BLATO KOT VIR STRATEŠKIH SUROVIN – POT DO SNOVNE SAMOZADOSTNOSTI

doc. dr. Tine Seljak

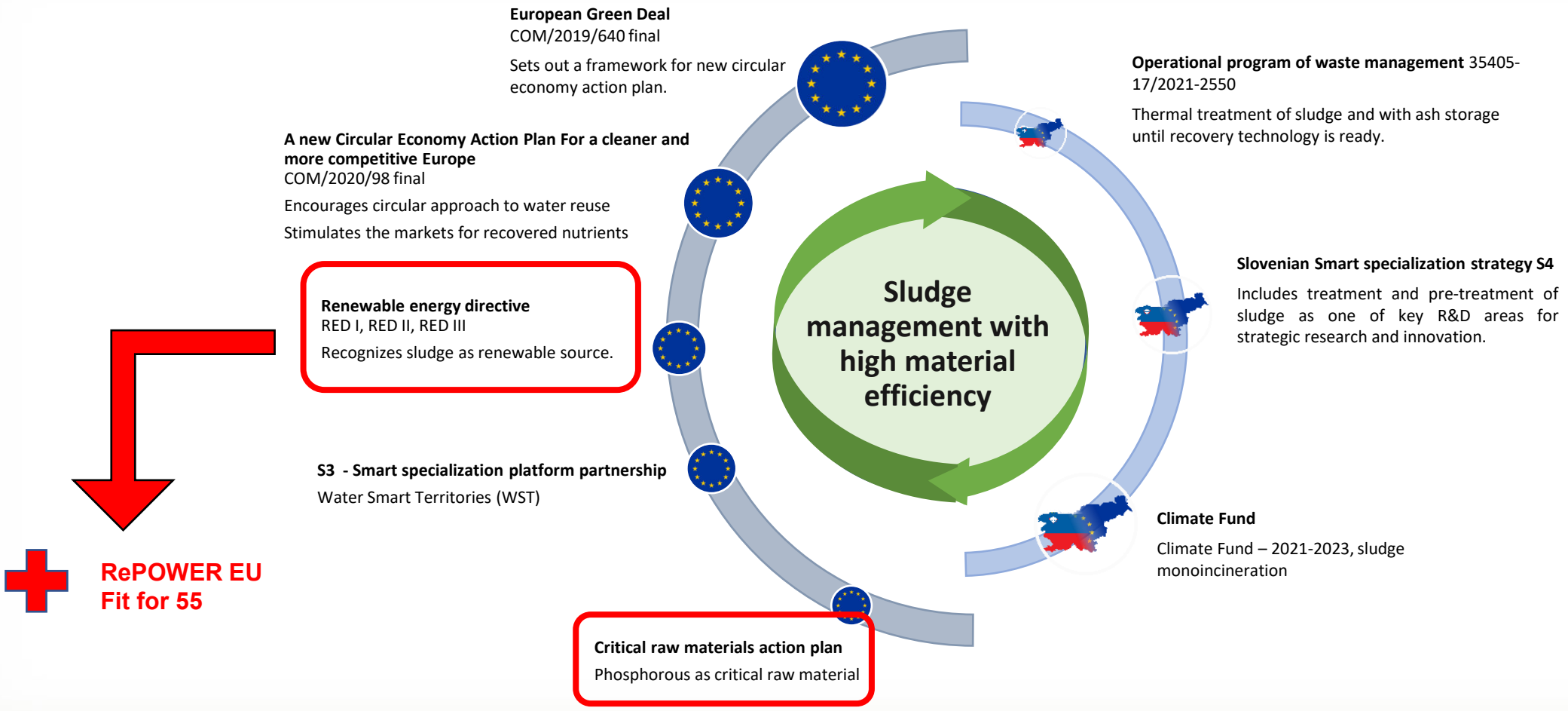
University of Ljubljana, 23 faculties, 3 art academies

23 faculties
3 art academies
6,000 staff
Ranked top 3%

Faculty of mechanical engineering

22 departments
20 professors
250+ researchers
400 staff

Okvirji


European Green Deal
COM/2019/640 final
Sets out a framework for new circular economy action plan.
A new Circular Economy Action Plan For a cleaner and more competitive Europe
COM/2020/98 final
Encourages circular approach to water reuse
Stimulates the markets for recovered nutrients
Renewable energy directive
RED I, RED II, RED III
Recognizes sludge as renewable source.
RePOWER EU
Fit for 55
S3 - Smart specialization platform partnership
Water Smart Territories (WST)
Critical raw materials action plan
Phosphorous as critical raw material
Sludge management with high material efficiency
Operational program of waste management 35405-17/2021-2550
Thermal treatment of sludge and with ash storage until recovery technology is ready.
Slovenian Smart specialization strategy S4
Includes treatment and pre-treatment of sludge as one of key R&D areas for strategic research and innovation.
Climate Fund
Climate Fund – 2021-2023, sludge monoincineration

Okvirji

RED I 2009/28/EC

2020:
- 20% CO_2
+ 20% Renewables
+ 20% Energy efficiency

ILUC 2015/1513

RED II EU 2018/2001

2030:
- 40% CO_2
+ 32% Renewables
+ 32,2% Energy efficiency

2050:
-80% CO_2

GD COM/2019/640 final

2030:
- 50-55% CO_2
+ 40% Renewables
+ 33-39% Energy efficiency

2050:
- 95% CO_2

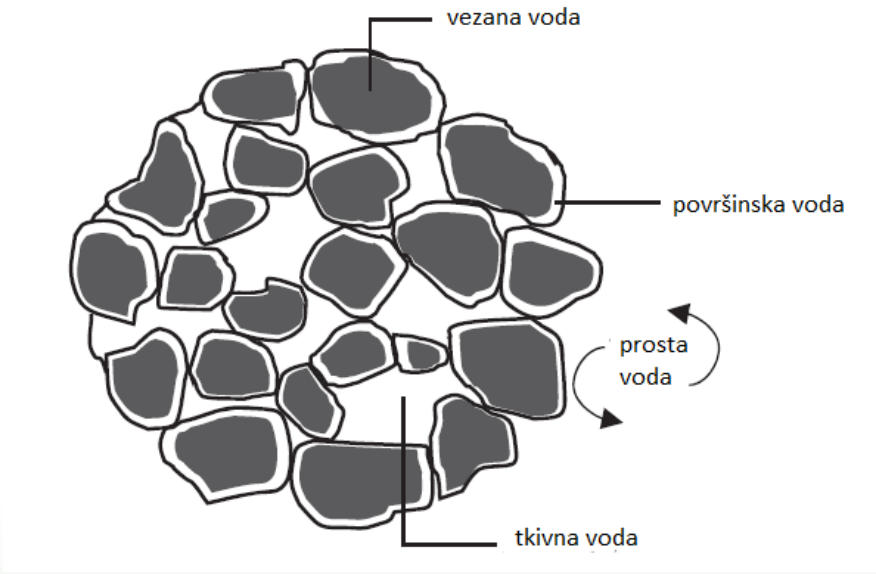
RePower EU COM/2022/230 final

2030:
+ 45% Renewables
+ 35bcm biogas

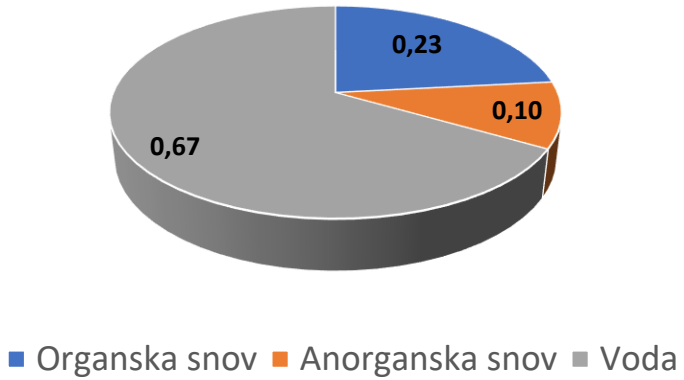
RED III 2023

Komunalni mulji - lastnosti

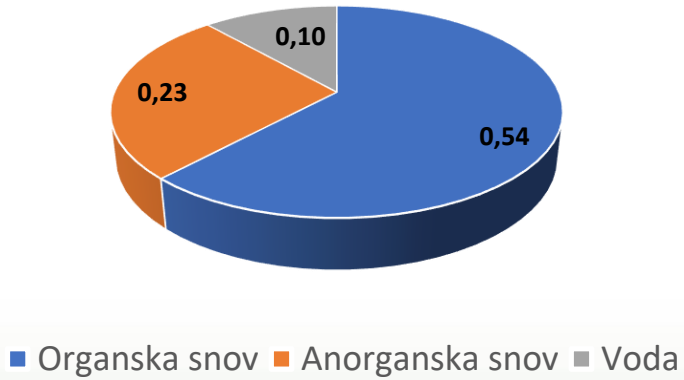
- Neobdelani mulji vsebujejo 1-12% suhe snovi
- Zgoščeni mulji vsebujejo 20-40% suhe snovi
- Suha snov vsebuje od 25-35% anorganskih snovi



Dehidriran mulj



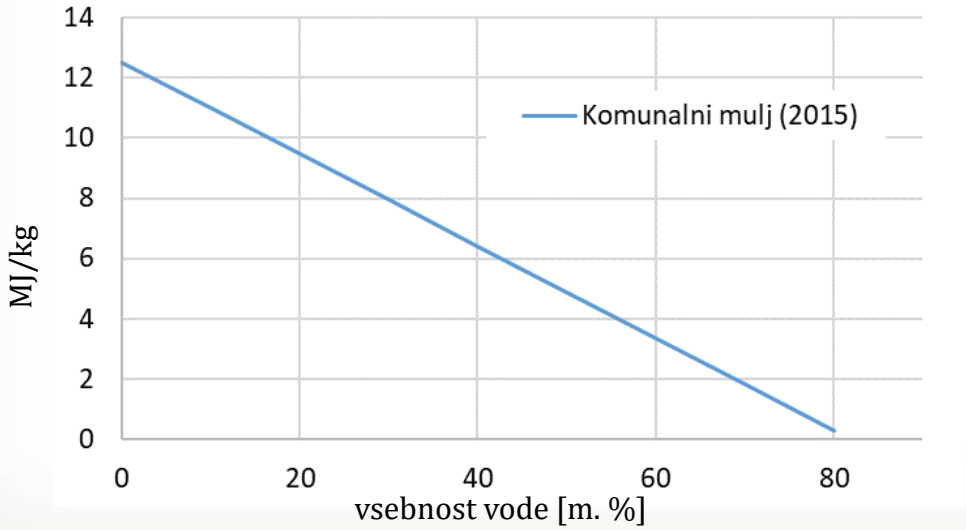
Sušen mulj



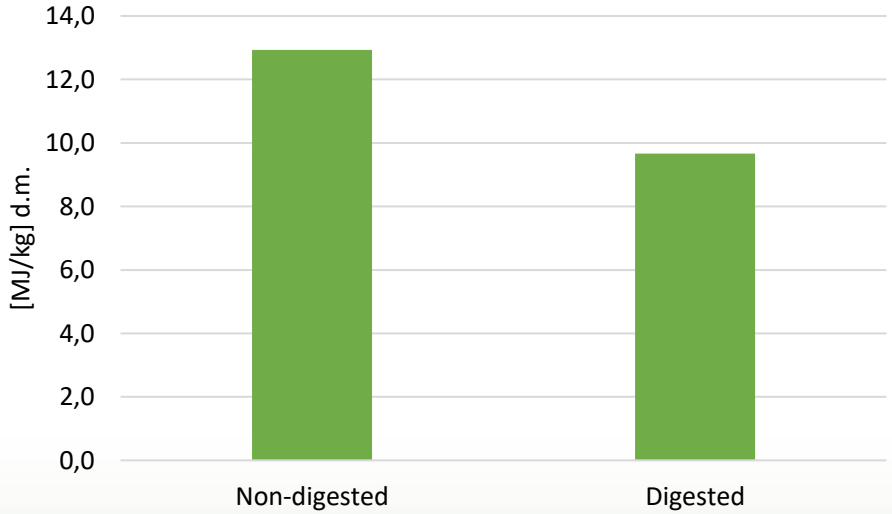
Komunalni mulji - lastnosti

- Gorljiva je **zgolj organska snov**.
- Redčenje“ organske snovi vodi v **nižjo kalorično vrednost** (anorganske snovi, voda).
- Anaerobno obdelan mulj ima lahko od **25-30% nižjo vsebnost energije**.
- Organsko snov (C, H, **izgubljamo v obliki CH_4 in CO_2**).

Vpliv vsebnosti suhe snovi



Vpliv načina obdelave

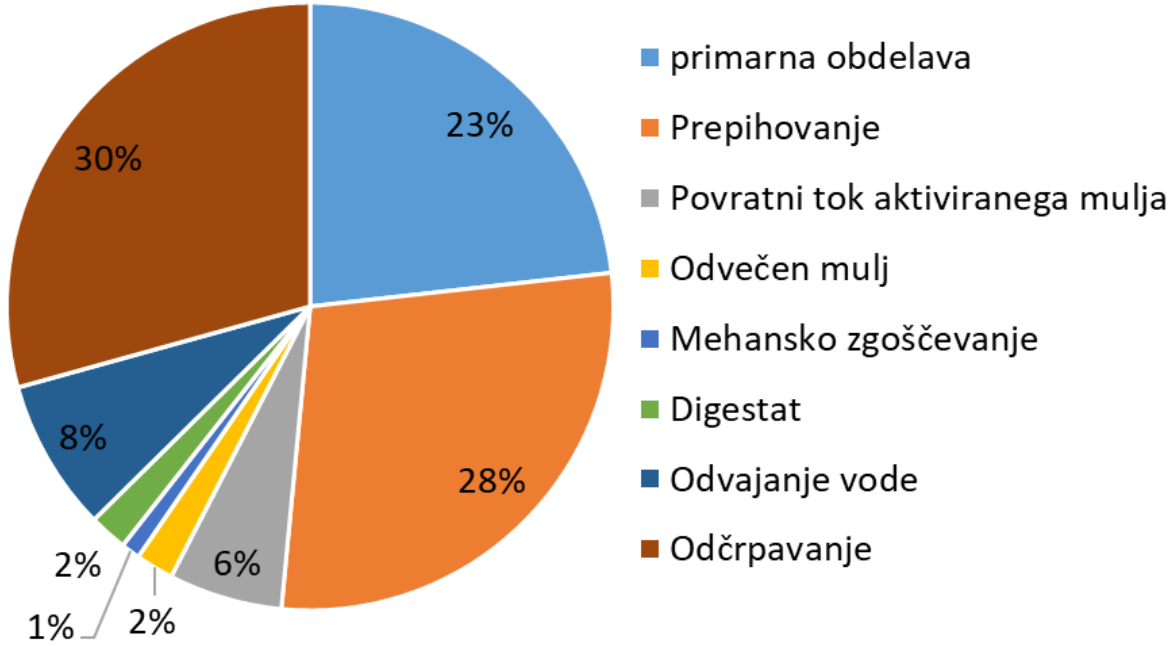


Komunalni mulji – ključni parametri

- **Vsebnost vode -** odvisna od načina sušenja, dehidracije - do okvirno 90%
- **Vsebnost pepela -** odvisna od vrste obdelave in osnovne surovine 25 – 35 %
- **Vsebnost kisika -** odvisna od vrste obdelave in osnovne surovine, do 20%
- **Kalorična vrednost -** odvisna od vrste obdelave in vsebnosti vode, 10 - 16 MJ/kg (suha snov)
- **Gorljiv, organski del lahko dosega kalorično vrednost 20 – 30 MJ/kg**.

Raba energije za predpripravo

- **Zgoščevanje** (dehidracija) muljev se izvaja večin mehansko (zgoščevalniki; 20 – 40 % d.m.).
- **Sušenje muljev** se večinoma izvaja s termičnim sušenjem (90+ % d.m.)
- **Mehansko zgoščevanje** je energijsko učinkovito in predstavlja rabo majhnega deleža energije v obdelavi muljev.

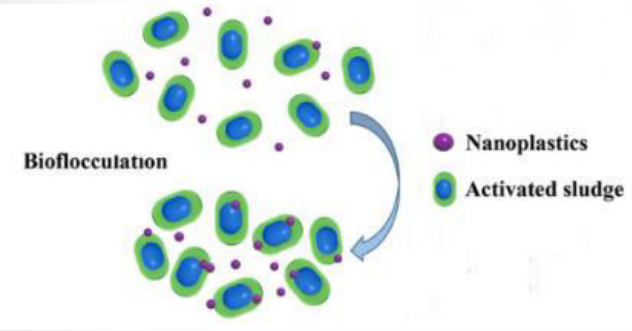


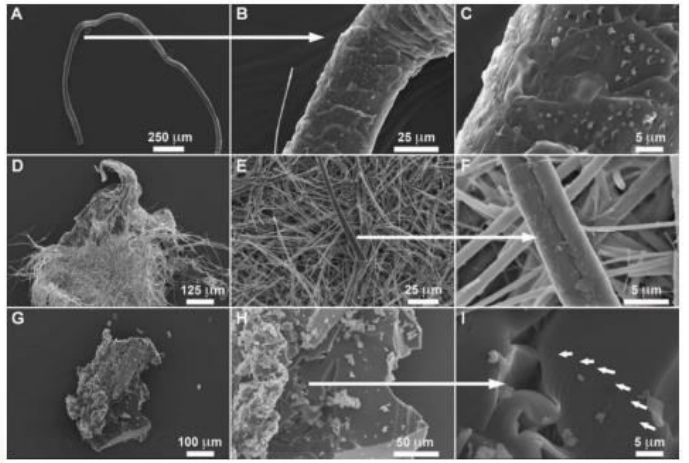
raba energije v postopku obdelave vod

Komunalni mulji - kontaminacija

- Mikroplastika: 5 .000- 15.000 delcev / kg suhe snovi mulja

Site no.	Treatment	Microplastic Types				
		Fibres	Fragments	Films	Spheres	other
1A	TD	9,113	511	255	89	44
1B	AD	2,065	611	67	0	0
2	TD	5,583	588	222	44	67
3	AD	4,007	855	111	33	150
4	TD	13,675	1,143	366	33	178
5	LS	10,778	3,075	122	11	78
6	LS	4,762	5,228	11	0	11



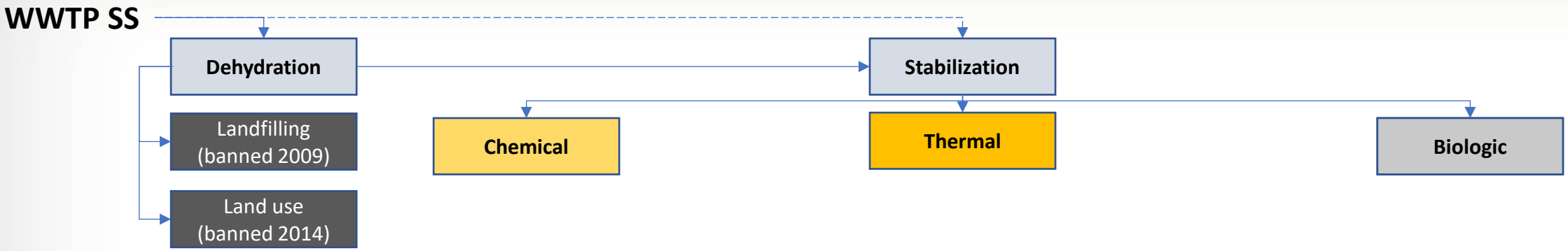


- Volatilne in pol-volatilne kovine z nizkim vreliščem

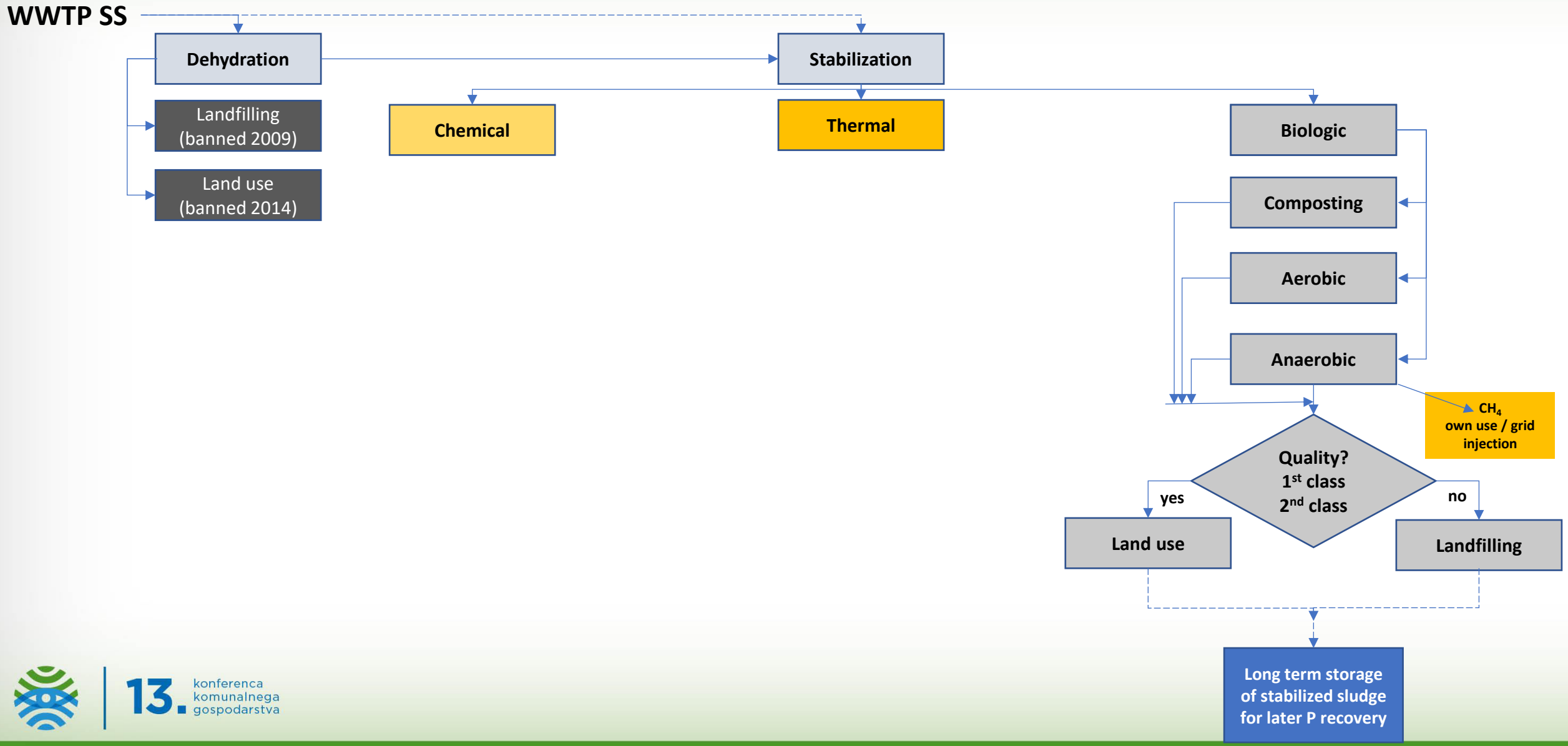
Kovina	Razpon	Mediana
	mg/kg	mg/kg
Arzen	1,1–230	10
Kadmij	1–3.410	10
Skupni krom	1–99.000	500
Kobalt	11,3–2.490	30
Baker	84–17.000	800
Skupno železo	1.000–154.000	17.000
Svinec	13–26.000	500
Mangan	32–9.870	260
Živo srebro	0,6–56	6
Molibden	0,1–214	4
Nikelj	2–5.300	80
Selen	1,7–17,2	5
Kositer	2,6–329	14
Cink	101–49.000	1.700

Vir: Effects of microplastics on wastewater and sewage sludge treatment andtheir removal: A review (2020)
Vir: Microplastics in Sewage Sludge: Effects of Treatment (2016)

Komunalni mulji – tehnologije obdelave

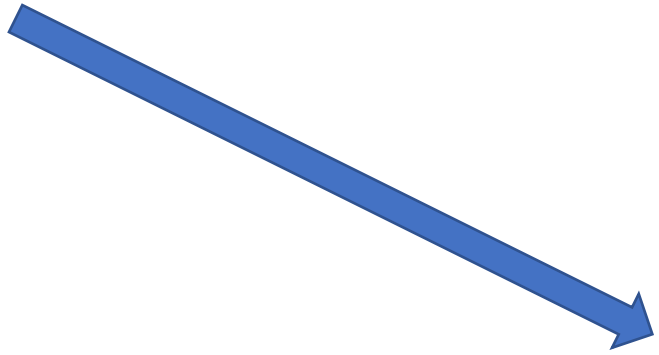


Komunalni mulji – tehnologije obdelave



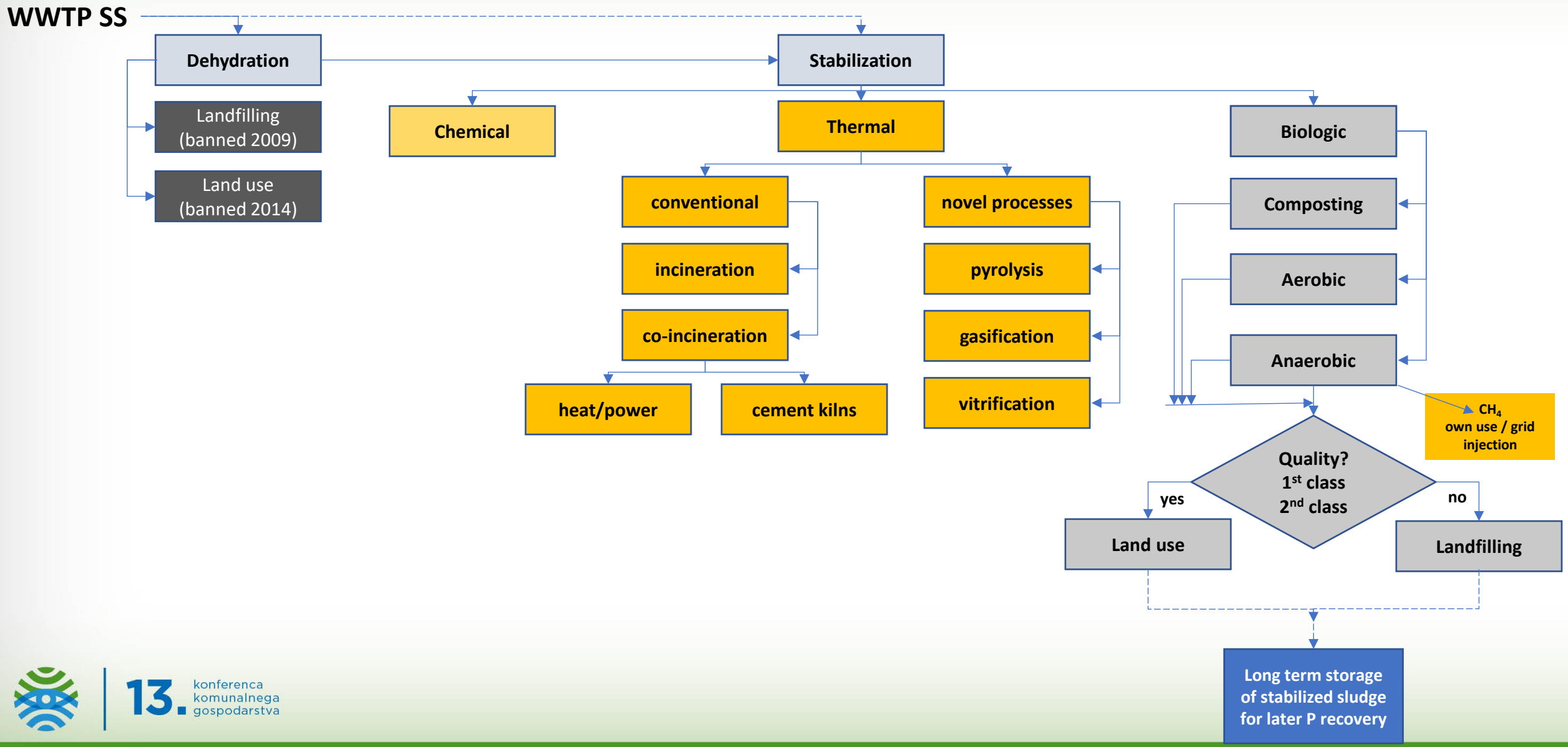
Komunalni mulji – tehnologije obdelave

- **91/271/EEC Urban Waste Water Treatment Directive** – UWWT – May 1991
- Revised in: 2008, 2003, 2013
- Evaluation in 2019
- **Revised directive in 2022**



- Small agglomerations (<2000 PE)
- Sludge treatment in line with waste hierarchy
- **Reduction of micro-pollutants**
- **Monitoring of micro-plastics**
- P and N recovery with minimum recovery rates to be set

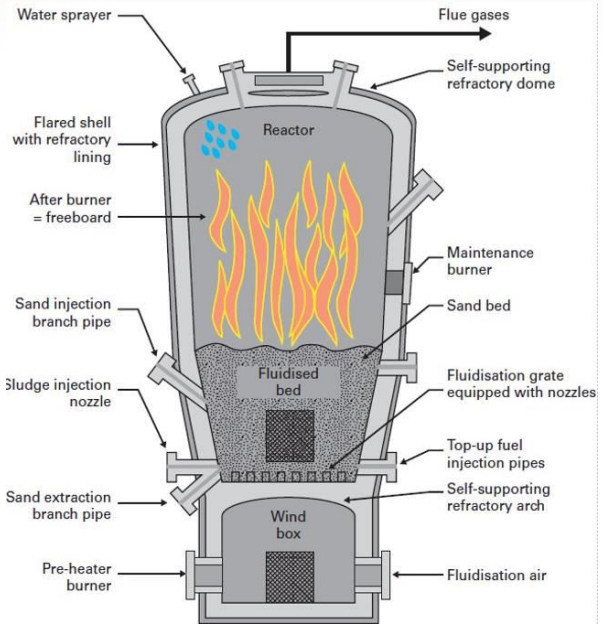
Komunalni mulji – tehnologije obdelave



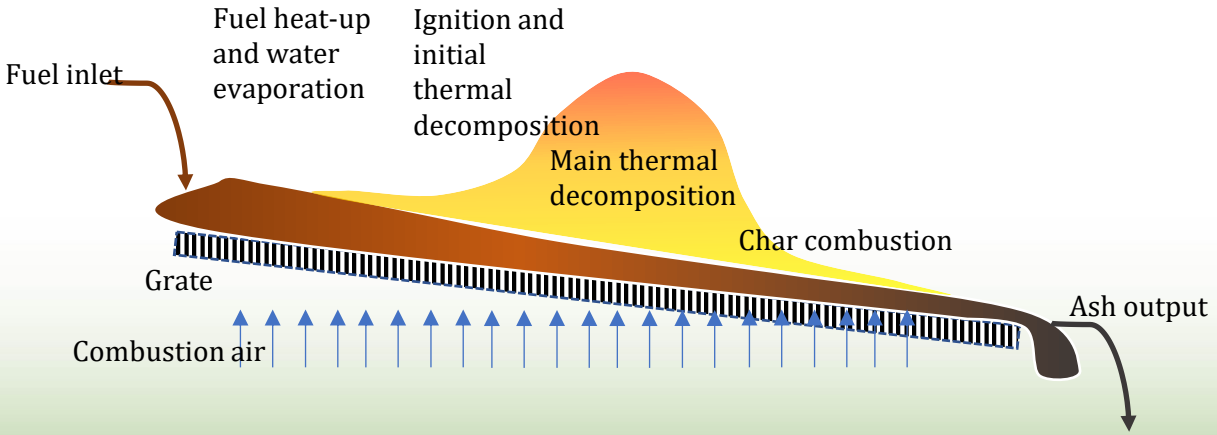
Termična obdelava - tehnologije

- Uveljavljen izraz = energetska raba
- Energijske bilance so lahko izrazito različne
- Minimalna energijska vsebnost

  - Tehnologija s fluidiziranim slojem **4,0 – 5,0 MJ/kg**



  - Tehnologija z rešetko **6,0+ MJ/kg**



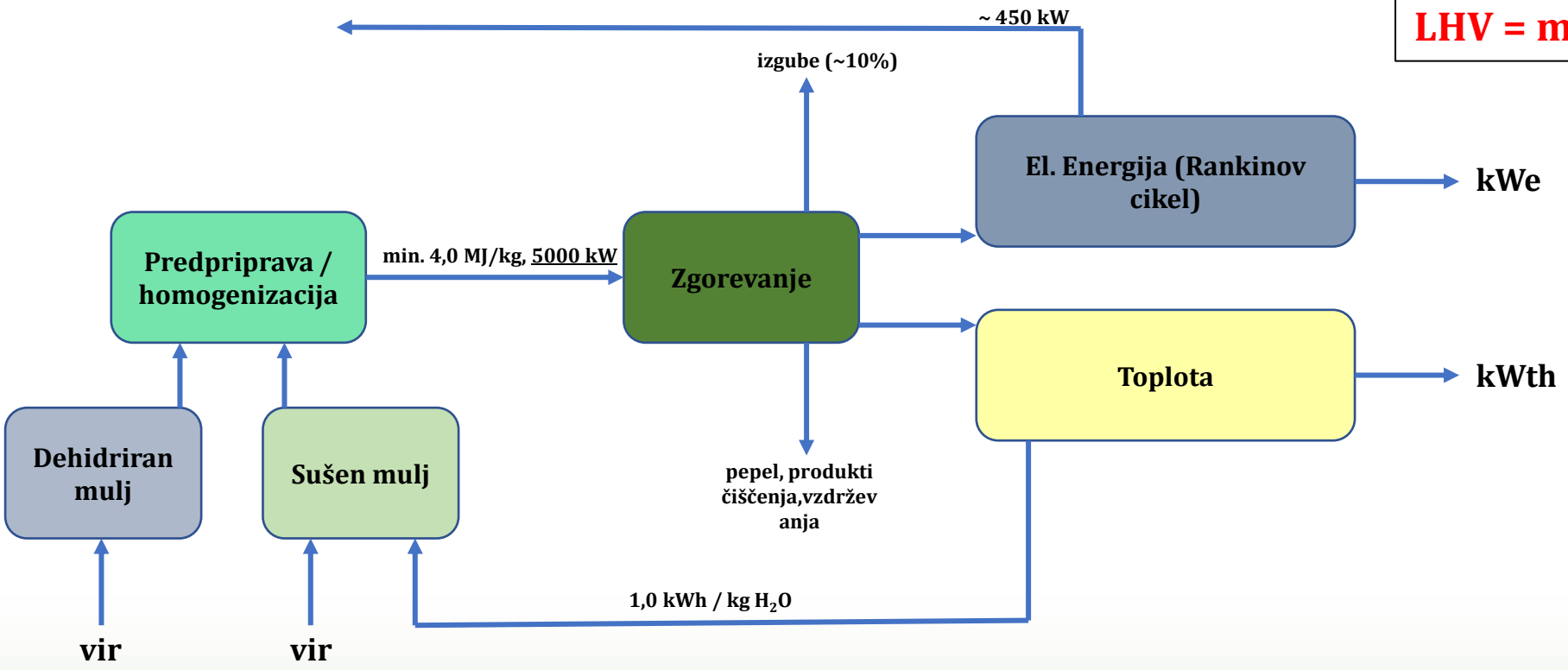
- **Delovanje pri delni obremenitvi je omejeno**
  - IED direktiva (EC, 2010) → 850 °C, 2s.

Termična obdelava – energijska bilanca

Poenostavljena topologija procesa termične obdelave:

Hipotetične Tehnične omejitve:

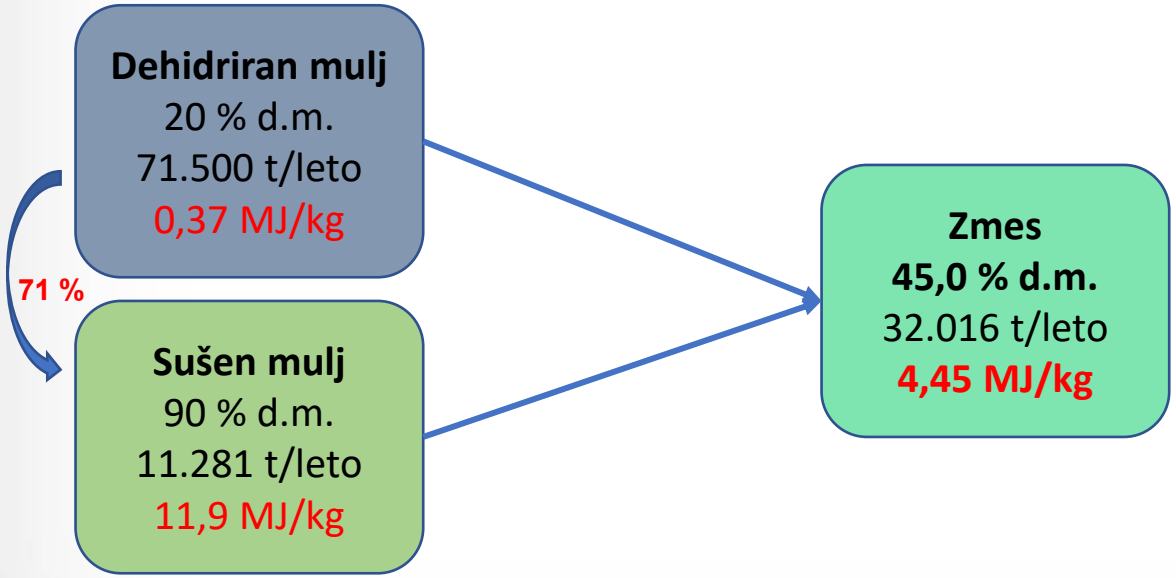
Nazivna moč = 5MW
LHV = min. 4,5 MJ/kg

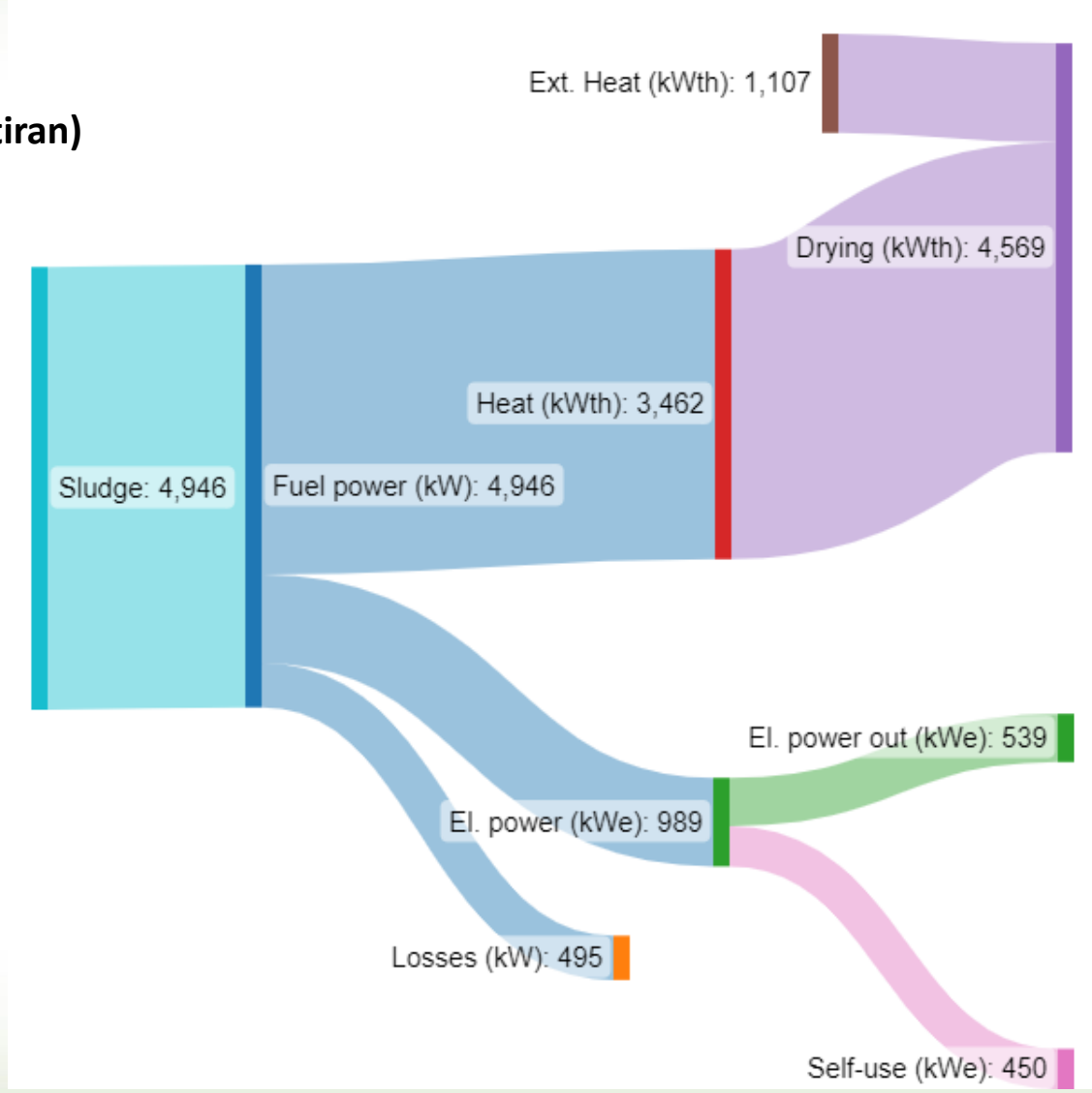


Termična obdelava – energijska bilanca

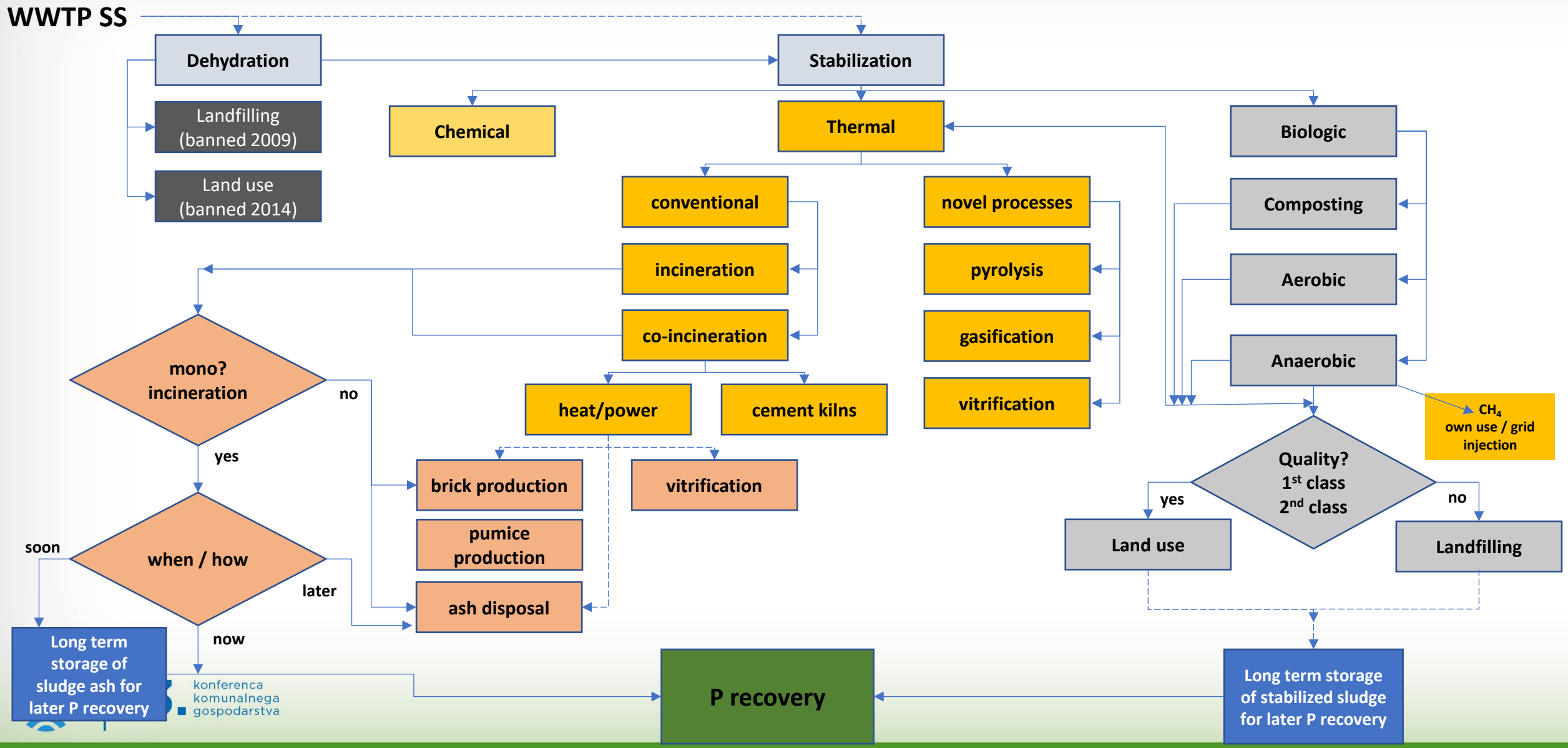
Skrajni primer **(visoke cene energije, RePower polno implementiran)**

- Prejmemo 71.500 t/leto dehidriranega mulja.
  - okvirno 71% dehidriranega mulja sušimo





Komunalni mulji – tehnologije obdelave



Aktivnosti "doma"

WWTP SS

Biologic

CINDERELA

https://www.cinderela.eu/

incineration

CELCYCLE
Discarded potentials of biomass

https://celkrog.si/?lang=en

pyrolysis

arrs
JAVNA AGENCIJA ZA RAZISKOVALNO DEJAVNOST REPUBLIKE SLOVENIJE

https://cris.cobiss.net/ecris/si/sl/project/18814

mono?
incineration

brick production

CINDERELA

erc

CH_4
own use / grid injection

SENERGY NETS

Phoster

https://phoster-project.eu/

P recovery

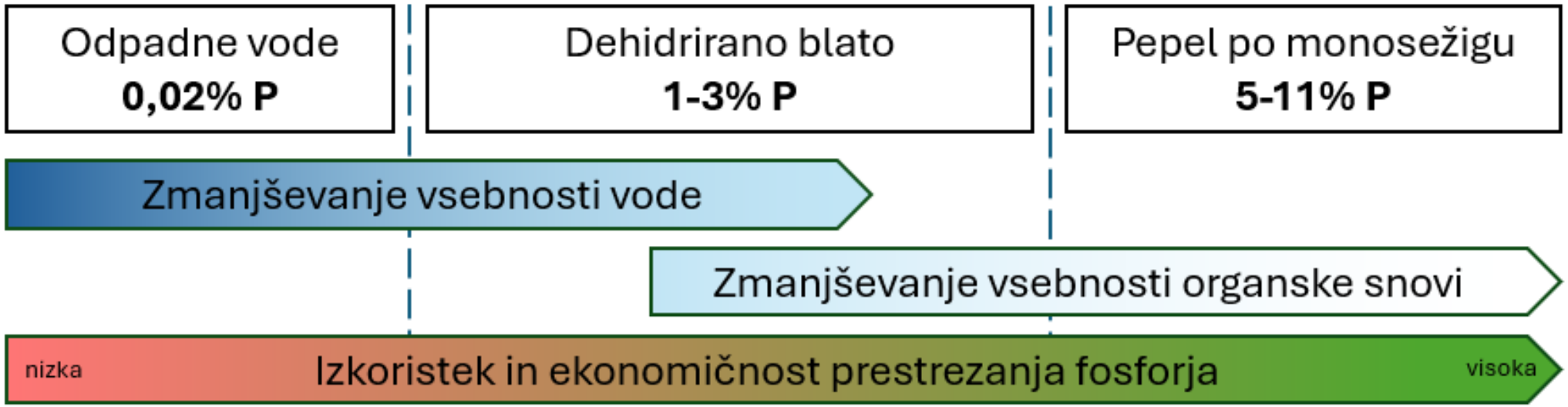
Long term storage of sludge ash for later P recovery

konferenca komunalnega gospodarstva

Long term storage of stabilized sludge for later P recovery

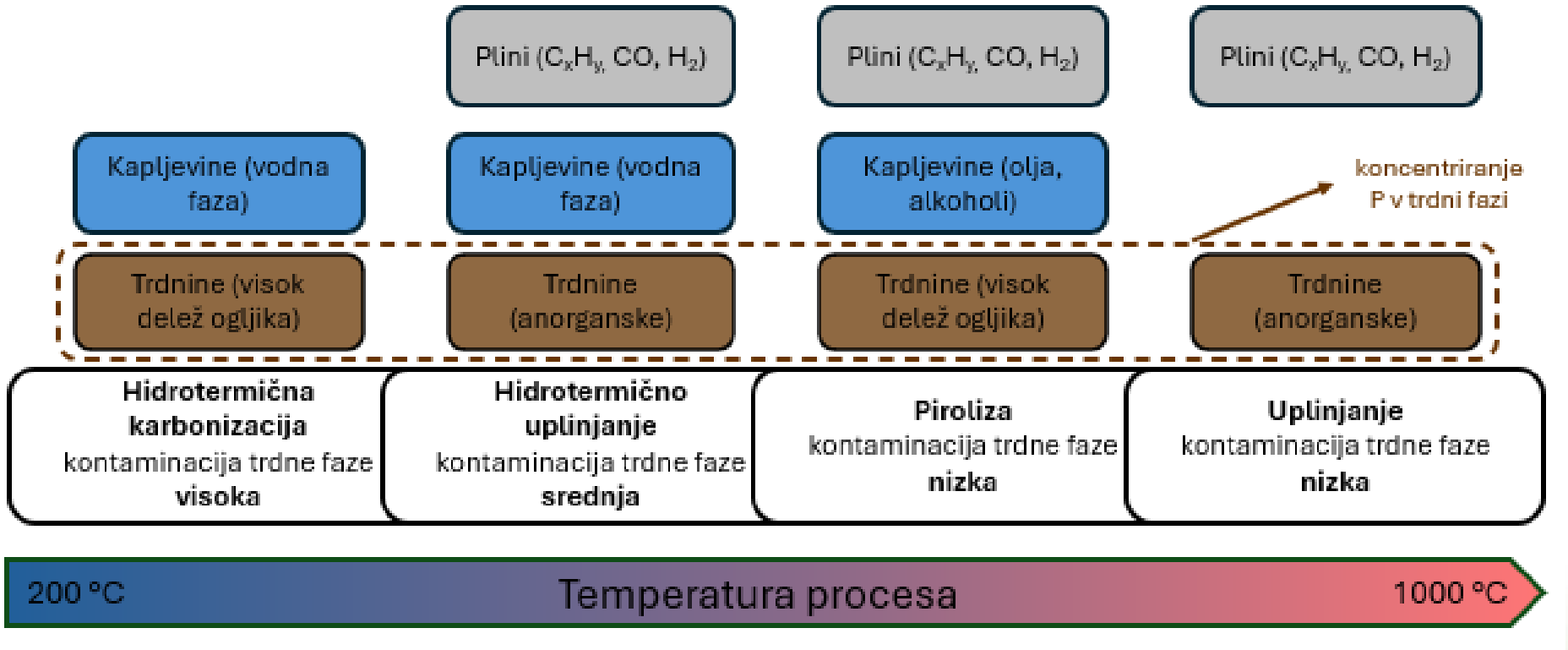
Kako do sekundarnih surovin?

- **Koncentracije fosforja se izdatno povečujejo z obdelavo odpadnih vod**
  - **Najprej zaradi odstranjevanja vode**
  - **Nato zaradi odstranjevanja organske snovi**
  - **PolyP (fosfor vezan v organske snovi) predstavlja manjši delež**



Kako do sekundarnih surovin?

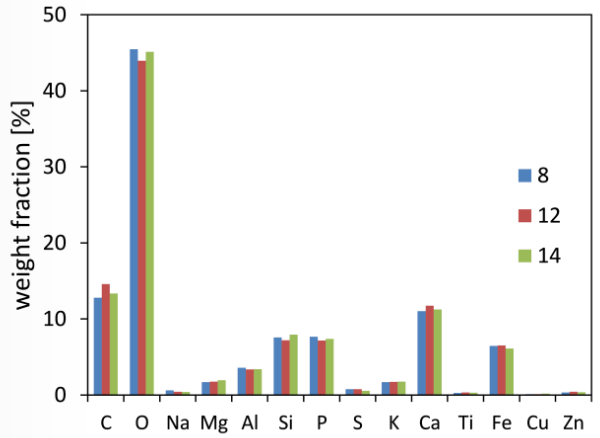
- **Pristopi za delno ali izdatno zmanjševanje vsebnosti organske snovi**
- **Sočasno poteka tudi dekontaminacija – odvisna predvsem od temperaturnega nivoja procesa**



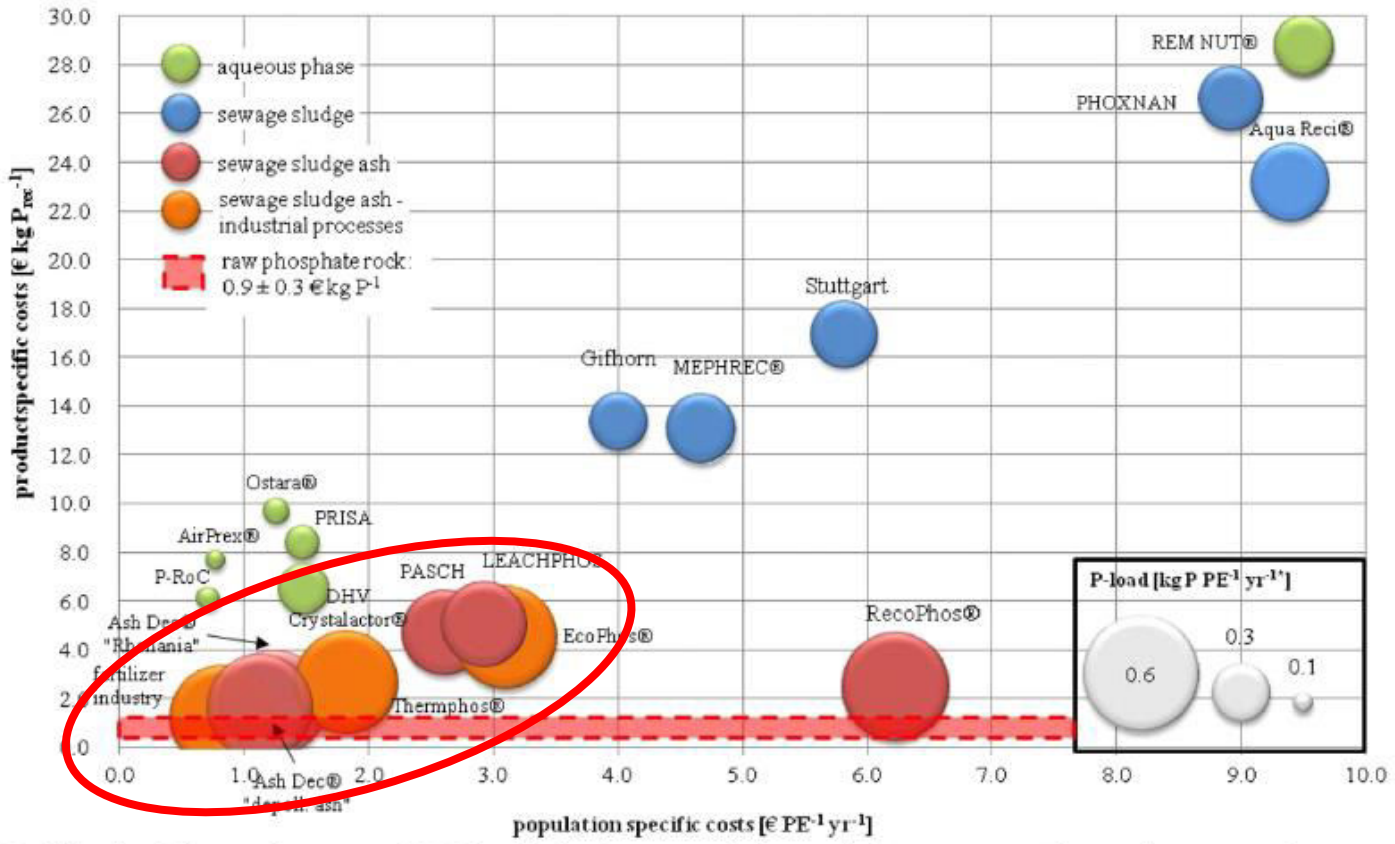
Snovna raba – možne poti

- **Zakaj visoke koncentracije?**

Ostanek po zgorevanju muljev vsebuje 5-11% Fosforja…



… kar je primerljivo z nizko do srednjekvalitetno fosfatno rudo.



* Bubble size indicates the recoverable P load in kg P per population equivalent per year. The maximum annual recoverable load of P is 0.66 kg PE^{-1} yr^{-1} or 65,700 kg (reference WWTP).

Phosphorus recovery from municipal wastewater: An integrated comparative technological, environmental and economic assessment 2016

Snovna raba – možne poti

AbfKlärVO - 2018 (DE)

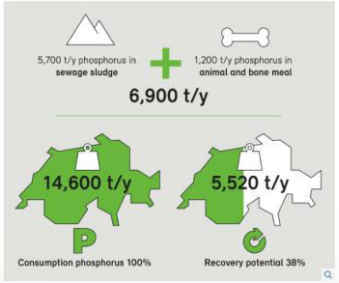
- Uvedba obveznega prestrezanja P ob koncentracijah >20g/kg suhe snovi mulja za enote >50.000 PE
- **Minimalna zahtevana učinovitost prestrezanja = 50%**

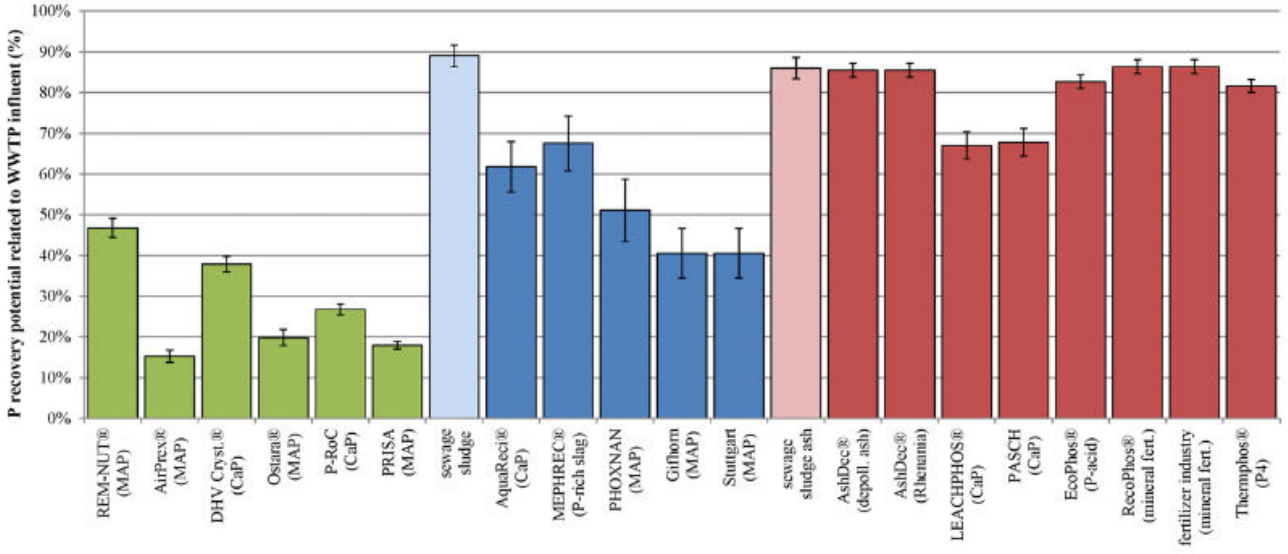
Abfallverbrennungsverordnung - 2024 (AT)

- Uvedba obveznega prestrezanja z učinkovitostjo vsaj 60% oz **80%** (po monosežigu) za naprave z >20 000 PE. do leta 2033

VeVA – 2016 (CH)

- **Obvezno prestrezanje**
- **Prehodno obdobje 10 let**



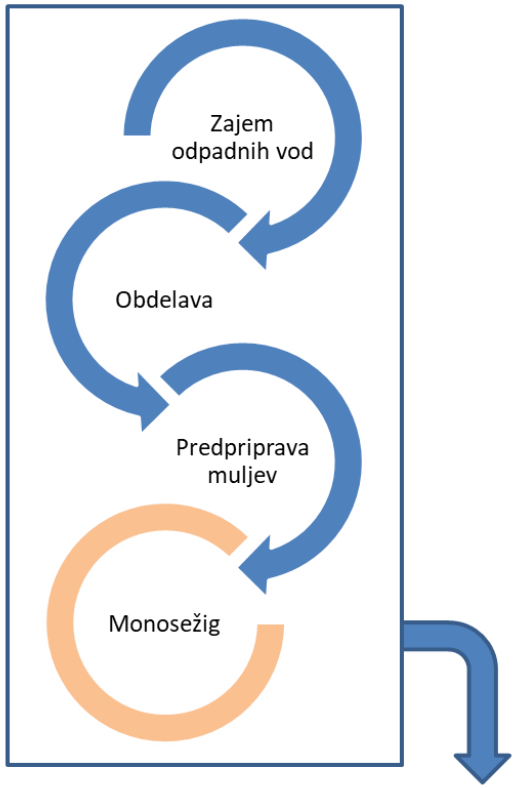


Kar lahko dosežejo skoraj izključno postopki prestrezanja iz pepela muljev.

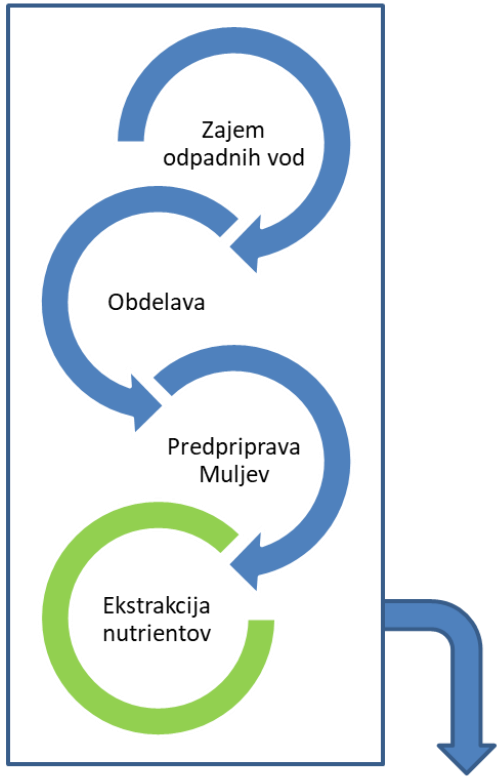
Phosphorus recovery from municipal wastewater: An integrated comparative technological, environmental and economic assessment 2016

Snovna raba – dejanske prioritete

Termična obdelava – Energetska ali snovna raba?



Stranski produkti:
- Ostanek po zgorevanju
- Produkti naknadne obdelave plinov



Stranski produkti:
- Toplota za sušenje
- Produkti naknadne obdelave plinov

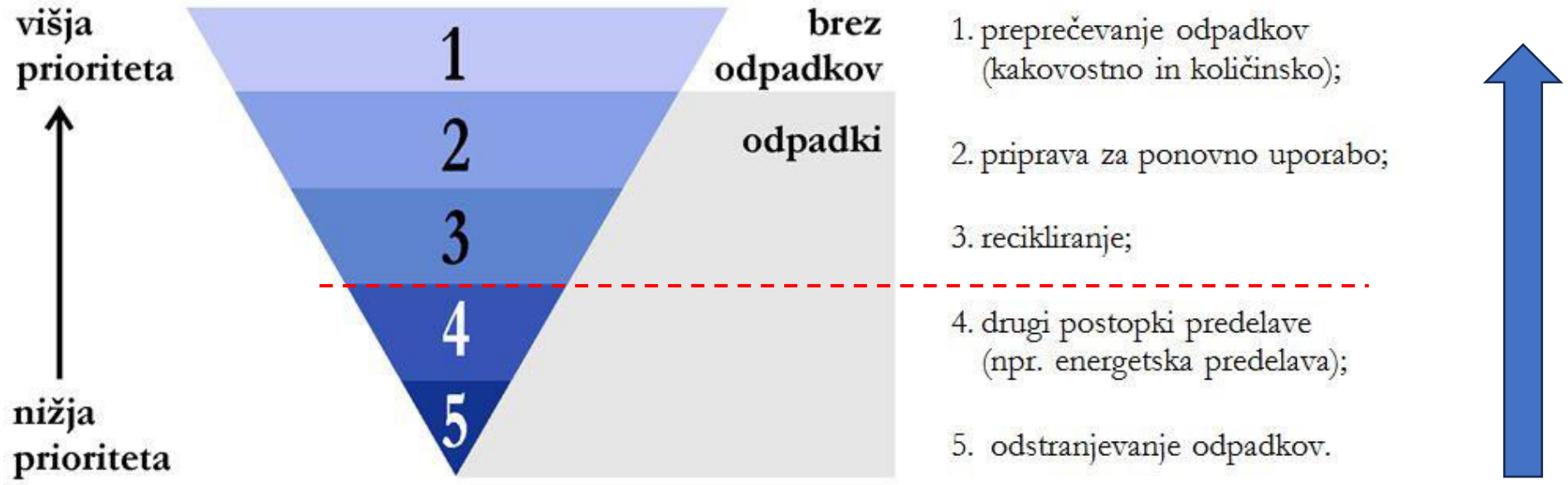
Snovna raba – dejanske prioritete

Zakaj visoke koncentracije, zakaj termična obdelava?

vstopni material	vodna faza	blato	pepel
izkoristek [kgP / PE / leto]	0,1 – 0,3	0,4 – 0,6	0,6 – 0,9
strošek [EUR / kgP]	6 – 10	12 - 28	2 – 6
stranski produkti	odpadna voda z organsko snovjo, mikrokontaminanti in patogeni	odpadna voda z organsko snovjo, mikrokontaminanti in patogeni	kisle raztopine anorganskih kontaminantov (pol-volatilne kovine)

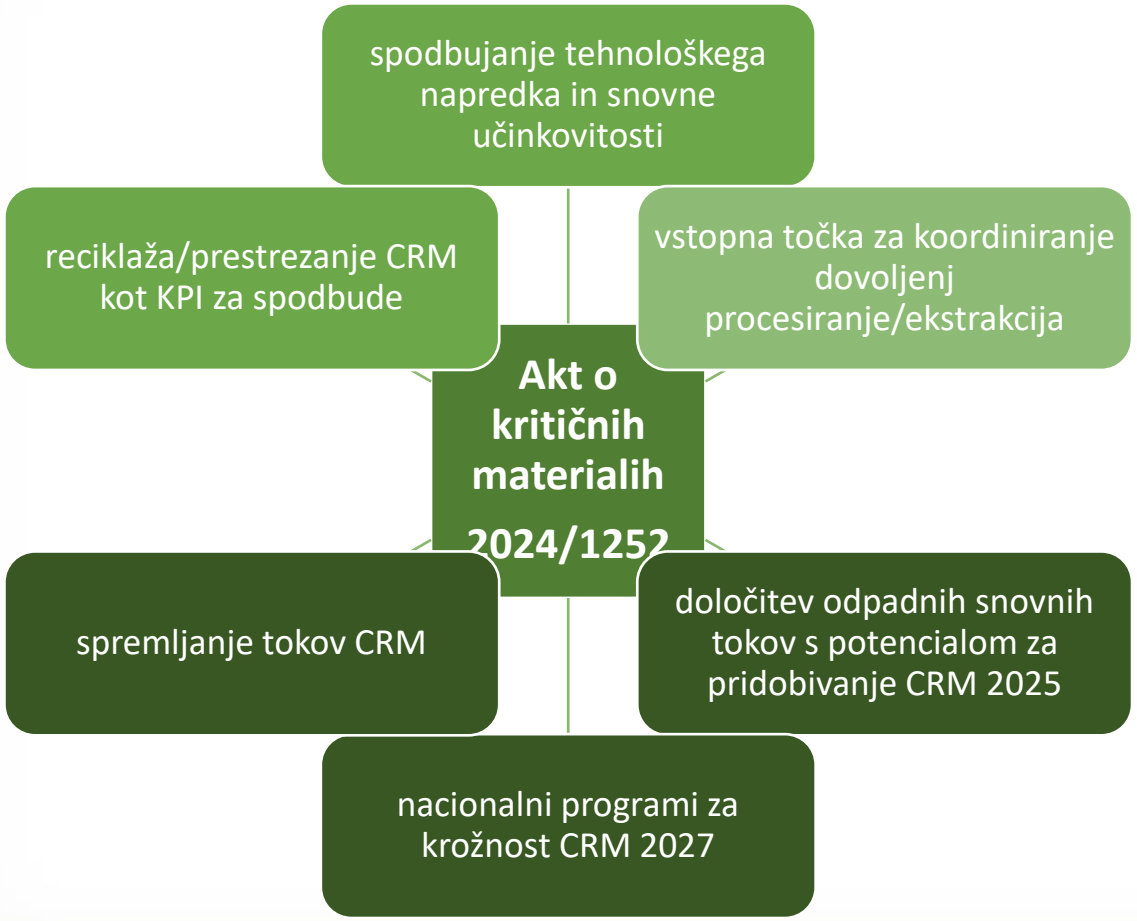
Snovna raba – dejanske prioritete

Termična obdelava ali namenski pred-postopek za ekstrakcijo?



Akt o kritičnih materialih 2024/1252

- 5.2: “incentivise technological progress and resource efficiency” of CRMs,
- 9: Member States must establish “Points of Single Contact” to facilitate and coordinate permitting of installations for **“extraction, processing or recycling” of CRMs**,
- 19: national exploration programmes for CRM resources,
- 24: Each Member State shall, by two years from the date of entry into force of the implementing act (2027) adopt and implement, or include in, national programmes containing measures designed to: ... *essentially CRM recovery*
- 24: By 24 May 2025, the Commission shall adopt implementing acts specifying a list of products, components and **waste streams that shall at least be considered as having a relevant critical raw materials recovery potential**
- 20: EU monitoring of CRM trade flows and obstacles to trade, demand, supply and supply concentration, production, bottlenecks, price volatility. This monitoring information (aggregated) will be made publicly available,
- 21: identification and monitoring of key CRM value chain operators,
- 26.1: (within 2 years) **national programmes for circularity of CRMs, including incentivising resource and materials efficiency, “collection, sorting and processing of waste with high critical raw materials recovery potential** …” and “increase the use of secondary critical raw materials including through measures such as taking recycled content into account in award criteria related to public procurement or financial incentives for the use of secondary critical raw materials”, ...



Prepoznamo priložnosti?