

Silicate sand

Cirkulær økonomi –
Værdiskabende
genanvendelse af
spildevandsslam

Dansk Betondag – 23. september 2021
Anita Rye Ottosen fra Rambøll
Yariv Cohen fra Easy Mining

RAMBØLL

Bright ideas.
Sustainable change.

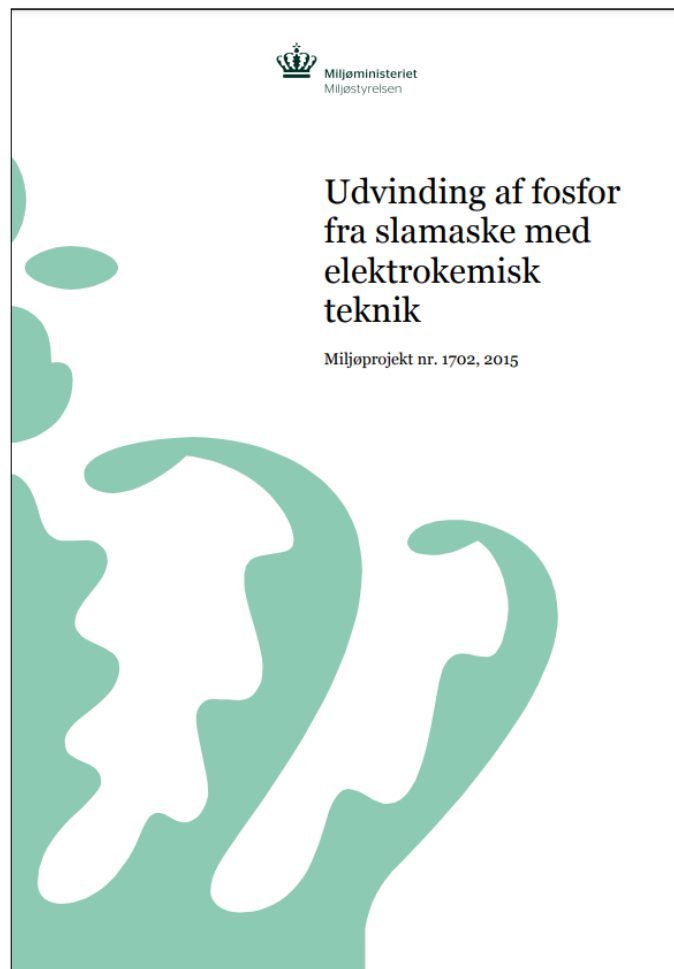
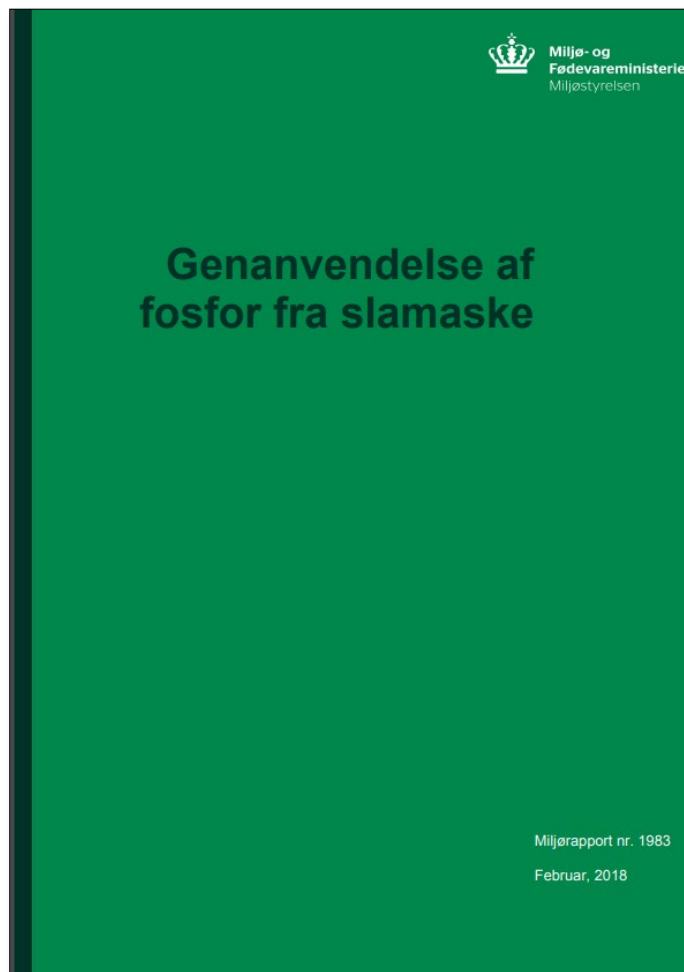
EasyMining

Silicate sand



- Fosforenanvendelse – Yariv
- Silicate sand som betonerstatning - Anita

Fra 2008 til 2018



Fra 2019 til 2021 – Silicate sand project

BIOFOS: Producerer slamaske

Easy Mining: Udvinder fosfor og vasker askerest (silicate sand)

DTU-byg: Laver test med brug af silicate sand som cement og sand erstatning i beton

Rambøll: Projektledelse og markedsanalyse

Finansiering: Ragn-Sell, Rambøll Fonden, Vargas projektet samt egenfinansiering hos Easy Mining og Rambøll

About EasyMining

35
Employees

2007
Year of foundation

**Uppsala, Gothenburg and
Berlin**
Sites

Fully owned by Ragn-Sells Group since 2014



PATENTED PROCESSES

EasyMining
commercializes
patented chemical
processes

ASH2PHOS

Phosphorus extraction
from sewage sludge
ash

ASH2SALT

Salt extraction
from fly ash

CLEANMAP

Energy efficient
production of
ammonium phosphate

PROJECT NITROGEN

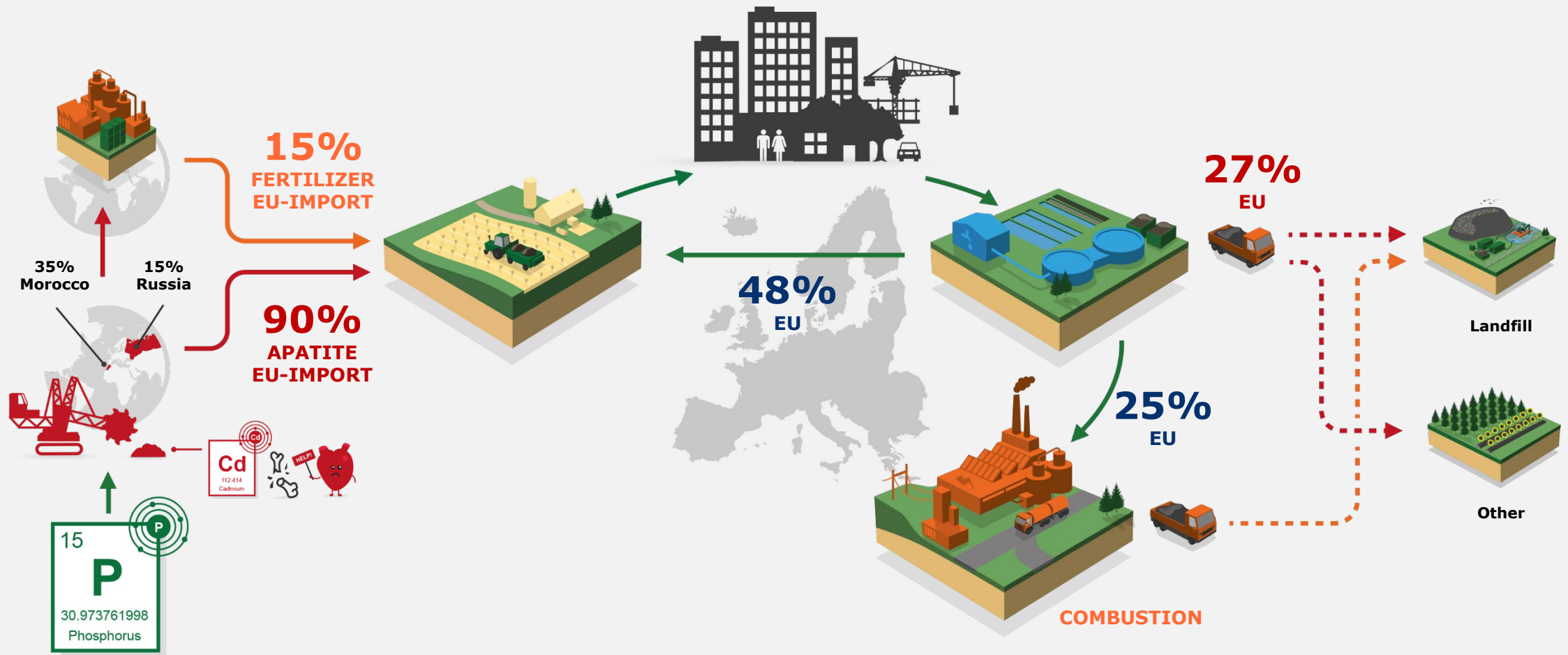
Recovery of nitrogen
from liquid waste
streams





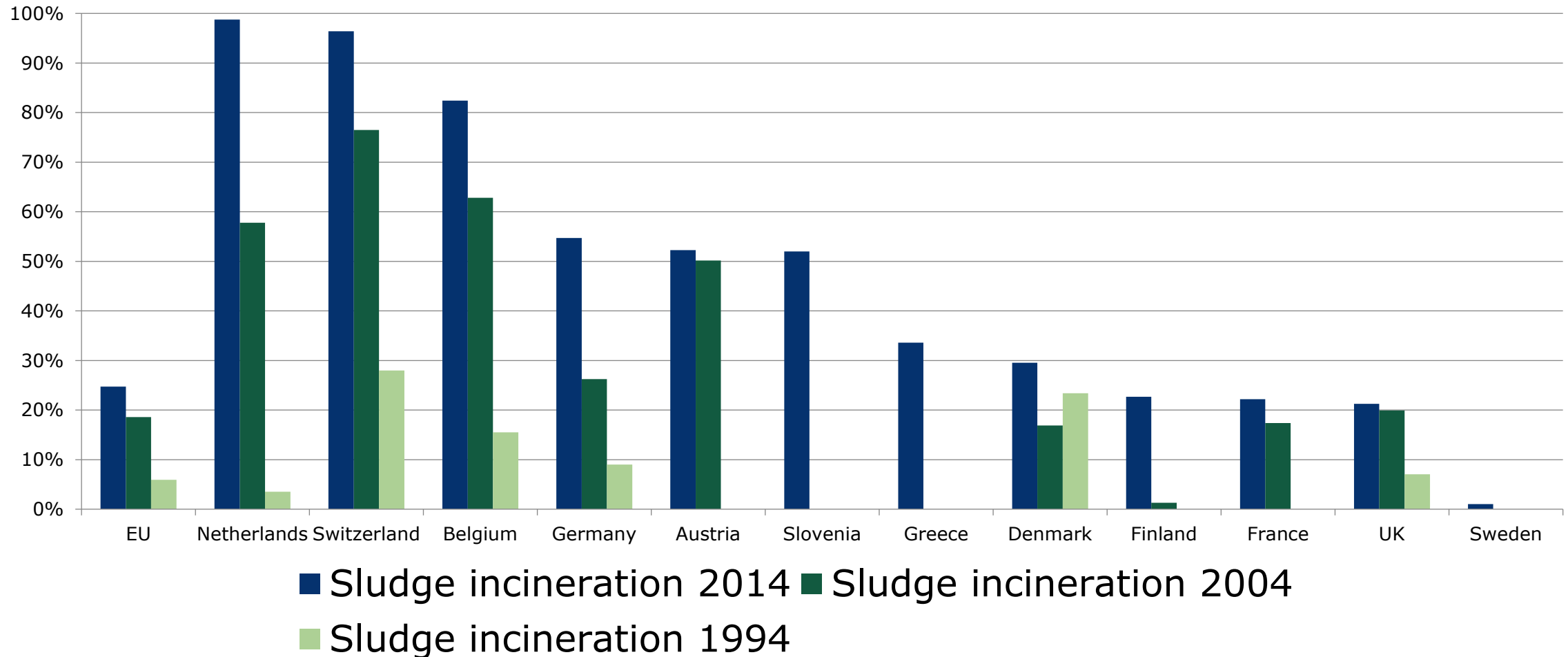
ASH2 © PHOS

From sewage sludge to clean phosphorus products



Background / Current solution in Europe:
Phosphorus recovery from sludge ash.

Sludge ash - Countries share of sludge combustion 1994 - 2014



Mandatory phosphorus recovery

German sludge and P-recovery ordinance moves forward

On 18th January, the new German new sewage sludge ordinance (AbfklärV), which will make phosphorus recovery obligatory for most of Germany's sewage, was **validated** by the German Cabinet (see ESPP eNews n°6). It is now expected to pass the parliament and Federal Council before summer 2017 and enter into force in January 2018, making phosphorus recovery obligatory for larger sewage works within 12 years (> 100 000 p.e.) or 15 years (> 50 000 p.e.), under certain conditions. P-recovery will thus be required for around 500 sewage works (out of a total of 9 300 in Germany), treating around 2/3 of German sewage. At present, around 26% of German sewage sludge is spread on arable

Switzerland banned direct use of sewage sludge on land in 2006, so the regulation will be
Since the first of January phosphorus recovery and recycling from sewage sludge and slaughterhouse waste is obligatory in Switzerland. The new regulation is introduced with a transition period of ten years. Switzerland claims to be globally the first country to oblige resource recovery.

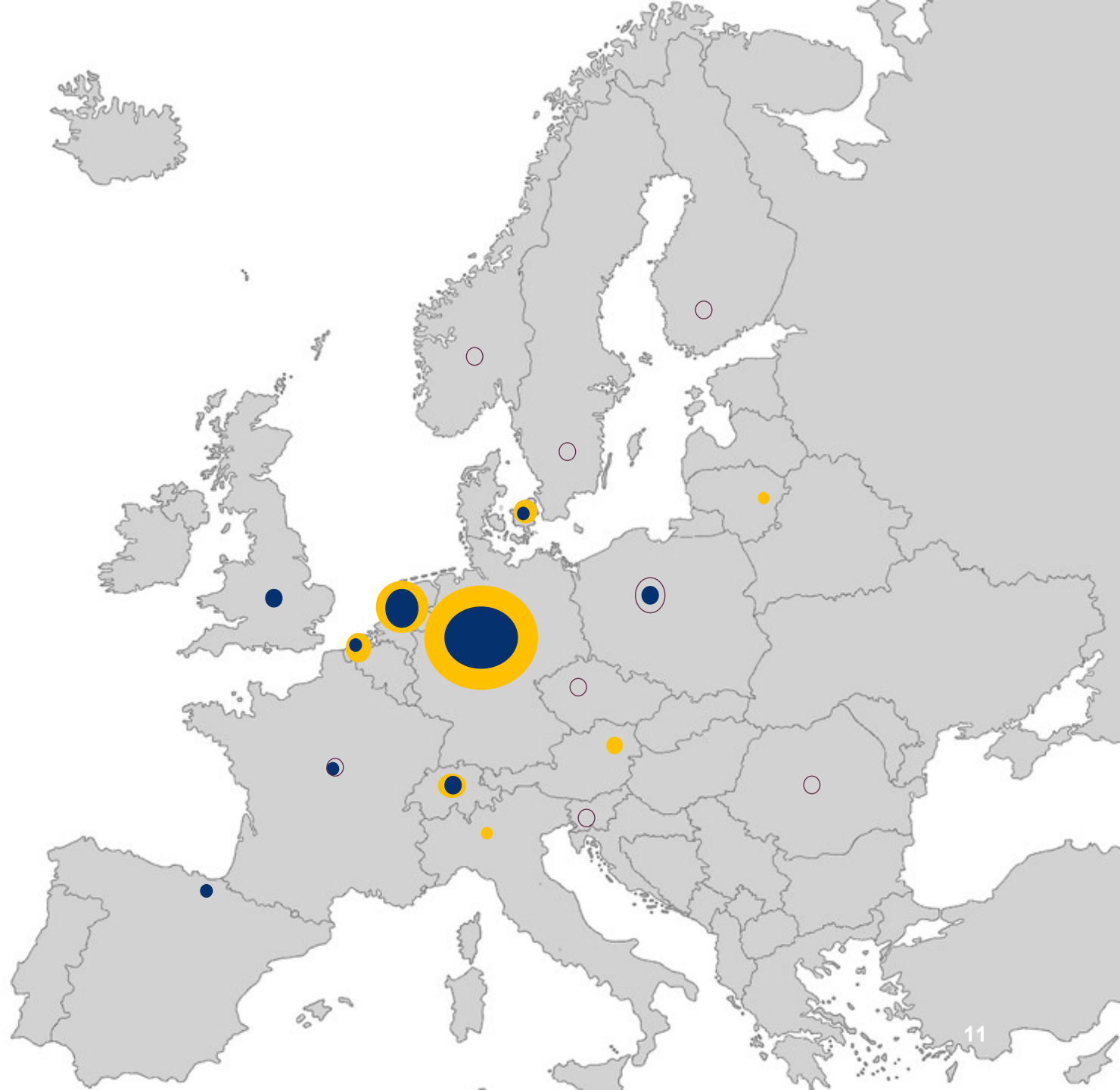
Austria opts for mandatory phosphorus recovery from sewage sludge

Following the legislative developments in Switzerland and Germany, Austria is now also opting for mandatory P recovery from municipal sewage sludge.

Switzerland is the first country making phosphorus recovery from sludge and meat and bone-meal obligatory and Germany is set to follow in passing legislation. The necessary investment volume for the Swiss transition has been estimated in the range between 100 and 400 MEUR the next ten years.

European SSA hotspots today and tomorrow

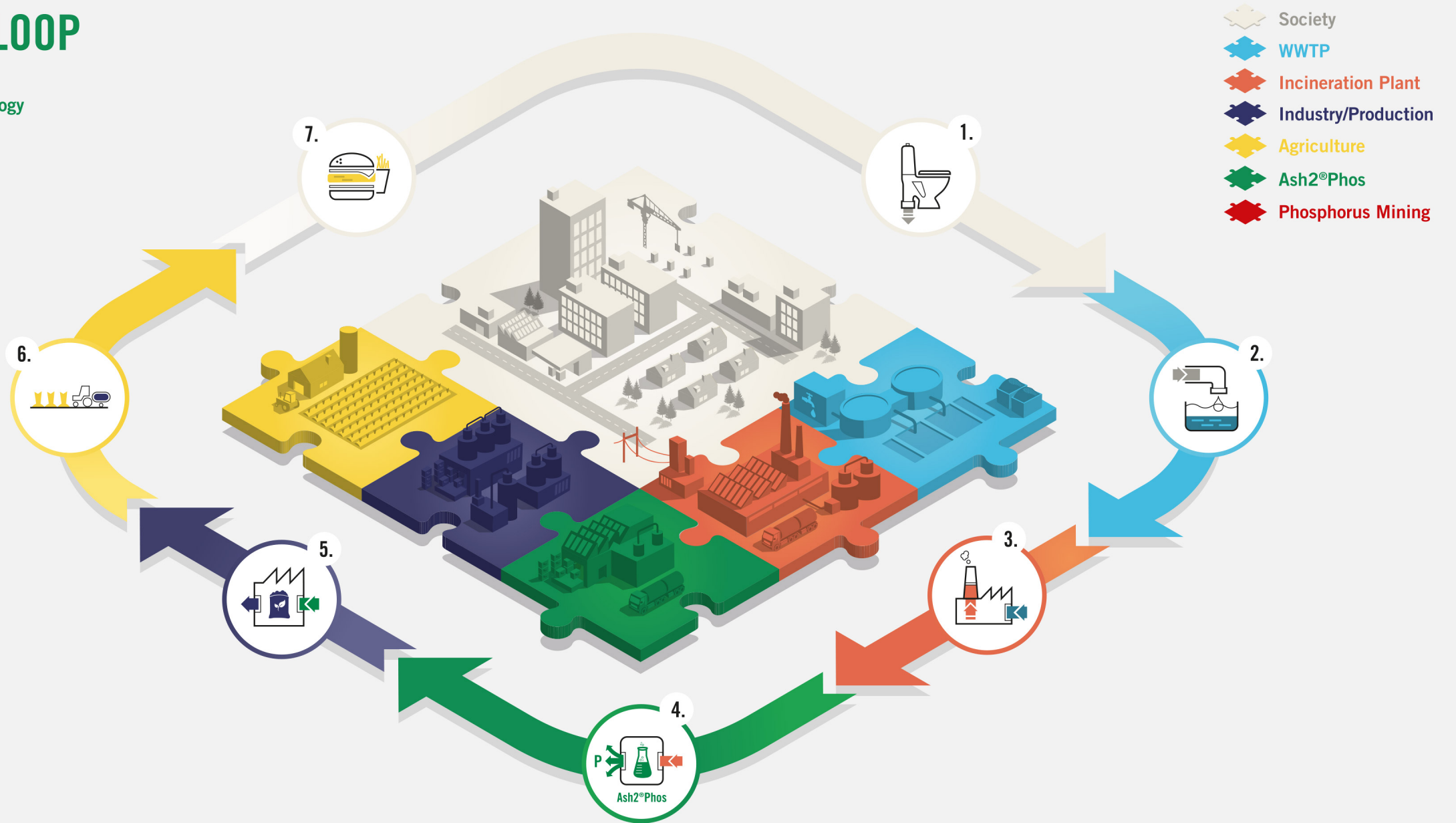
Country	total	Mono-inc. T DS		Ash qty in t	
	sludge DS	2017	2030+	2017	2030+
AT	270000		65000		30000
BE (FL)	90000	28000	60000	14000	30000
CH	200000	110000	170000	50000	80000
CZ	260000		100000		50000
DE	1710000	668000	1400000	300000	700000
DK	132000	34000	40000	15000	20000
ES	2600000	Bilbao		10000	10000
FI	160000		80000		40000
FR	870000	Paris		9000	20000
IT	950000		16000		6000
LT	18000		2500		1000
NL	320000	178000	250000	57000	80000
NO	130000		65000		30000
PL	540000	60000	80000	27000	40000
RO	170000				
SE	200000		100000		50000
SL	28000				
UK	108000			20000	20000
Total:	8756000	1078000	2428500	502000	1207000



- Sludge ashes produced today
- New volumes produced by 2030
- Maybe new volumes produced by 2030

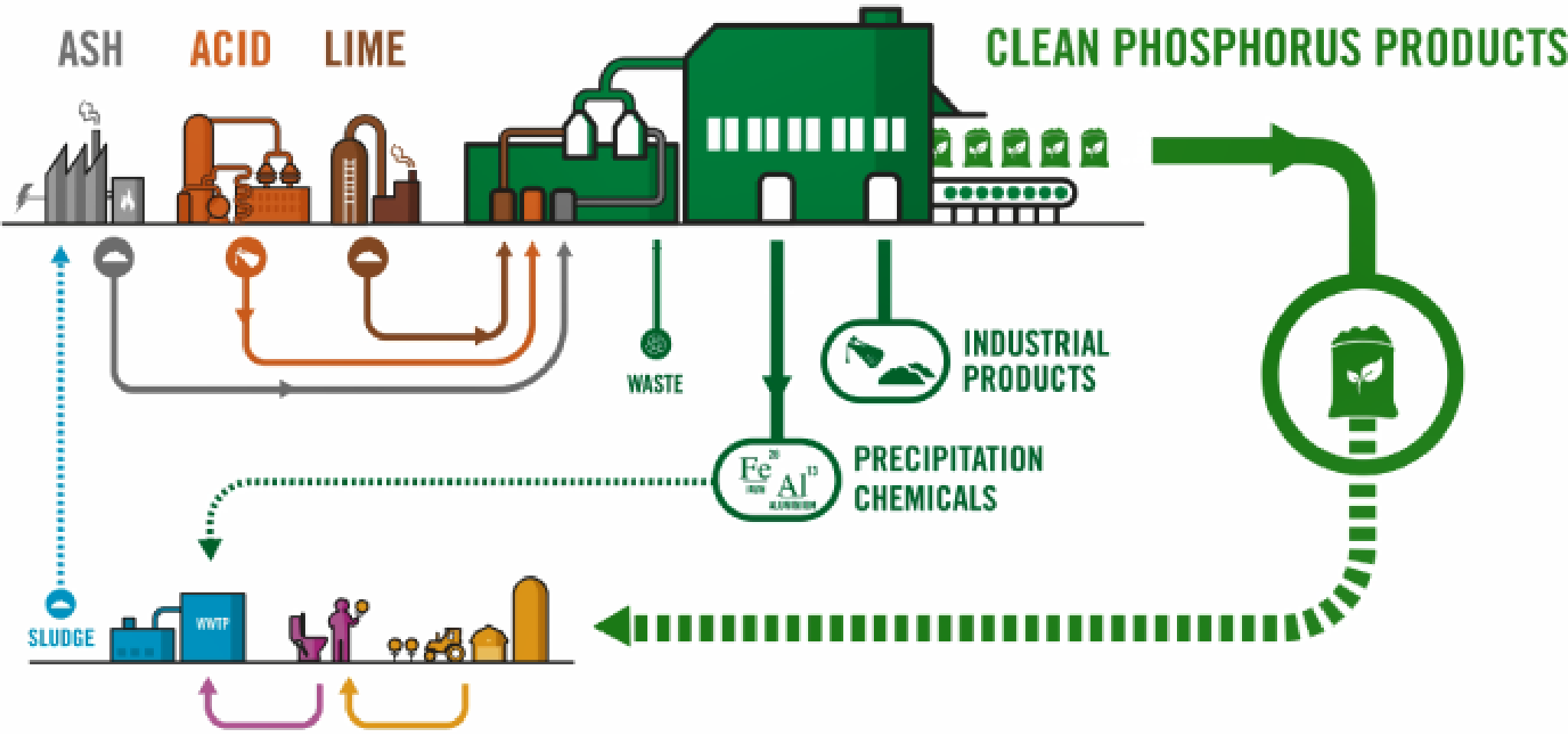
CLOSED LOOP

Ash2®Phos Technology

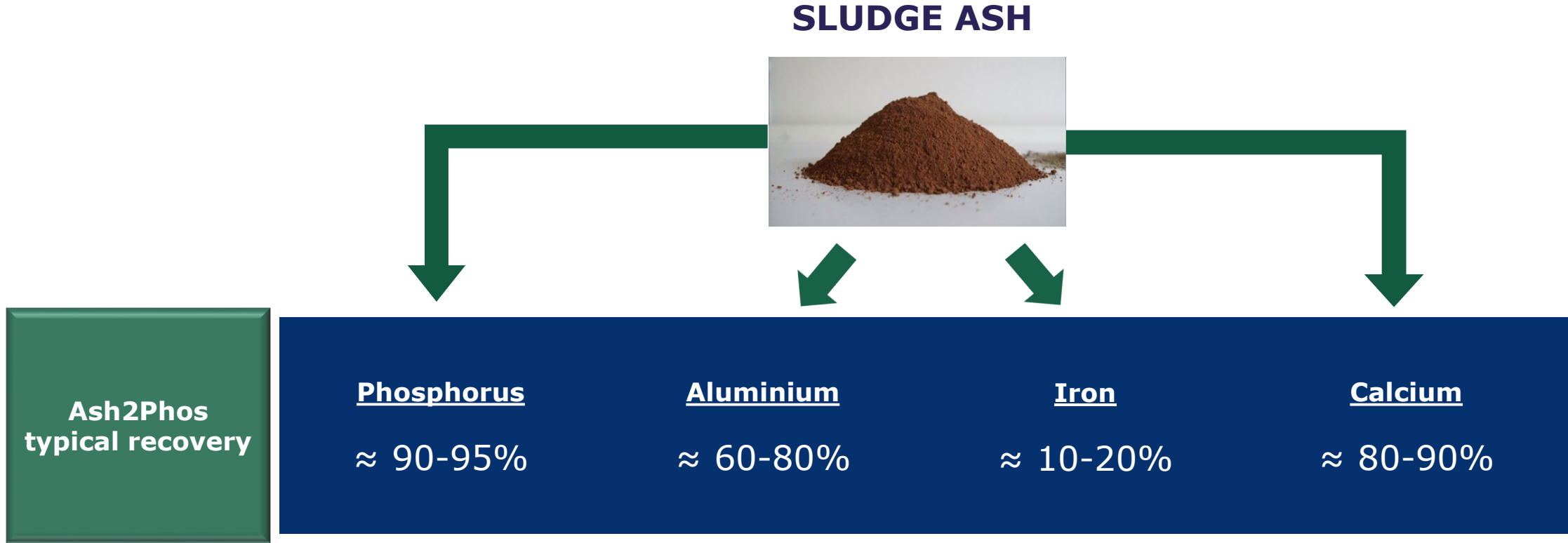


- Society
- WWTP
- Incineration Plant
- Industry/Production
- Agriculture
- Ash2®Phos
- Phosphorus Mining

Ash2Phos process



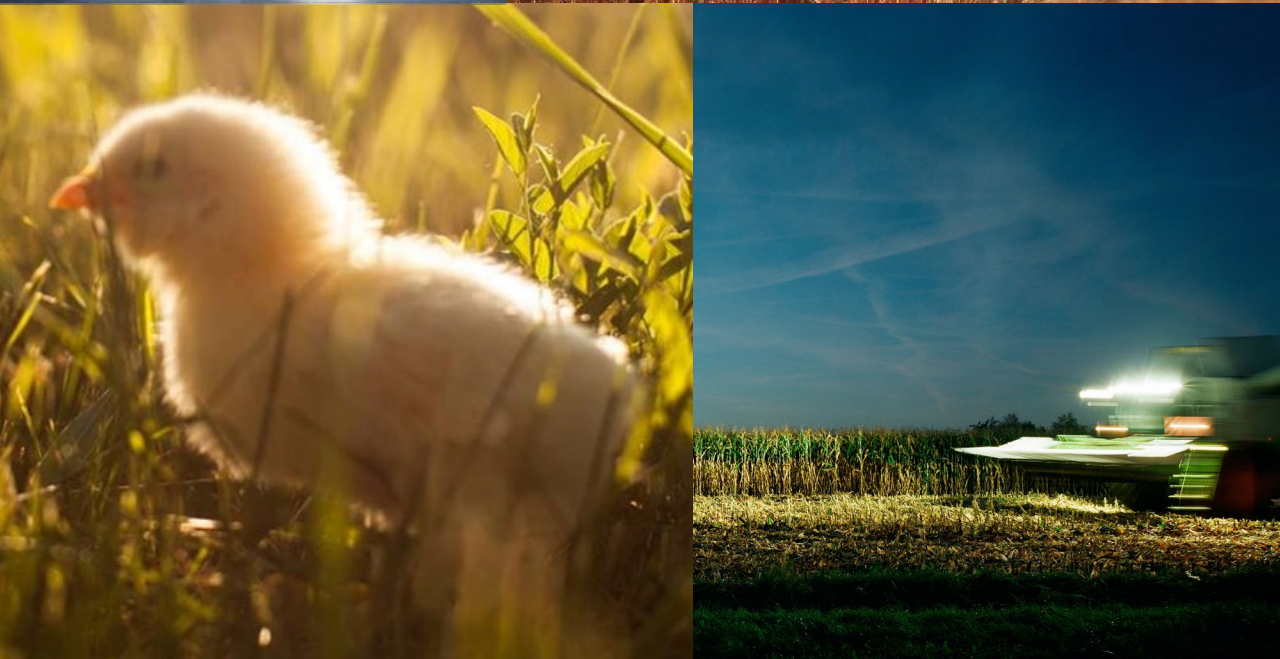
Ash2Phos – Process performance





ASH2PHOS – products

Ash2Phos results in clean, well known products where the input chemicals become part of the final product. Products are effective in their applications.



Products from the process >95% can be used

- Phosphorus
- Precipitated Calcium Phosphate (PCP)
- Converted PCP: MAP, SSP, DCP, MCP
- Precipitation chemicals
 - Iron Chloride
 - Aluminium product
- Silica sand

Precipitated Calcium Phosphate (PCP)

KEY PARAMETERS	VALUE
Phosphorus (P)	16-17%
Calcium (Ca)	35%
DS	95%
Cas No	12167-74-7



Ash2phos – detoxifies circular flows

		Recovered P	Ash	% Reduction
As	mg/kg	1,5	34,6	96
Cd	mg/kg	0,1	5,5	98
Co	mg/kg	0,7	32,4	98
Cr	mg/kg	1,7	232	99
Cu	mg/kg	5,5	1756	100
Fe	mg/kg	1340	202826	99
Hg	mg/kg	-	0,0526	100
Pb	mg/kg	3,6	344	99
Zn	mg/kg	45,9	6780	99
Ni	mg/kg	2,6	164,6	98

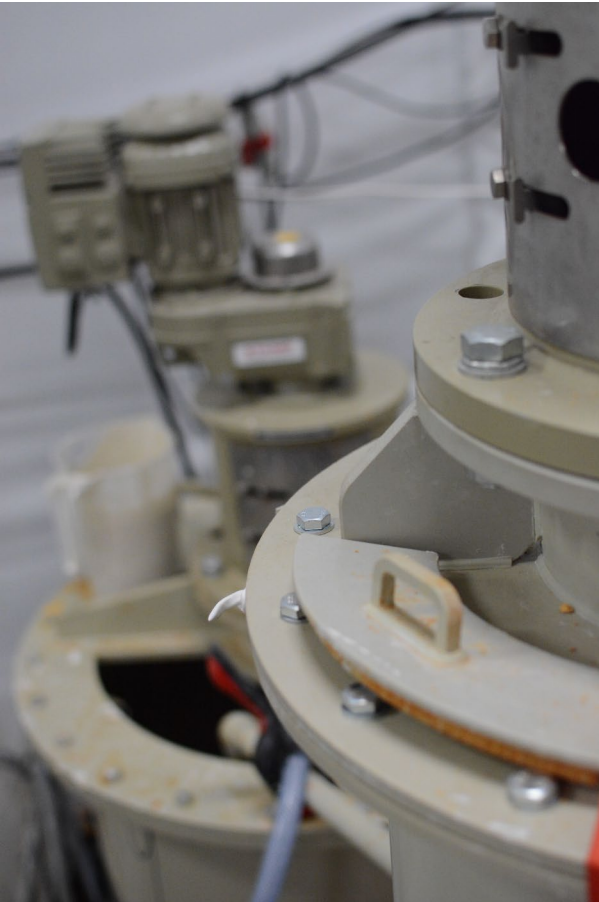
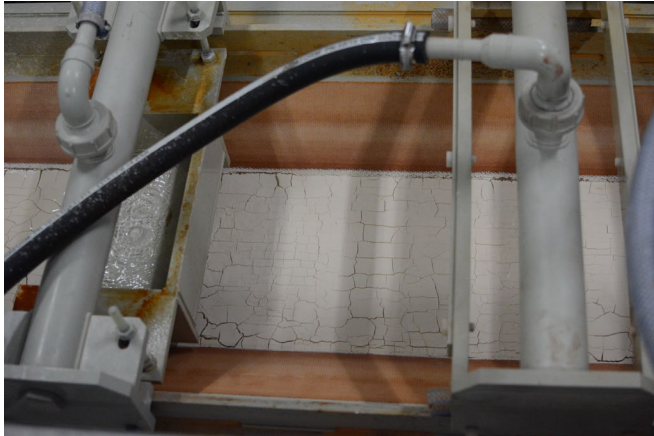
More than 96% reduction in heavy



FEED TESTS

- **PCP as feed phosphate:**
 - same solubility in citric acid as MCP
 - low in fluorine
- **Actions**
 - Digestability tests: ongoing on pigs and poultry
 - Legal discussion together with European Phosphorus Plattform (ESPP)
 - Next step: riskassessment for European Food Safety Authority (EFSA)
- **Results**
 - Q3-Q4 2021

Several Pilot runs conducted



Ash2Phos plant in Germany

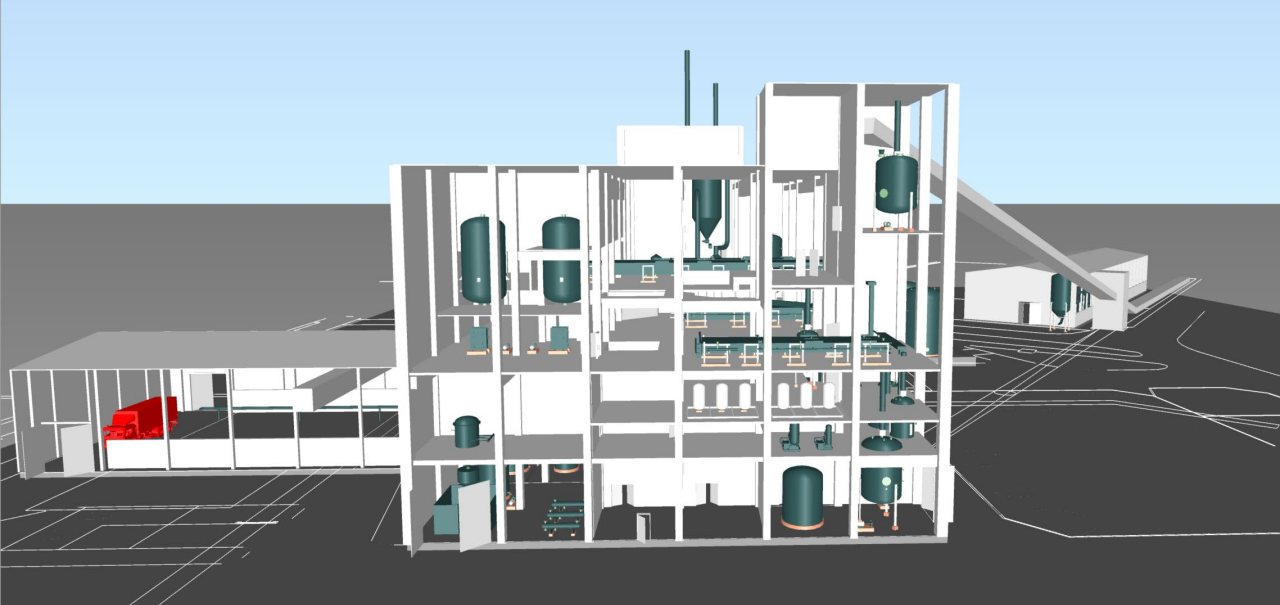
- Partnership Gelsenwasser and EasyMining
- Capacity: 30 000 ton ash/year
- Expected start of production: 2024
- Status: Basic engineering ongoing





Ash2Phos site in Helsingborg

- Capacity: 30 000 ton ash/year
- Expected start of production: 2024-25
- Status:
 - Basic engineering finished
 - Permit application submitted



Silicate sand

	Enhed	Koncentration	Grænseværdi EN450-1
Cl	%	<0,1	<0,1
SO ₃	%	0,3	<3,5
CaO	%	1,5	<11*
MgO	%	1,4	
P ₂ O ₅	%	3,0	<5,5
K ₂ O	%	2,9	
Na ₂ O	%	<0,5	
Total alkalis (Na ₂ O _{eq})	%	<2,4	5,5
SiO ₂	%	48,3	
Al ₂ O ₃	%	7,2	
Fe ₂ O ₃	%	22,9	
SiO ₂ +Al ₂ O ₃ +Fe ₂ O ₃	%	78,4	>65
Glødetab (950°C)	%	2,3	<7**

*) Fri CaO

***) For kategorien flyveaske

EN450-1 standard for
flyveaske i beton



Silicate sand

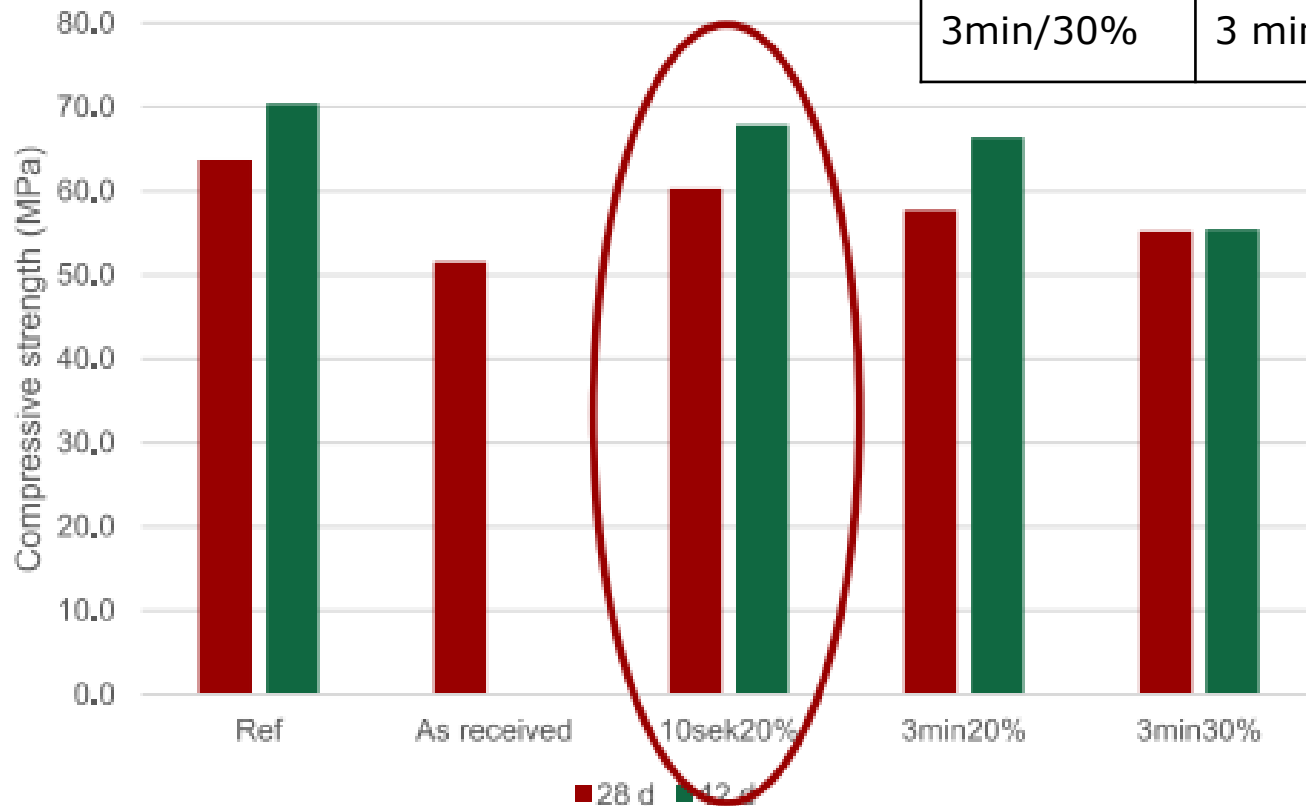
	Enhed	Koncentration
pH		$5,9 \pm 0,01$
Konduktivitet	mS/cm	$0,6 \pm 0,02$
Densitet	g/cm ³	$2,65 \pm 10$
Cadmium - Cd	mg/kg	$1,5 \pm 0,2$
Kobber - Cu	mg/kg	133 ± 11
Bly - Pb	mg/kg	$62 \pm 3,6$
Zink - Zn	mg/kg	442 ± 35

Mikroskopi af silicate sand
En blanding af ren kvarks sand og jern rige aske partikler



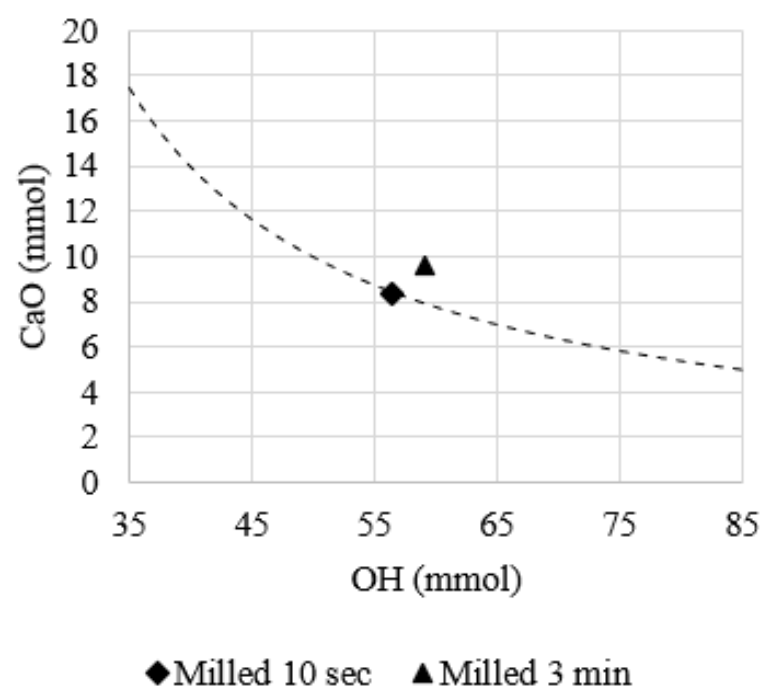
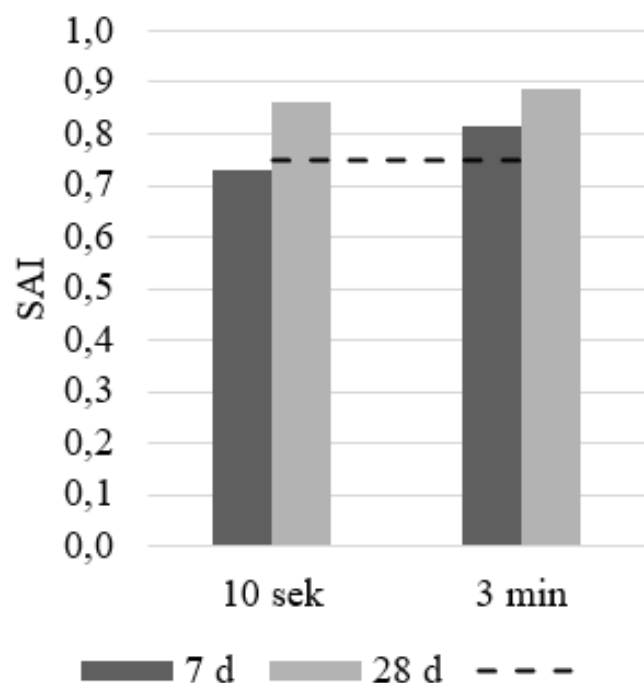
DTU test – Blandinger og styrketest

	Neddeling	Cement (g)	Silicate sand (g)	Vand (g)	Reference sand (g)
Reference		450	0	225	1.350
0sek/20%	Ingen	360	90	225	1.350
10sek/20%	10 sek. (A)	360	90	225	1.350
3min/20%	3 min (B)	360	90	225	1.350
3min/30%	3 min (B)	315	135	225	1.350



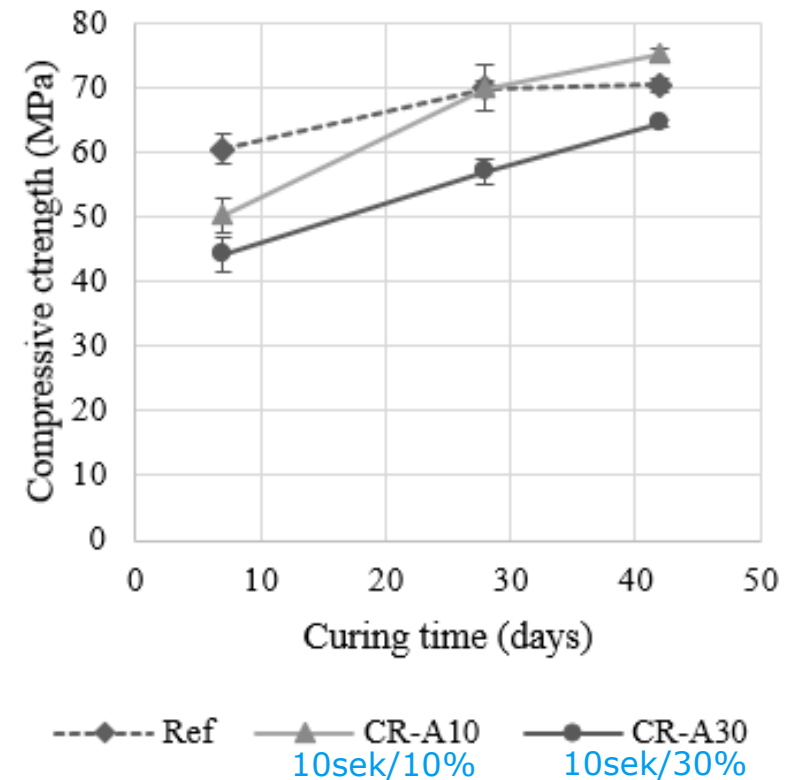
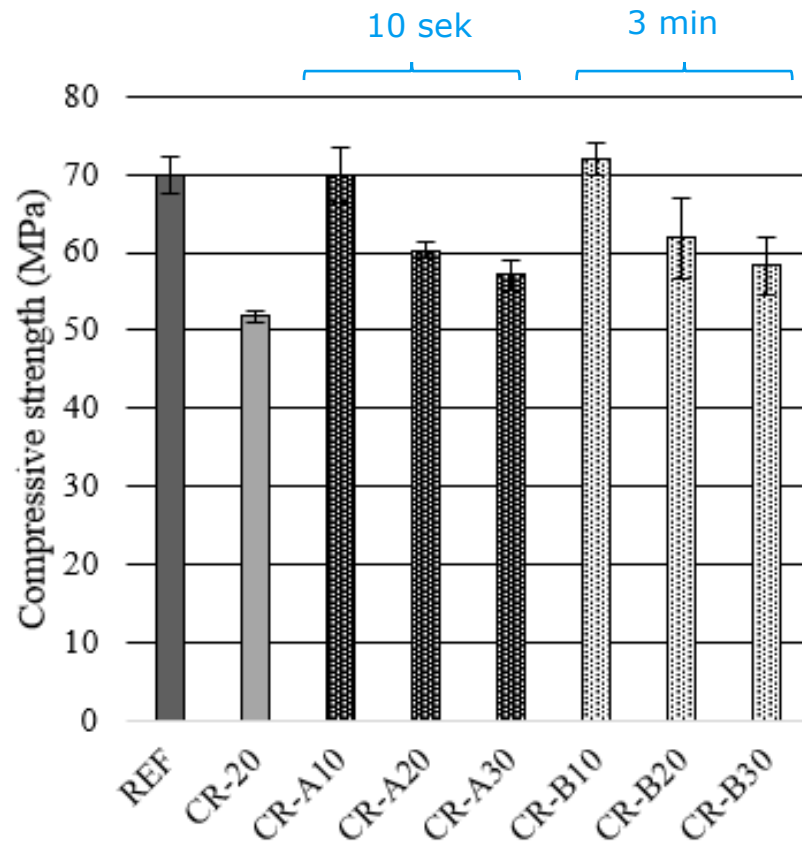
DTU test – pozzolanisk aktivitet

- $\text{SiO}_2 + \text{Al}_2\text{O}_3 + \text{Fe}_2\text{O}_3 > 70\%$ indikerer pozzolanisk aktivitet. Sammenlignet med kulflyveaske er Al_2O_3 laveres mens SiO_2 er højere.
- SAI (Strength activity index): 3 min neddeling viser pozzolanisk aktivitet, mens 10 sekunder neddeling kun viser pozzolanisk aktivitet ved 28 dage.
- Frattini test: Over linien = ingen pozzolanisk aktivitet



DTU test – Styrkeudvikling over tid (42 dage)

- Silicate sand bidrager til sen styrkeudvikling ligesom fx kulflyveaske.



DTU – Ny artikel på trapperne

*Revised version submitted to Resources, Conservation and Recycling
28.08.2021*

1 Utilization of acid-washed sewage sludge ash as sand or cement
2 replacement in concrete

3

4 *Lisbeth M. Ottosen¹, Dines Thornberg², Yariv Cohen³, Sara Stiernström³*

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6 ²Biofos A/S, Refshalevej 250, 1432 Copenhagen, Denmark.

7 ³EasyMining Services Sweden AB, Travvågen 8, 756 51, Uppsala, Sweden

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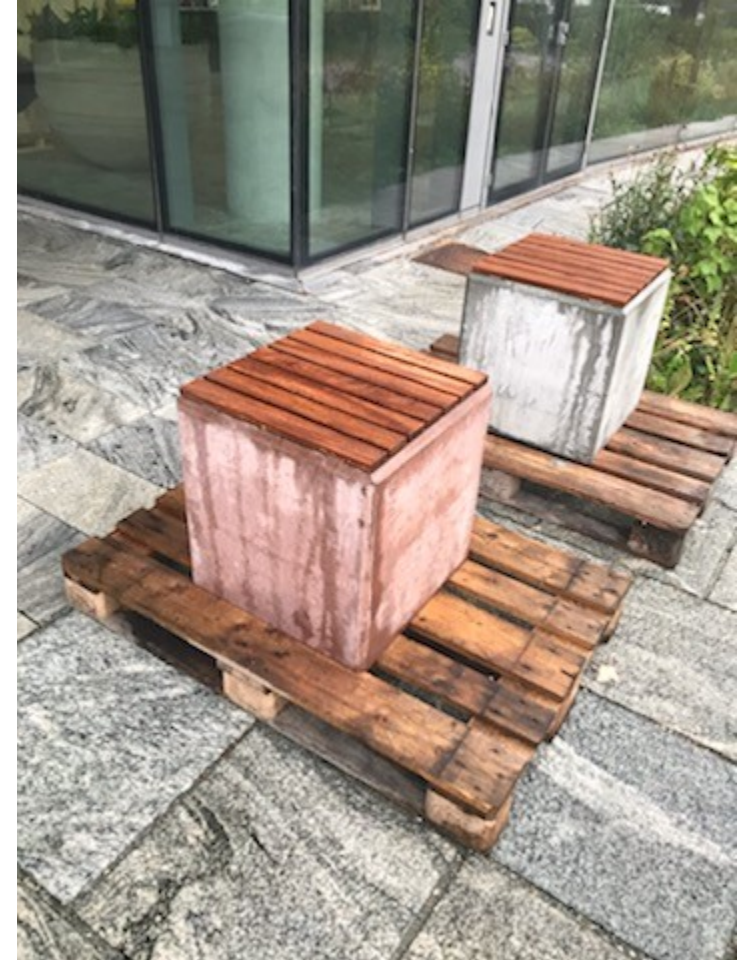
9 **ABSTRACT**

10 The transition towards a Circular Economy necessitates the development of methodologies for
11 optimal utilization of secondary resources. One such resource is sewage sludge ash (SSA). SSA
12 can be utilized in construction materials, but as it contains a high concentration of the critical raw
13 material phosphorous (P), extraction of P before the use in construction materials must be
14 considered. EasyMining in Sweden has developed a method for acid extraction of P (Ash2Phos).

Rambøll - Markedsanalyse

Virksomheder der har bidraget til markedsanalysen:

- Rambøll
- Henning Larsen
- DTU-byg
- Bureau Veritas
- Dansk Byggeri
- IBF
- BB Fiberbeton
- Weber
- SWEROCK
- Tredje natur
- 3XN
- Studio Other Spaces



Betonbænke foran Rambølls Hovedkontor, hvor den røde er med Silicate Sand

Rambøll - Markedsanalyse

Typer af betonprodukter der potentielt er egnede til silicate sand:

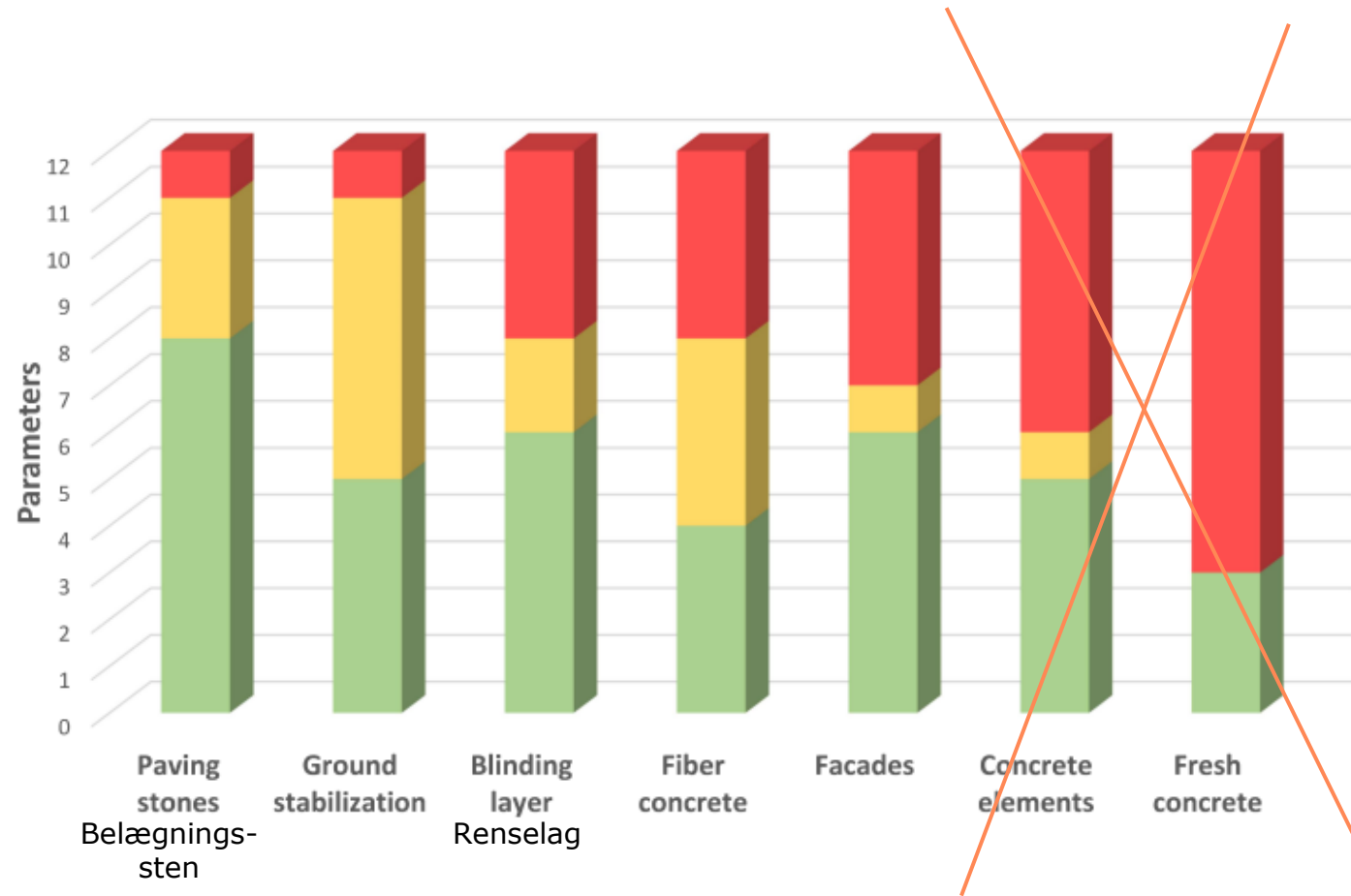
- Betonelementer
 - Facader
- Præfabrikerede betonprodukter
 - Belægningssten (paving stones)
- Fiberbeton
- Jordstabiliserin
- Renselag (blinding layer)
- Frisk beton



Rambøll - Markedsanalyse

Kvalitetskrav og potentielt egnede betonprodukter:

1. No changes to silicate sand
2. Milling silicate sand
3. Red color
4. Amount available
5. Workability
6. Compressive strength
7. Tensile strength
8. Pozzolanic effect
9. Leaching
10. ASR
11. Potential profit
12. How strict standards are



Rambøll – Markedsstørrelse i Europa

13.000.000 tons tør spildevandsslam

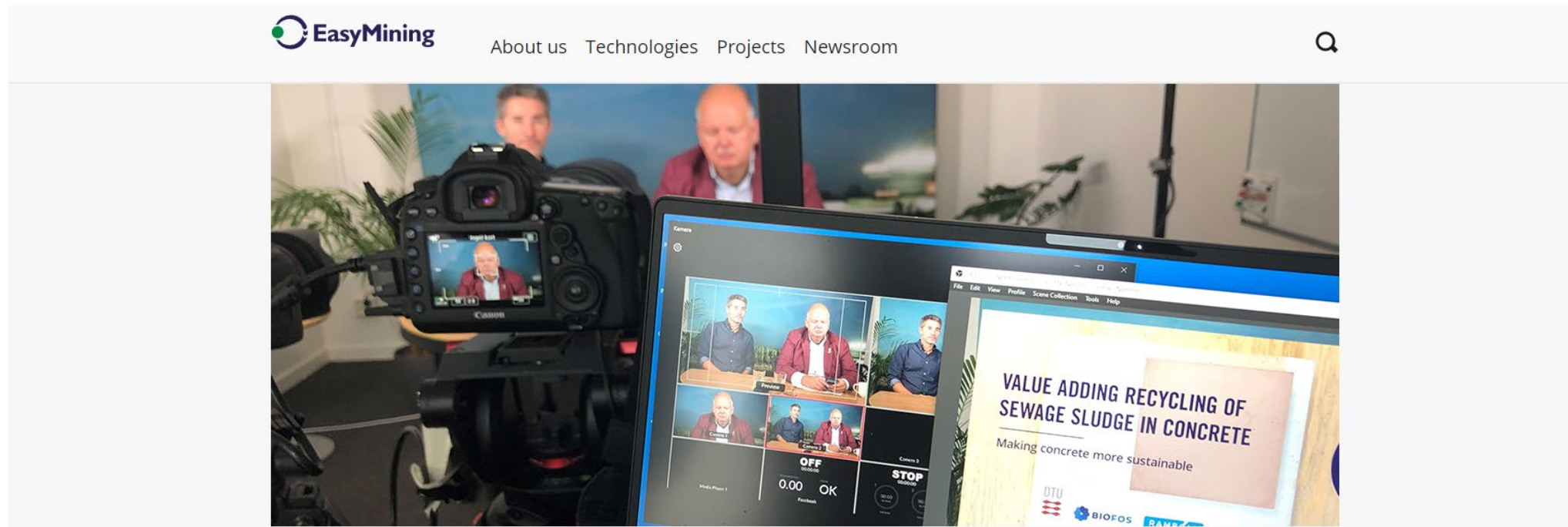
3.700.000 tons tør slamaske (hvis det hele mono-forbrændes)

1.850.000 tons tør silicate sand (hvis det hele behandles med EasyMinings teknologi)

Projekt webinar online

<https://www.easymining.se/projects/sustainable-concrete/>

2 timers webinar fra den 26. august 2020 med DTU (Lisbeth Ottosen), BIOFOS (Dines Thorberg), Easy Mining (Yariv Cohen) og Rambøll (Katrine Orland led)



Webinar 2/10: Value adding recycling sewage sludge in concrete

Interesseret i at samarbejde...??

Kom forbi Rambølls stand og få en snak 😊

