Phosphorus recovery process

Phosphogreen

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Context

Context

Facts and figures about phosphorus

today, a nutrient

- essential to life (creation of DNA, cell membranes…)
- non-substitutable
- intensively used as an additive in food industry and agriculture

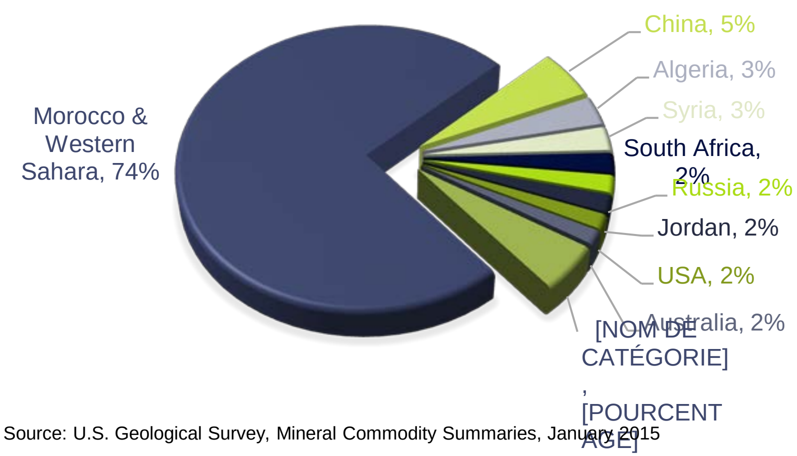
tomorrow, a geopolitical issue?

- depletion foreseen by the end of 21st century
- reserves unequally distributed throughout the world:

  95 % of the reserves located in only 9 countries

- complicated geopolitical situation in some countries
- Europe has *no* phosphate reserves

Phosphate reserves distribution worldwide
(Total: 67 Mt)



Source: U.S. Geological Survey, Mineral Commodity Summaries, January 2015

Solution
Phosphorus recovery

considering that

- 20% of current world demand of phosphorus could be covered by recovery from wastewater
- 80% of phosphorus extracted from phosphate ores is intended for fertilizers

the solution is

to convert **phosphorus** present in wastewater into a **valuable fertilizer**

to help our clients take a step forward towards **sustainable development** and **circular economy**

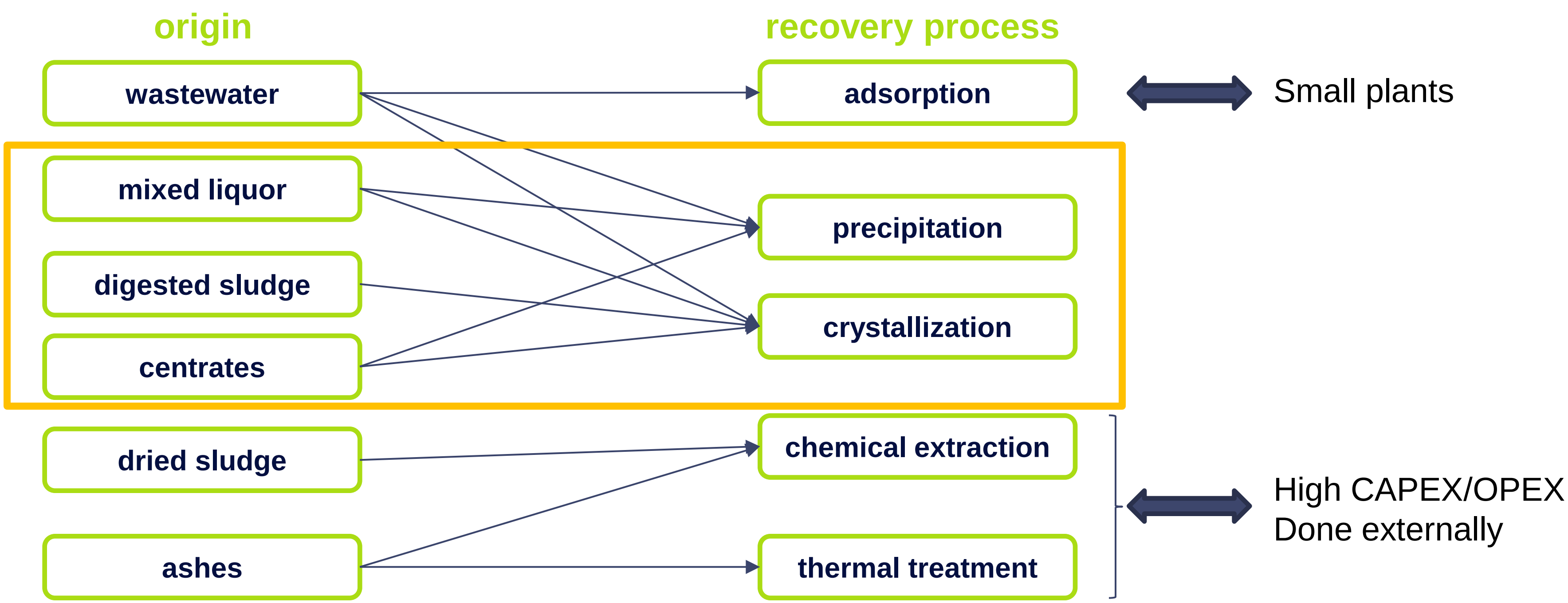
Phosphorus recovery processes

P-recovery processes

one aim

extract phosphorus from wastewater in a form that can be used directly as a fertilizer or as a raw material for industries.

various processes



P-recovery processes
Precipitation-crystallization reactions

Dissolved phosphate ions can be converted into solid phase by precipitation-crystallization.

Reaction	possible recovery of phosphorus?	use of the product as fertilizer?
$PO_4^{3-} + \mathbf{Fe^{3+}} \rightarrow FePO_4$ **ferric chloride, $FeCl_3$,**	no	no
$PO_4^{3-} + \mathbf{Al^{3+}} \rightarrow AlPO_4$ **aluminum sulphate, $Al_2 (SO_4)_3$**	yes (electrothermal treatment)	no
$2\ PO_4^{3-} + \mathbf{3\ Ca^{2+}} \rightarrow Ca_3(PO_4)_2$ **- HAP** **lime, $Ca(OH)_2$**	yes (electrothermal treatment)	low bioavailability
$PO_4^{3-} + \mathbf{Mg^{2+}} + \mathbf{NH_4^{+}} \rightarrow MgNH_4PO_4, 6\ H_2O$ **- MAP** **magnesium chloride, $MgCl_2$** **struvite** ($MgNH_4PO_4, 6\ H_2O$)	yes (as is)	yes

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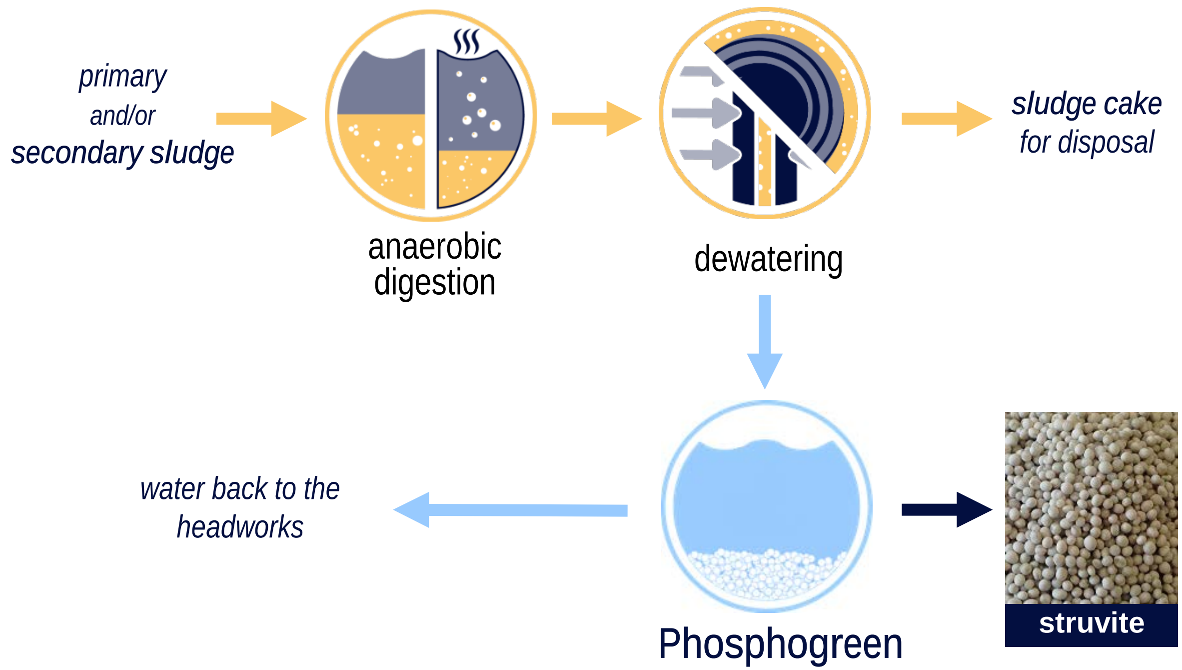
Phosphogreen
Technology description

Phosphogreen
Principle

application field

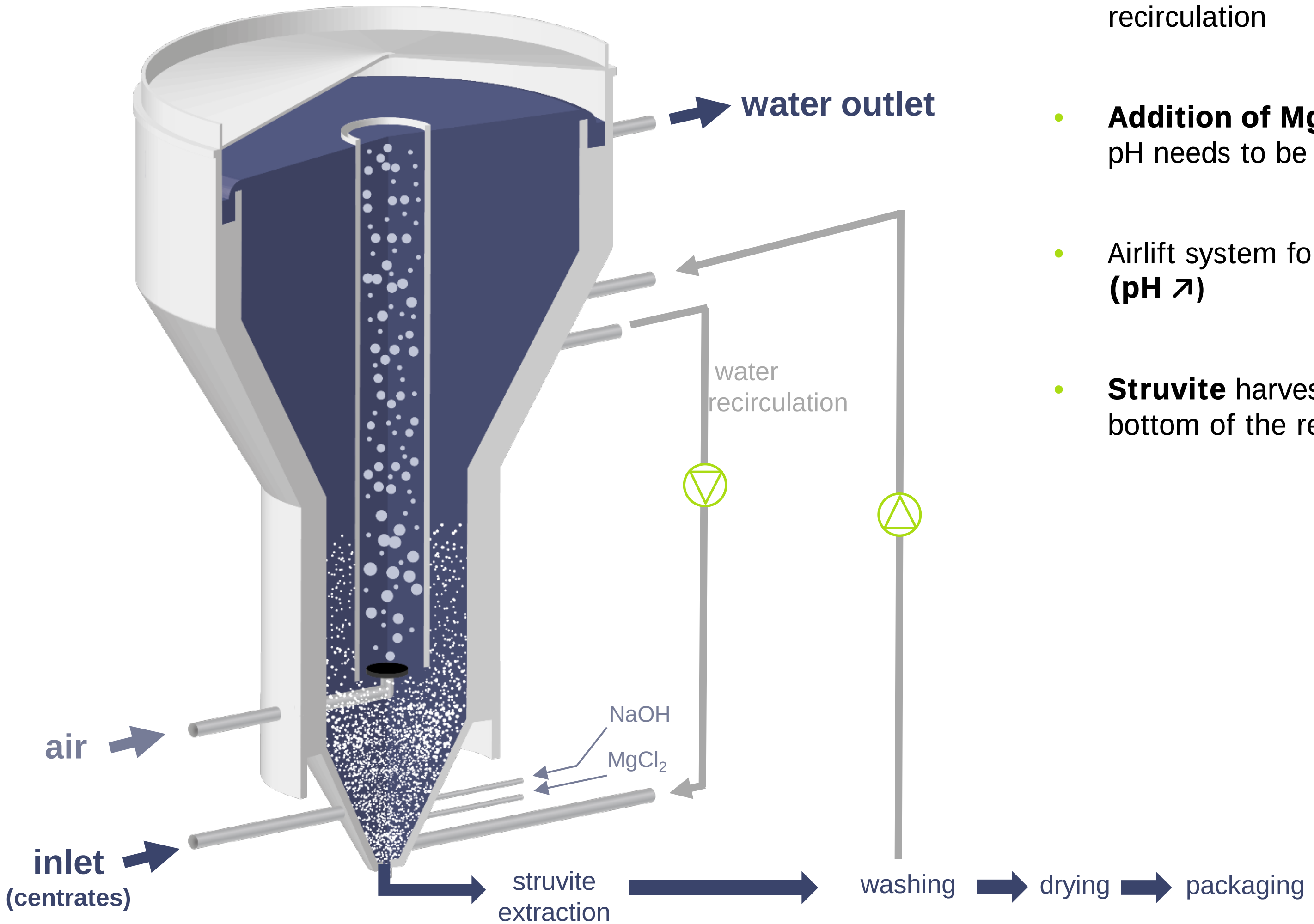
- WWTP capacity > 40,000 PE
- Bio-P removal
- Anaerobic digestion
- Phosphorus in digested sludge centrates ≥ 70 mg/L

position in the treatment line



Phosphogreen

Process overview



- **Fluidized bed reactor** with recirculation
- **Addition of $MgCl_2$** and **NaOH** (if pH needs to be adjusted)
- Airlift system for **CO_2 stripping (pH ↗)**
- **Struvite** harvested from the bottom of the reactor

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Phosphogreen
Struvite characteristics

Struvite ↔ **$MgNH_4PO_4,6\ H_2O$**

- granule size: 1 to 3 mm

including
- 12.2% w/w phosphorus
- 5.8% w/w nitrogen
- 10.4% w/w magnesium

- heavy metals content (mg/kg):

	struvite	Danish standards for sludge
Cd	0.06	0.8
Hg	<0.1	0.8
Pb	<0.2	120
Ni	0.5	30
Cr	4.5	100
Zn	7.4	4000
Cu	0.8	1000

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References

Phosphogreen references

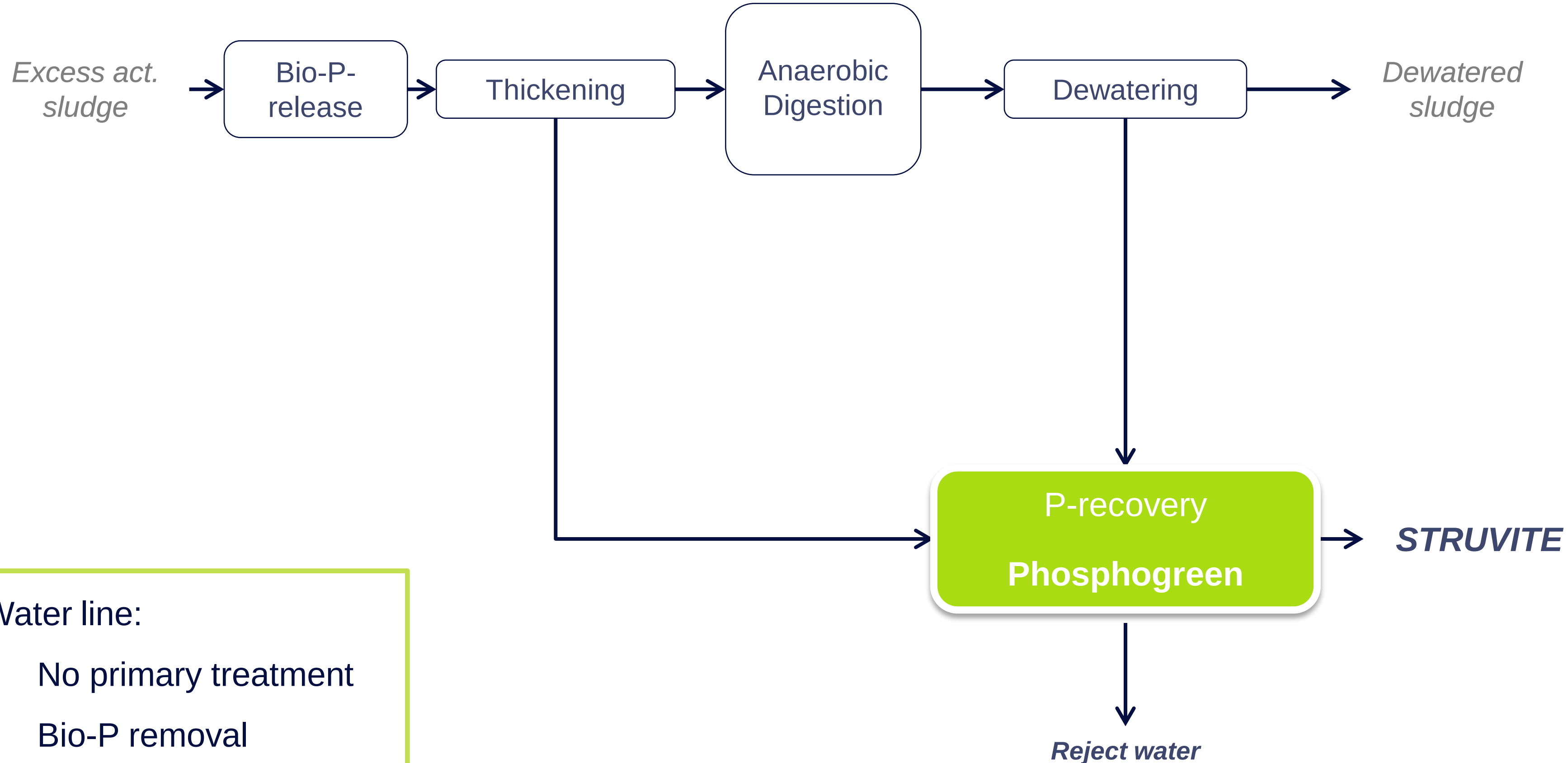
Åby (Aarhus, Denmark)

plant's characteristics

- 84,000 PE
- No primary treatment
- P-recov. unit start-up date: 2013
- **WWTP's inlet:**
  450 kg/d N_{tot}
  105 kg/d P_{tot}
- **Outlet:**
  300 kg/d struvite
  (incl. 37 kg P/d)

➡ ~ 35% of P recovered

Phosphogreen references
Åby (Aarhus, Denmark)



Water line:

- No primary treatment
- Bio-P removal

Phosphogreen references
Herning (Denmark)

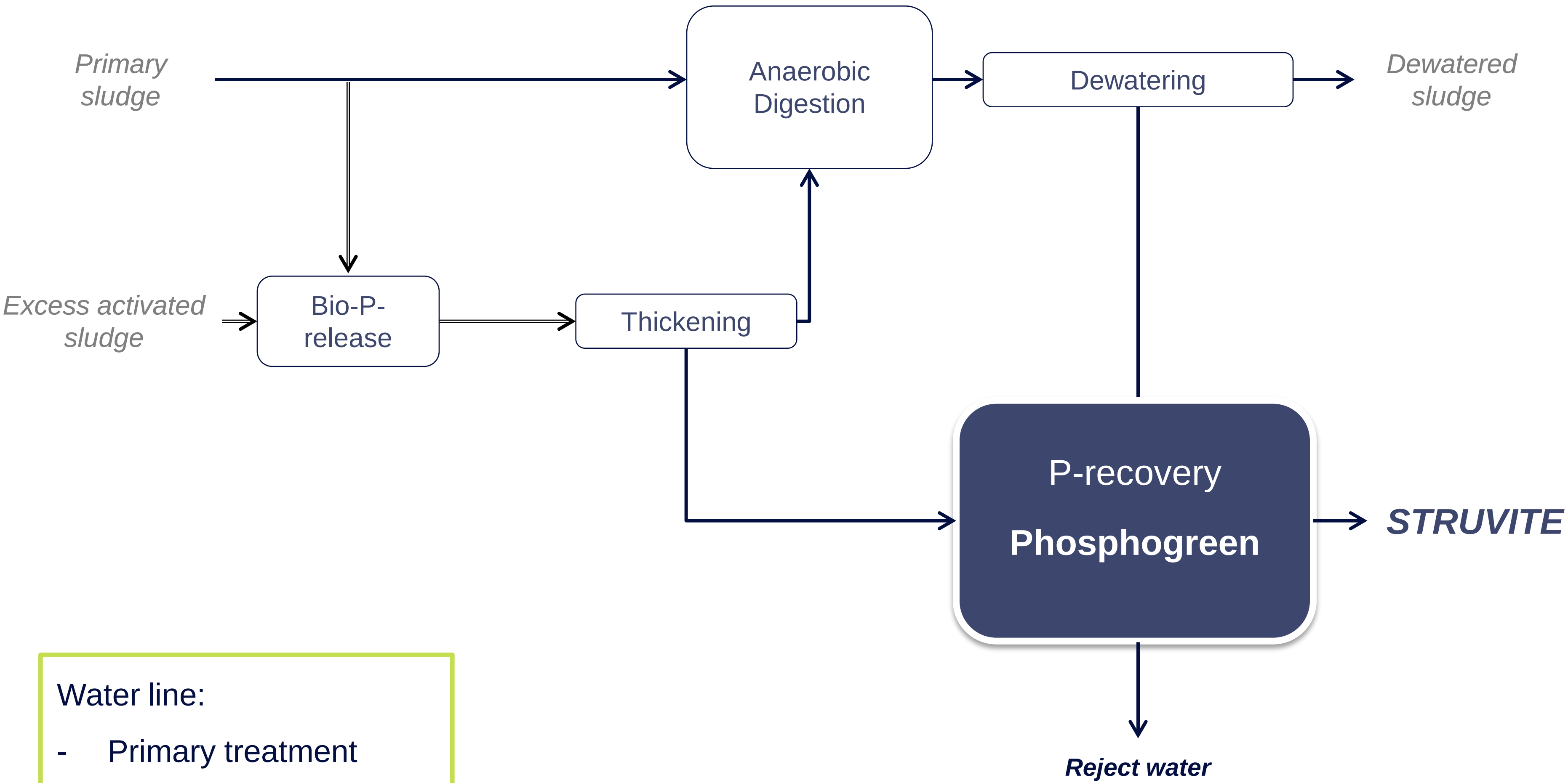
plant's characteristics

- 150,000 PE
- Primary treatment
- P-recov. unit start-up date: 2015
- **WWTP's inlet:**
  1200 kg/d N_{tot}
  240 kg/d P_{tot}
- **Outlet:**
  290 kg/d struvite
  (incl. 36 kg P/d)

➡ ~ 15 % of P recovered

Phosphogreen references

Herning (Denmark)



Water line:

- Primary treatment
- Bio-P removal

Benefits

Phosphogreen
Benefits

financial revenue

- Sale of struvite as fertilizer (75 to 300 €/t)
- ROI 5 to 10 years

savings on various levels of the process

- **reduction of chemicals consumption** for phosphorus physicochemical treatment
- **less energy** consumed for biological treatment (removal of a part of nitrogen by struvite precipitation)
- **increased equipment service life** thanks to controlled and localized precipitation of struvite
- **reduction of sludge disposal costs** by minimization of sludge volumes

commitment to sustainable development

- **resource recovery** (phosphorus, nitrogen): contribution to the circular economy
- **lower environmental footprint** through energy savings, sludge volume reduction, increased equipment service life, reduced chemical consumption

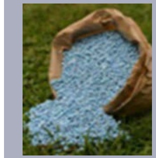
Regulation constraints

European legislative and regulatory framework

the regulatory framework is complex for phosphorus recovery projects:

spreading plan

- limited quantities
- many quality controls



fertilizer regulations

- national standards
- EU directive on fertilizers

national approval
(usually necessary)

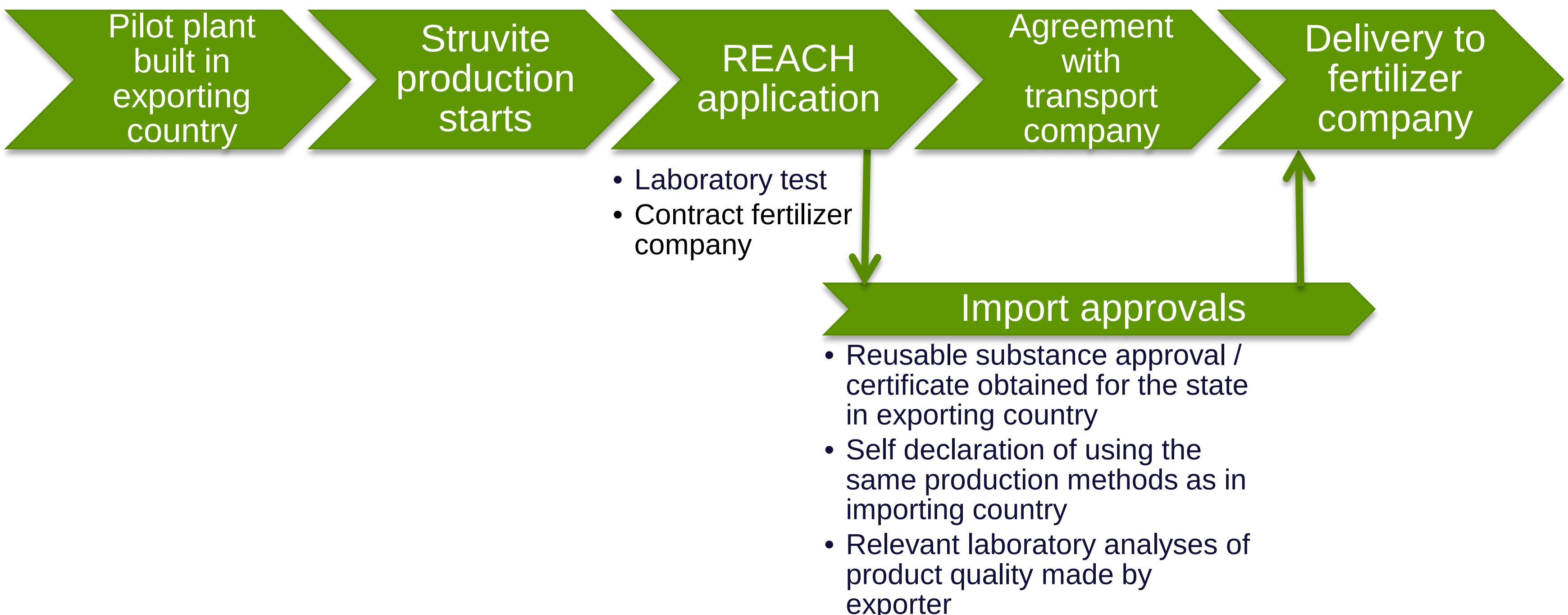
A significant number of laws and regulations apply in Europe, which complicates the phosphorus recycling projects. Simplification's works are underway (end of waste status).

Regulation constraints

Struvite homologated as a fertilizer in some countries (DK, UK), but not in others (FR, …)

- No standardized European regulation
- Slow down the development of P recycling plants

Difficulties to import/export struvite between EC members while there is a market



Thank you for your attention