Advances in Particle Separation for Waste2Value concepts in Wastewater Treatment

dr. ir. Arjen van Nieuwenhuijzen MSc. PhD.
Chief Technology Officer Energy, Water and Environment

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Content

- Introduction
- Resource Pinching: characterisation of waste flows – search for valuables
- Focus on water and fossil resources: Carbon, Phosphorous, Nitrogen, Cellulose
- Routes and Techniques
- Case examples

Witteveen + Bos

Witteveen + Bos GROUP

- independent engineering consultants
- found by Mr Bos (37) and Mr Witteveen (54) in 1946
- 4 Business Lines
  - Deltas, Coasts and Rivers
  - Infrastructure and Mobility
  - Built Environment and Urban Development
  - **Energy, Water and Environment**

- milestones 2016:
  - 1,100 employees Worldwide
  - turnover EUR 140 million (2016)

70 YEARS OF EXCELLENCE 1946 - 2016

Business line organisation Energy

CTO
Arjen van Nieuwenhuijzen

Business Line Director
Egbert Teunissen

- Drinking Water — Fred de Bruijn
- Waste Water — Freek Kramer
- Information Technology — Erik Jansen
- Industry & Energy — Eveline Buter
- Soil Remediation & Hazardous Waste — Maarten Kraneveld
- Asset Management — Auke de Wit

Global Presence

- Netherlands (Amsterdam, Rotterdam, The Hague, Breda, Heerenveen, Deventer)
- Belgium (Antwerp, Brussels)
- United Kingdom (London)
- Indonesia (Jakarta)
- Kazakhstan (Almaty, Atryrau, Aktau)
- Latvia (Riga)
- Russian Federation (St Petersburg)
- Vietnam (Ho Chi Min)
- Singapore
- UAE (Dubai)
- Ghana (Accra)

Strategic European Expertise Network (SEEN)

- Partners:
  - Witteveen+Bos (Netherlands)
  - Tyréns (Sweden)
  - NIRAS (Denmark)
  - Artelia Group (France)
- Aims:
  - Exchange of expertise
  - Sharing experience
  - Developing (international) business

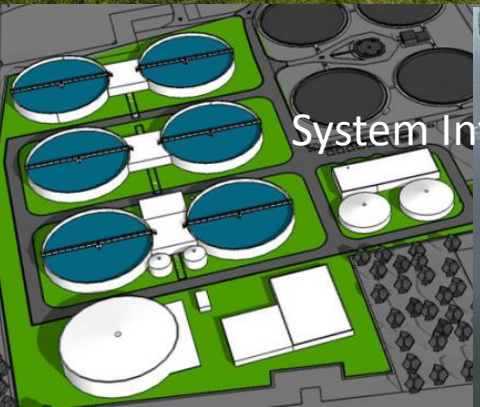

Municipal and industrial application
Food, beverage, Steel&Metals, Oil&Gas


Conventional activated sludge BNR


Conventional and advanced
sludge treatment


digestion and


MBR, RO, Oxidation, GAC
Ultra Pure Water
Micro Pollutant Removal


System Integrator of Nereda™-Technology


Energy & Resource Factories
Waste2Value

Advanced Particle Removal for Energy and Resource Recovery from Waste and Waste Water

Main Drivers: Cost Savings + Sustainability

- ✓ Reducing further (central) treatment (costs)
- ✓ Saving energy (costs)
- ✓ Decrease of final waste residues (costs)
- ✓ Resource recovery (added values and benefit, sustainable)
- ✓ Reduction of green house gas emissions (sustainable)


R&D
Knowledge
Experience
Smart System Integration
Design Principles

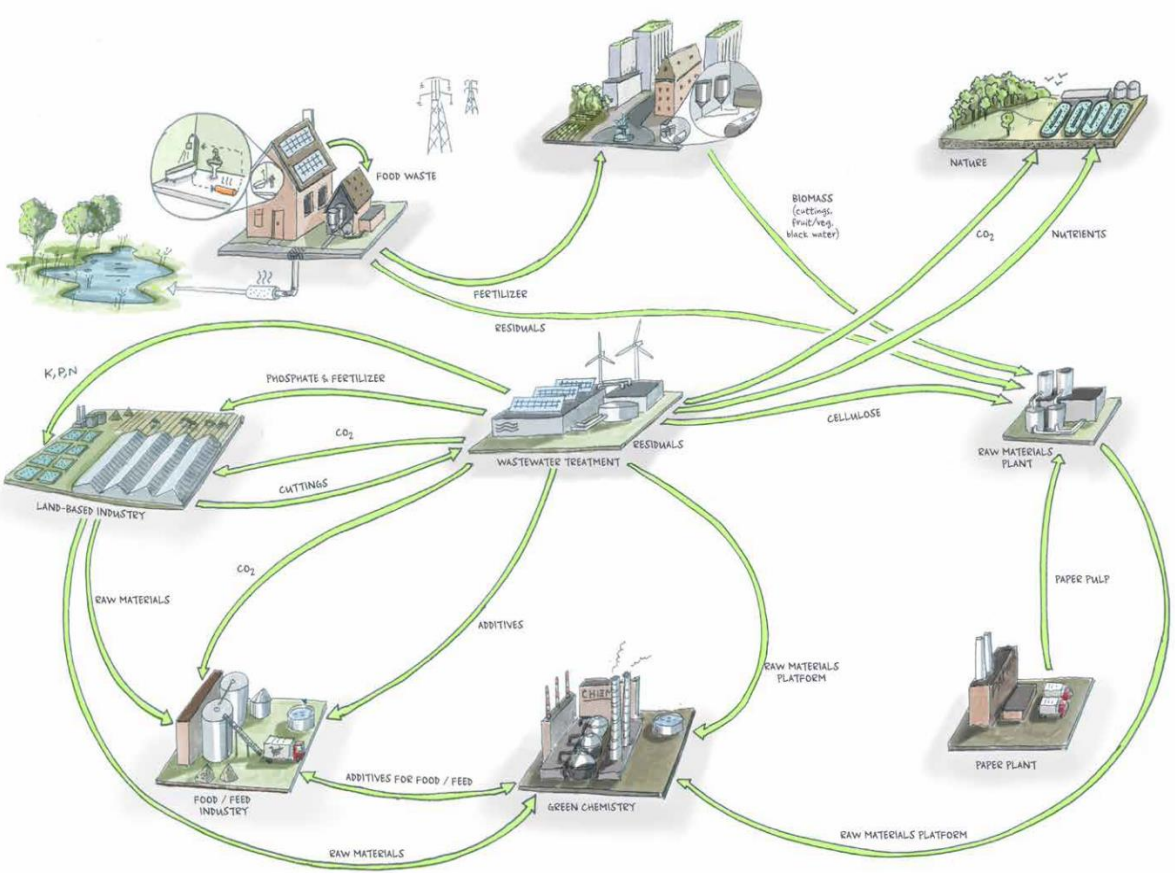
7 Witteveen+Bos Sustainable Project Principals based on the 17 UN SDG's

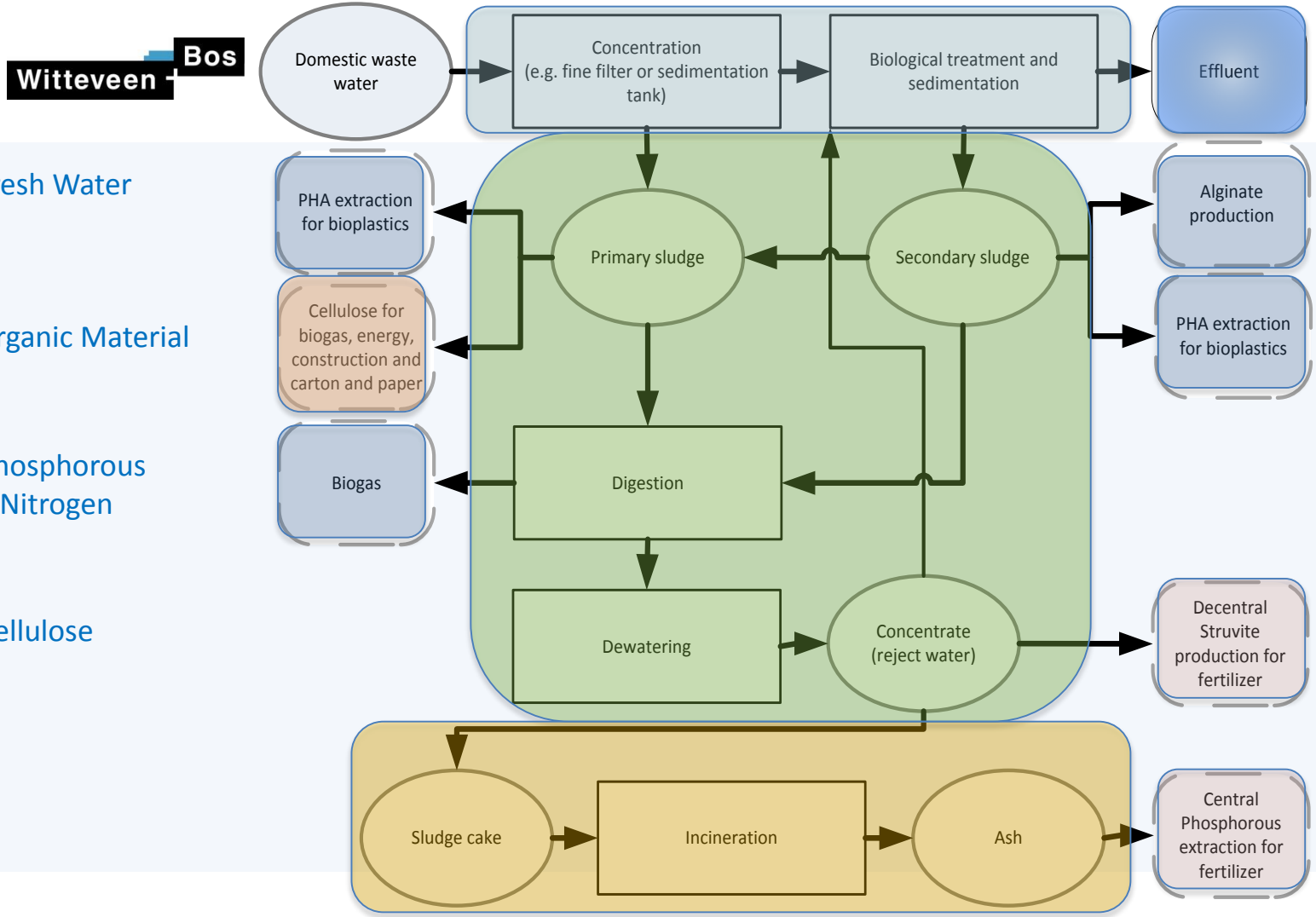
Use Circular Economy
Think Waste2Value

Identify waste streams
- internally (production lines)
- externally (neighbours)

1. Fresh Water
2. Organic
3. Nutrients
4. Cellulose

Cost Savings – higher profit
Sustainability – social return




Witteveen + Bos
Domestic waste water
Concentration (e.g. fine filter or sedimentation tank)
Biological treatment and sedimentation
Effluent
WWTP
Fresh Water
Organic Material
Phosphorous + Nitrogen
Cellulose
PHA extraction for bioplastics
Cellulose for biogas, energy, construction and carton and paper
Biogas
Primary sludge
Secondary sludge
Digestion
Dewatering
Concentrate (reject water)
Alginate production
PHA extraction for bioplastics
(Only from Nereda™ Plant)
Decentral Struvite production for fertilizer
Sludge treatment
Sludge cake
Incineration
Ash
Central Phosphorous extraction for fertilizer
Sludge cake disposal

Resource Pinching: Identify your own resource values

- **Organic Material** (carbon):
  - Convert into:
    - Renewable (bio) gas for electricity production (via digestion, enhanced digestion)
    - Bio materials, like bio plastics (PHA/PHB), alginate (Granular Sludge), fatty acids
- **Nutrients** (P, N):
  - Convert into:
    - Bio Fertilizer (struvite)
    - Phosphoric acid
    - Ammonia sulphate, Ammonia Nitrate, Protein production (nitrogen conversion)

Resource Pinching: Identify your own resource values

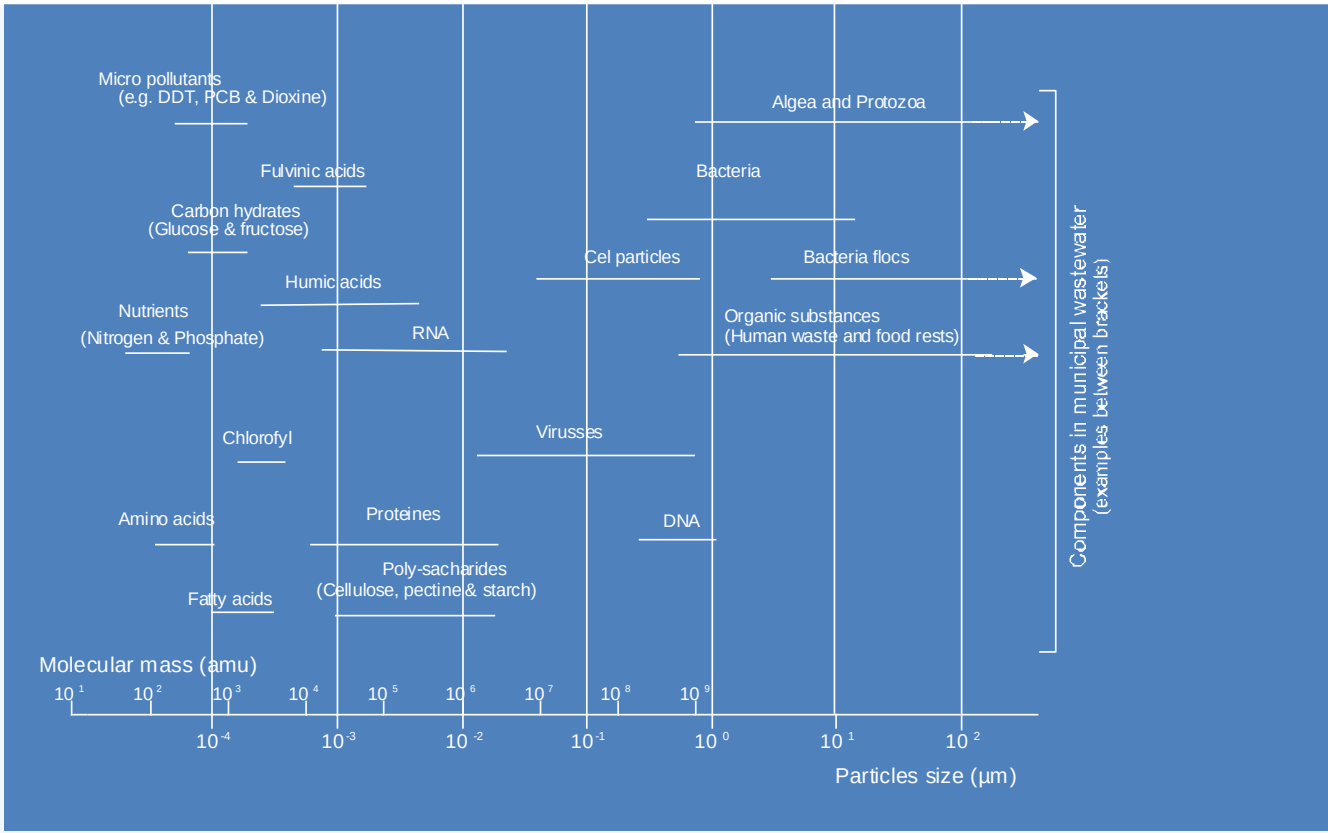
- **Cellulose (fibre materials)**
  - Convert into:
    - ➢ Renewable (bio) fuel / pallets for electricity production
    - ➢ Bio composite
    - ➢ Asphalt reinforcement additive

Particle Removal is the key to optimisation at waste water treatment

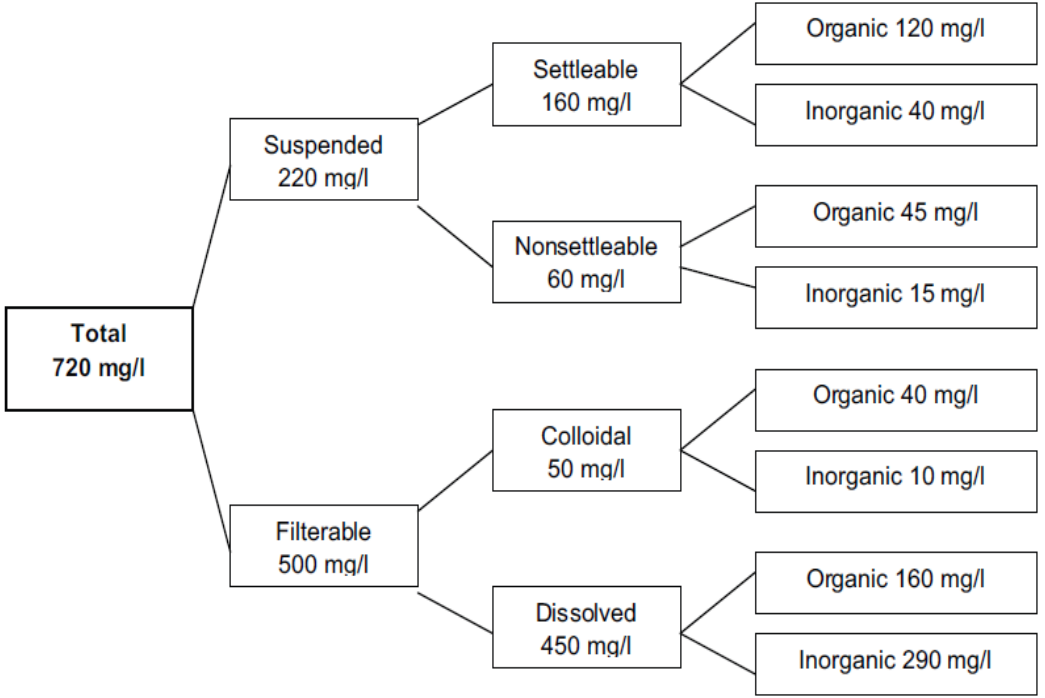
- Focus on advanced pre-treatment of waste water for particle removal
- Maximum capture of organic matter and valuables
- Physically-chemically enhanced (particle) removal techniques
- Decrease pollution load to biological waste water treatment plant
- Save aeration energy
- Maximising energy recovery and resource capture
- Minimisation of residual waste production

zero energy waste water treatment possible with potential cost savings

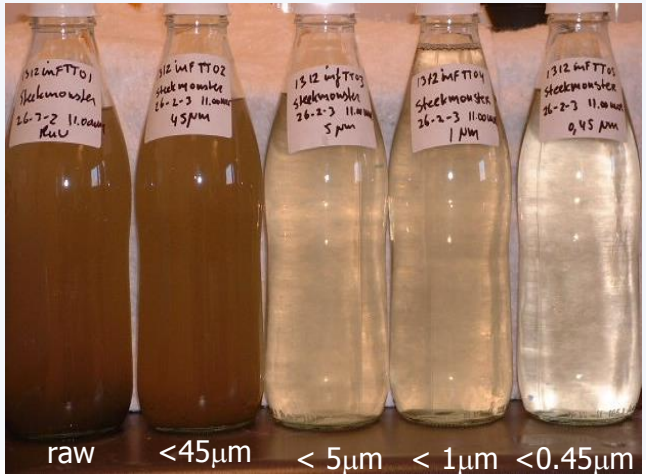
Particle characteristics are important

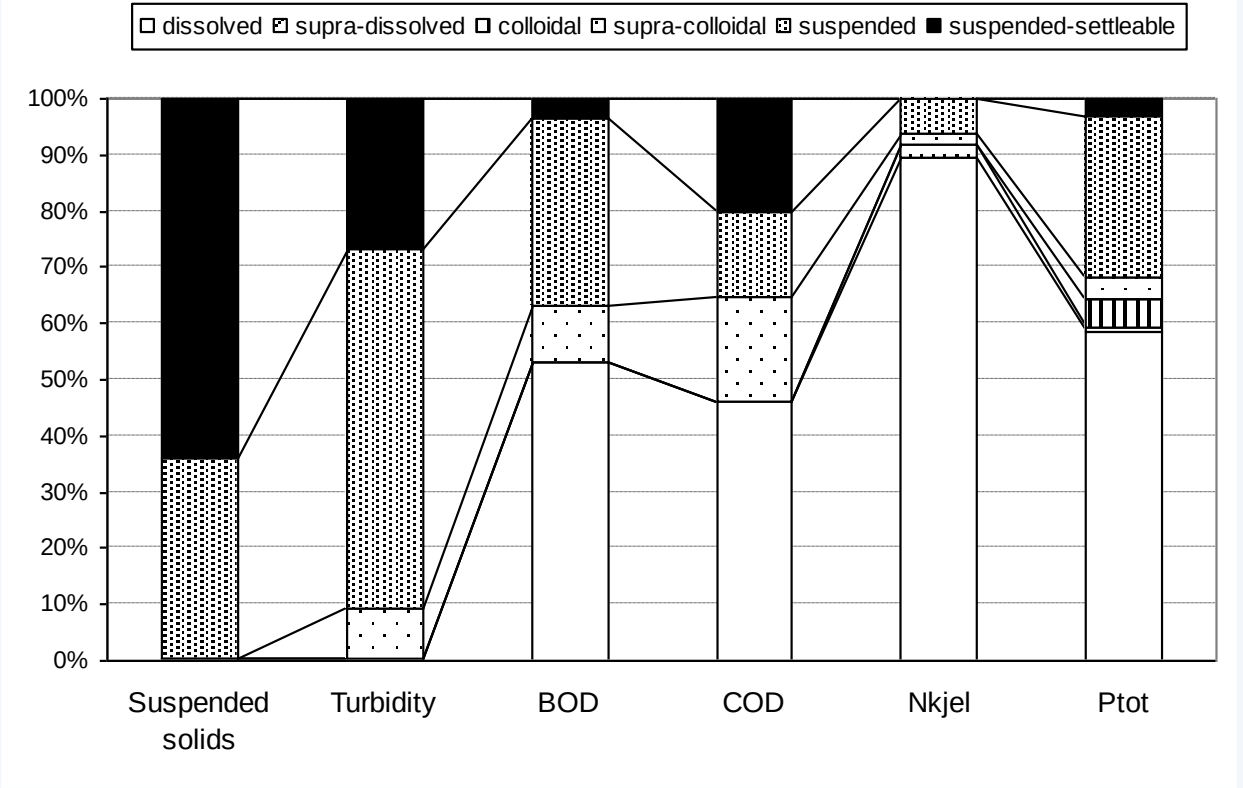


Particle characterisation ‘example COD’



Waste water fractionation over particle characteristics





Forcing particle behaviour

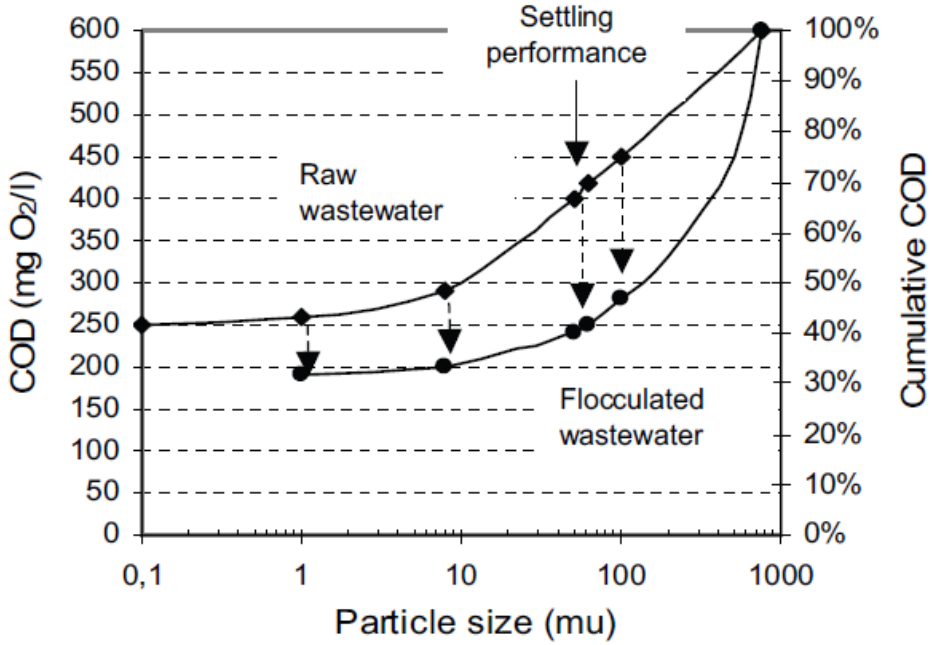
Improving removal performance

Shifting organic fractions

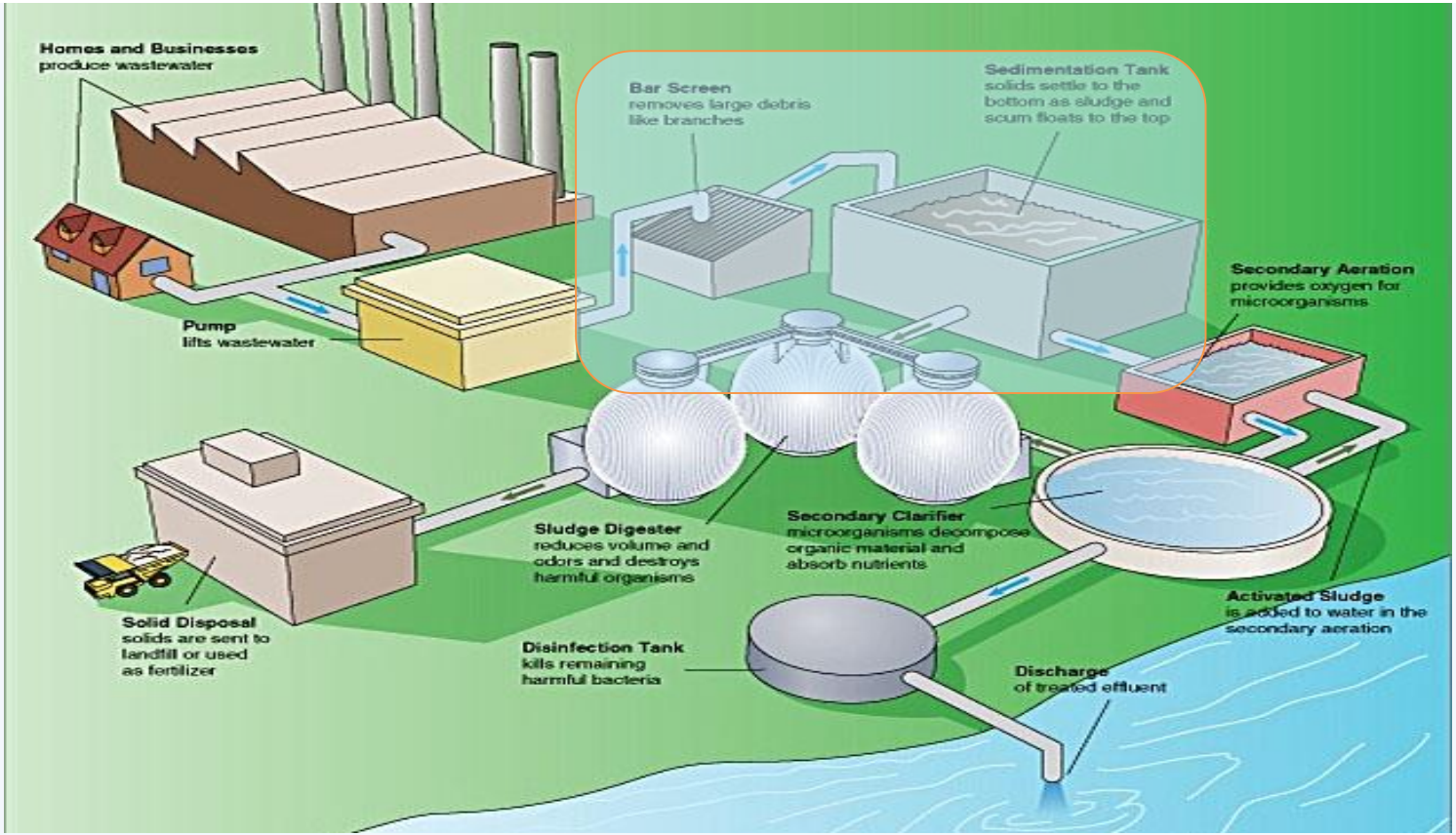
Extracting valuable organics and useless inerts

Maximising primary sludge

Minimising organic load



Optimization: saving and extraction

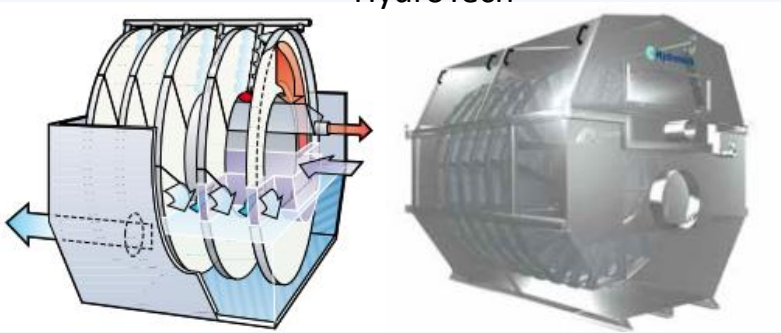


Optimisation: savings and extraction

Chemically enhanced sedimentation

Disc Filtration

HydroTech

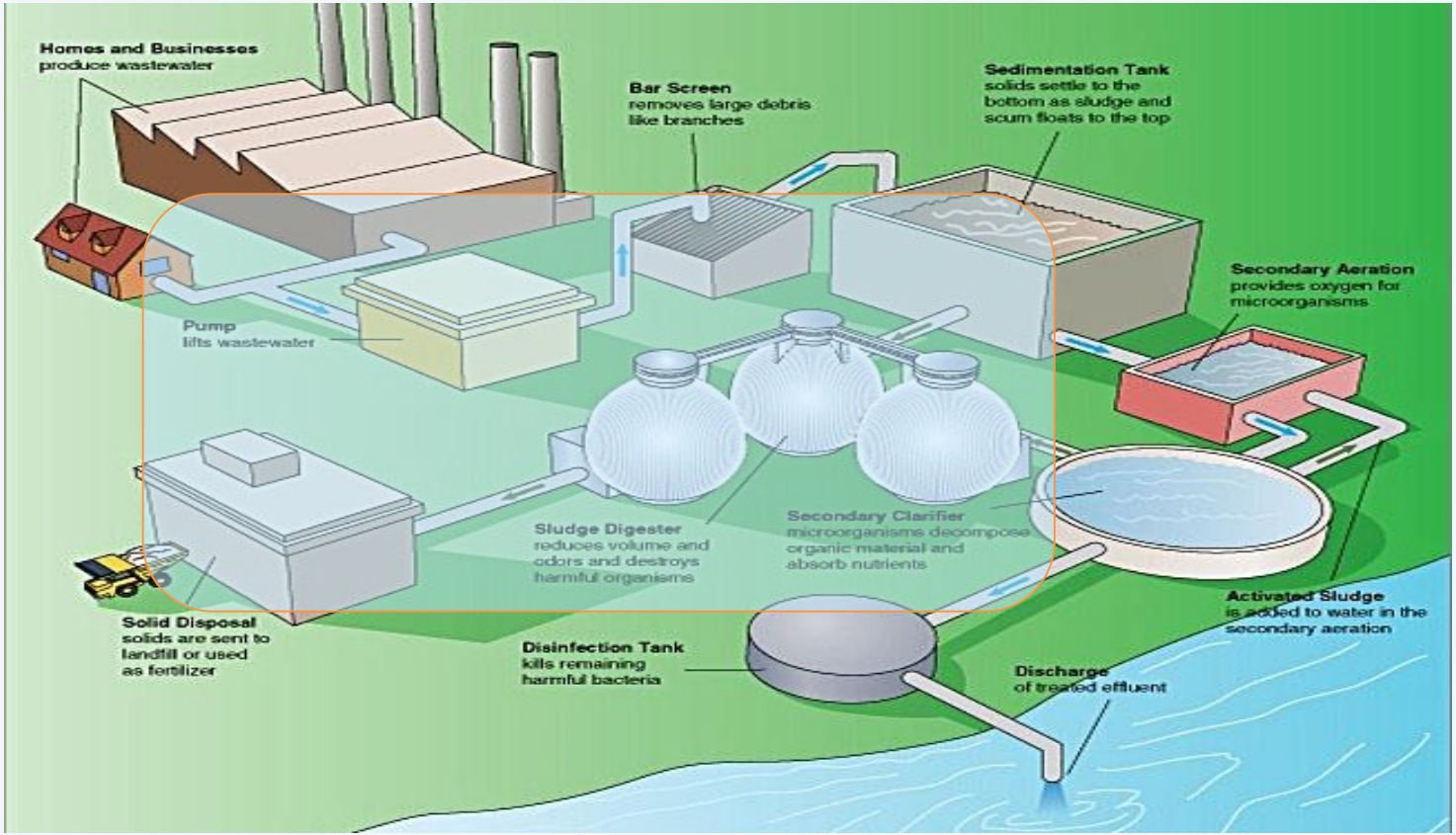


Dissolved Air Flotation (DAF)

Micro (Drum) Screening

HydroTech

Organics: Energy recovery and bioplastics



Digestion of organic waste and sludge

Waste minimisation and max bio-energy production:

- Decrease of final waste production due organic waste conversion;
- Decrease water content for further handling;
- Sludge stabilisation to prevent uncontrolled decomposing;
- Odour and pathogen reduction for a more hygienic product;
- Generation of power (and heat).

Cost reductions:

- Mostly reduced by decreasing volume of sludge;
- Reduced amount and volume lowers transportation costs;
- Disposal options reduced by controls on land filling and agricultural use.

Several choices of optimizing digestion process

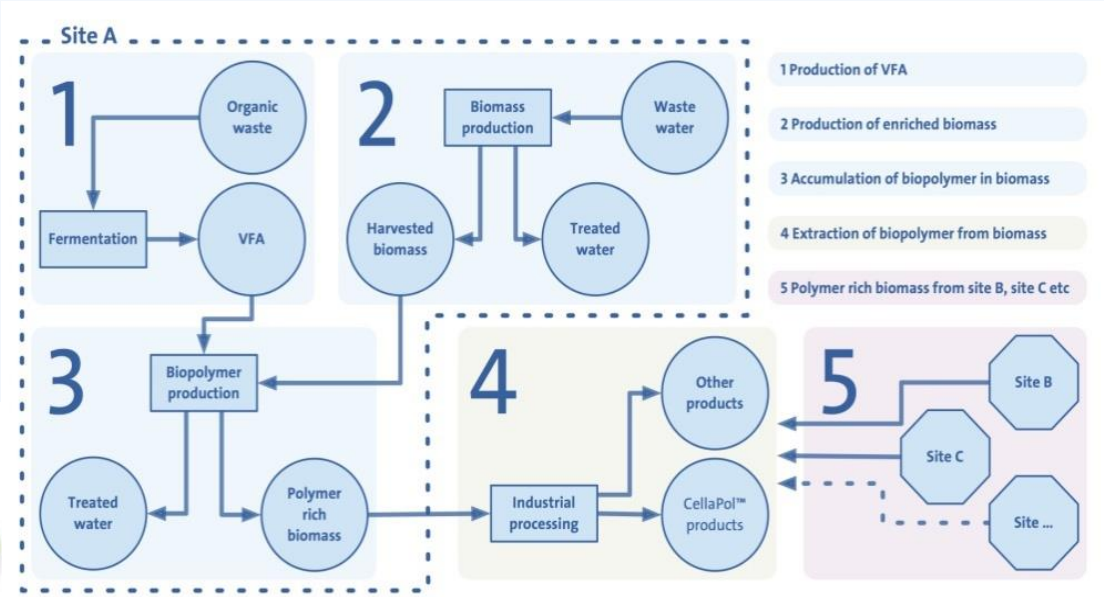
- Affects waste reduction methane generation phase of digestion;
- **Mesophilic digestion**: 30 – 40 °C, retention time of 15 – 25 days. Stable, traditional (inefficient) technology;
- **Thermophilic digestion**: 45 – 55 °C, retention time of 10 – 15 days. Requires more control but greater biogas yield;
- Advanced Digestion: **Thermal Pressure Hydrolysis**: Pre-treat sludge at 160°C and high pressure (6-7 bars), up to 40% more biogas, Class A Biosolid production.

Reference Project – Amsterdam West Harbour Area

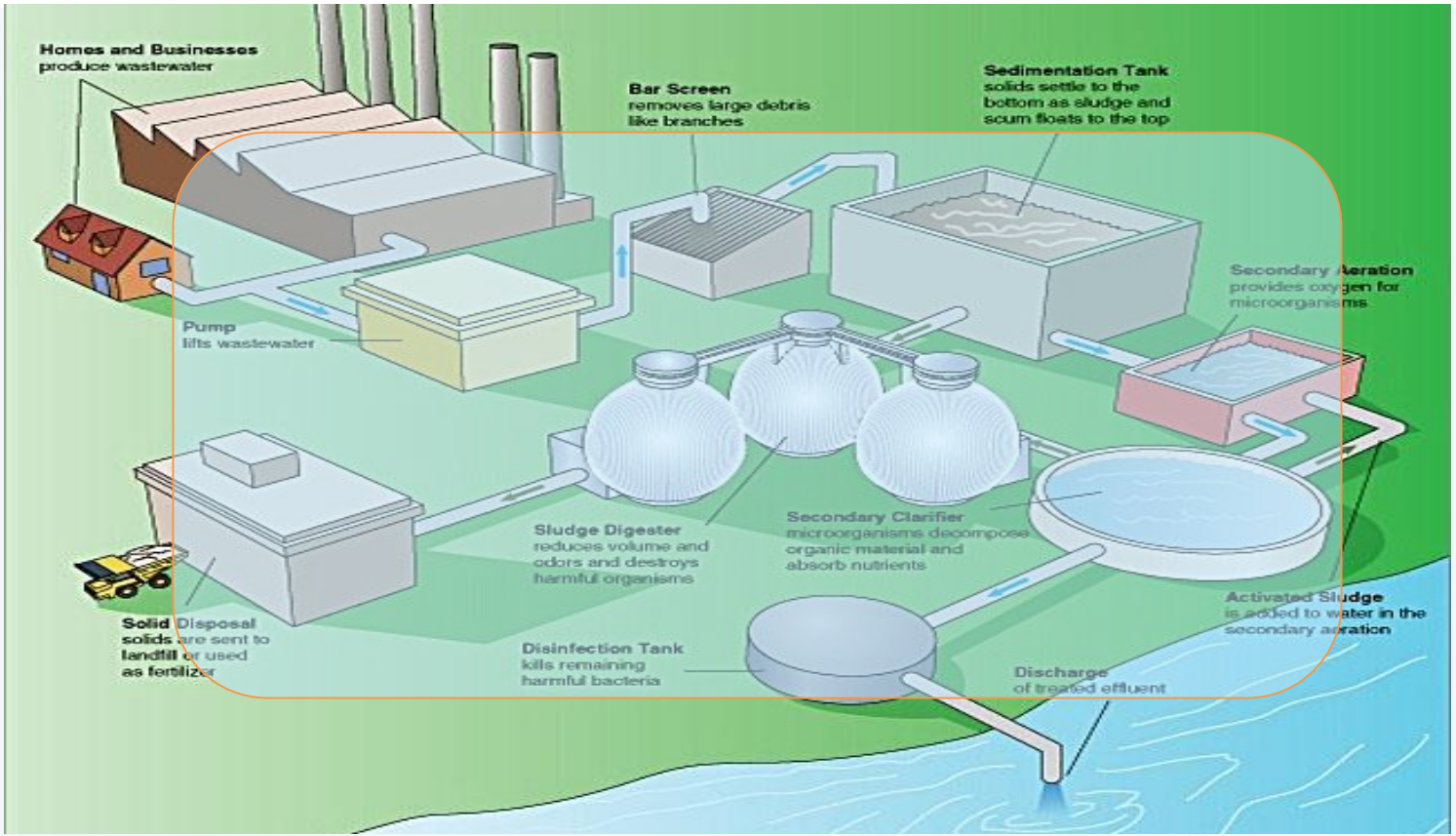
Further up-valuation of organic material: bio-plastic production

PHA from waste

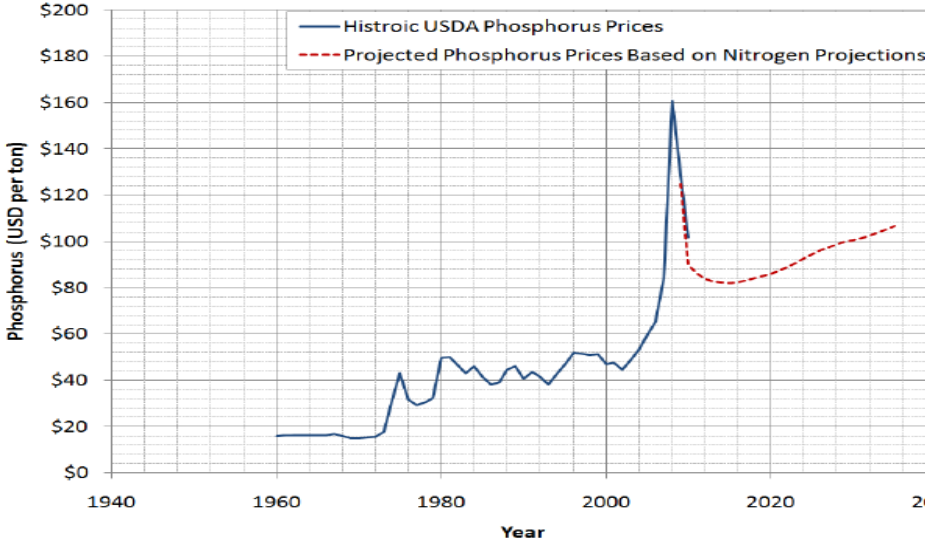
- PolyHydroxyAlkanoaat
- Biological degradable polyester
- Process under development
- High value product

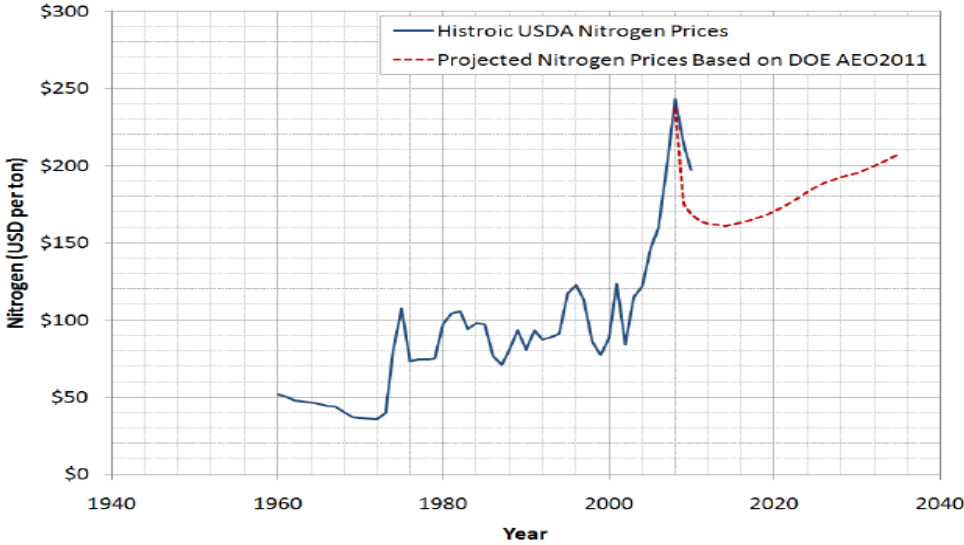


Resource Recovery: Nutrient and Cellulose Recovery



Market price developments (Phosphorous)





P+N recovery by Struvite:

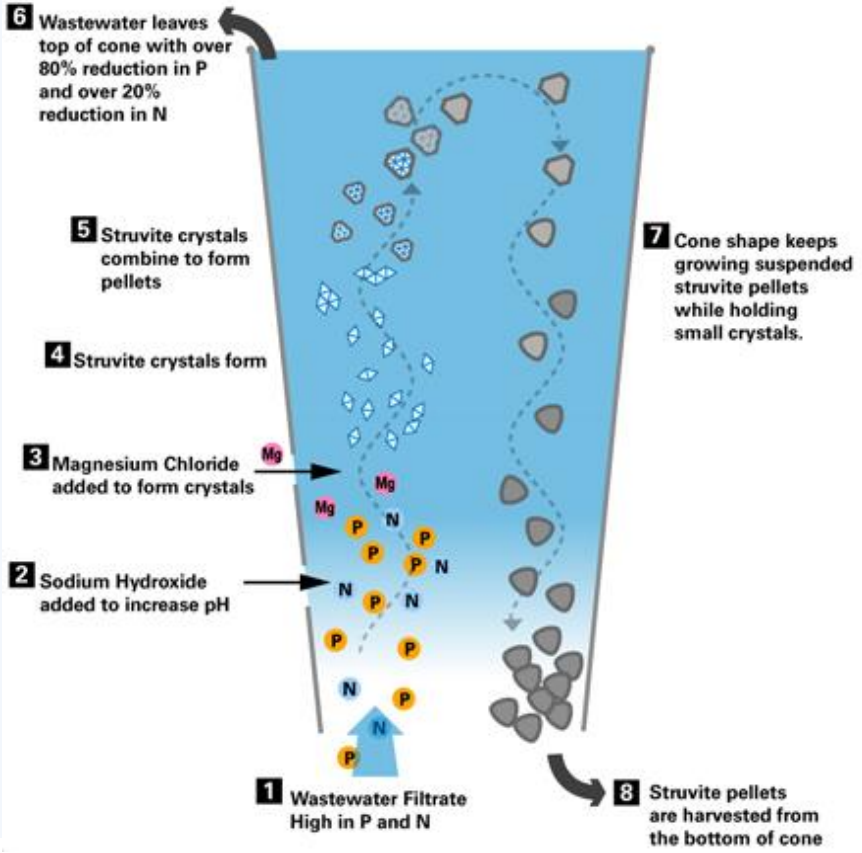
$MgNH_4PO_4 . 6 H_20$

Focus of P recovery

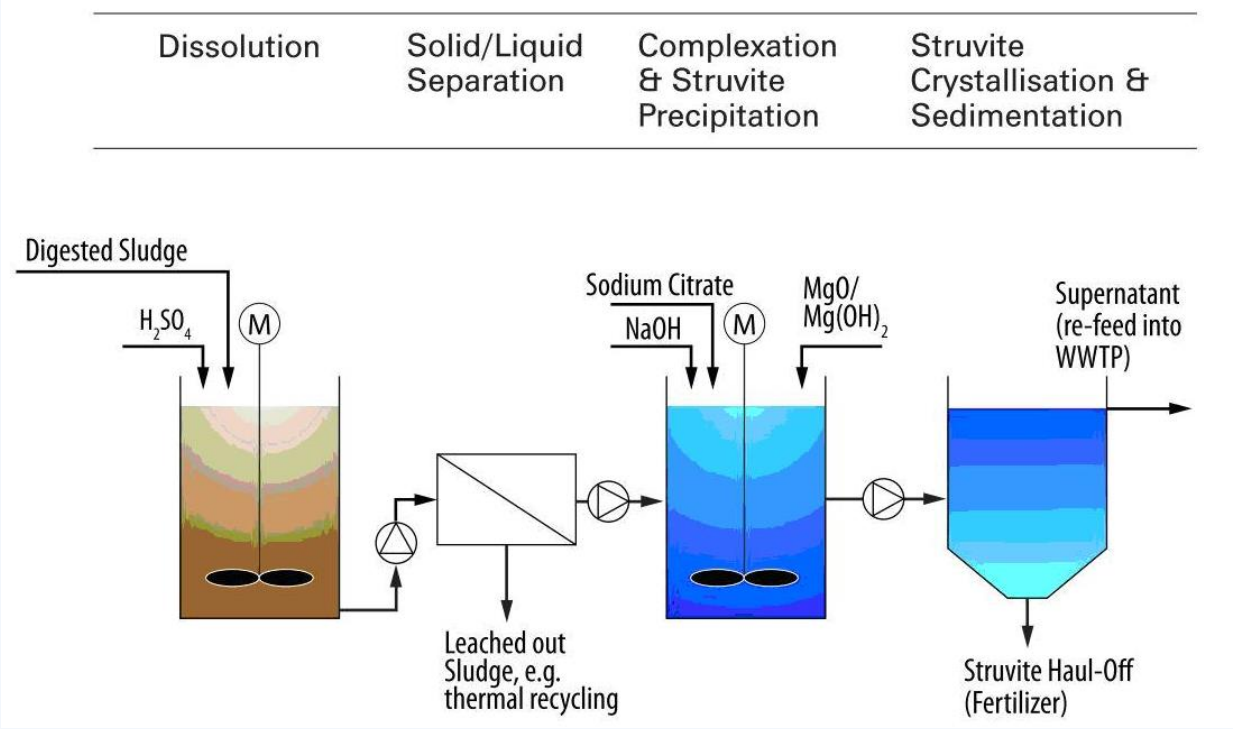
(limited resource)

Also N recovery

(energetically interesting)



Struvite processes

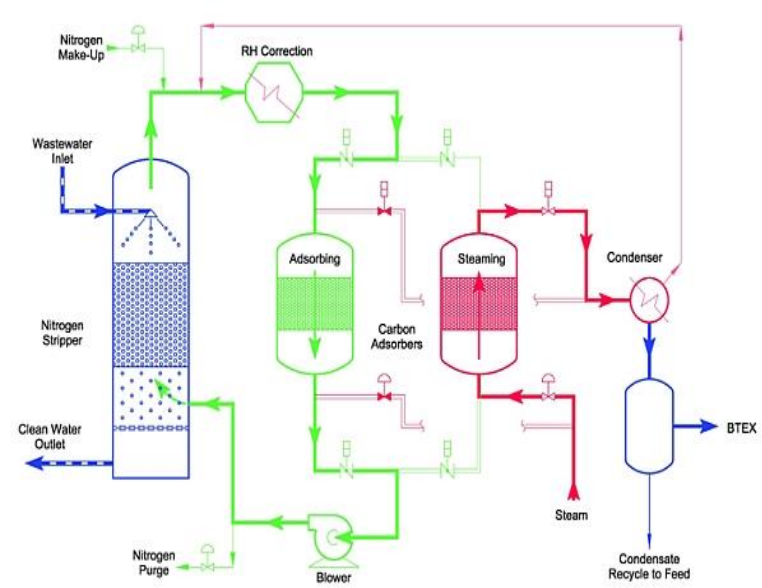


Struvite installations

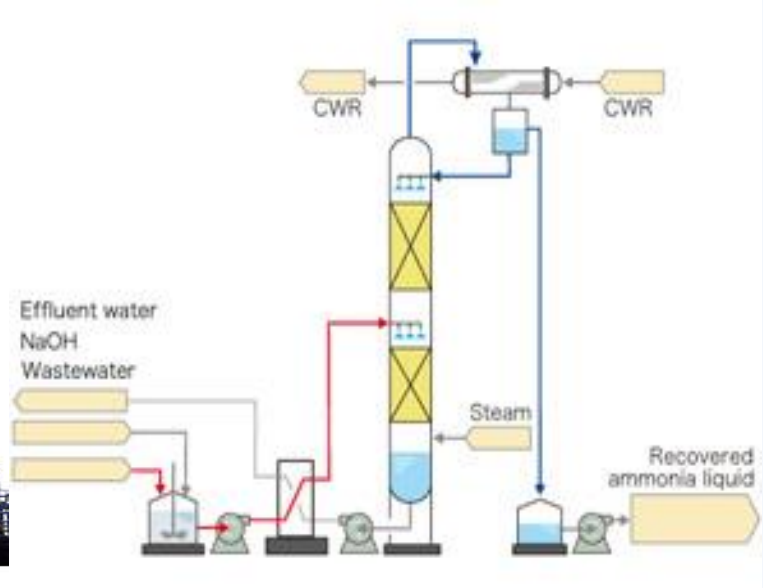
Nitrogen recovery routes

Mainly Ammonia stripping (from NH_4 enriched water of off gas flows)

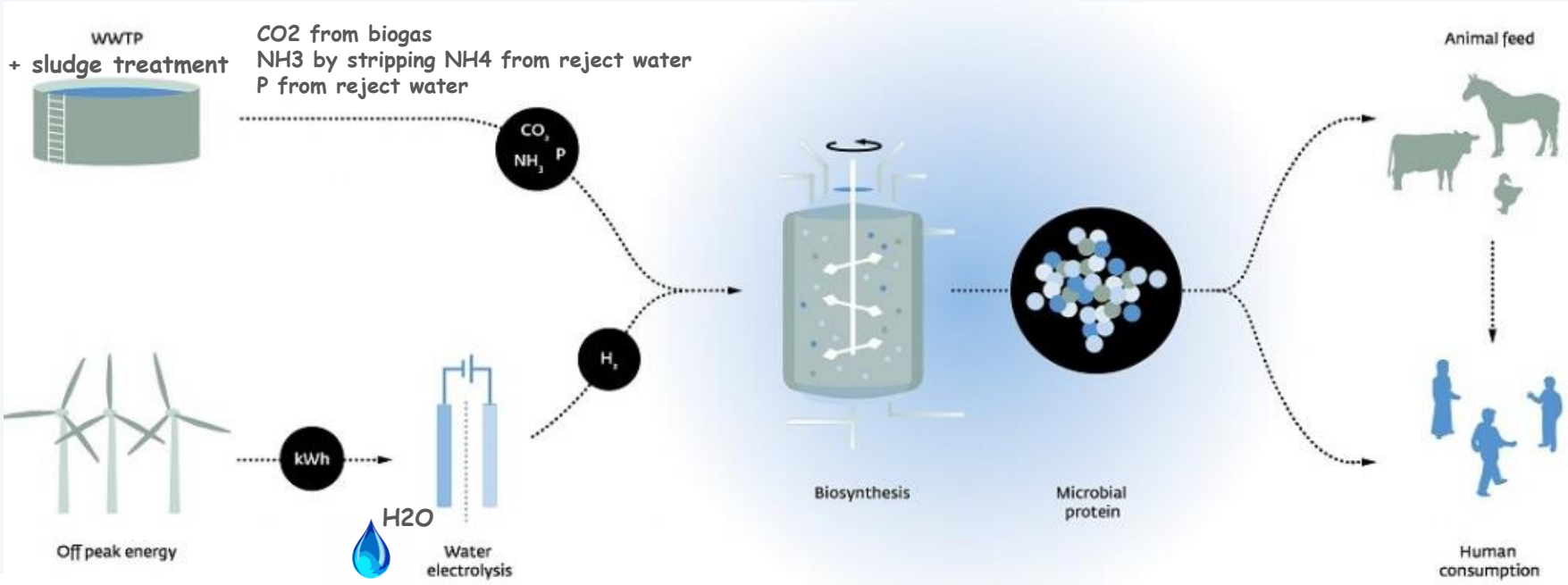
- Ammonia sulphate $(NH_4)_2SO_4$ products
- Ammonia Nitrate NH_4NO_3 products



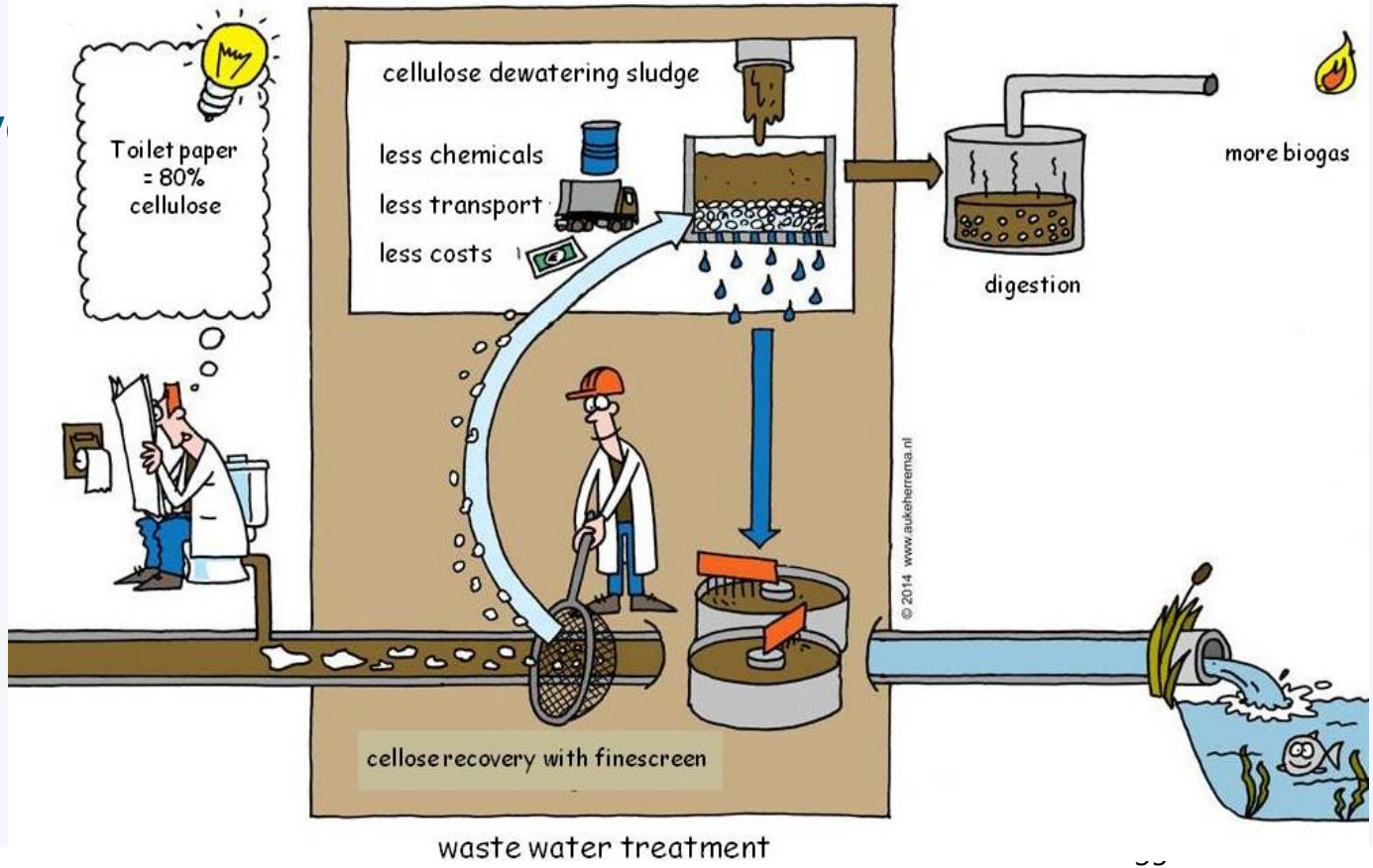
Ammonia Separation and Recovery Process



Power to Protein concept (under development)
UGent, Dutch waterboards, KWR, W+B



Cellulose recov



Selected reference Waste2Value projects of W+B

- Energy & Resource Factory Apeldoorn: TPH TurboTec + Thermophilic digestion + P+N struvite from digestate + centrate
- Energy & Resource Recovery WWTP Tilburg: TPH Cambi + P+N struvite from centrate
- Energy Factory Bath: thermophilc digestion
- Design Waste2Value Resource Recovery Plant – Manila: Digestion + trial TPH + Fertilizer production and Class A Biosolids
- Energy Factory Henglo: TPH Cambi system selection
- Faecal Sludge Valuation Plant Accra – Ghana
- Salt recovery SIX Brine WTP Andijk – Demo and Full Scale Design
- Treatment and Metal recovery from bottom ash Waste Incineration Plant AEB Amsterdam West

Energy and Resource Factory Apeldoorn

Energy and Resource Factory Apeldoorn

Energy+Resource Factory Apeldoorn: Energy, P and N

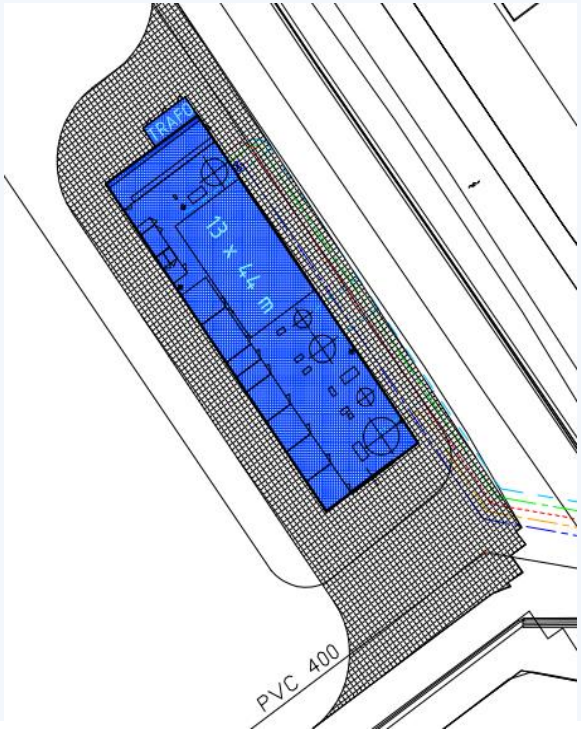
Energy and Resource Recovery WWTP Tilburg

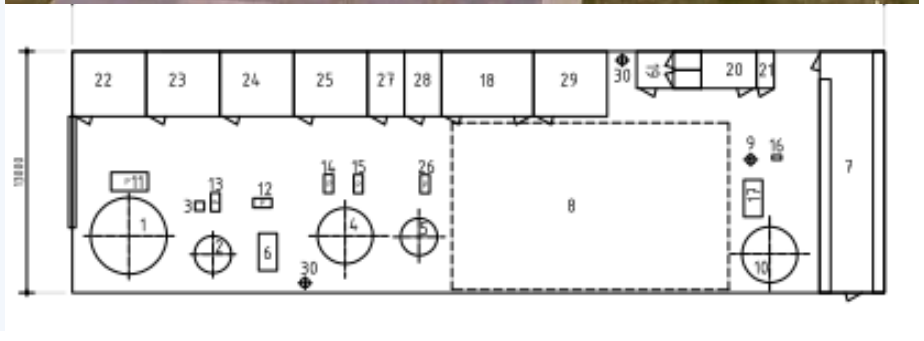
Energy Factory Hengelo: Integration of Cambi Thermal Hydrolysis Process

Energy Factory Bath

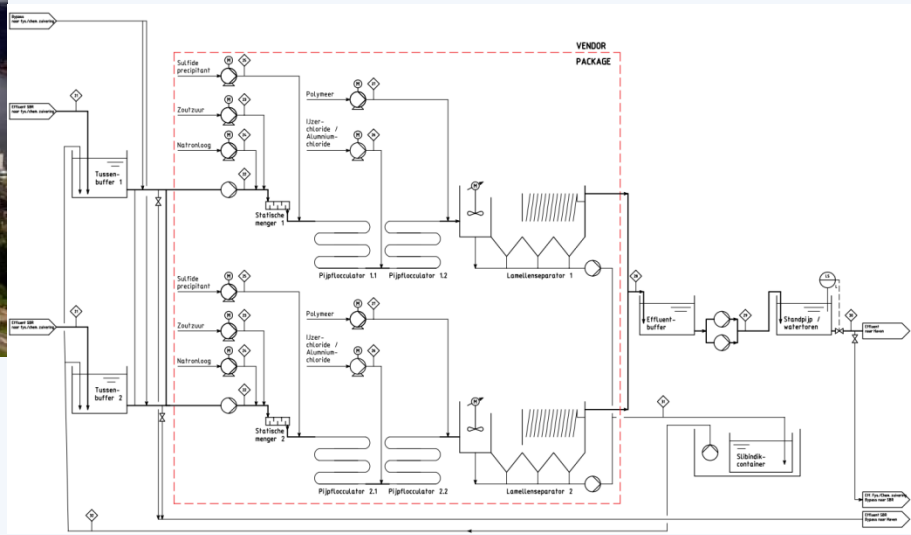

Energy Factory Nieuwveer
Digestion
Biomass storage facilities
Biogas and engine
Heating
Biomass processing

Salt Recovery from brine by EDR Technology





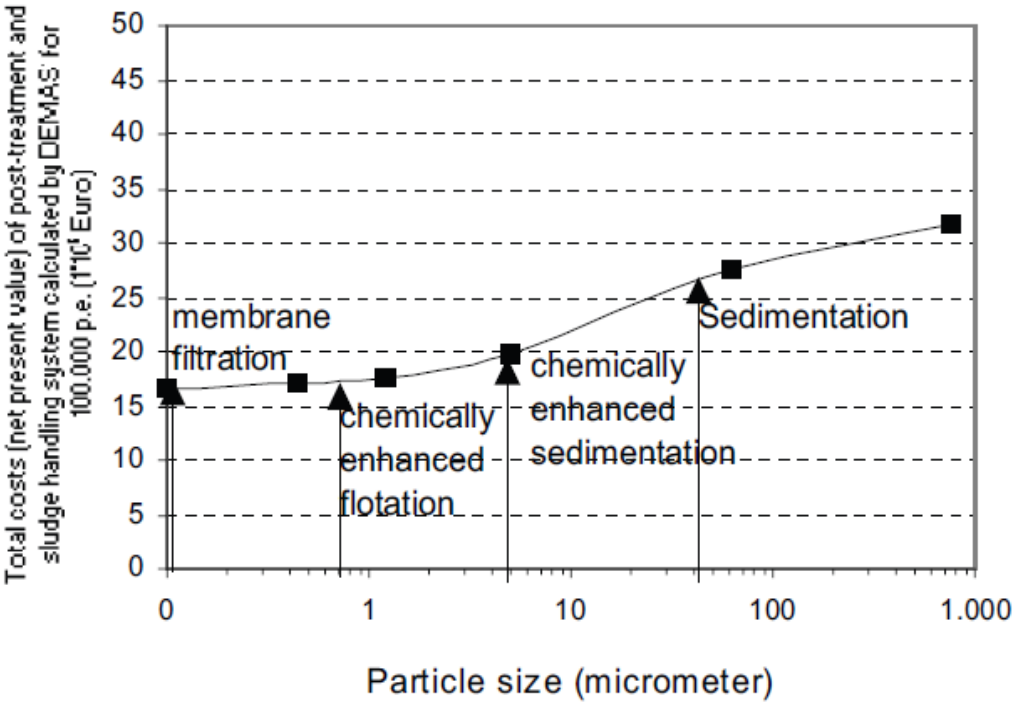
Metal Recovery at Treatment Bottom Ash Water



Questions?

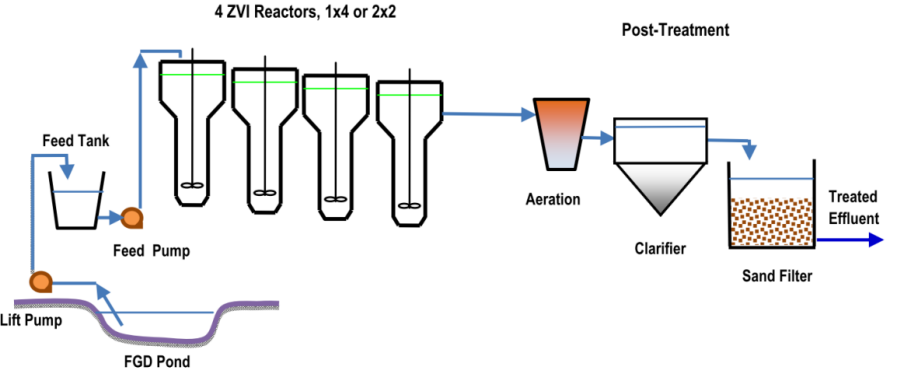
arjen.van.nieuwenhuijzen@witteveenbos.com

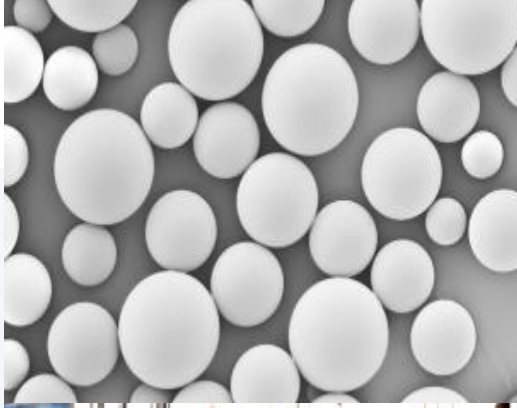
www.witteveenbos.com


Total costs (net present value) of post-treatment and sludge handling system calculated by DEMAS for 100.000 p.e. (1*10⁶ Euro)
50
45
40
35
30
25
20
15
10
5
0
membrane filtration
chemically enhanced flotation
chemically enhanced sedimentation
Sedimentation
0
1
10
100
1.000
Particle size (micrometer)

Metal removal and recovery

- Innovative selective technologies
  - Molecular Imprinted Polymers (MIP): platinum, silver, titanium
  - Activated Iron Technology: selenium, arsenic and mercury
  - Metal precipitation technologies (sulphide)

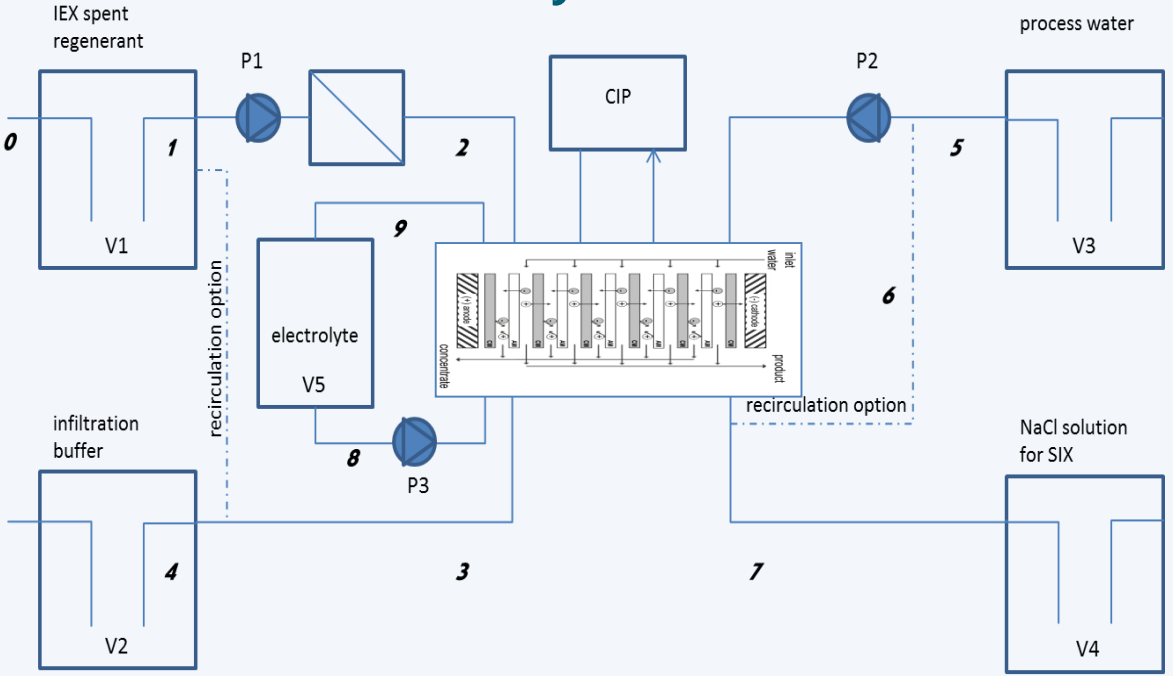




Salt recovery from brines, concentrates, salty waste waters

- selective recovery Cl, Na, SO4
- Electro Dialysis (Reverse) EDR
- Forward / Reverse Osmosis

Designed with PWN-T



Witteveen + Bos

STRATEGIC
EUROPEAN
EXPERTISE
NETWORK