Interactive Water Management

Interreg
Baltic Sea Region

EUROPEAN UNION
EUROPEAN REGIONAL DEVELOPMENT FUND

DWA-IWAMA-2nd International Capacity Development Workshop „Energy Production in WWT“

EMSCHER GENOSSENSCHAFT EGLV.DE LIPPE VERBAND

Possibilities of sludge disintegration

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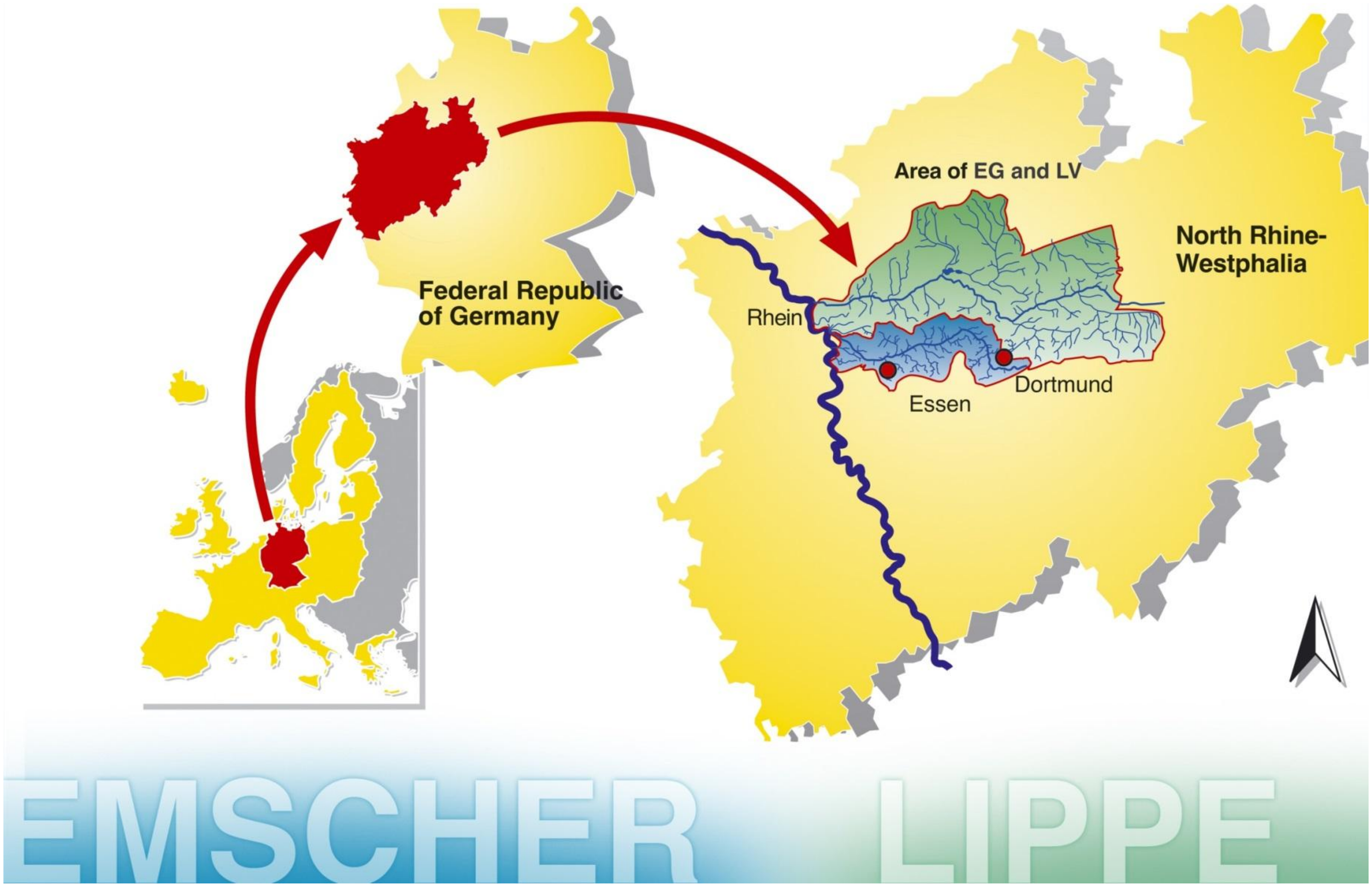
Content

CV – Personal Details

- Karl-Georg Schmelz
- 56 years, married, 3 Kids
- Since 1990 working for Emschergenossenschaft and Lippeverband
- Misc. working areas, currently in the R&D departement, responsible for sewage sludge and industrial wastewater
- Member of different specialist groups of the DWA (i.a. DWA KEK 1.6: Sewage Sludge Disintegration“)
- Education of WWTP-operators and students at the University Duisburg-Essen

Operating Area EG/LV



Our catchment area

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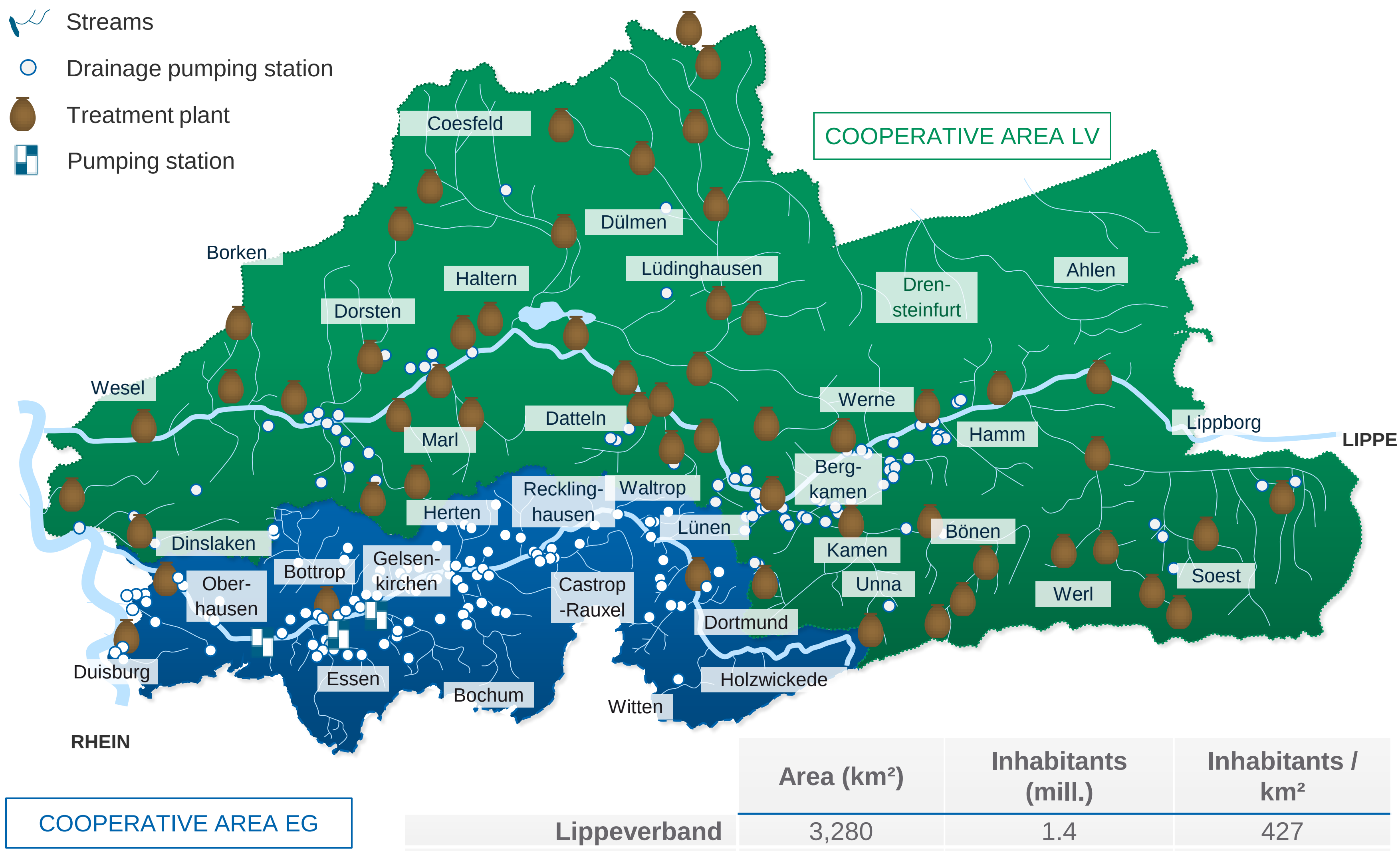

	Area (km²)	Inhabitants (mill.)	Inhabitants / km²
Lippeverband	3,280	1.4	427
Emschergenossenschaft	865	2.2	2,546

Sewage Sludge Disintegration
DWA-Specialist Group KEK 1.6

- **Merkblatt DWA-M 302 (guidelines)**
  - **Published in December 2016**
- **Specialist group is working since 1996**
  - **6 working documents**
- **Members:**
  - **Müller-Schaper, Johannes (Speaker)**
  - **Bormann, Hinnerk**
  - **Heinzmann, Bernd**
  - **Kopplow, Ole**
  - **Oles, Jürgen**
  - **Rand, Wiebke**
  - **Schmelz, Karl-Georg**
  - **Seiler, Kainan**
  - **Wagenbach, Anja**

Definition of Sewage Sludge Disintegration

- **Disintegration** of sewage sludge through the **impact of external forces** (physical, chemical, biological)

- **Degree of disintegration** depends on used procedure, energy input and characteristics of sludge
  - Disintegration of flocs (reduction of particle size, destruction of microorganism chains; < 0,1 kWh/ kg DS)
  - Disintegration of cells (> 0,25 kWh/kg DS)

- **Objectives:**
  - Increase bioavailability of the organic carbon
  - improvement of the sludge characteristics

Disintegration of sewage sludge

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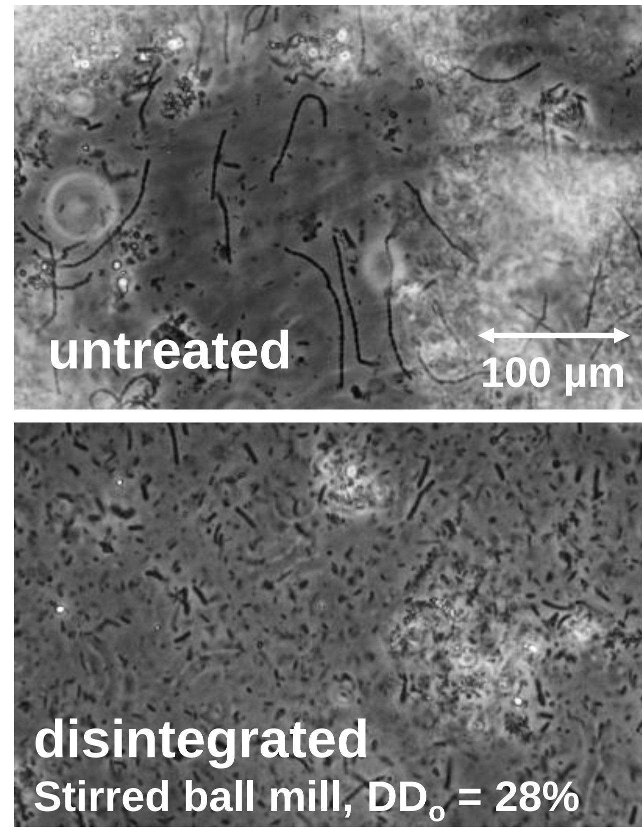
Application of physical, chemical, biological forces

↓

- **Destruction of flocs**
- **Disruption of micro-organisms**

↓ **= Disintegration**

- **Decrease in particle size**
- **Increase in soluble compounds (C, N, P)**



Pre-treatment of sewage sludge

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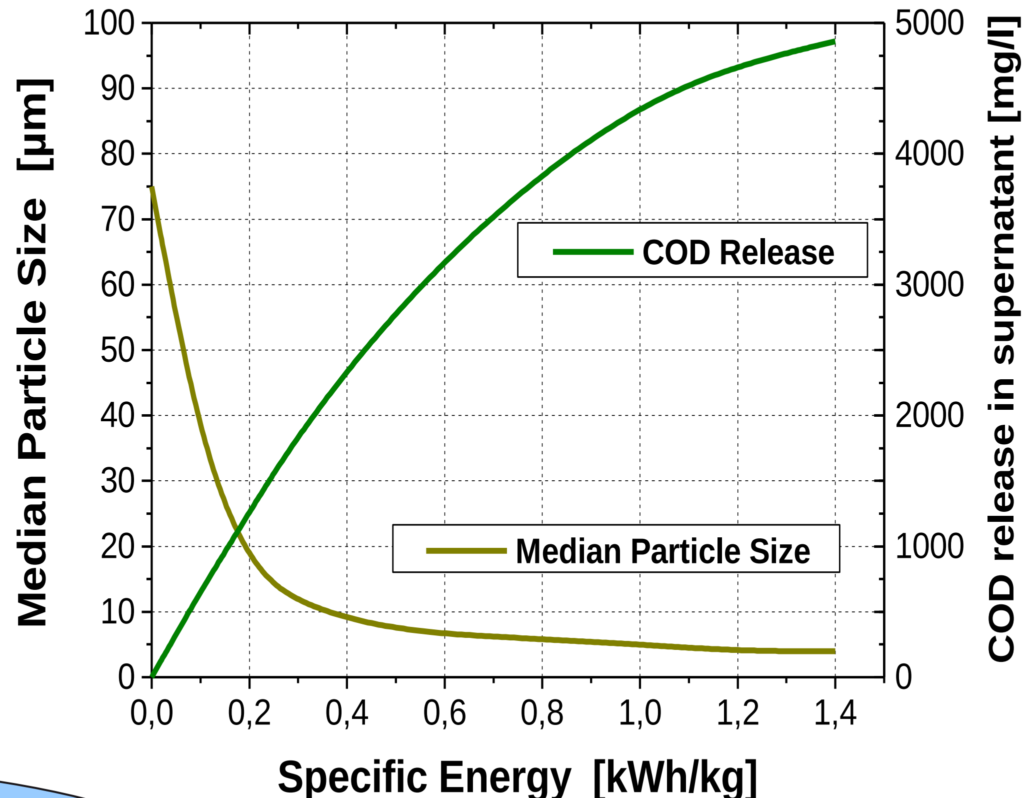
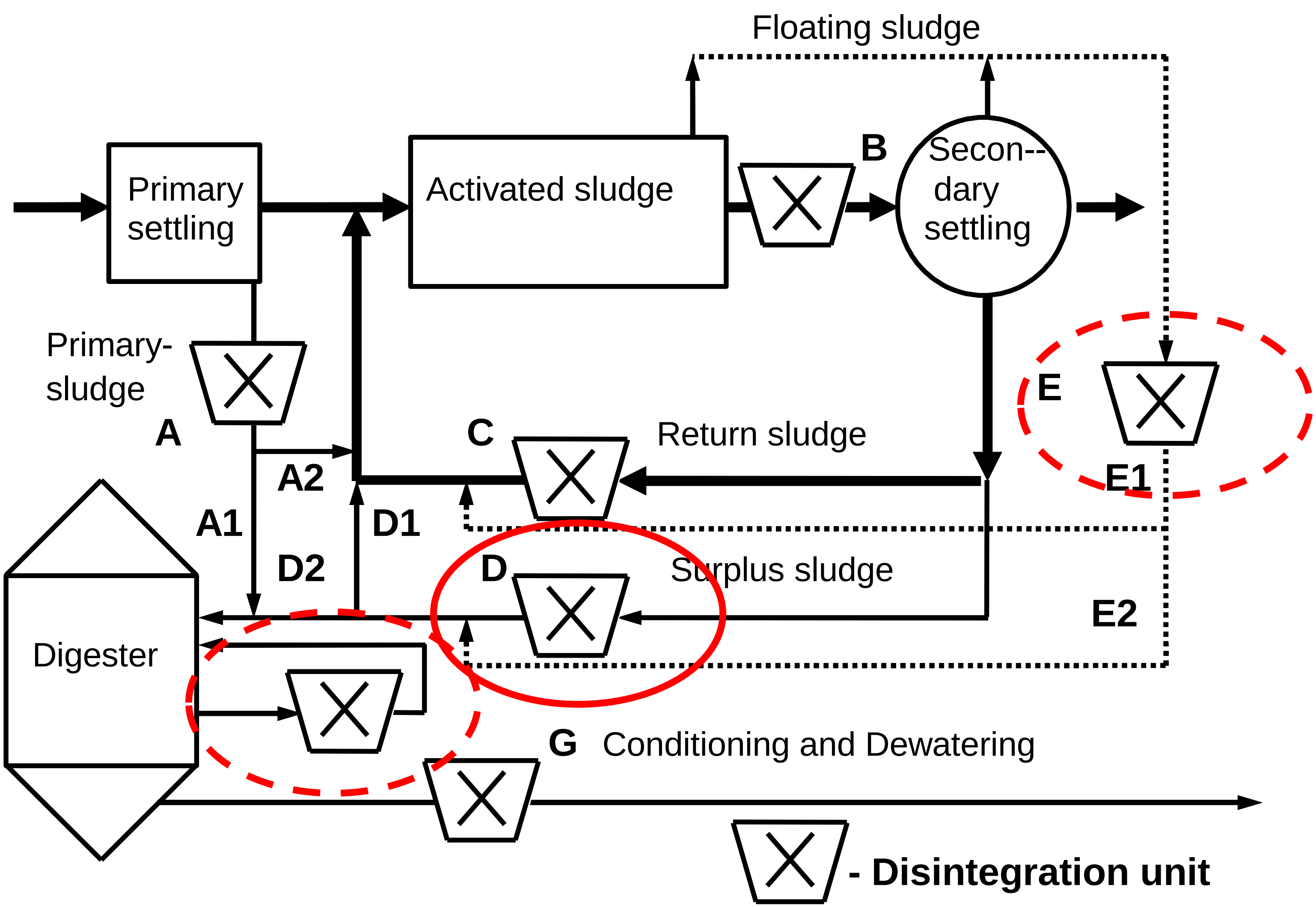


- Decrease in particle size
- Increase in soluble compounds (C, N, P)

Locations for disintegration



Areas of Application *(selection)*

- **Optimisation of digesting process**
  - Increase of biogas production
  - Reduction of sludge amount
  - Improvement of dewatering behaviour
- **Prevention / Reduction of operating problems**
  - Reduction of bulking sludge and foam
  - Improvement of settling characteristics
  - Prevention of cloggings
  - Reduction of sludge viscosity

Secondary effects (selection)

- Increased return load of WWTP (COD, N, P, particles)
- Reduction of particle size (higher demand of polymers or change of polymers)
- Formation of organic compounds with low bioavailability
- Increase of pollutant-concentrations (e.g. heavy metals)
- Odour

Methods for the Disintegration of sludge

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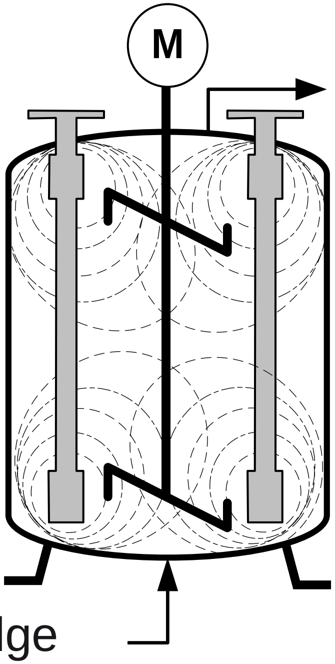
- **Mechanical disintegration**
  ultrasonic, mills, high pressure homogenisers, lysat centrifuge and other
- **Heat treatment**
  temperature range from 80 to 180 °C, heat exchangers or direct steam
- **Oxidation processes**
  partial oxidation using ozone and hydrogen peroxide
- **Biological treatment**
  Autolytic processes, enzyme dosage, special micro-organisms, detergents, micronutrients
- **Chemical treatment**
  using acids or alcali, pH values below 2 or over 12
- **Freeze/thaw-treatment**
  natural or technical freezing
- **Combinations**
  Heat/chemical, Mechanical/biological and other

Methods available for full scale operation

Ultrasonic Disintegration

- Generation of acustic waves with high frequency (> 20 kHz)
- Compression and expansion of the medium
- Cavitation and collapse of steam bubbles
- Destruction of flocs and cells through shear forces

Ultrasonic Disintegration Example: VTA



Reference: VTA

Ultrasonic Disintegration
Example: Ultrawaves/Sonotronic

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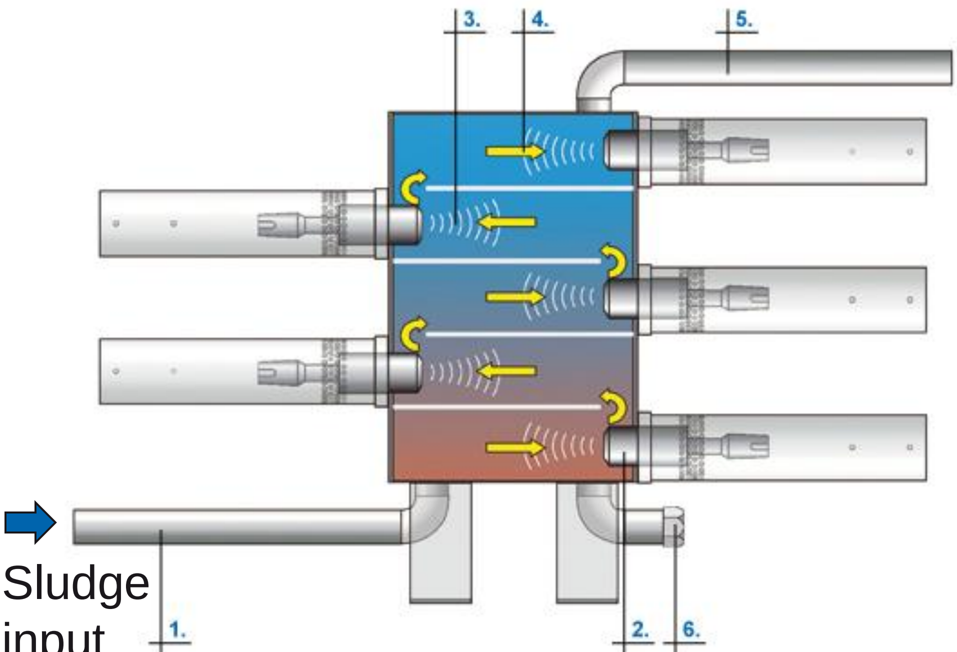

Thermal Disintegration

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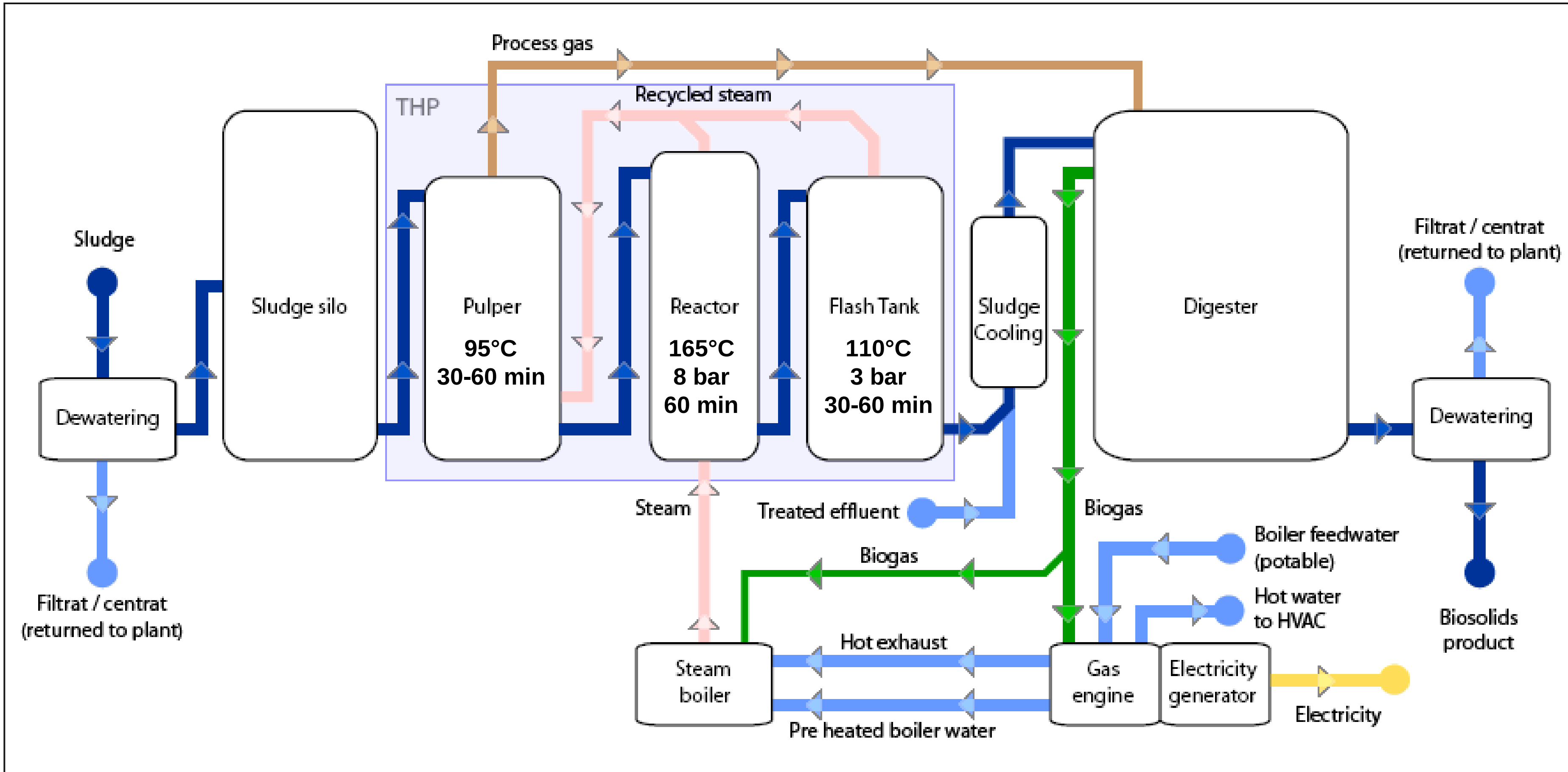
- Input of heat (< 100 °C normal pressure, > 100 °C high pressure)
- Use of heat exchangers or steam injection
- Chemical and physical reactions
- Changes in cell-structure
- Break up of bio-chemical structures
- From 170 °C up increase of hardly biodegradable compounds (Maillard-reaction)

Thermal hydrolysis

- **Provider:** Cambi, Veolia, (Stulz), Haarslev …
- Working temperature 150 – 170 °C
- Input of heat: generally by steam injection

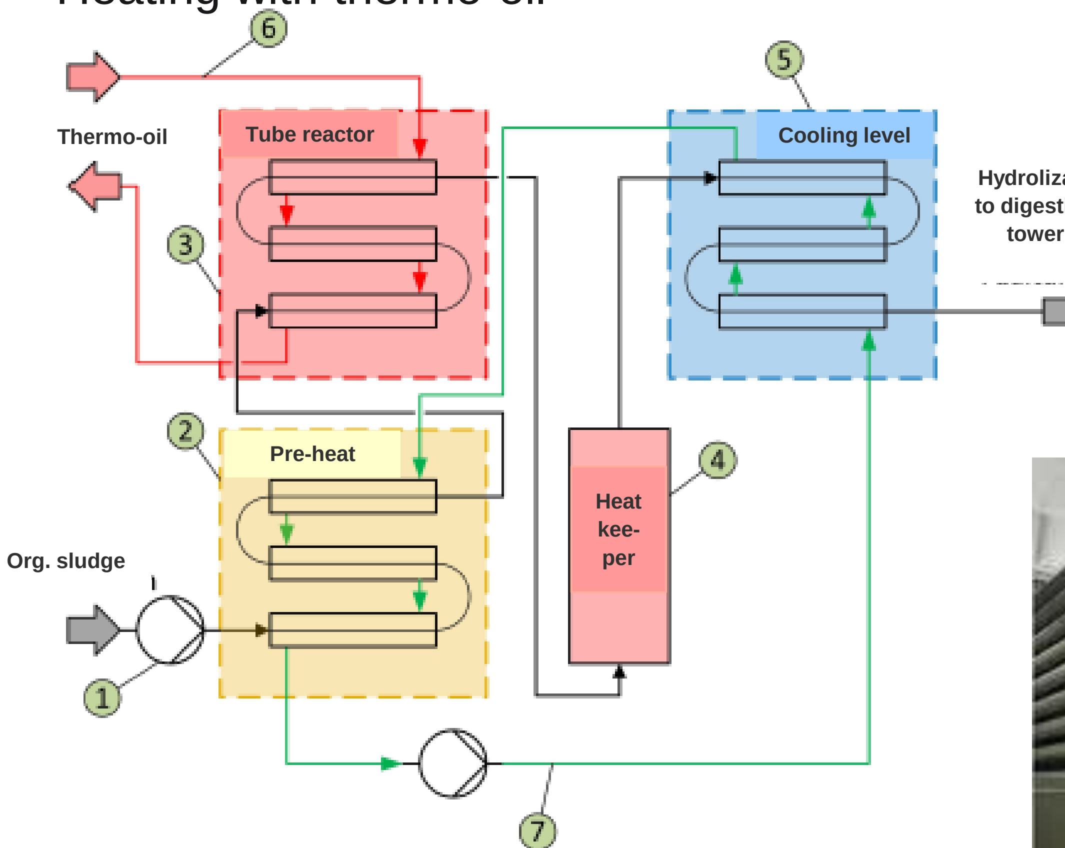
Thermal hydrolysis
Example: CAMBI



1 plant was operated in Germany (Geiselbullach)

Thermal disintegration
Example: Stulz (Lysotherm)

Heating with thermo-oil



1 operating plant in Germany (Lingen)

Chemical-thermal disintegration
Example: Pondus

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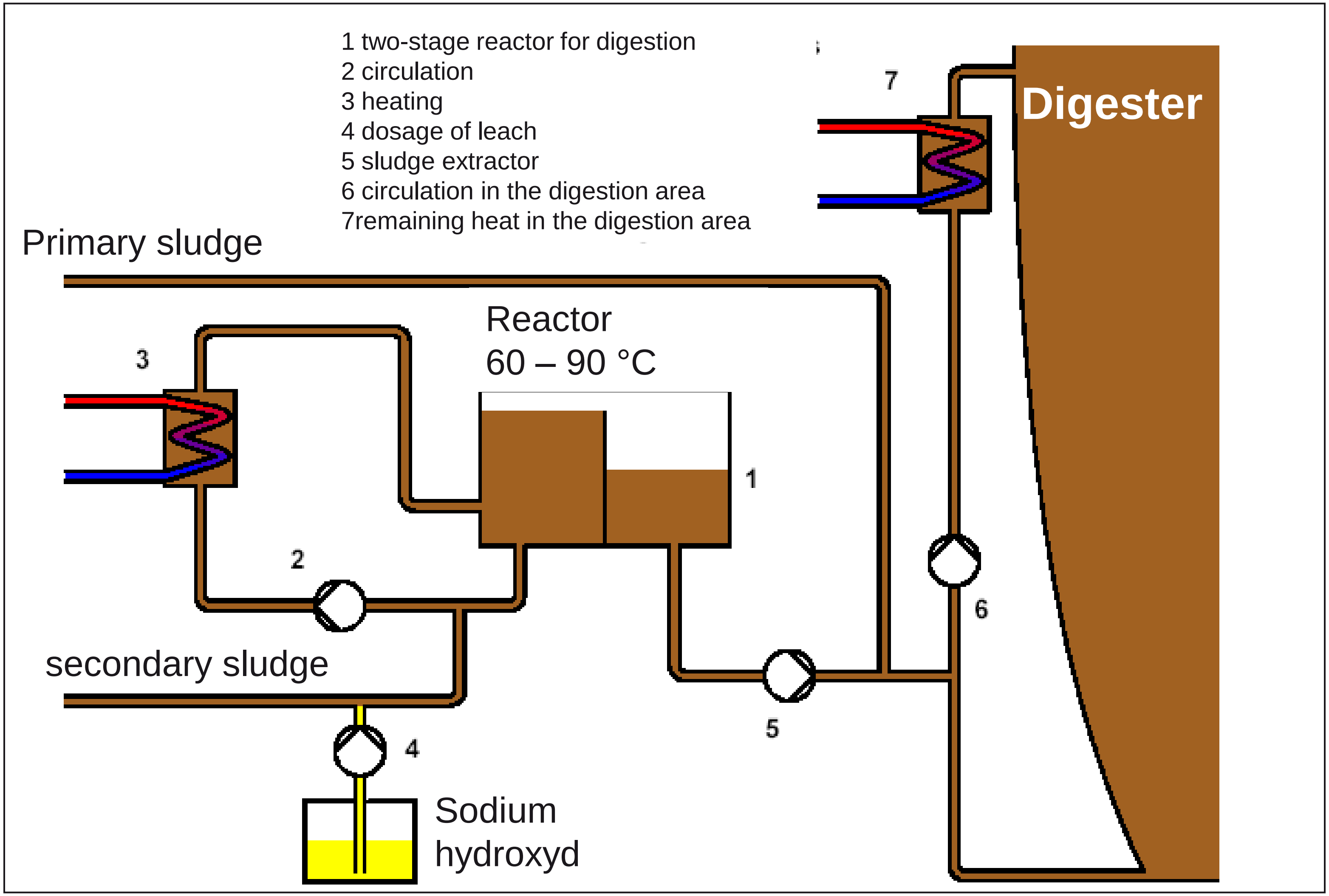

Chemical-thermal disintegration Example: Pondus

- Treatment-temperature between 60 and 90 °C
- Additional dosage of sodium hydroxyd (ca. 2 l/m³)
- Use of exeed heat of the CHPP by heat exchanger
- Several operating facilities in Ger-many (Gifhorn, Ratekau, Uelzen)
- Capacity 700 - 1 000 t DS/a surplus sludge

Enzymes

- Catalysing the degradation
- Enzymes are specific for substrate and effect
  - „key - lock – principle“
- Speeding up the degradation of long-chained compounds
- Start up-dosage at the beginning (inoculation)
- Further dosage dependent on the sludge amount

Assessment of selected techniques

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- **Ultrasonic**
  - Simple to integrate, low investment
  - Limited effects (more biogas, low effect on dewatering result, effects direct dependent on energy input)
  - Reasonable e.g. for poor working digesters
- **Thermal Disintegration**
  - Medium investment for thermal-chemical disintegration (→medium sized WWTPs)
  - High investment for thermal hydrolysis (→ big WWTPs)
  - Significant increase of gas production and degradation
  - Improvement of dewaterability
- **Enzyms**
  - Mainly product-costs, very low investment
  - Limited effects (more biogas, improvement of clogging problems, very specific on the sludge)

Results (overview)

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	Method	Results	Remarks
mechanical	mechanical 0,5 KWh/m³ – 20 KWh/m³	A_{CSB} up to 20 %; η_{oTM} up to 50 % higher; sometimes better settling behaviour and reduced foam	• Need of electric energy; • Chemical composition is not changing if temperature is constant; • Ultrasonic is used on several WWTPs
thermal	thermal 130 °C – 180 °C 130 kWh_{th}/m³ – 190 kWh_{th} /m³	A_{CSB} up to 50 %; η_{oTM} up to 70 % higher; less foam, better dewatering results	• Heat-energy cheaper than electric energy • Heat recovery up to 95 % possible • Formation of heavily degradable compounds • Desinfection of the sludge possible • several facilities for thermal treatment (160 – 180 °C) in Europe
electro-magnetic	High-performance pulse technique, electro-kinetic disintegration		• Only few investigations • Low operating costs, simple to integrate • Several operating facilities

Results (overview)

	Technique	Results	Remarks
chemical	Hydrolysis	with chemicals A_{COD} up to 100 %;	• Neutralisation of the sludge with acids or bases, salting • Particulary in the industrial WWT
chemical	Oxidation (Ozon) 0,05 g O_3 /g oDM– 0,2 g O_3 /g oDM 0,19 kWh/kg DS and 2,5 kWh/kg DS	Dependent on Ozondosage A_{COD} up to 80 % η_{oDM} up to 20 % higher	• Positive effects with very low ozon-dosages • no current investigations for anaerobic digestion
biologic	Hydrolysis	η_{oDM} up to 30 % higher	• Low investment, easy handling • On some WWTPs in operation, positive effects on floating cover and cloggings possible
combi-nations	Thermal-chemical 60 °C – 70 °C 40 – 50 kWh/m³ NaOH: 1,5 bis 2,0 l/m³	A_{COD} up to 50 %; less foam, better dewatering results	• Use of low temperature heat • Several facilities in Germany

Sewage Sludge Disintegration

Selection of Techniques

Target for degree of disintegration A_{COD}	Generally required energy for disintegration	Suitable Methods
< 10 %	Low <10 kWh/m³	• Electro-kinetic Disintegration • Hydrocavitation • Surfactants • Enzyms • Lysatcentrifuge • Ultrasonic
10 % – 30 %	Medium >10 kWh/m³ – < 50 kWh/m³	• Ultrasonic • High-pressure homogenisers
30 % – 50 %	High > 50 kWh/m³	• Thermal methods • Oxidation (Ozon, H2O2) • Thermal-chemical methods

Application of Sewage Sludge Desingetration
Basic Procedure I

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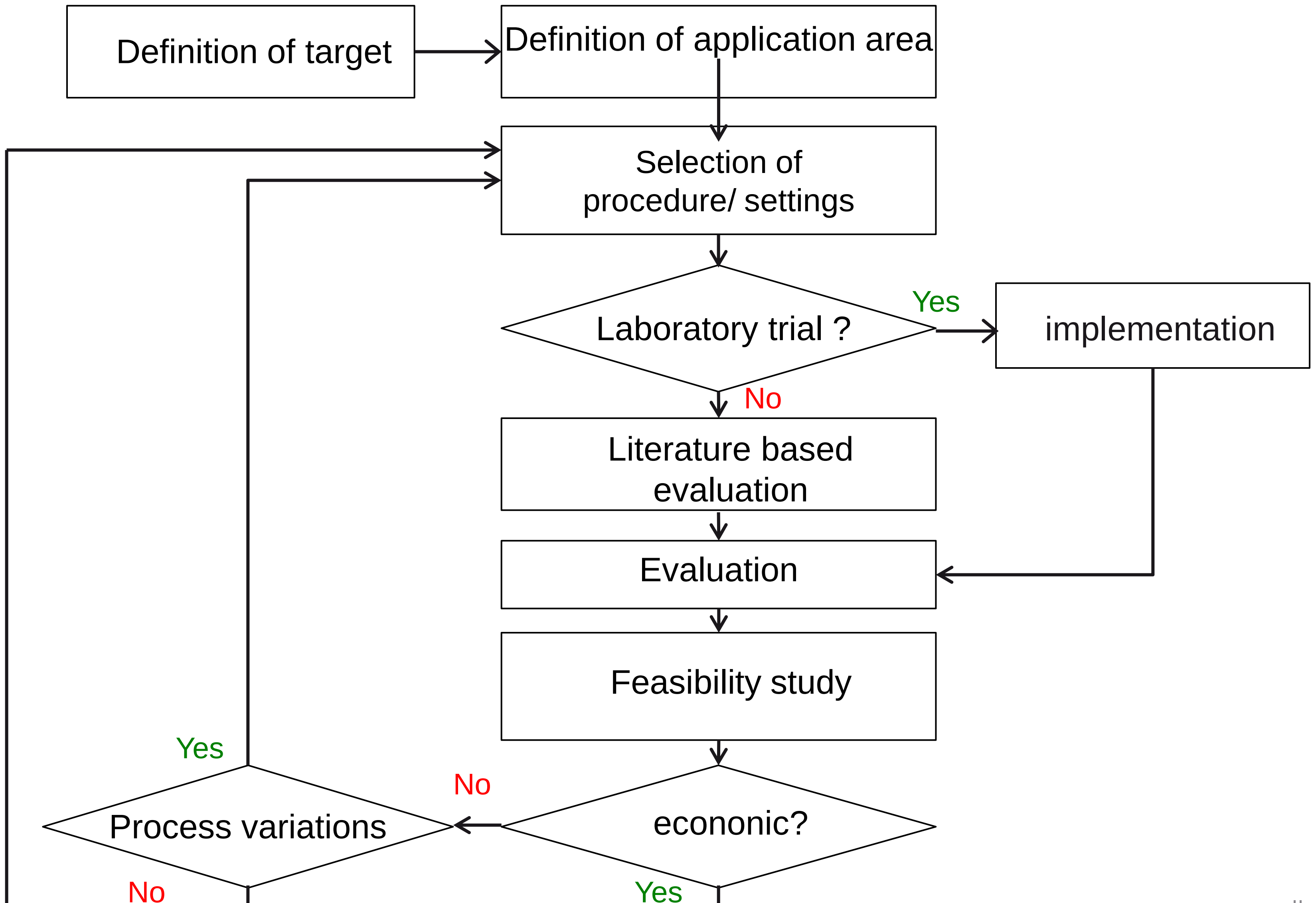
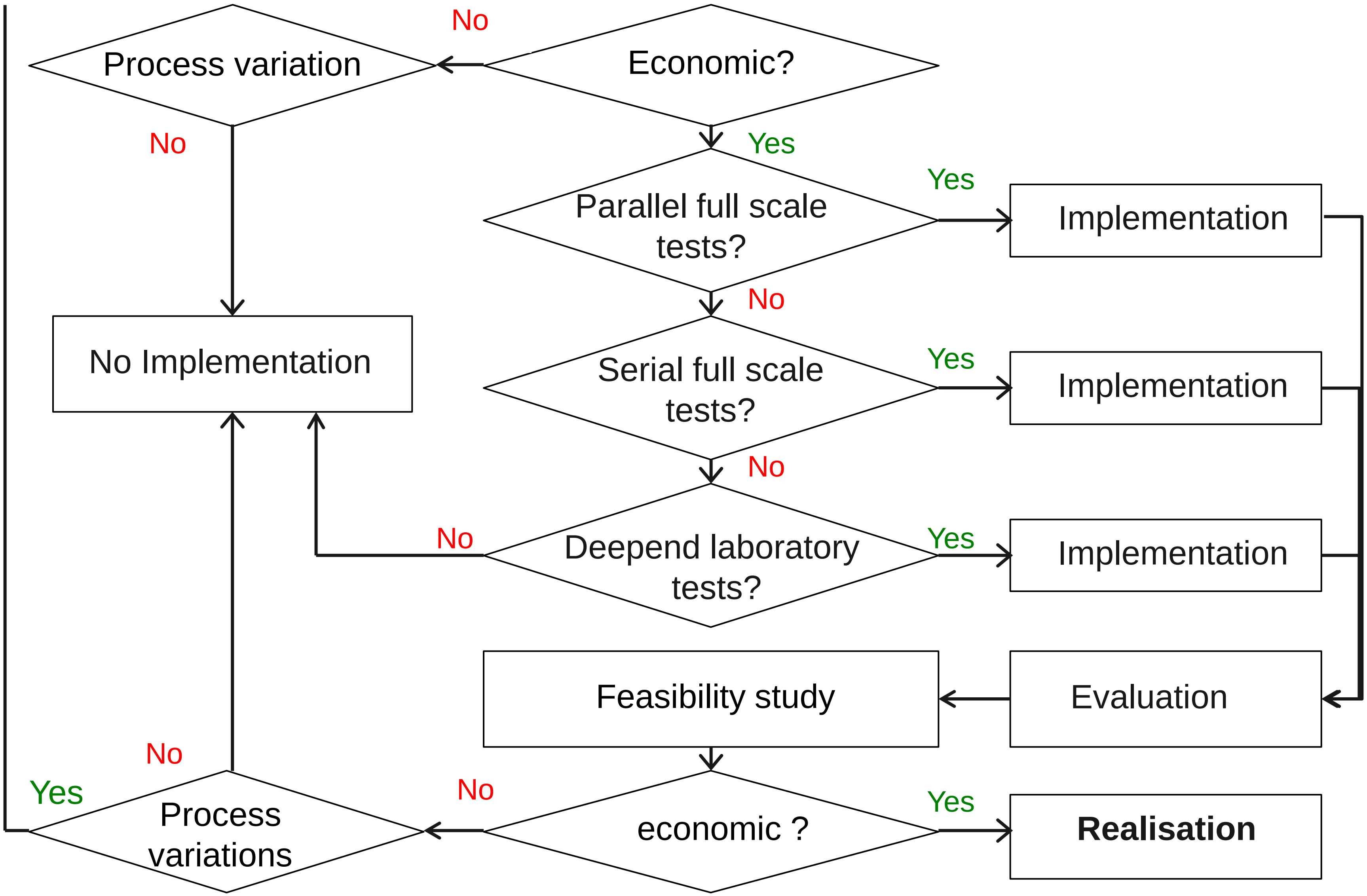


Application of Sewage Sludge Desingetration

Basic Procedure II



Summary

- **Application of Sewage Sludge Disintegration**
  - Preferred in secondary sludge
  - Optimisation of sludge characteristics (viscosity, settling, foam)
  - Relaese of organic carbon for better degredation especially in anerobic digestion
  - Negative secondary effects are possible (N-reload)
  - In most cases a high energy input is needed for a drastic increase of degredation
- **Ultrasonic-, thermal disintegration and dosage of enzymes are sucsessfull for optmisation of anaerobic digestion on several WWTPs**
- **Installing of a disintegration technique requires previous tests**
- **Besides the energy balance, the primary and secondary effects must be considered for an economic application of disintegration on WWTPs**


Thank you for your attention!