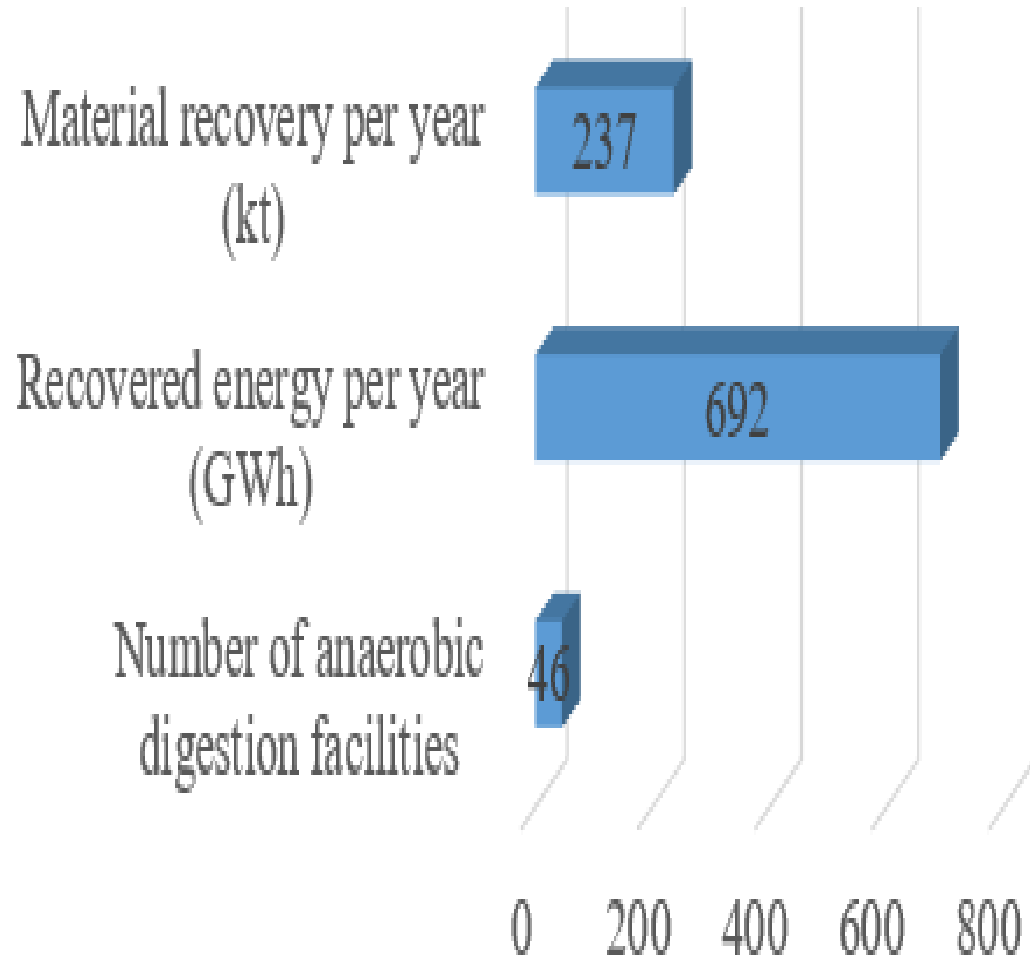


Do we need MCDA analysis with GIS?



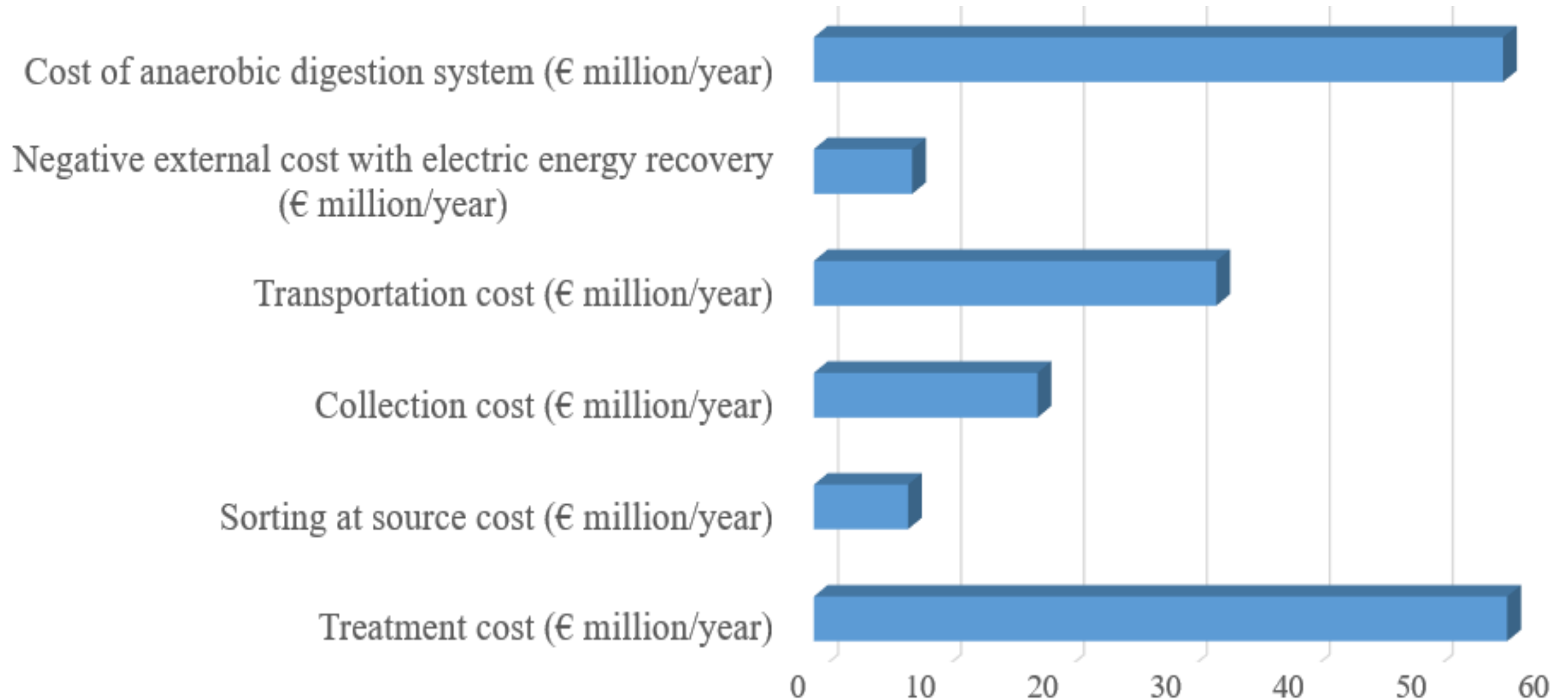


Number of anaerobic digestion facilities and recovered energy and material



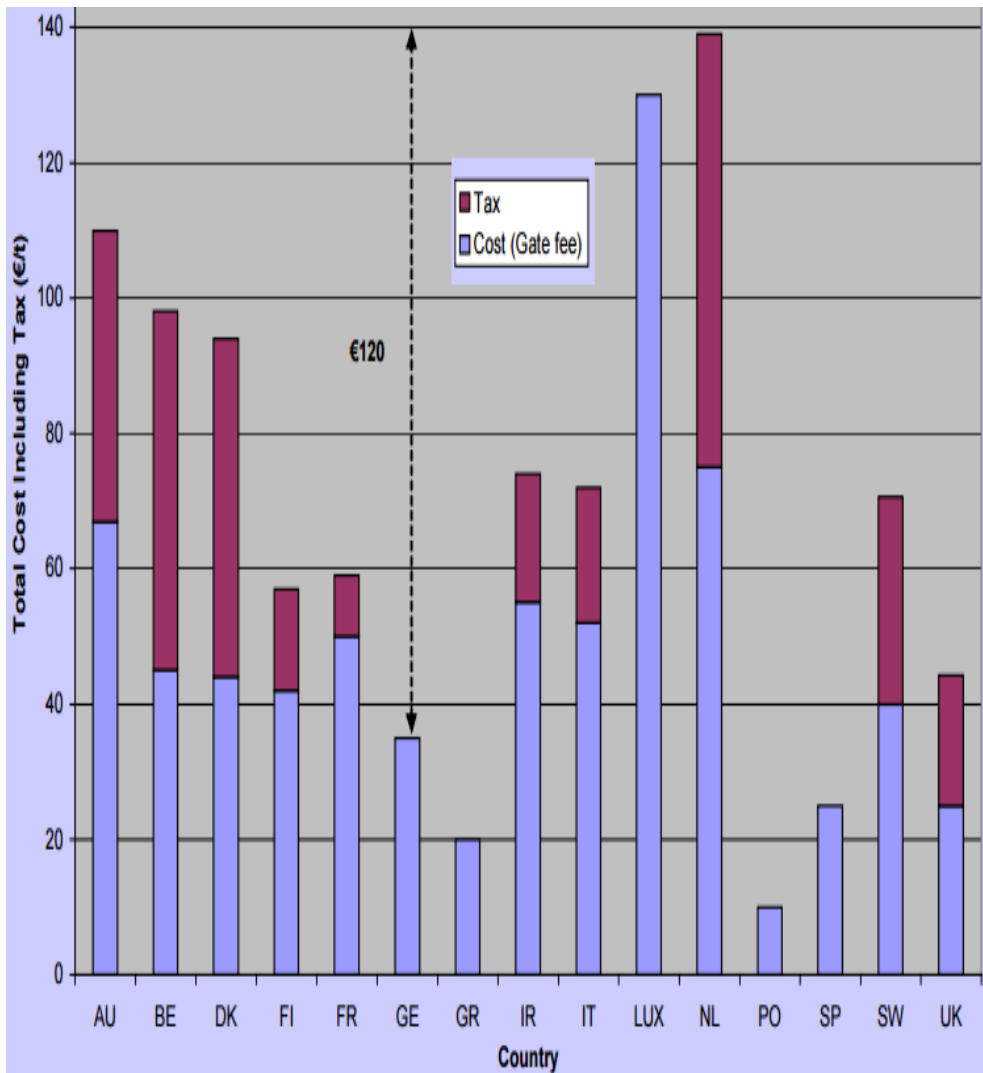


Cost of anaerobic digestion system





Cost of landfilling and biodegradable disposal



Year	Biodegradable municipal waste in 1995 (kt)	Disposal to earth [landfill, dump (t)]	Organic waste (kt)	Organic waste disposal in landfills or dumps (t)	Anaerobic digestion of organic waste (kt)
1995	2,100	2,100	1,400	1,400	0
2013				700	700
2020				490	910



Circular economy aspects in Catalonia



THE ORGANIC MATTER CYCLE



	Compost Nutrients	Nutrient Demand*	
		Winter Cereal	Horticulture
Organic Matter	350 kg/t		
Available N	10 kg/t	40 kg/ha	200 kg/ha
Posphorus (P2O5)	18 kg/t	80 kg/ha	80 kg/ha
Potassium (K2O)	13kg/t	60 kg/ha	300 kg/ha
Compost Demand t/ha		6-10 t/ha	20 t/ha

4 Facilities



PROs

- Requires less area
- Allows better management of emissions / odors
- Allows recovery of energy (biogas)
- Fuel for vehicles

CONs

- High costs (investment /management)
- More sofisticated and sensitive technology
- Requires high input quantities
- Requires homogeneous input
- More feasible on the industrial scale

20 Facilities



PROs

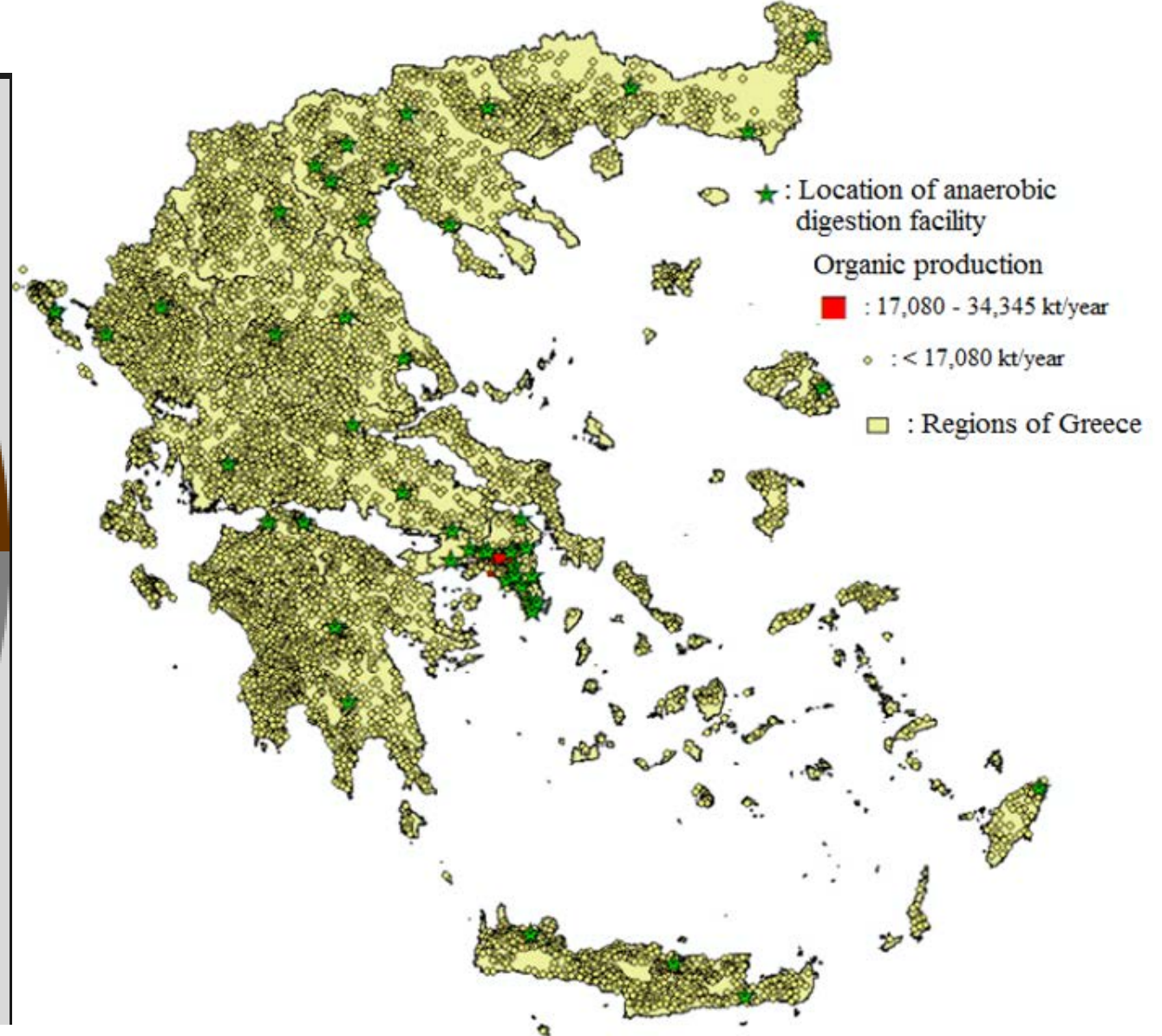
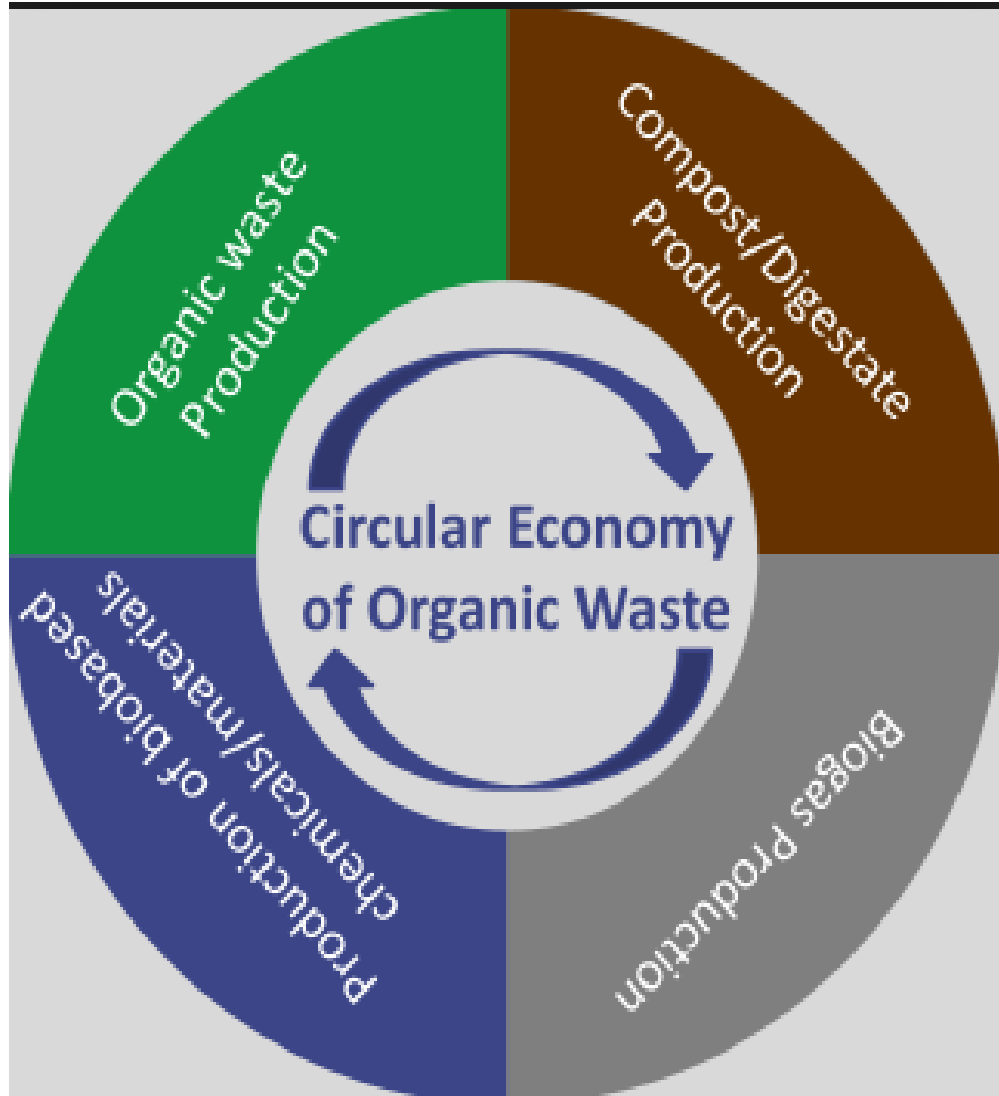
- Simple, robust technology
- Flexibility (capacity/modules)
- Biological process less complicated
- Process allows and requires input of woody materials (green waste)
- Lower costs (investment/management) than AD

CONs

- Slower process



Circular economy aspects in Greece





Conclusions

- Forty six (46) anaerobic digestion facilities were proposed
- The energy recovery was calculated to 692 GW_h
- The recovered material, in the form of compost, yielded to 237 kt.
- The total negative external cost for managing the 910 kt of bio-waste in Greece, was estimated to €8 million for the year 2020
- The cost for the treatment of organic waste was 56.4 M €, while the cost for its source separated collection was calculated to €7.7 million.
- Tools for implementing circular economy:
 - Linear integer programming and Multi-Objective programming (among others).
 - GIS
 - Anaerobic digestion databases



Thank you for your attention!

