Phosphorus re-use and recycling in the EU: A techno-scientific assessment

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Workshop: La gestione circolare del fosforo

11th March 2026

European Commission

Article 20 of the Directive

"The Commission is empowered to adopt delegated acts in accordance with the procedure referred to in Article 27 to supplement this Directive by specifying a combined minimum reuse and recycling rate for phosphorus from sludge and from urban wastewater not reused under the derogation of Article 15(1), taking into account available technologies, resources and the economic viability of phosphorus recovery as well as the phosphorus content of the sludge and the level of saturation of the national market with organic phosphorus from other sources while ensuring that there is safe sludge management and no adverse impact on the environment or human health. The Commission shall adopt those delegated acts by 2 January 2028."

Recital (42): "contribute to the strategic autonomy of the Union fertiliser industry"

The Joint Research Centre

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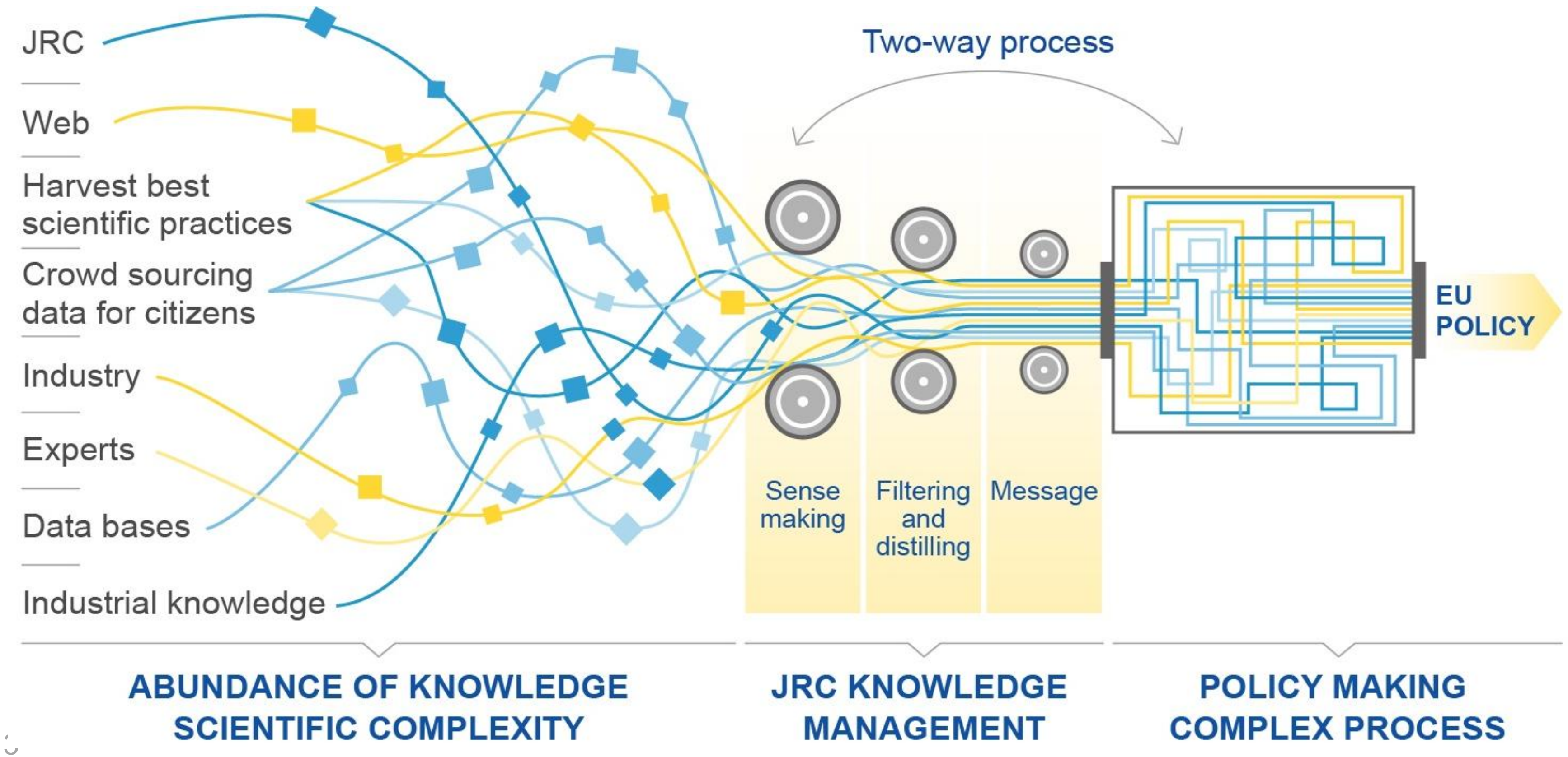
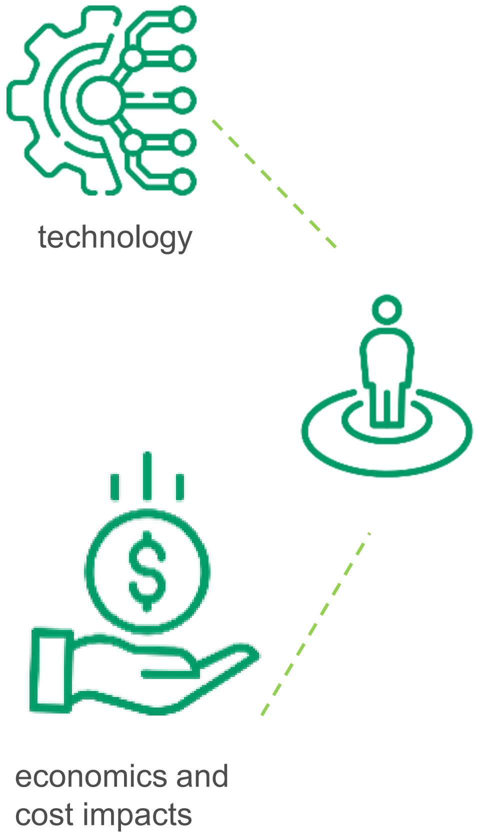


JRC tasks and timeline



- Overview of the existing and future phosphorus recovery techniques
- Current and future estimations of management routes in different geographic regions of the EU (e.g. landspreading shares, capacities for mono-incineration, regulations on mandatory P-recycling)
- **Delivered: Q3 2025**

- Collection of information on market viability of recovered phosphorus and integration of waste hierarchy
- Based on cost assessment of management routes (life cycle perspective)
- Scenario analysis when moving up management routes up in the waste hierarchy
- **Tentative timeline: Q2 2026**

JRC tasks and timeline

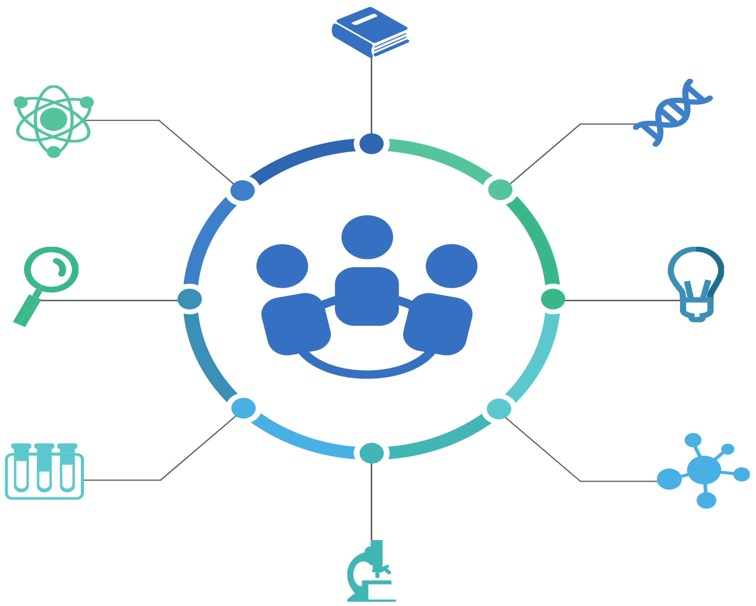
safety

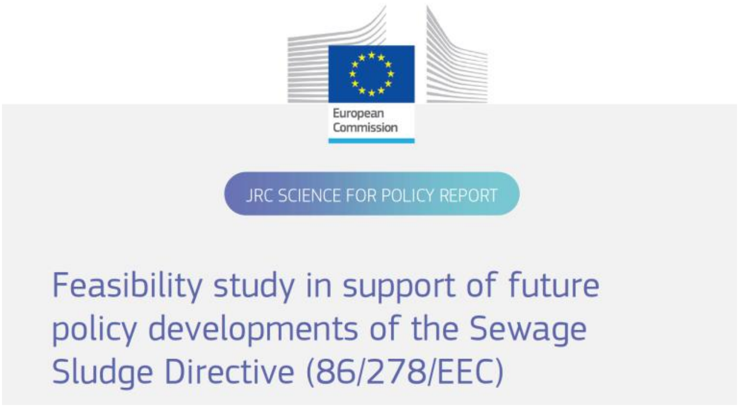
- Development of risk assessment methods
- More thorough assessment for selected priority contaminants
- Risk mitigation measures
- **Tentative timeline: Q4 2026**

integration of results

- Integrate knowledge and evidence collected to develop policy options
- Provide technical recommendations for delegated act
- **Tentative timeline: Q2 2027**

Building on stakeholder consultations and science

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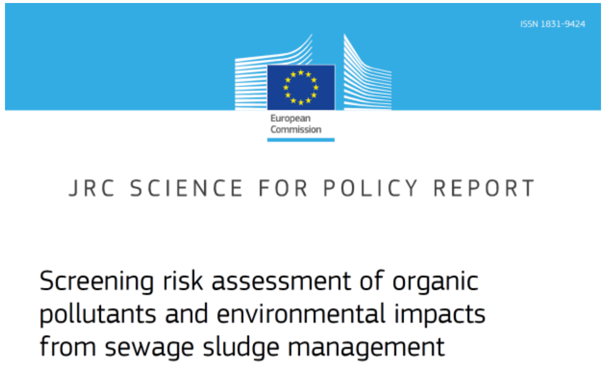
JRC SCIENCE FOR POLICY REPORT

Feasibility study in support of future policy developments of the Sewage Sludge Directive (86/278/EEC)


ISSN 1831-9424

European Commission

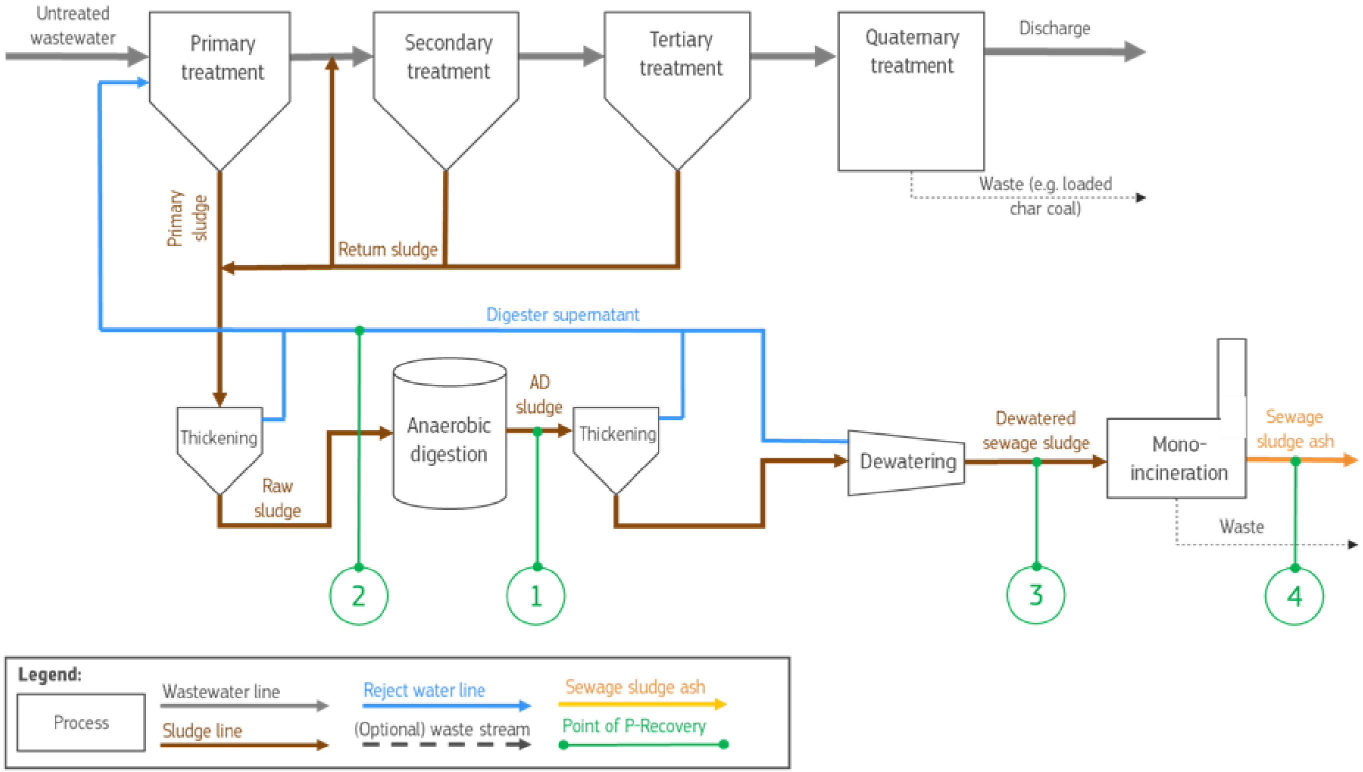
JRC SCIENCE FOR POLICY REPORT

Screening risk assessment of organic pollutants and environmental impacts from sewage sludge management

- Stakeholders will be consulted in written and oral form through the project
- The JRC will depart from preliminary evidence and suggested ways forward in previous Science for Policy reports, complemented with new scientific findings

Overview on the various streams in a wastewater treatment plant and possible access points for technical P-recovery

- Recover dissolved phosphorus within a WWTP (1, 2);
- Recover P that is bound in sewage sludge (2);
- Recover P from sewage sludge ash (SSA) after mono-incineration (4)



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Technology overview on P recovery technologies

Three tables provide overview on P-recovery technologies for the various access points and include information on:

- Objective of the recycling technology
- Targeted output material and possible application of P-outputs
- Waste output materials
- P-recycling rate (%) related to the recovery process input and related to WWTP influent
- Planned/installed recycling capacities in Europa (quantitative assessment)

Table 3. Overview on technologies recovering P from sewage sludge ash (SSA)

Approach	**Objectives**	**Targeted output material and possible application of the P output:**	**Waste output material**	**P-rec. rate (%) related to recovery process input[13]**	**P-rec. rate (%) related to WWTP influent[14]**	**(Planned) Installations in Europe, best estimate** (incl. capacities per year)
Full scale plants in operation or under permitting/construction (TRL 8-9)						
Wet-chemical leaching	Acidic wet chemical leaching by Ash2Phos/Easymining: P is leached from SSA with HCl and H_3PO_4 and as such separated from the ash. Contaminants that go into solution together with P are removed by ion-exchange, liquid-liquid separation or precipitation (Easymining, 2021). Two investments in prospect: Helsingborg (SE) (plant permit granted, investment decision made) Schkopau (DE) (plant permit granted)	RevoCaP, $FeCl_3$, $NaAlO_2$ Application(s): - raw material fertiliser production; - direct application as slow-release fertiliser (e.g. organic farming); - feed.	Sand, metal concentrate	>90%	~80%	Schkopau (DE): Plant in operation: 2027 (input: 30,000 t yr^{-1} SSA; output: 15,000 t yr^{-1} of CaP) Helsingborg (SE): Plant in operation: 2028 (input: 30,000 t yr^{-1} SSA; output: 15,000 t yr^{-1} of CaP).
	Acidic wet chemical leaching by SusPhos: P is leached from SSA with H_3SO_4. The product recovered are phosphoric acid, sulphuric acid, and salts from iron and aluminium as well as circular supplementary cementing material that can replace Portland cement in cement production. (Susphos, 2025) SusPhos partners with Slibverwerking Noord-Brabant, Europe's largest sludge incinerator, to build first-of-its-kind phosphate recycling factory.	- Phoenix Emerald (liquid mix of phosphoric and sulphuric acid, and salts from iron and aluminium); - Phoenix SSPlus, (a solid single super phosphate) Application(s): - raw material fertiliser production; - agriculture.	Sand, gypsum	80%	~70%	NL: Installation starts: 2025 Plant in operation: 2027 Planned input: 50,000 t SSA yr^{-1}; output: unknown)

Preliminary conclusion

- Technologies for recovering **dissolved phosphorus from WWTP side-streams** are currently the most frequently implemented in the EU, but the overall recover potential for P is limited. Output such as struvite are well known, but application is limited.

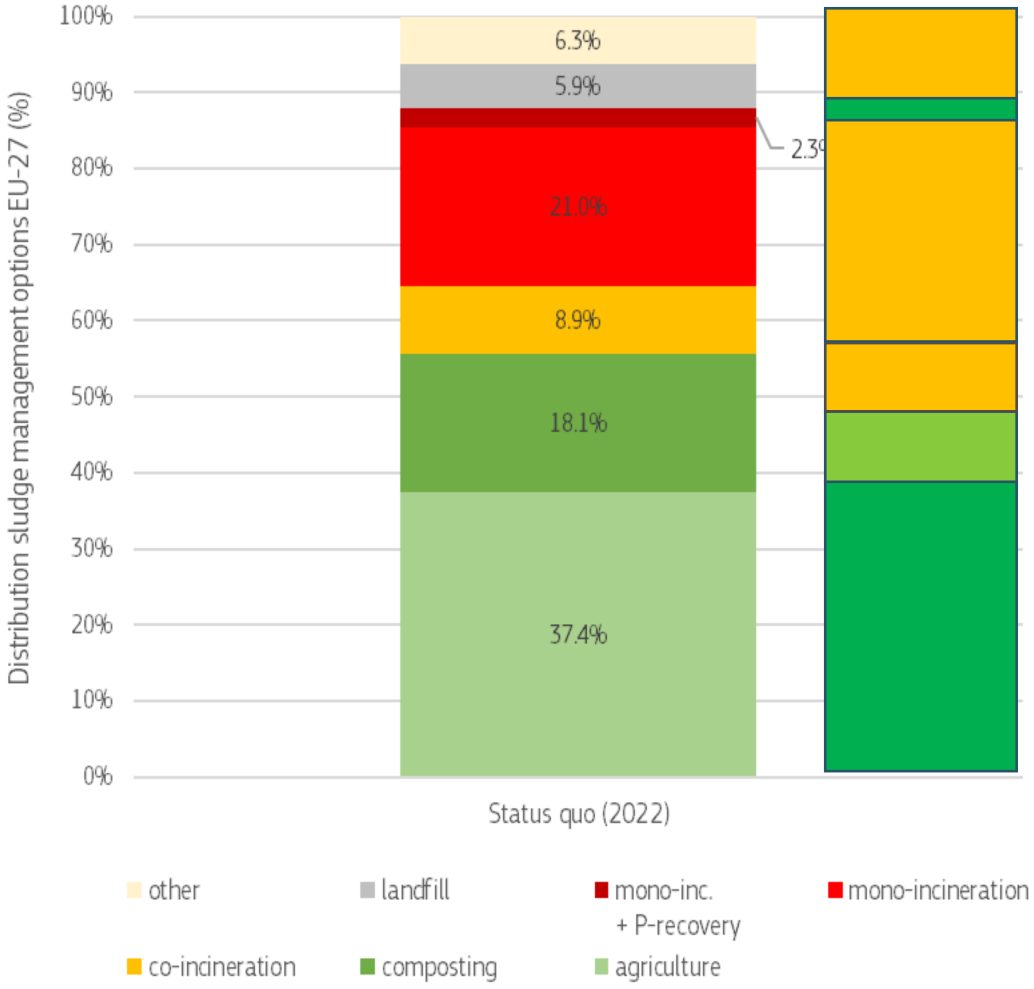
- P recycling from **sewage sludge** is hindered by several factors: High water content makes transportation costly and logistically challenging; P content and complex composition of sewage sludge render the recycling process technically complicated, requiring significant amounts of energy and resources, which ultimately drives up costs.

- P recovery from sewage sludge **mono-incineration**: Incineration increases the P content and allows the destruction of all organic compounds, SSA is inert that can be stored and even shipped over long distances to central recycling plants (economy of scale). Further advantages:
    - P output materials can serve various sectors at the same time (e.g. fertiliser sector, organic and conventional agricultural sector, animal feed sector, chemical industry);
    - Other components such as Fe, Al, or Ca can also be recovered;
    - Pollutants can be targeted extracted and removed to a large extent.

Status quo

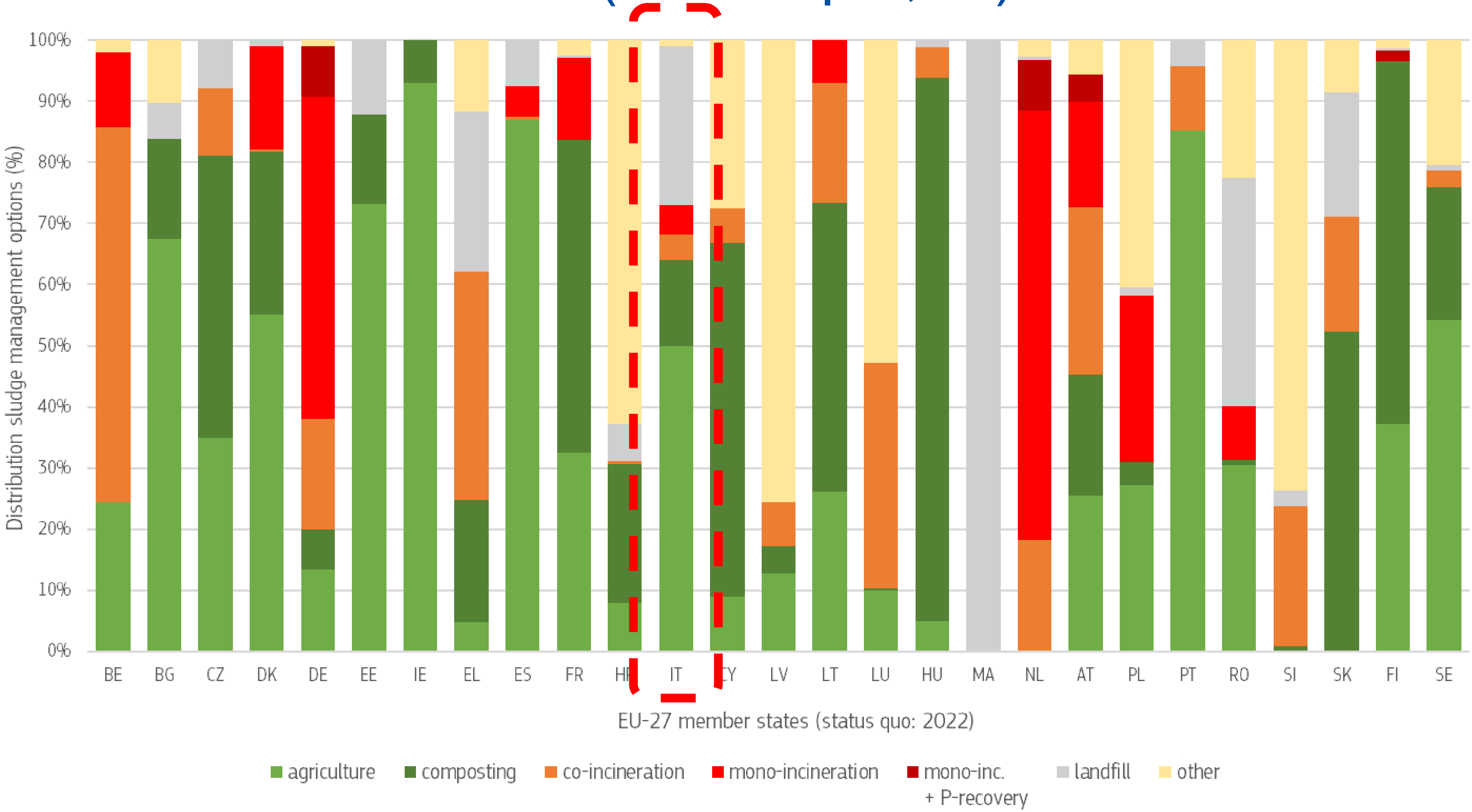
49 % circular
51 % non-circular

- **7,600 kt of sewage sludge (dry matter)** were produced in the EU-27 in 2022
- Sewage sludge contains **219 kt P**[1]
- 37% of sewage sludge is returned to the nutrient cycle through direct agricultural use
- Around 1/5 is composted, with unclear final use of the produced compost
- ~30 % of sewage sludge is incinerated and mono-incineration is already the dominating incineration approach.
- Mono-incineration is dominated mainly by four Member States (DE, FR, NL and PL).

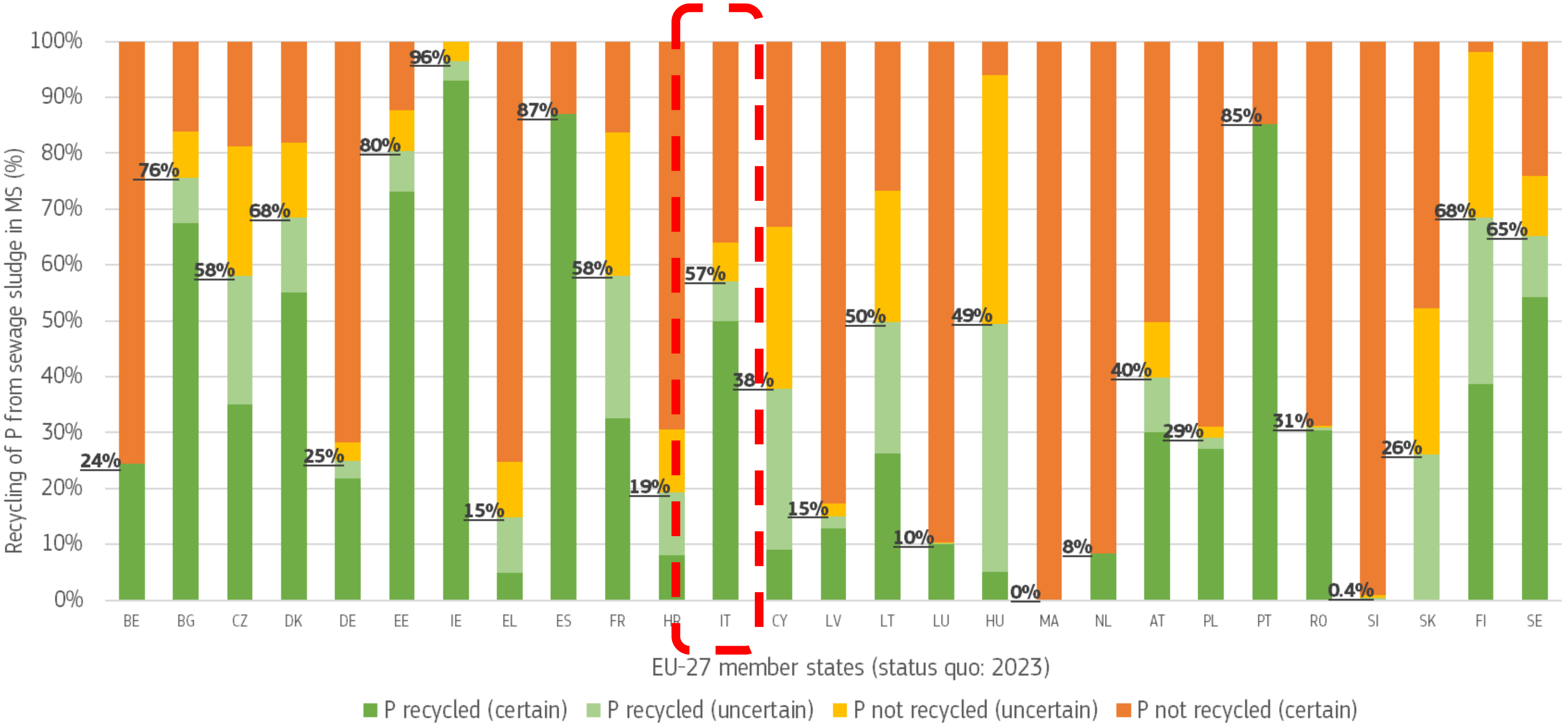


[1]P load calculated for EU 27 by (van Dijk et al., 2016): 233 kt P yr^{-1}

Estimated distribution of sewage sludge management for each Member State (status quo; %)



Translation into estimated current recycling rate (%)



Recycling rate - status quo

- Inhomogeneous situation in Europe
- Recycling rate reach from 0 % to 96 %
- Member States with preference for agricultural sewage sludge spreading reach already high recycling rates (≥70 %)
- In many cases very high uncertainty due to unclear path of composted sludge (one Member State up to 90 % composting).
- Member States with recently low recycling rate set already strategies or even national legal frameworks[1] to achieve high P recycling apart from direct agricultural sludge use.

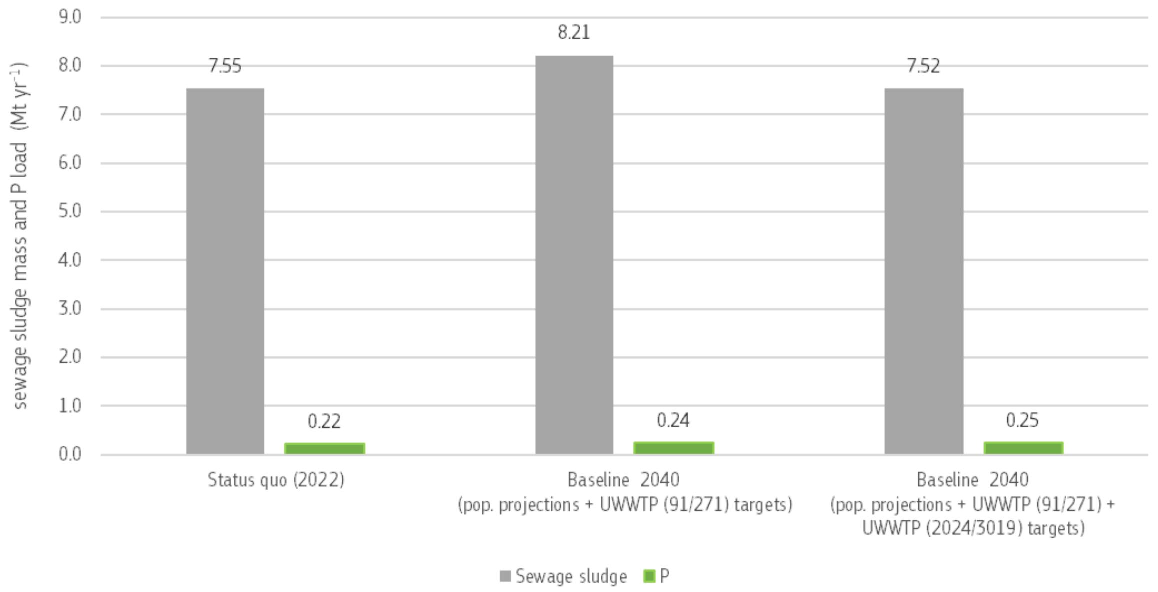
[1]See overview on national legal frameworks on nutrient recovery (Annex 3)

Baseline (2040)

- Slight decline of sewage sludge production from **7,55 to 7,52 Mt yr^{-1}**: expected increased sludge production due to compliance with UWWTD (EU 91/271) and targets of revised UWWTD (EU 2024/3019) is compensated by additional implementation of anaerobic digestion (goal for WWTP energy neutrality)

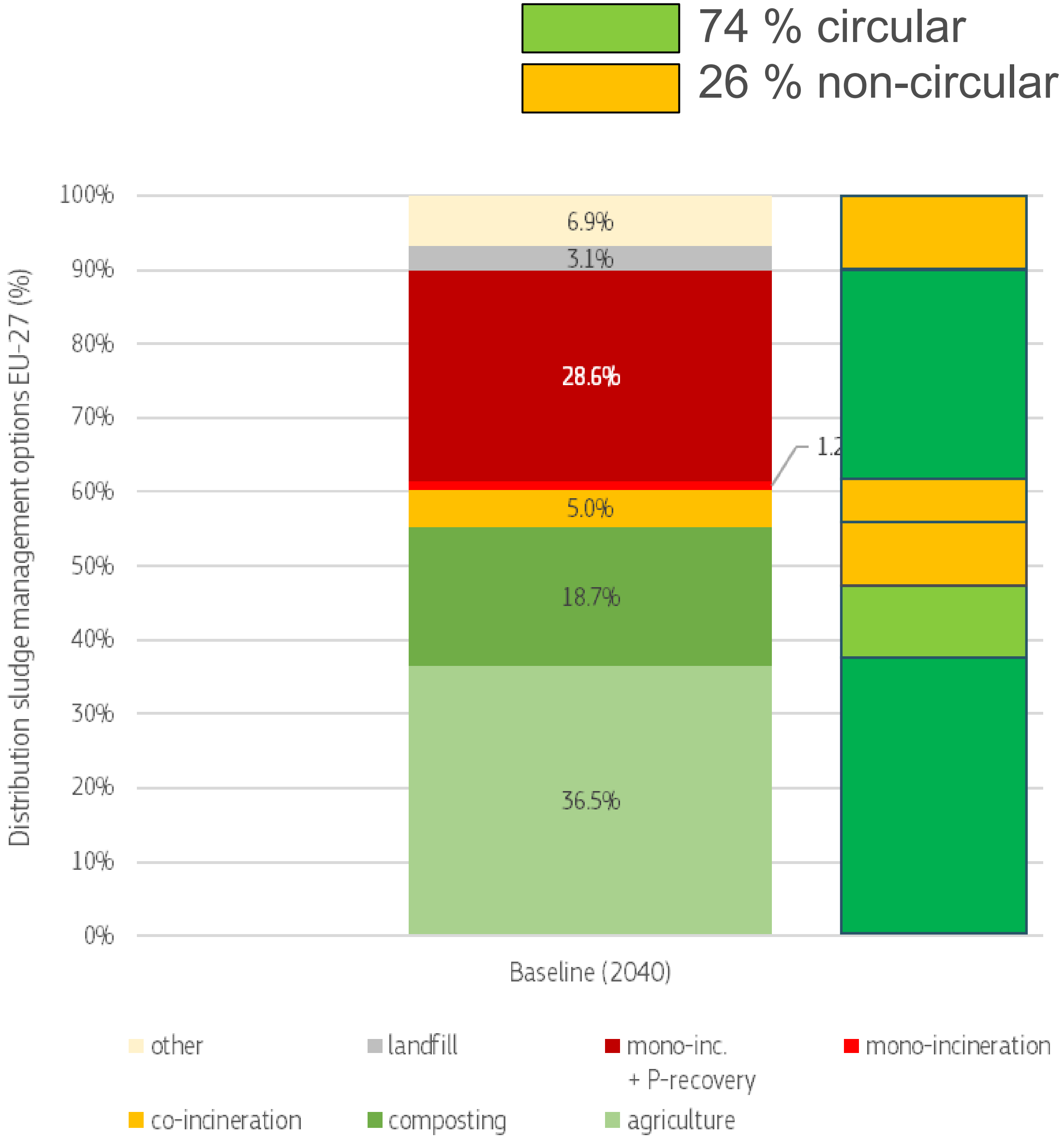
- Slight increase on P in sewage sludge from **0.22 to 0.25 Mt yr^{-1}** due to stricter effluent limit values (revised UWWTD (EU 2024/3019))

- Only slight increase for P in sewage sludge is the result that certain MS already achieve or even overperform P removal targets.

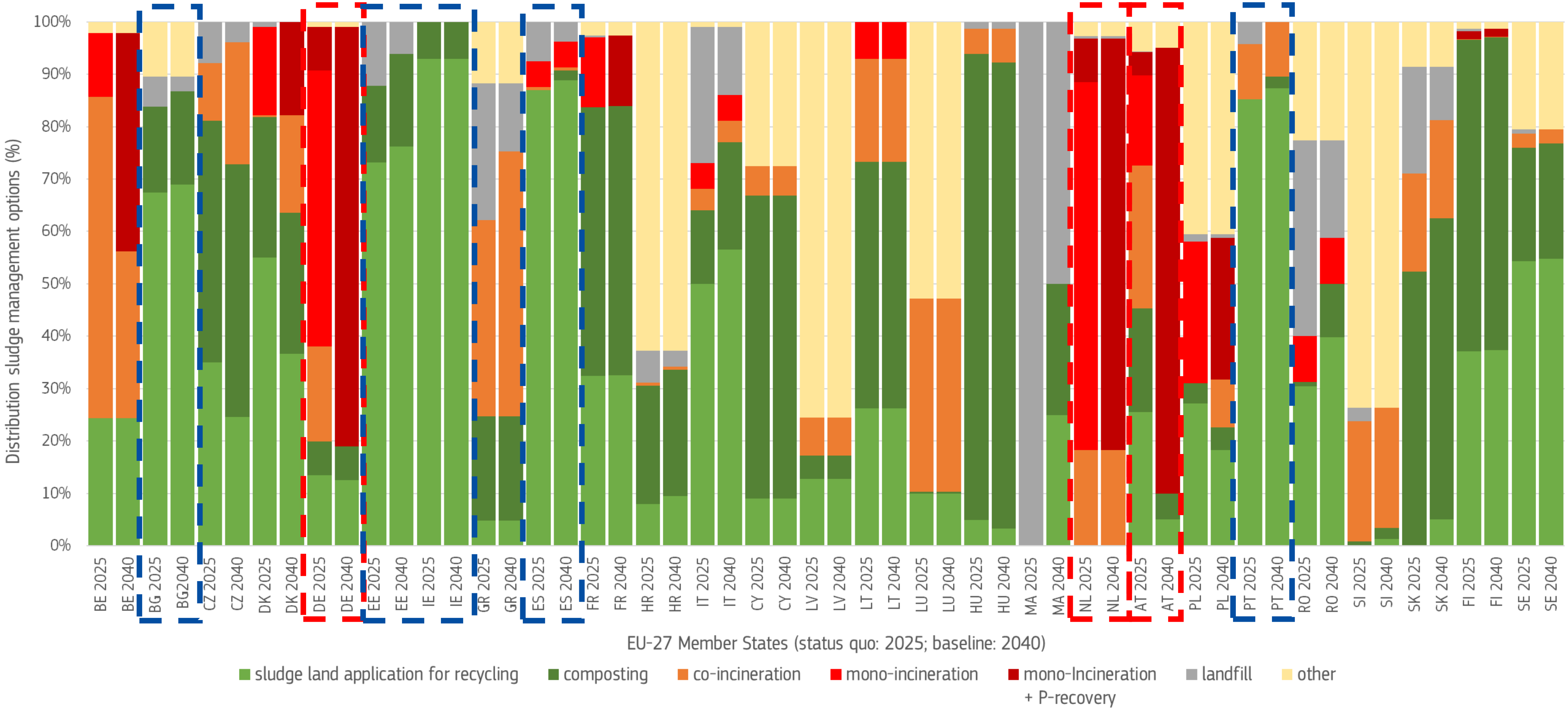


Baseline

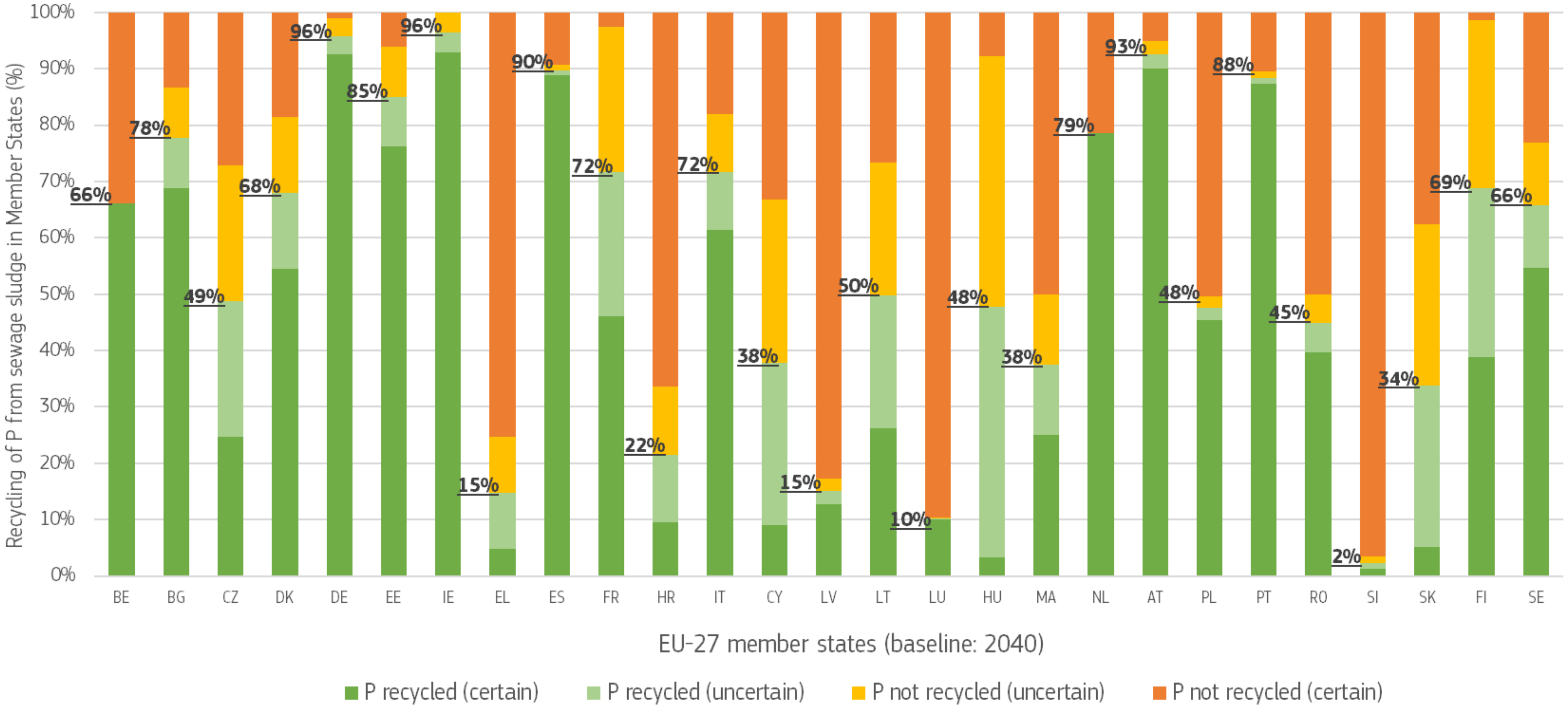
- Agriculture use and composting are expected to be constant.
- The increased P circularity is solely attributable to the (mandatory) implementation of recycling targets in Member States.
- The future scenario is considered to have high uncertainties and the data presented for the EU and individual Member States represents the best possible estimate.
- JRC welcomes data to further refine and reduce uncertainty.



Estimated distribution of sewage sludge management for each Member State (status quo vs. baseline; %)



Translation into estimated baseline recycling rate (%)



Challenge JRC assumptions and fill knowledge gaps in particular for Italy

technology

- Total amount of sludge generated and use, treatment and disposal routes (e.g. agriculture, compost, incineration, landfill, other)
- Sludge treatment and disposal
  - Detailed insight into ***'other'*** and what is the final fate of sludge classified as ***'other'***
  - How is ***'composted sludge'*** or 'compost containing sludge' used (e.g. to agriculture, to landscaping, landfill cover)? → circular P-use: YES/NO affects the current recycling rate
  - Incineration: Planned expansion of mono-incineration capacities
  - Planned P-recycling strategies in Member States
  - Cost for the various sludge management options (in €/t DM)

Concluding slide

- Study has been launched and current focus economic assessment and risk assessment
- Continue close interactions with stakeholders
- Supplementary databases or reference scientific works of interest can be shared with JRC at JRC-P-CIRC@ec.europa.eu

Thank you
and keep in touch

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Mono-incineration capacity Italy

IT	Bologna	6,250
	Milan	14,950
	Prato	7,360
	Pustertal	5,681
	Sum	34,241