



## HIGH-POWER ULTRASOUND TREATMENT TO IMPROVE BIOMASS DIGESTION

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Energenecs

WWOA Oct. 2019

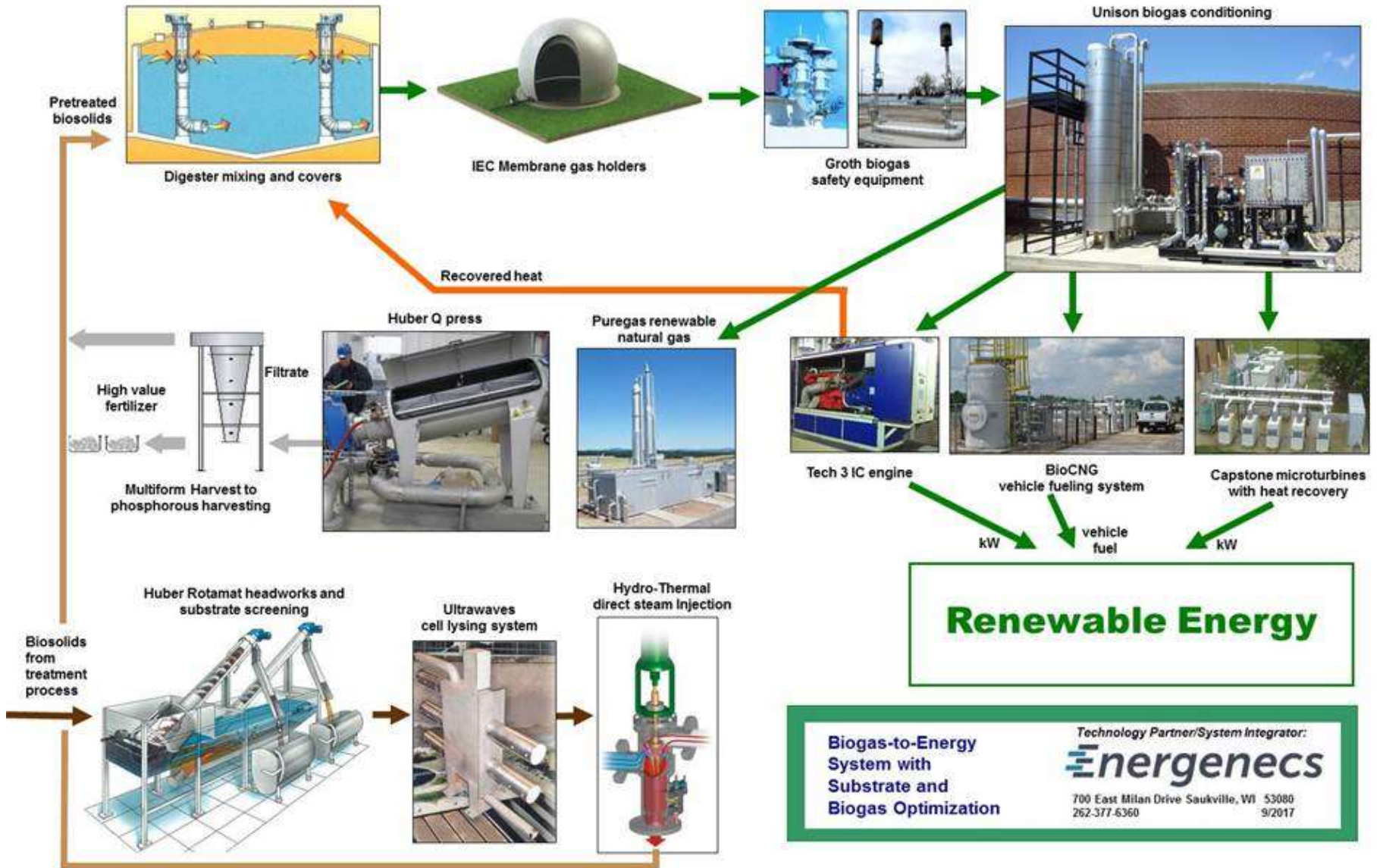
# Who We Are and What We Do

- Water and wastewater system integrator
- 40+ personnel
- Systems approach
- Emphasis on energy efficiency
- Emphasis on cost-effective integration of process and controls

# Corporate Headquarters, Saukville, WI



# Sustainability: Shifting from waste to resource recovery



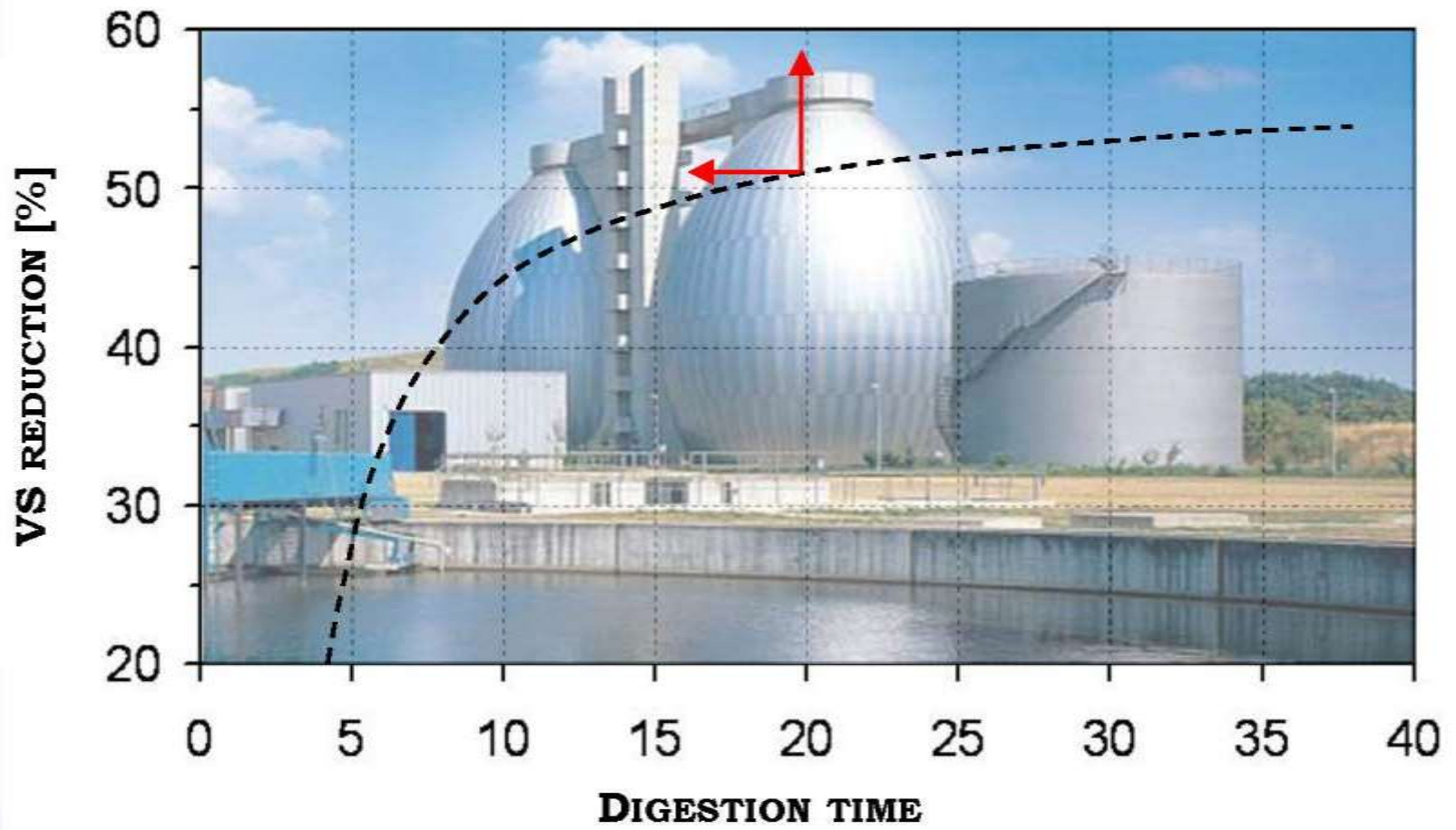
# CONTENT

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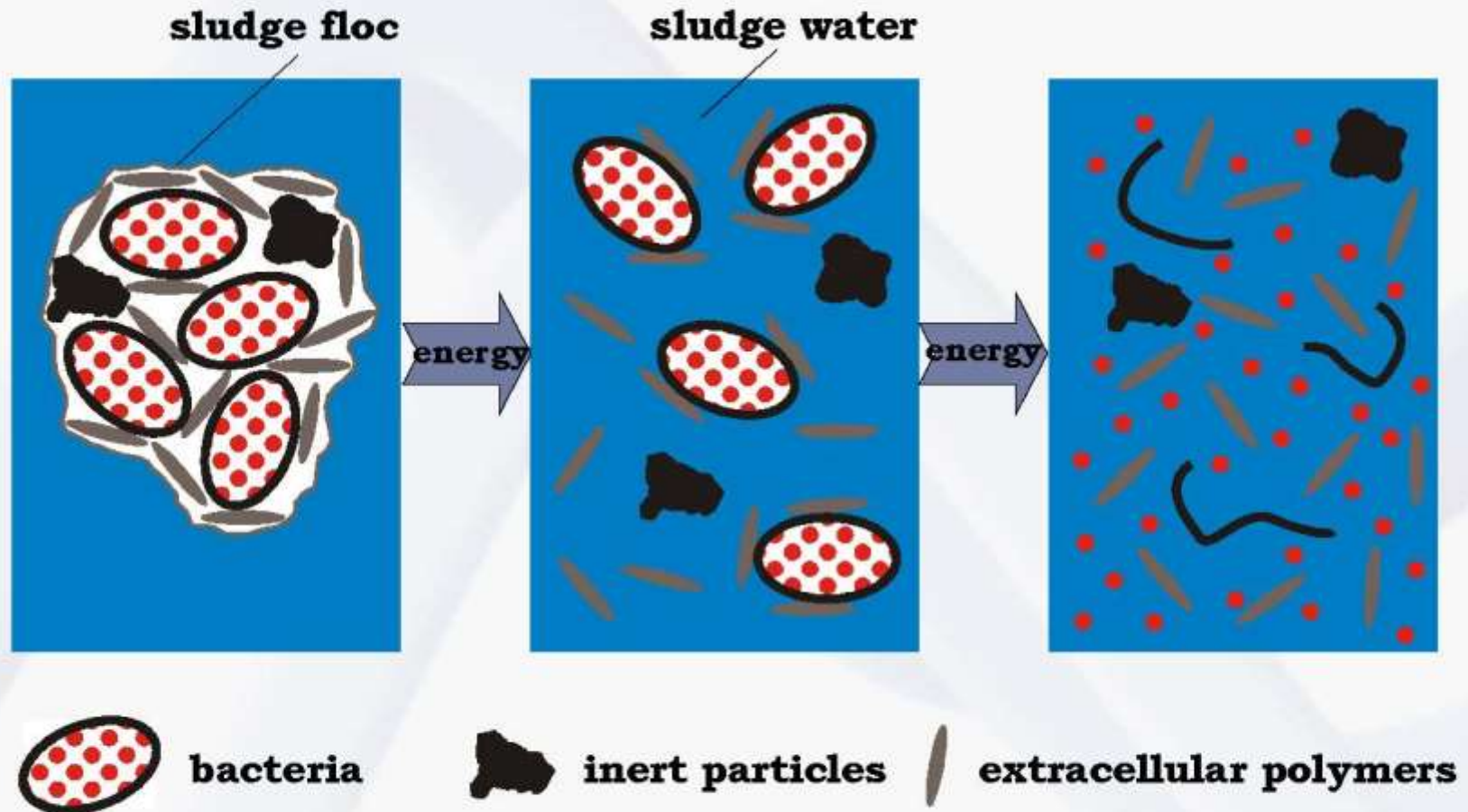
1. **Ultrasonic Disintegration of Biomass**
2. **Enhancing Biomass Digestion on wastewater treatment plants (WWTP)**
3. **Combating Filamentous/Foaming Sludge**
4. **Enhancing Anaerobic Biomass Digestion on farmland biogas plants (FBP)**
5. **Enhancing Anaerobic Digestion of Spent-Wash**
6. **Enhancing Anaerobic Biomass Digestion on food waste biogas plants (FWBP)**
7. **Development of HPUS-reactor**

# ULTRASONIC DISINTEGRATION OF BIOMASS

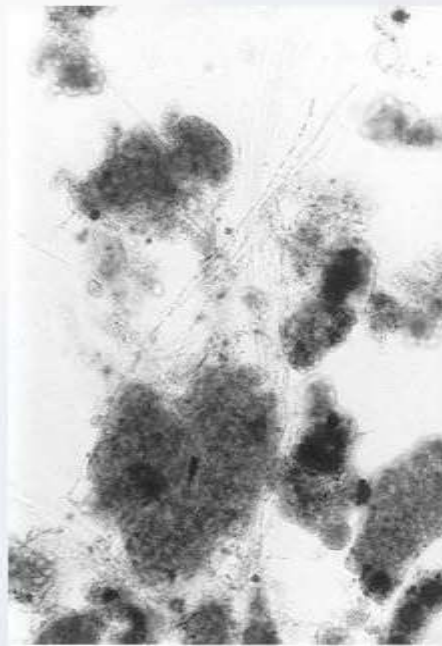
# ANAEROBIC DIGESTION – LIMIT OF DEGRADATION



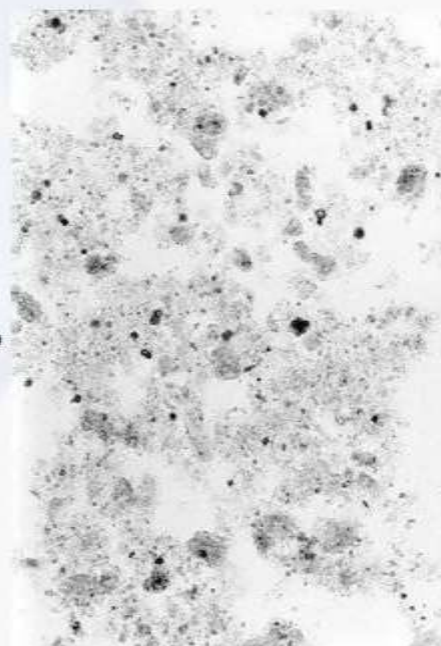
# DISINTEGRATION OF BIOSOLIDS



# LIGHT-MICROSCOPICAL ANALYSIS



**untreated WAS**

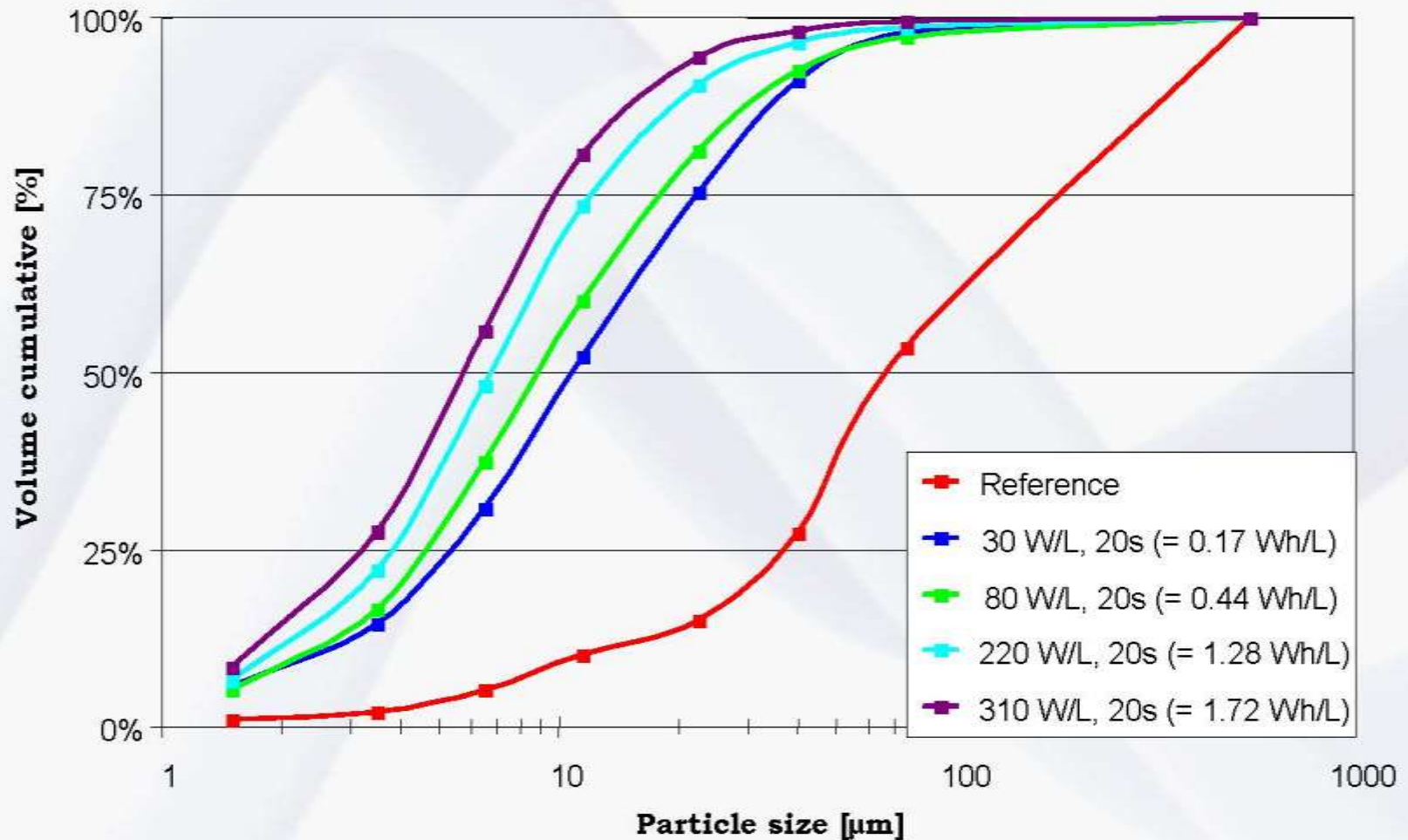


**30s sonicated**



**90s sonicated**

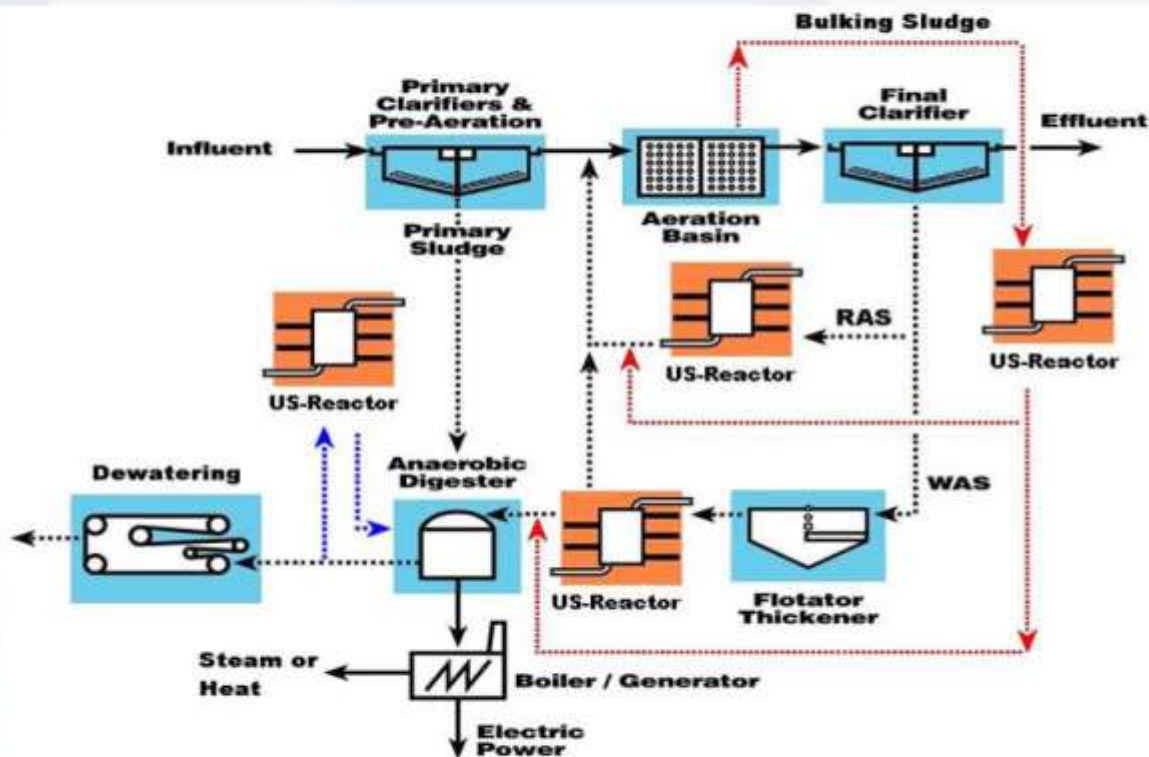
# EFFECT OF SONICATION ON PARTICLE SIZE DISTRIBUTION



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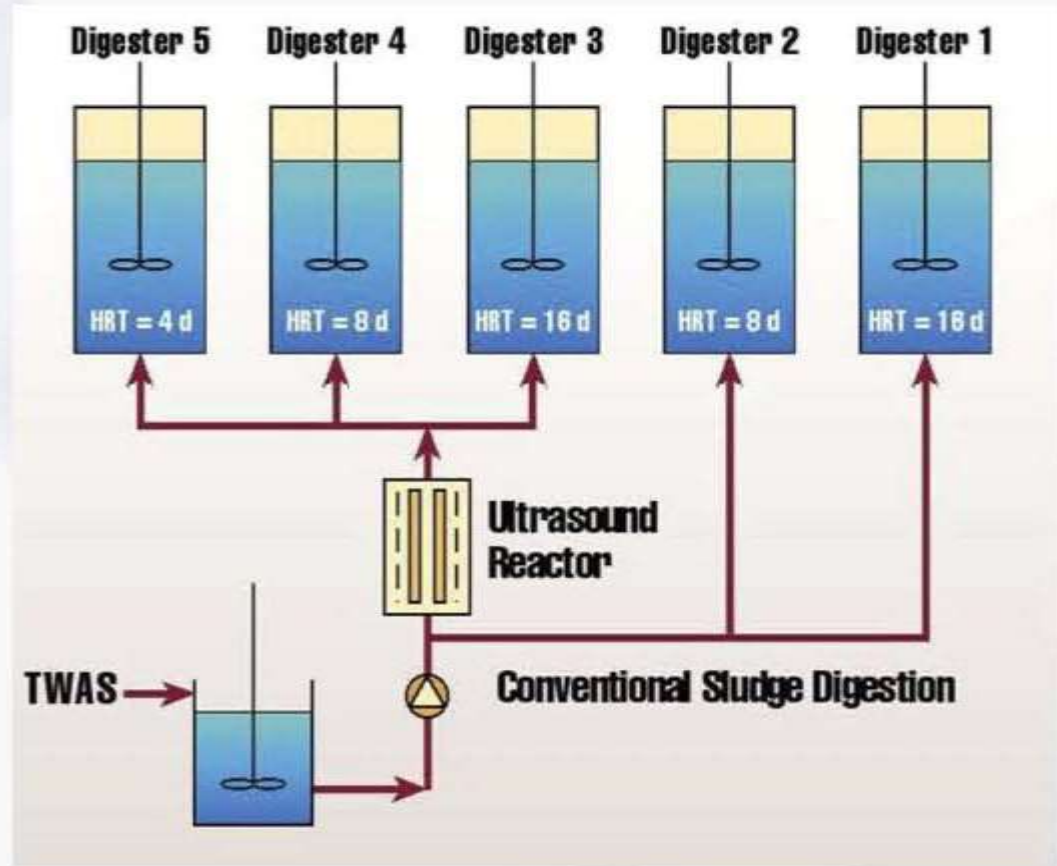
# ENHANCING BIOMASS DIGESTION ON WASTEWATER TREATMENT PLANTS (WWTP)

# OPTIONS FOR BIOSOLIDS DISINTEGRATION

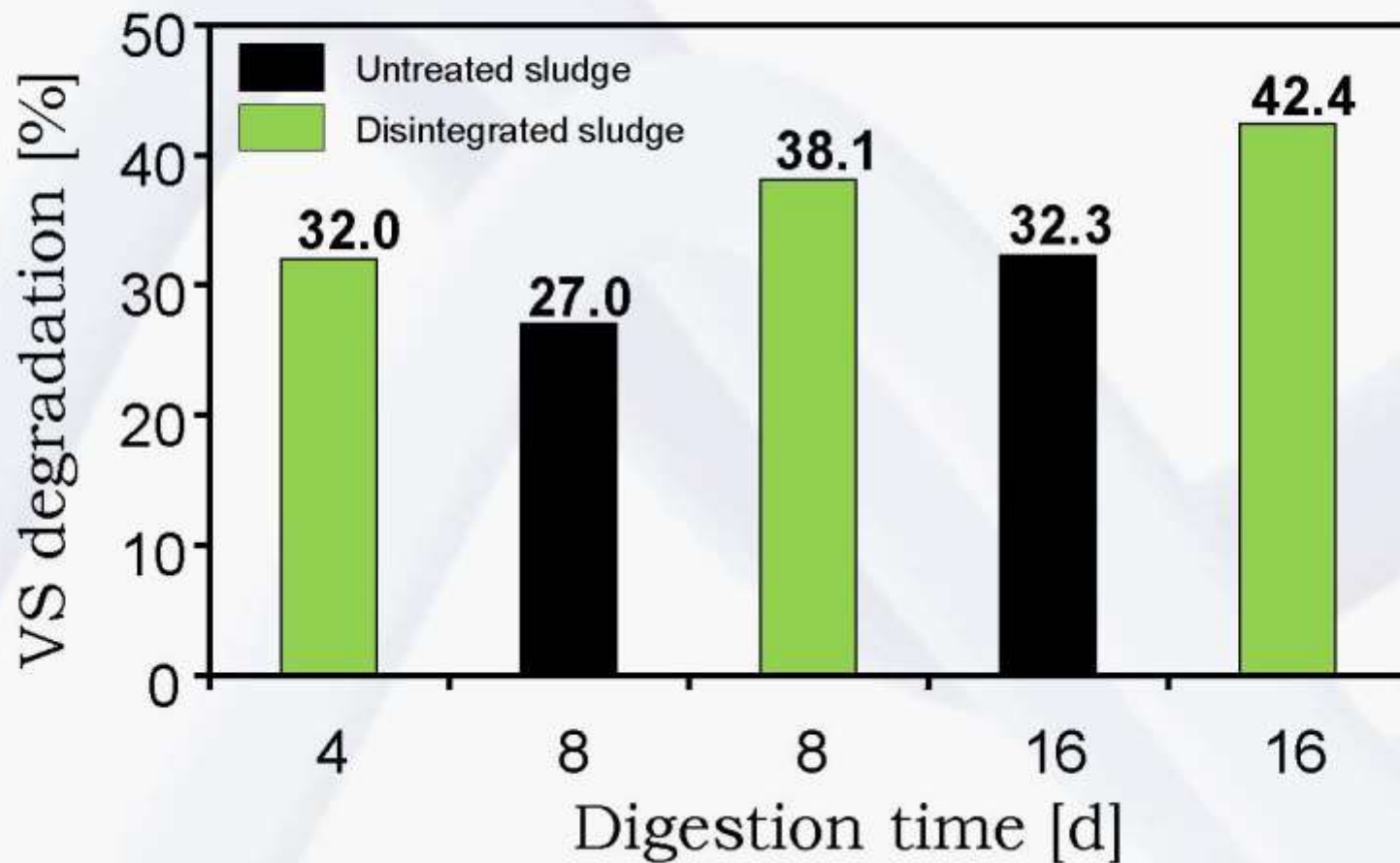


- Intensification of anaerobic biosolids digestion
- Intensification of aerobic biosolids digestion
- Combating bulking and foaming sludge

# Pilot scale plant set-up



# Anaerobic biomass degradation



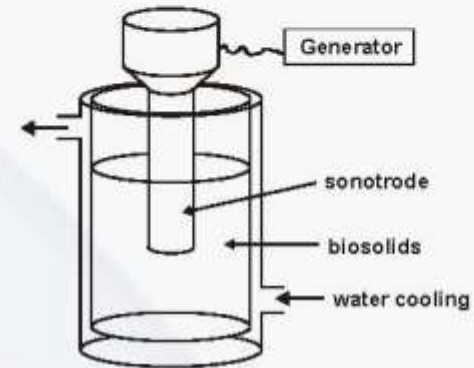
# INTRODUCTION OF US-TECH. ON WWTP

## 1. Questionnaire



The image shows two pages of a questionnaire form. The left page contains a list of questions with checkboxes and some numerical input fields. The right page contains a similar list of questions, some with checkboxes and some with numerical input fields. The form is titled 'US-TECH. ON WWTP' and includes a logo at the top.

## 2. Lab test



## 3. Full-scale test



## 4. Full-scale installation



# Ultrawaves Lab Testing



# Ultrawaves Lab Testing



# Ultrawaves Pilot



# Bamberg WWTP, Germany



# Bamberg WWTP, Germany

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## Initial conditions:

- Design capacity: 220,000 PE
- Actual Load: 330,000 PE
- 150 m<sup>3</sup>/d primary sludge, 250 m<sup>3</sup>/d WAS
- (3) egg shaped digesters with 18 d digestion time
- 35% average VS degradation

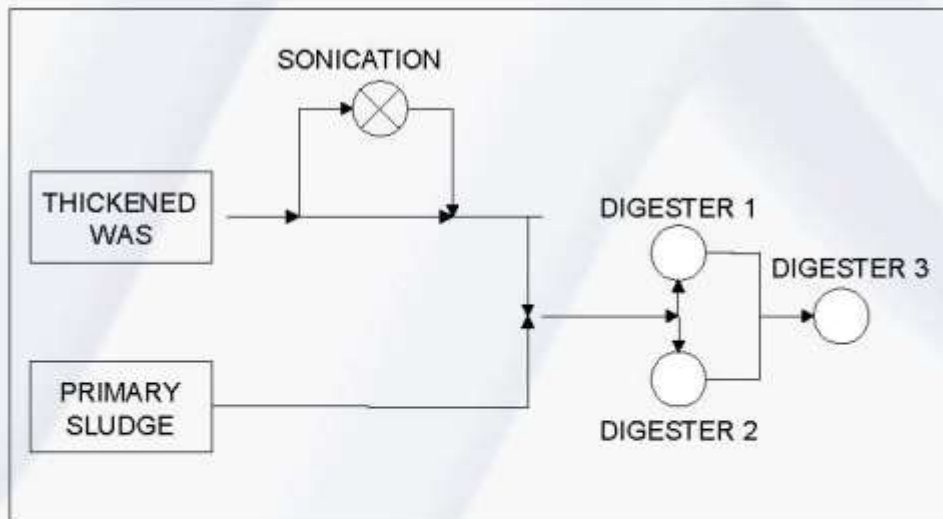
## Goal:

- Achieve a minimum of 40% VS degradation
  - Solution 1: Build another 3,000 m<sup>3</sup> egg shaped digester
  - Solution 2: Use of ultrasound to increase VS destruction

# Bamberg WWTP, Germany

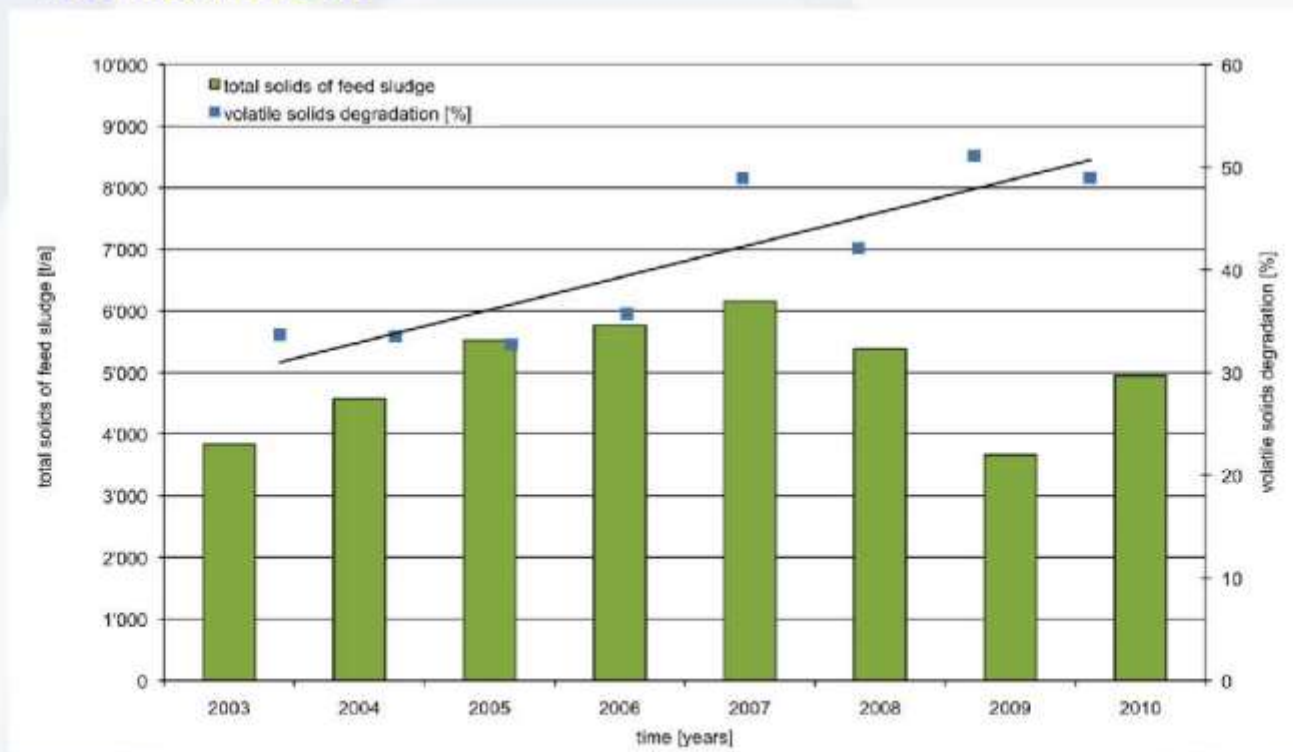
## Ultrasound installation in 2004:

Sonication of 30% (in 2004) - 80% (in 2007) of the WAS  
(~ 70 - 100 m<sup>3</sup>/d) @ 2 - 3 kWh/m<sup>3</sup>

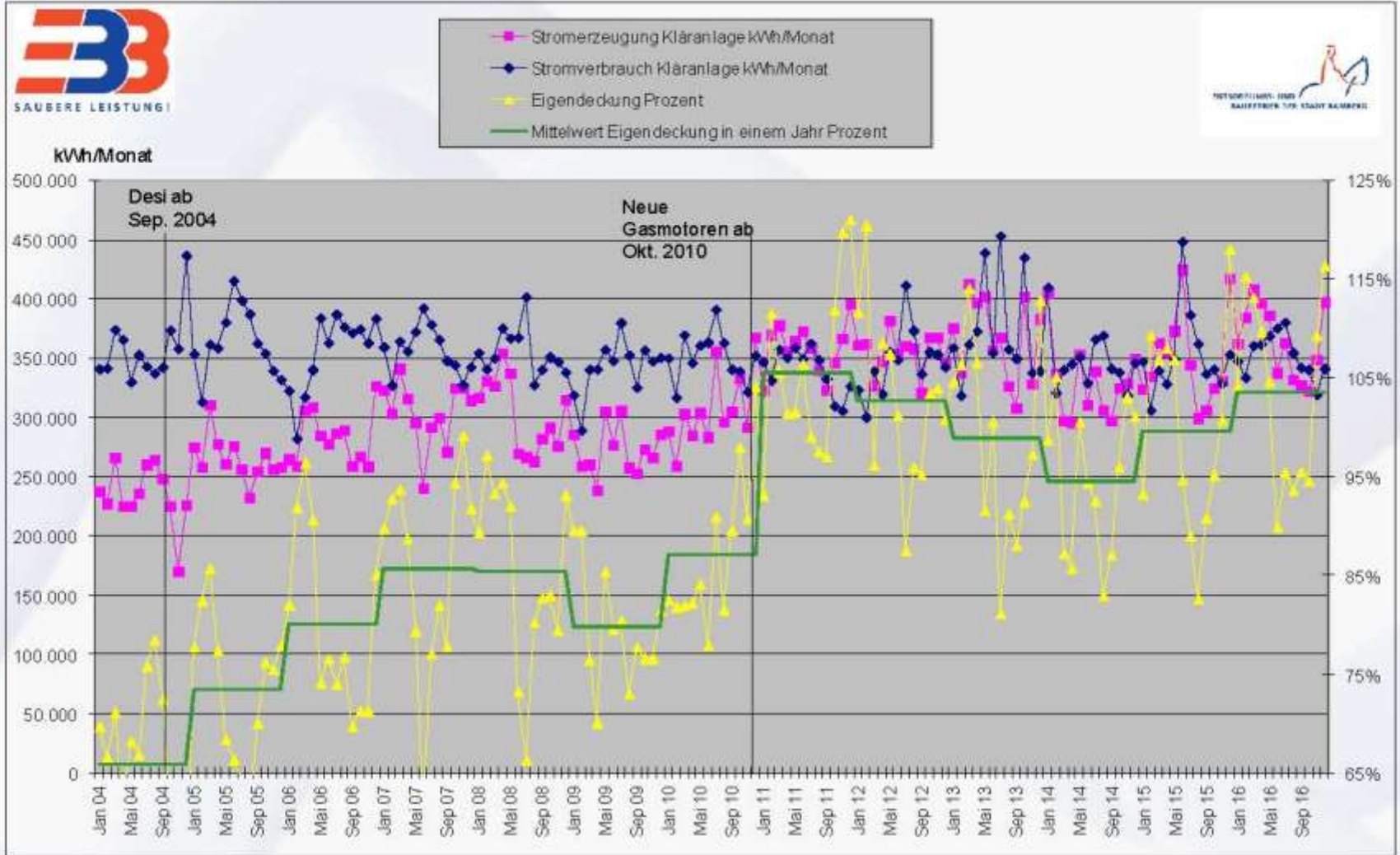


# Bamberg WWTP, Germany

- Results:**
- Volatile solids destruction improved from 34 to 50%
  - Significantly increased biogas production (+ 45%)
  - Avoided construction of a new digester = savings of 1.5 million EUR



# Energy-self-sufficient operation on Bamberg WWTP



# LEINETAL WWTP, GERMANY

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# COMBATING FILAMENTOUS/FOAMING SLUDGE

# LEINETAL WWTP, GERMANY

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## **Initial Conditions:**

- Design capacity: 50,000 PE
- Actual Load: 65,000 PE
- Extended aeration (simultaneous aerobic sludge digestion) @ 18 d sludge age
- Floating sludge due to excessive growth of filamentous micro-organisms

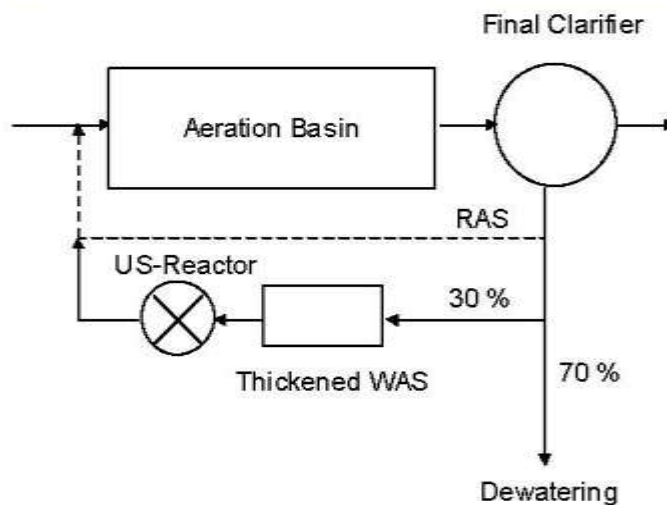
## **Desired Goal:**

- Improvement of aerobic sludge treatment
  - Solution 1: Build another activated sludge tank
  - Solution 2: Use of ultrasound to increase VS destruction

# LEINETAL WWTP, GERMANY

## Ultrasound Installation in 2003:

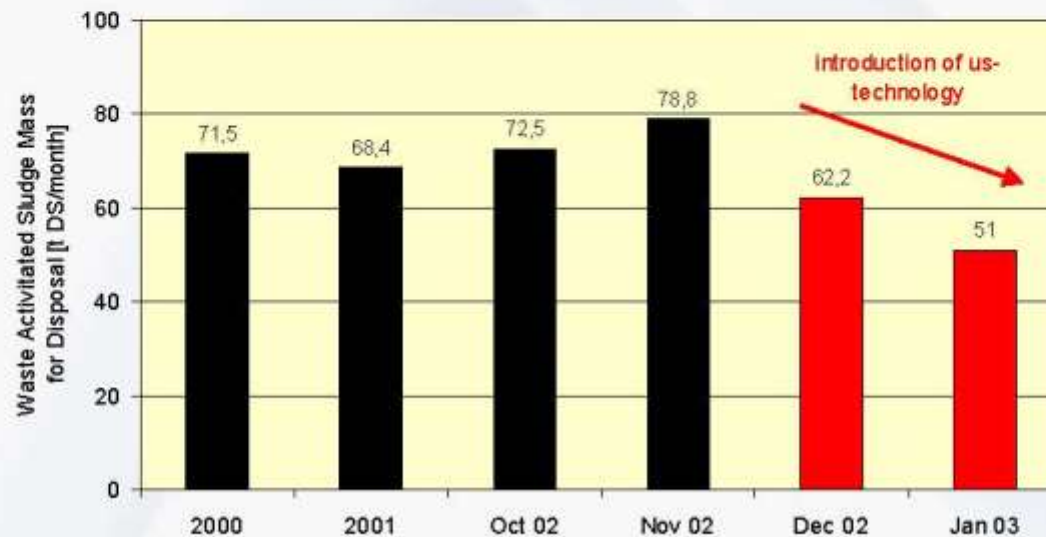
Sonication of 30% of the WAS ( $\sim 33 \text{ m}^3/\text{d}$ ) @  $3.6 \text{ kWh}/\text{m}^3$



# LEINETAL WWTP, GERMANY

## Results of US-installation:

- Reduction of sludge mass of about 25%
- Better stabilised end product (reduced organic content)
- No foam and no floating sludge in the aeration tank
- **Avoided construction of a new aeration tank**



# BÜNDE WWTP, GERMANY



# BÜNDE WWTP, GERMANY

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## **Initial Conditions:**

- Design capacity: 40,000 PE
- Actual Load: 54,000 PE
- Alternating nitrification and denitrification @ 22 d sludge age
- Floating sludge due to excessive growth of filamentous micro-organisms

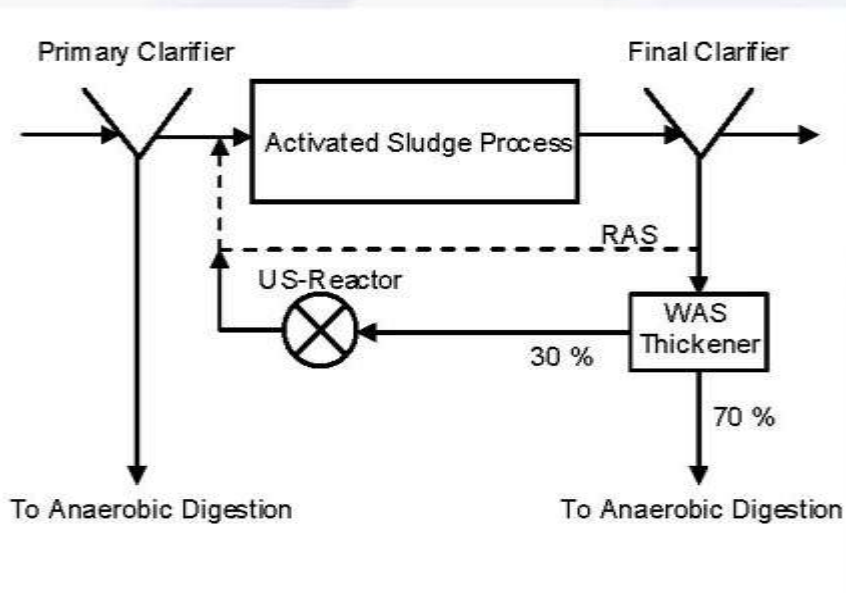
## **Desired Goal: Reduction of process fluctuations**

- Minimization of waste activated sludge production
- Sustainable reduction of N-conc. in the effluent
- Combating filamentous organisms

# BÜNDE WWTP, GERMANY

## Ultrasound Installation in 2006:

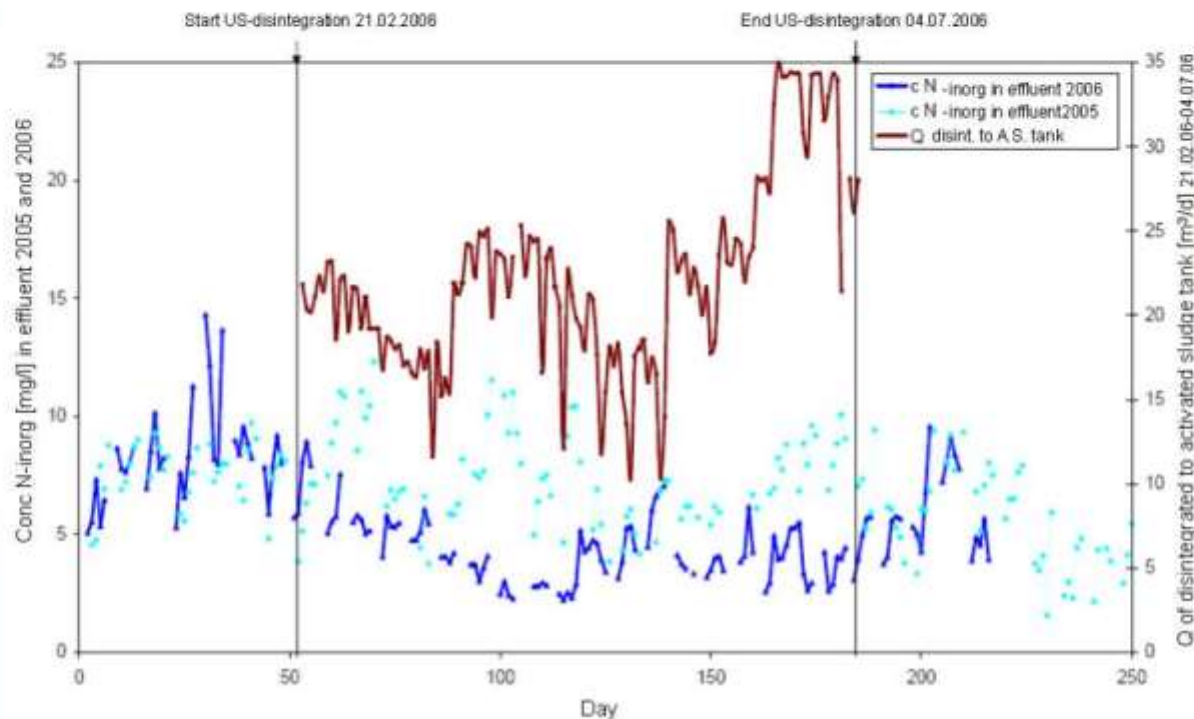
Sonication of 30% of the TWAS ( $\sim 30 \text{ m}^3/\text{d}$ ) @  $4.0 \text{ kWh}/\text{m}^3$



# BÜNDE WWTP, GERMANY

## Results of US Installation:

- No foaming or bulking sludge in the activated sludge tank
- 25% reduction of waste activated sludge mass
- Reduction of the nitrogen concentration in effluent ( $N < 5$  mg/l)



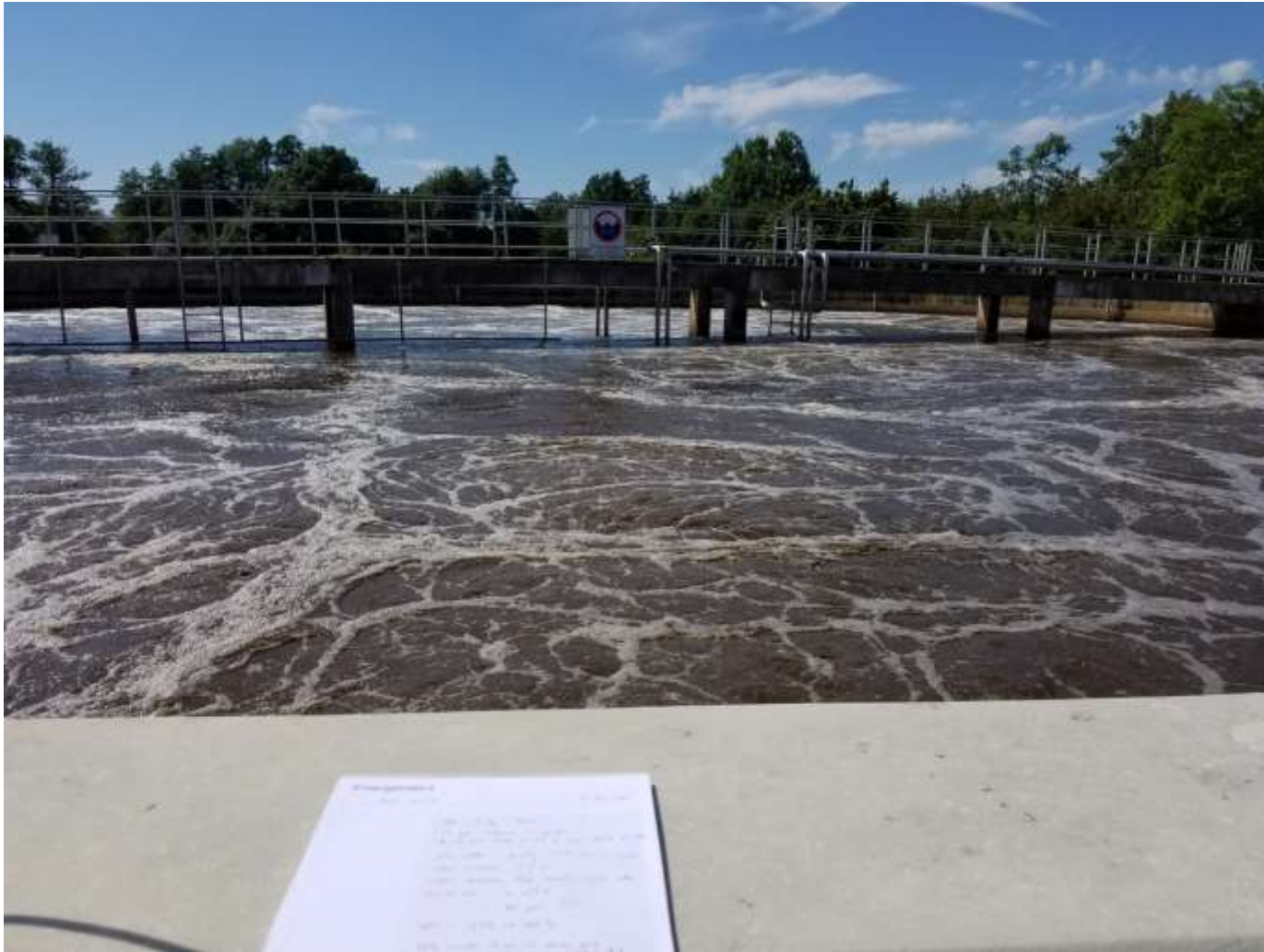
# Ultrawaves at Bunde WWTP Germany



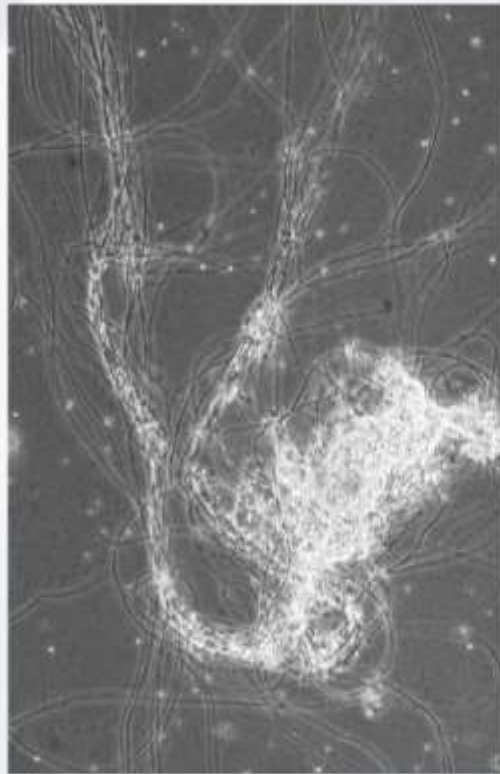
# Ultrawaves at Bunde WWTP Germany



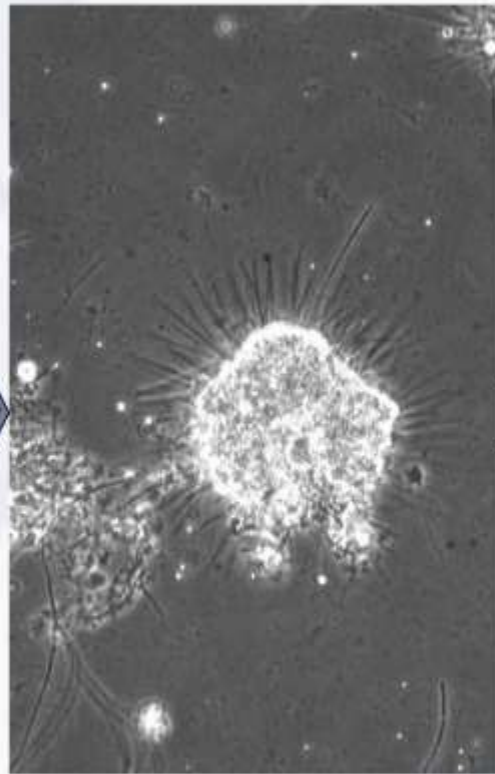
# Denite System at Bunde



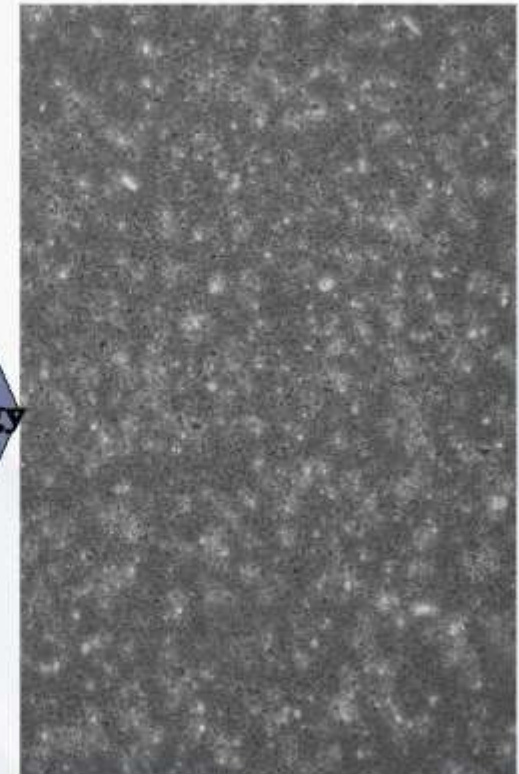
# COMBATING FILAMENTOUS SLUDGE



Original



Short Sonication



Long Sonication

# SEEVETAL WWTP, GERMANY (165,000 PE)

**Sonication of Return Activated Sludge (1% RAS @ 2 kWh/m<sup>3</sup>)**



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# **ENHANCING ANAEROBIC BIOMASS DIGESTION ON FARMLAND BIOGAS PLANTS (FBP)**

# BORDESHOLMERLAND FBP, GERMANY



# BORDESHOLMERLAND FBP, GERMANY

## Initial conditions:

- 2 parallel lines
- size 2 x 537 kW
- 2 main digester à 2.500 m<sup>3</sup>, 2 post digester à 2.500 m<sup>3</sup>,  
2 storage à 2.500 m<sup>3</sup>
- input: 2 x 25 t/d maize
- retention time: 90 days/digester
- biogas production: 2 x 6150 m<sup>3</sup>/d
- methane concentration ca. 50%

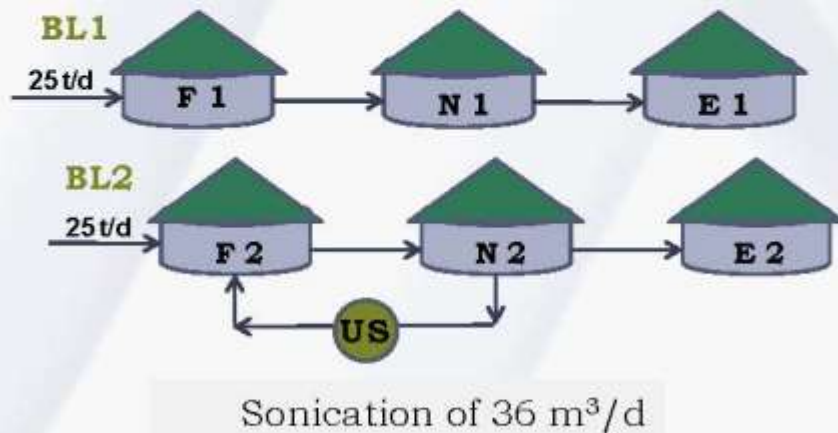
## Goal:

- reduce amount of substrate

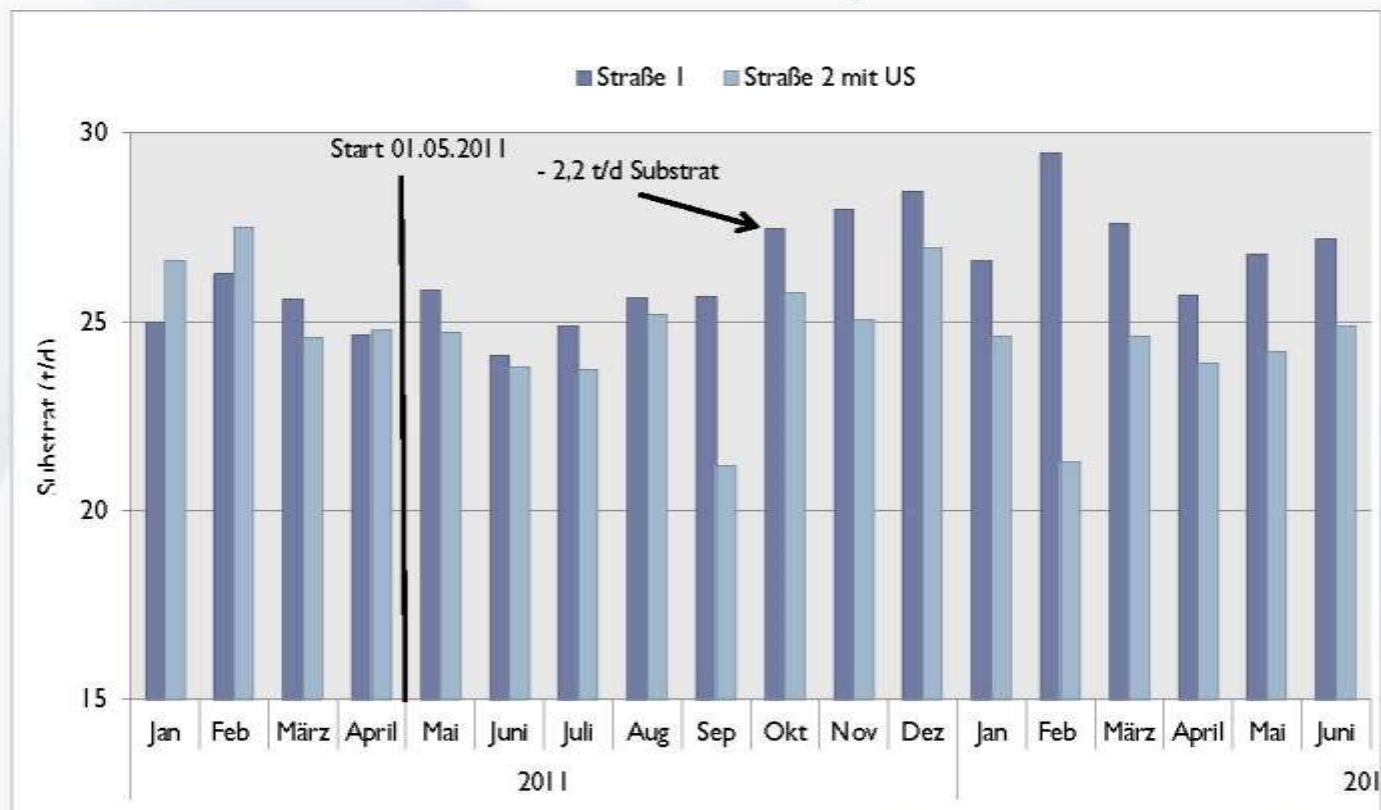
# BORDESHOLMERLAND FBP, GERMANY

## Ultrasound installation in 2011:

Sonication of partial flow ( $36 \text{ m}^3/\text{d}$ ) from post digester to main digester (@  $3.3 \text{ kWh}/\text{m}^3$ ) in line 2



# BORDESHOLMERLAND FBP, GERMANY



- Results:**
- 2,2 t/d less substrate on line 2 compared to line 1
  - increase in methane content to 53% (+ 3%)
  - increase in el. power production from 537 kW (line 1) to 570 kW (line 2)

# Farm Digester Feed Substrate



# Farm Digester with Ultrawaves Since 2005



# New Farm Digester - CHP



# New Farm Digester System



# New Farm Digester System



# New Farm Digester – Substrate Bunker



# ENHANCING ANAEROBIC DIGESTION OF SPENT-WASH

# AD OF SPENT-WASH: LOBURG DISTILLERY, GER

## ▶ **Initial Conditions:**

- ▶ Power capacity: 560 kW
- ▶ 2 MD @ 1.270 m<sup>3</sup>, 1 ST @ 2.280 m<sup>3</sup>
- ▶ Feed: maize silage, maize silage waste, sorghum silage, spent-wash (wheat), cow manure
- ▶ HRT: 40 d/digester



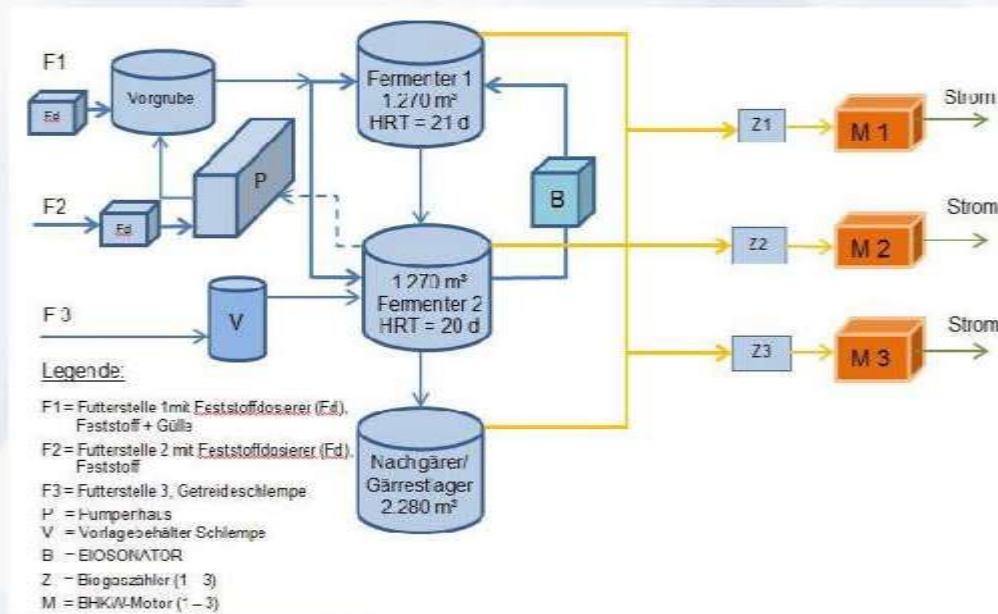
## ▶ **Desired Goal:**

- ▶ Reduction of the daily feed
- ▶ Improvement of the specific biogas production

# AD OF SPENT-WASH: LOBURG DISTILLERY, GER

## ▶ ULTRAWAVES HPUS BIOSONATOR installation since 2012:

- ▶ Sonication of 29 m<sup>3</sup>/d (5 kW, 4.1 kWh/m<sup>3</sup>) of activated biomass from MD 2 and recirculation into the MD 1.



# AD OF SPENT-WASH: LOBURG DISTILLERY, GER

## ▶ Results of the HPUS-Installation:

- ▶ 8% less substrate (-17% cost reduction, 52.000 EUR/a)
- ▶ Stabilized and increased gas production (+ 16%, 19.800 EUR/a)

	01.04.2012 till 31.09.2012 without BIOSONATOR	01.02.2013 till 30.07.2013 with BIOSONATOR	Difference related on <b>6</b> comparable month
Maize silage	2.266 t	2.288 t	+22 t
Maize silage waste	406 t	402 t	- 4 t
Millet silage	891 t	750 t	-141 t
Rye grain, grinded	275 t	155 t	-120 t
Corn mash (wheat)	2.414 t	3.072 t	+658 t
Cattle liquid manure, dairy cattle	2.778 t	3.184 t	+406 t
Fresh bulk, sum	9.030 t	9.850 t	+820 t
Dry solids, sum	1.606 t	1.631 t	+ 25 t
Thereof fast degradable dry solids (rye grain + wheat mash)	<b>385 t</b>	<b>319 t</b>	<b>- 66 t</b>
Total costs substrate	152.719 EUR	126.797 EUR	- 25.922 EUR
Total costs substrate per year	305.438 EUR	253.594 EUR	- 51.844 EUR

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**ENHANCING ANAEROBIC BIOMASS DIGESTION  
ON  
FOOD WASTE BIOGAS PLANTS (FWBP)**

# MARIKS FWBP, GERMANY



# MARIKS FWBP, GERMANY

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## **Initial conditions:**

- 2 main digester à 1.800 m<sup>3</sup>, 1 post digester à 1.800 m<sup>3</sup>, storage tank à 5000 m<sup>3</sup>
- input: 73 t/d
- retention time: 40 days
- electrical power production: 700 kW
- methane concentration ca. 56-61%

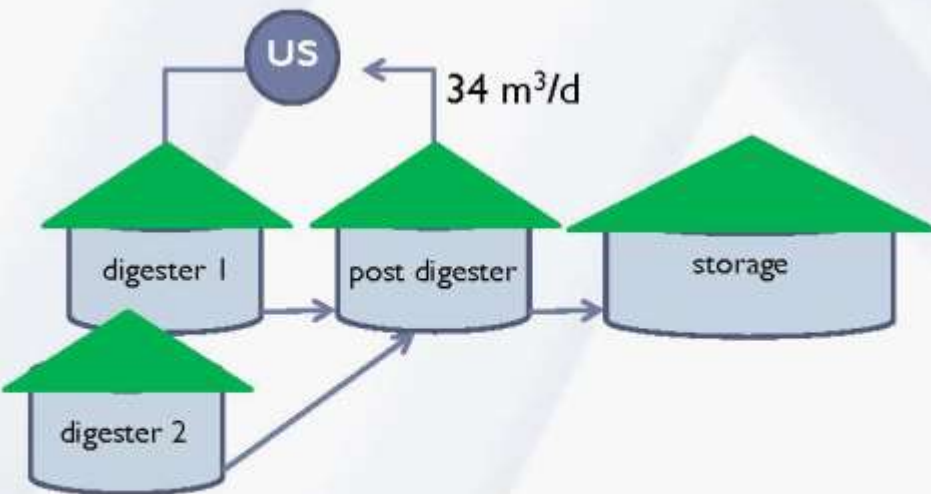
## **Goal:**

- increase in biogas production

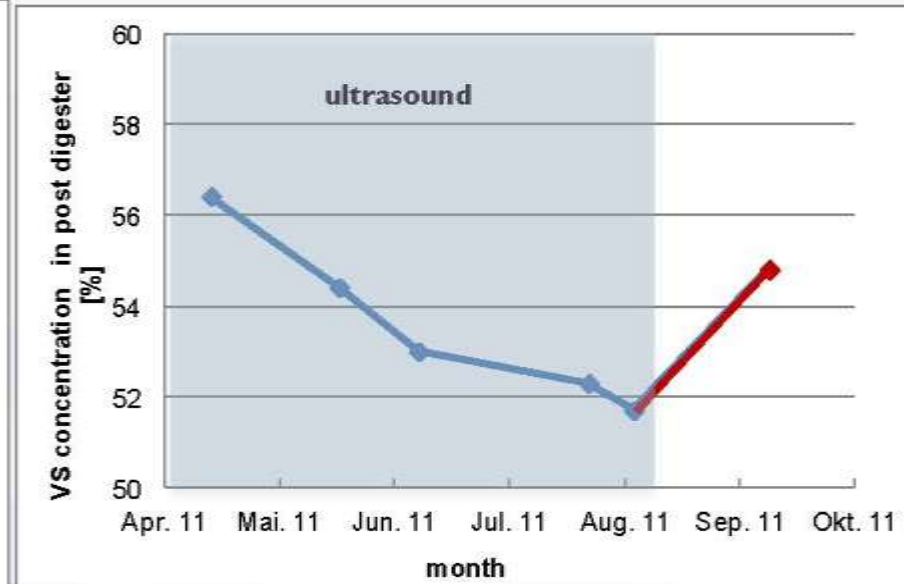
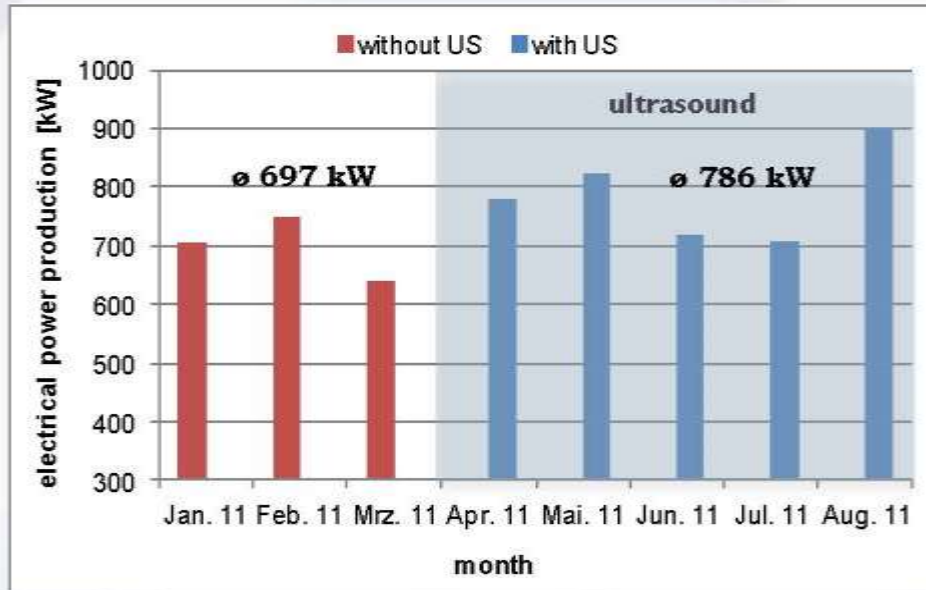
# MARIKS FWBP, GERMANY

## Ultrasound installation in 2011, April - August:

Sonication of partial flow ( $34 \text{ m}^3/\text{d}$ ) from post digester to main digester ( $@ 3.5 \text{ kWh}/\text{m}^3$ )



# MARIKS FWBP, GERMANY



## Results:

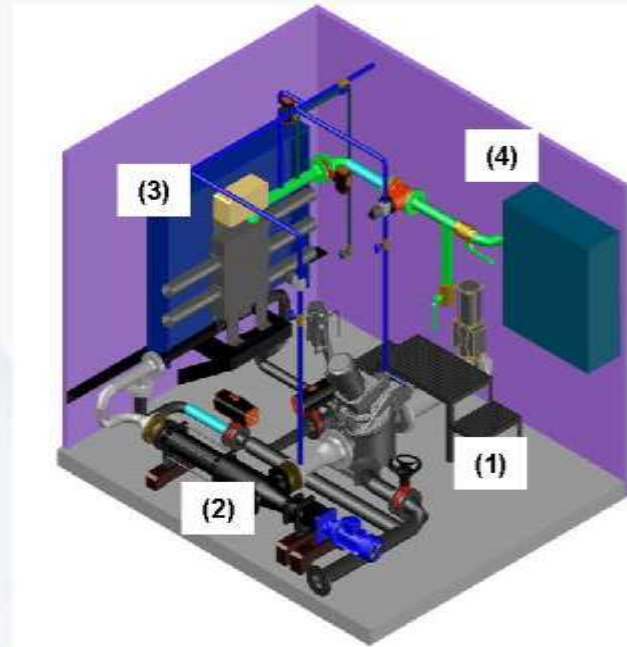
- improved electrical power production from 697 to 786 kW (+13%)
- decrease of VS concentration from 56% to 52% in post digester

# BIOSONATOR: P&P-SYSTEM



## ▶ Components:

- ▶ Macerator (1)
  - ▶ Modified Excentric Screw Pump (2)
  - ▶ HPUS (3)
  - ▶ Volumetric flowmeter (4)
- ▶ Completely automated (24/7) & simple integration



# AD ON FBP/FWBP: MORE CASES

- ▶ Beerlage FBP, GER (1,500 kW)
- ▶ Bispingen FBP, GER (1,100 kW)
- ▶ Ense FBP, GER (3,500 kW)
- ▶ Hellweg FBP, GER (500 kW)
- ▶ Haren FBP, GER (590 kW)
- ▶ Lindow FBP, GER (500 kW)
- ▶ Löhndorf FBP, GER (1,000 kW)
- ▶ Wittenburg FBP, GER (716 kW)
- ▶ Wulkow FBP, GER (400 kW)



# Conclusions

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- **Biomass treatment with ultrasound is an established technology**
- **Detailed studies have demonstrated the potential of ultrasound for enhanced biodegradation of biomass**
- **More than 200 Ultrawaves HPUS reference installations**

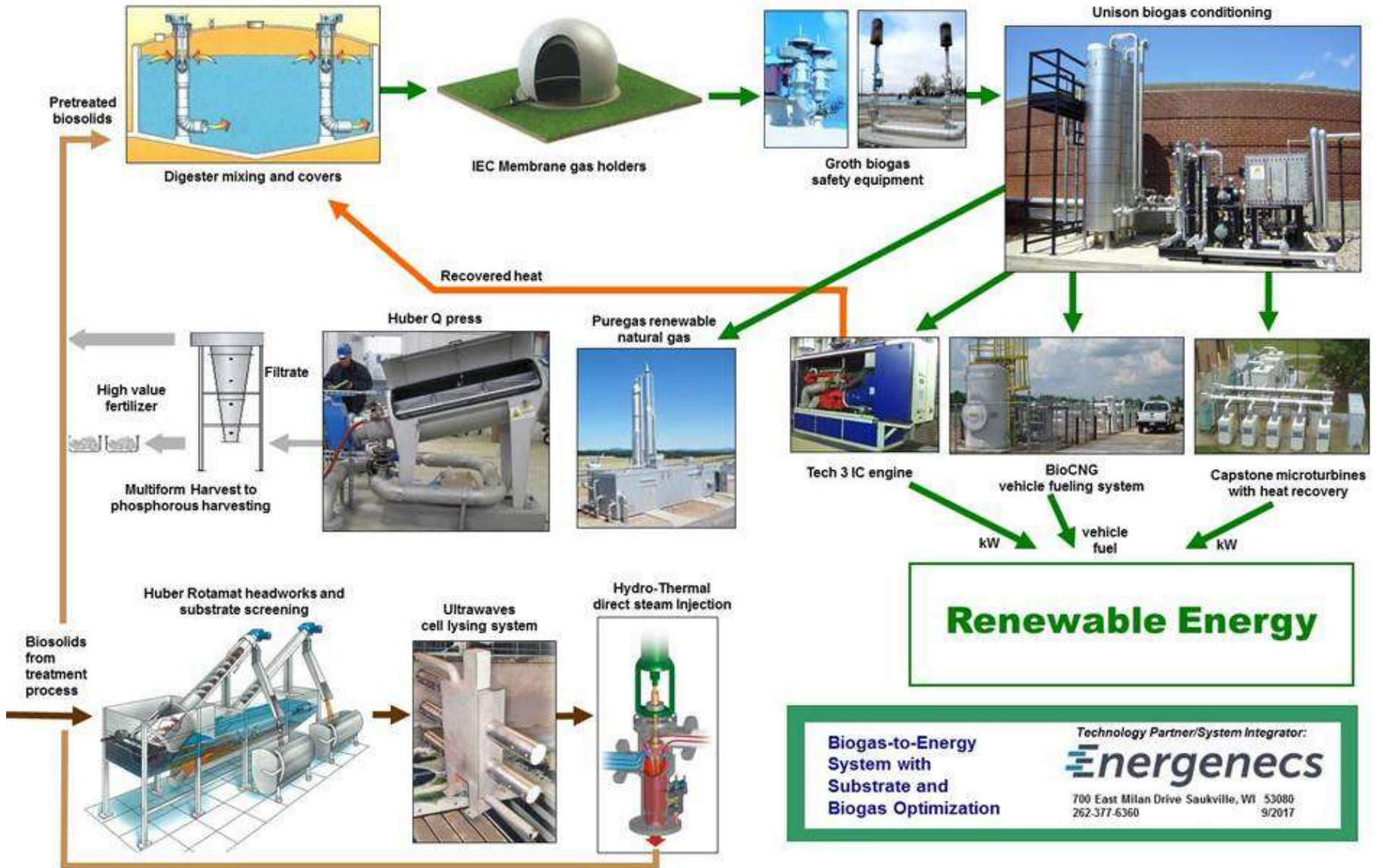
# Ahrensburg Germany installation for AD enhancement



***Process.  
Control.  
Service.***

**Question  
s?**

# Sustainability: Shifting from waste to resource recovery







# ULTRAWAVES – partner

The image displays a world map with several Ultrawaves product brochures and technical documents placed over different regions, illustrating global reach. The documents include:

- EIMCO Sonolyzer** (Europe): Brochure for "Budget Sonolyzers and Ultrasonics".
- SONOFLEX** (North America): Brochure for "Réacteur de production de la biomasse par ultrasons".
- EURO-OPEN KFT** (South America): Brochure for "Catalizadores de bioprocesos".
- DUMO** (Africa): Brochure for "DUMO".
- 50% INCREASE** (Asia): Brochure for "INCREASE YOUR BIOGAS OUTPUT UP TO 50%".
- コトフキ ウェーブインバクター** (Japan): Brochure for "コトフキ ウェーブインバクター".
- DAEWOO** (South Korea): Brochure for "DAEWOO".
- Multiplier** (Australia): Brochure for "Multiplier The ultimate bioconverter".
- Other documents**: Various technical papers and brochures in multiple languages, including Chinese and Japanese, scattered across the map.