

# UK Case Study & Sludge Processing Methods

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LOVE EVERY DROP. PUT WATER AT THE HEART  
OF A WHOLE NEW WAY OF LIVING.

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  - Biosolids assurance scheme (BAS)
- Treatment Technologies
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  - Enhanced digestion systems
- Overview of our strategy
  - Our advanced digestion technologies

# Water Industry

## England & Wales



# ofwat

The economic regulator of the water sector in England and Wales



Department  
for Environment  
Food & Rural Affairs



Environment  
Agency

# Anglian Water

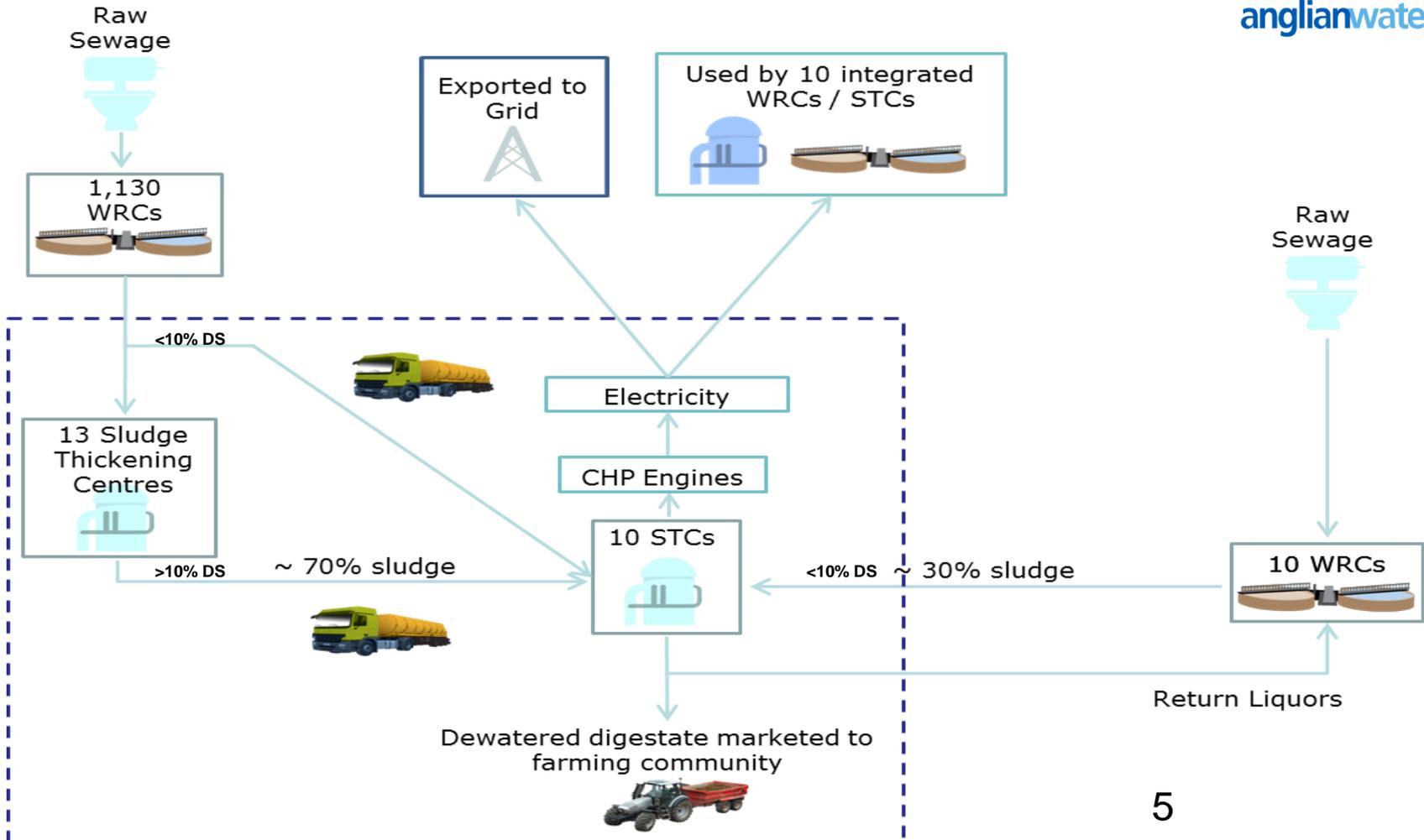


- We serve 6 million domestic customers
- Supply 1.2 billion litres of water per day
- Collect 927 million litres of waste water for recycling at 1128 centres
- Treat 150,000 tonnes dry solids (TDS) per annum of sewage sludge producing 400,000 wet tonnes of biosolids product for recycling to agriculture as a soil conditioner
- Generate 100GWh per annum of renewable electricity from sewage sludge biogas



# Water 2020 Bio-Resource Price Control

Scope of assets and activities covers as per diagram below



# ANGLIAN WATER CARBON STORY

## 2006 CHALLENGES

CLIMATE CHANGE & POPULATION GROWTH



## 2006 RESPONSE

Energy Initiative launched promoting action in energy efficiency.



Anglian Water takes leaders from its supply chain to the MayDay Summit - Action Pledged.

## TARGETS

Back to back with the supply chain. £2 billion programme.

Deliver a 50% reduction in capital (embodied) carbon by 2015 from a 2010 baseline

Exceed a 10% reduction in real terms in gross operational carbon by 2015 from a 2010 baseline

2010

love every drop  
anglianwater

Water Innovation Network Launched Challenging SMEs in response to the carbon challenge.

## SUPPLY CHAIN

Collaboration and engagement in meeting the carbon challenge.



## GOVERNANCE

Capital and operational carbon challenged against baseline prior to construction.

## 2007 STRATEGY

Measurement and Baseline Capital and operational carbon for the 2010-2015 business plan.



2008

2009

2011



Bedford Water Recycling Centre

## SUCCESS

- Aligning the Supply Chain
- 66% reduction in capital carbon
  - 170% reduction in operational carbon
  - 43% reduction in capital costs

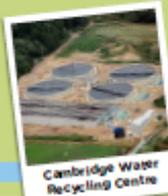
## INNOVATION

Through zero cement concrete. 60% carbon reduction in the base slab.



Low carbon concrete

Proud recipients of the Queens Award for Enterprise: Sustainable Development



Cambridge Water Recycling Centre

## 2010 TARGETS DELIVERED

- Exceeded 10% reduction in operational carbon in real terms
- 54% reduction in capital carbon

2015

2014

2013

2012



Awards - Promoting positive behaviour in our supply chain

## PAS2060

Carbon management in infrastructure. Anglian Water the first company to be verified globally. Next step PAS to ISO.



## EXEMPLAR PROJECT

- Saved 7,302t CO2e
- Saved £1.4m

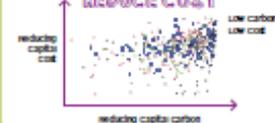
This project bought together the learning of the past five years. From early design collaboration with operations and the supply chain, to using innovative materials, off site build and zero material removed from site, faster delivery and zero accidents.

## UPDATED TARGETS

Deliver a 60% reduction in capital (embodied) carbon by 2020 from a 2010 baseline

Exceed a 7% reduction in real terms in gross operational carbon by 2020 from a 2015 baseline

## REDUCE CARBON REDUCE COST



## ICR

HM Treasury Infrastructure Carbon Review Aimed at leaders to deliver carbon and cost reduction. Through the Green Construction Board, Anglian Water at the heart of this document.

## 2017 NEW TARGET

CARBON NEUTRALITY BY 2050

2016



£1.4 large scale solar installation cost built towards renewable energy from biogas and wind

# Biosolids Recycling recent history



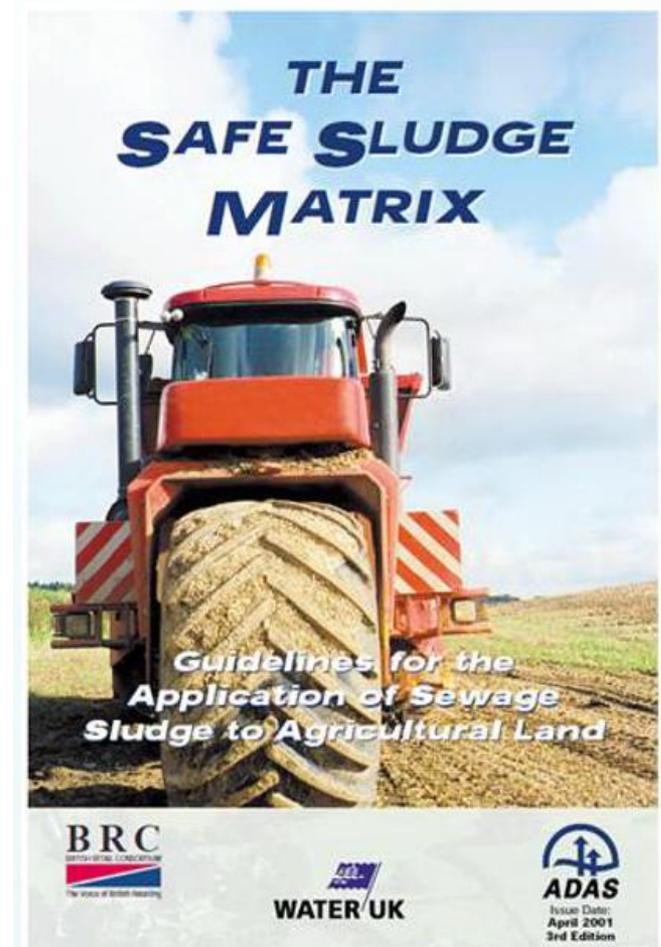
- Sewage sludge directive 1996
- Safe sludge in Agriculture Regulation (1989)
- Introduction of 'safe sludge matrix' in 1998 was catalyst of new wave of technology development. Incentive for renewable fuels and electricity from 2000 has further boosted development
- DEFRA Code of Practice introduced in 1996
- Biosolids Assurance Scheme (BAS) introduced in 2016
- OFWAT Water 2020 – Bioresource Markets



# Safe Sludge Matrix



- Code agreed between WASC's and British Retail Consortium in 1998
- Introduces two treatment standard
  - Conventional
  - Enhanced
- Matrix sets out use of biosolids based on crop type and rotation



# Safe Sludge Matrix



## THE SAFE SLUDGE MATRIX

CROP GROUP	UNTREATED SLUDGES	CONVENTIONALLY TREATED SLUDGES	ENHANCED TREATED SLUDGES
FRUIT	X	X	✓
SALADS	X	X (30 month harvest interval applies)	✓
VEGETABLES	X	X (12 month harvest interval applies)	✓
HORTICULTURE	X	X	✓
COMBINABLE & ANIMAL FEED CROPS	X	✓	✓
GRASS & FORAGE - GRAZED - HARVESTED	X	X (Deep injected or ploughed down only)	✓
	X	✓ (No grazing in season of application)	✓

10 month harvest interval applies (for Fruit, Salads, Vegetables, Horticulture)

3 week no grazing and harvest interval applies (for Grazed Grass & Forage, Harvested Grass & Forage)

NOTE : ✓ All applications must comply with the *Sludge (Use in Agriculture) Regulations and DETR Code of Practice for Agricultural Use of Sewage Sludge (to be revised during 2001)*.

X Applications not allowed (except where stated conditions apply)

# End Product Standards



## Conventional Standard

- 2log reduction in indicator pathogen E.coli 0157

## Enhanced Standard

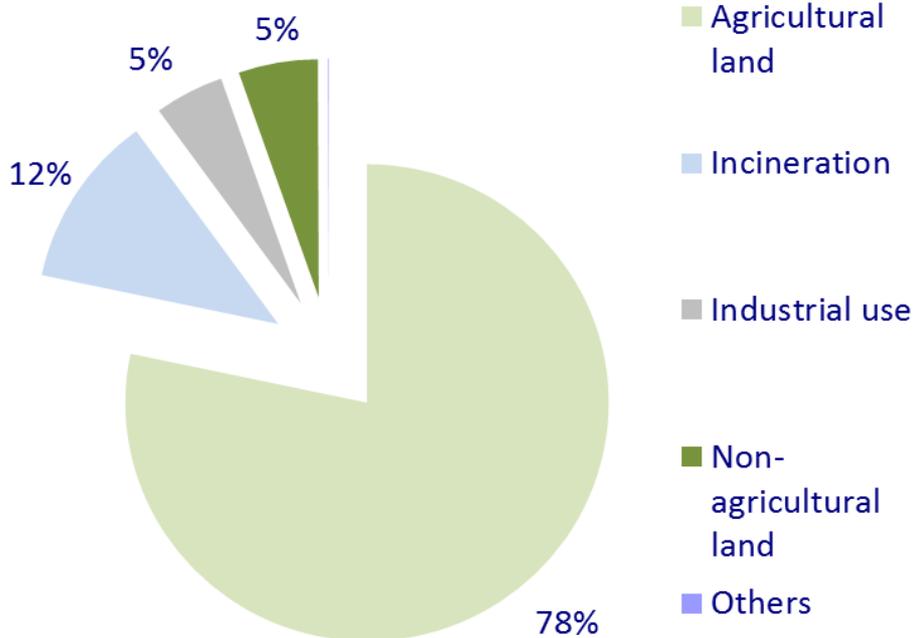
- 6 log reduction in indicator pathogen E.coli 0157
- Absence of salmonella

HACCP (Hazard Analysis Critical Control Points) applied to treatment process. Examples, set process hold time above a minimum temperature or minimum dose rate of lime per tonne treated with pH monitoring

# Biosolids Recycling in UK



Currently 11 WaSCs united in ambition to maintain confidence in biosolids recycling by adopting best practice (BAS) – also creates a level playing field



Post Water 2020 there could be say 100 companies handling sludge containing materials – a very different & commercialised market?

# Maintaining Confidence



Must demonstrate biosolids are beneficial to agriculture and the environment as a whole

That it is a safe and sustainable practice

That they are a valuable resource



Must maintain support from food chain stakeholders

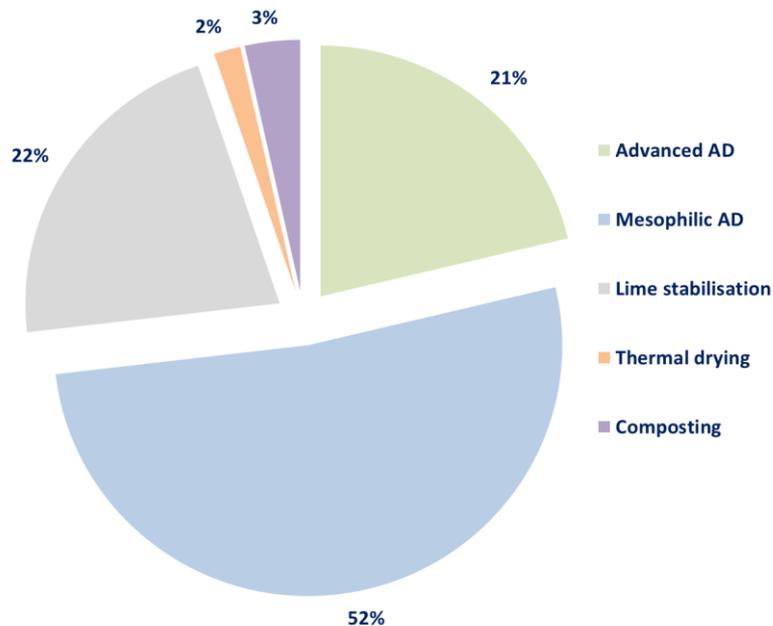
Must have Government support

and a clear regulatory framework which supports biosolids use as a resource rather than waste

# Sludge Treatment

Various treatment technologies used to produce biosolids

73% output treated by AD with advanced AD treatments gradually replacing lime treatment and conventional AD



Higher quality products reduce the potential for odour nuisance

Odour probably has the greatest impact on public perceptions

So odour control is directly linked to maintaining confidence

# Recycling to agriculture



3.6 million tonnes per annum biosolids are recycled to agricultural land

Applied to 146,000 hectares/annum

Biosolids product is mainly *cake* at 20 – 25% dry solids



It can be safely & securely stored in field heaps before spreading & incorporation

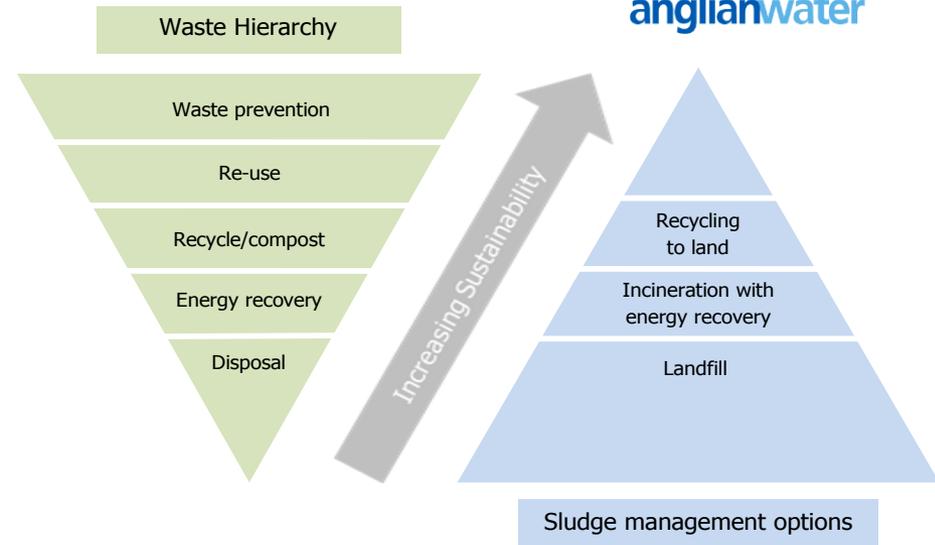
**There are very few problems and the current systems work well**



# Recycling to agriculture

Aligns with UK the Government recycling strategy and the EC Circular Economy

Nutrient value to UK agriculture £25m/annum - mainly Phosphate (4.5%) and Nitrogen (4.0%) plus Sulphur, Potash and Magnesium



Strong demand from farmers – it is worth £170/hectare in nutrients alone

Anglian Water sell it as  for £2.8m/annum - reduces customer water bills

**Biosolids - a resource with considerable value!**

# Benefits to soils & environment



Improved soil structure

Increased water retention capability

Increased life in soil (from microbes to earthworms)

These lead to.....



- .... Less soil work and energy required
- .... Increased crop yields & reduced risk of yield loss
- .... Maintaining soil structure and nutrient levels
- .... Reduced risk of diffuse pollution
- .... A natural provision of nutrients &
- .... Greenhouse gas reductions

It will be essential to maintain the benefits to soil & the environment.



# Sustainable, safe recycling

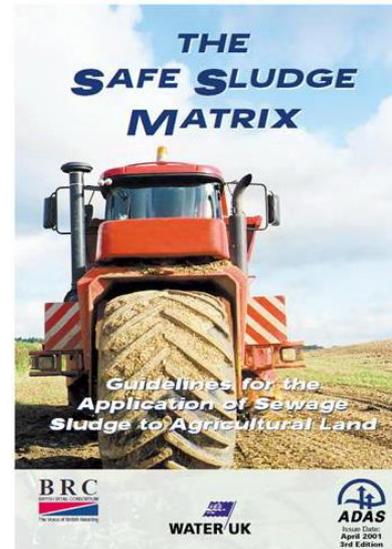


Product testing for microbiological parameters, elements and nutrients.

Soil analysis for elements and nutrients.

Safe Sludge Matrix (since 2001) defines treatment standards and minimum periods between application and harvest/grazing.

HACCP principles for treatment processes.



**THE SAFE SLUDGE MATRIX**

CROP GROUP	UNTREATED SLUDGES	CONVENTIONALLY TREATED SLUDGES	ENHANCED TREATED SLUDGES
FRUIT	X	X	✓
SALADS	X	X (30 month harvest interval applies)	✓ 30 month harvest interval applies
VEGETABLES	X	X (17 month harvest interval applies)	✓
HORTICULTURE	X	X	✓
COMBINABLE & ANIMAL FEED CROPS	X	✓	✓
GRASS & FORAGE	X	X (Sludge applied or ploughed down only)	✓ 1 week after grazing and harvest interval applies
	X	✓ (No grazing or harvest interval applies)	✓ 1 week after grazing and harvest interval applies

**NOTE:** ✓ All Applications must comply with the Sludge (Use in Agricultural) Regulations and DE TR Code of Practice for Agricultural Use of Sewage Sludge (to be revised during 2011).  
X Applications not allowed (except where stated conditions apply)

**MATRIX CROPPING CATEGORIES**

Fruit	Salad (to be ready to eat crops)	Vegetables	Horticulture	Combinable and animal feed crops		Grassland and forage	
				Harvested	Grazed		
Big fruit apples, pears &c	Lettuce, Spinach, Broad beans, Pea pods, Broad beans, Pea pods, Broad beans, Pea pods, Broad beans, Pea pods	Peas, Beans, Broad beans, Pea pods, Broad beans, Pea pods, Broad beans, Pea pods	Soft fruit, Strawberries, Raspberries, Blackberries, Blueberries, Currants, Gooseberries, Elderberries, Mulberries, Damsons, Plums, Cherries, Apples, Pears, Quinces, Medlars, Quinces, Medlars, Quinces, Medlars	Wheat, Barley, Oats, Rye, Maize, Sorghum, Millet, Rice, Sunflower, Rapeseed, Linseed, Soybean, Mung bean, Chickpea, Lentil, Broad bean, Fava bean, Lupine, Pea, Bean, Vetch, Clover, Lucerne, Ryegrass, Fescue, Timothy, Phleum, Orchard grass, Ryegrass, Fescue, Timothy, Phleum, Orchard grass	Maize (grain), Maize (silage), Sorghum (grain), Sorghum (silage), Rice (grain), Rice (straw), Sunflower (oilseed), Sunflower (meal), Rapeseed (oilseed), Rapeseed (meal), Linseed (oilseed), Linseed (meal), Soybean (oilseed), Soybean (meal), Mung bean (oilseed), Mung bean (meal), Chickpea (oilseed), Chickpea (meal), Lentil (oilseed), Lentil (meal), Broad bean (oilseed), Broad bean (meal), Fava bean (oilseed), Fava bean (meal), Lupine (oilseed), Lupine (meal), Pea (oilseed), Pea (meal), Bean (oilseed), Bean (meal), Vetch (oilseed), Vetch (meal), Clover (oilseed), Clover (meal), Lucerne (oilseed), Lucerne (meal), Ryegrass (oilseed), Ryegrass (meal), Fescue (oilseed), Fescue (meal), Timothy (oilseed), Timothy (meal), Phleum (oilseed), Phleum (meal), Orchard grass (oilseed), Orchard grass (meal)	Grass (silage), Grass (hay), Maize (silage), Maize (hay), Sorghum (silage), Sorghum (hay), Rice (straw), Sunflower (oilseed), Sunflower (meal), Rapeseed (oilseed), Rapeseed (meal), Linseed (oilseed), Linseed (meal), Soybean (oilseed), Soybean (meal), Mung bean (oilseed), Mung bean (meal), Chickpea (oilseed), Chickpea (meal), Lentil (oilseed), Lentil (meal), Broad bean (oilseed), Broad bean (meal), Fava bean (oilseed), Fava bean (meal), Lupine (oilseed), Lupine (meal), Pea (oilseed), Pea (meal), Bean (oilseed), Bean (meal), Vetch (oilseed), Vetch (meal), Clover (oilseed), Clover (meal), Lucerne (oilseed), Lucerne (meal), Ryegrass (oilseed), Ryegrass (meal), Fescue (oilseed), Fescue (meal), Timothy (oilseed), Timothy (meal), Phleum (oilseed), Phleum (meal), Orchard grass (oilseed), Orchard grass (meal)	

The Water Industry is consolidating this into the Biosolids Assurance Scheme.

To provide increased transparency and reassurance to food chain stakeholders

# Biosolids Assurance Scheme

Water Industry initiative to provide reassurance to the food chain and consumers.

Brings together regulations and best practice into a single transparent Standard.

Sets a minimum Standard – protects the environment & creates a level playing field for all, whilst facilitating sludge trading.

Stakeholder input and support are essential to maintain validity and credibility.

Third party audit by NSF Certification

Aspiration for UKAS Accreditation

Commitment from Water UK Board to achieve 100% BAS compliance



# Treatment Technologies



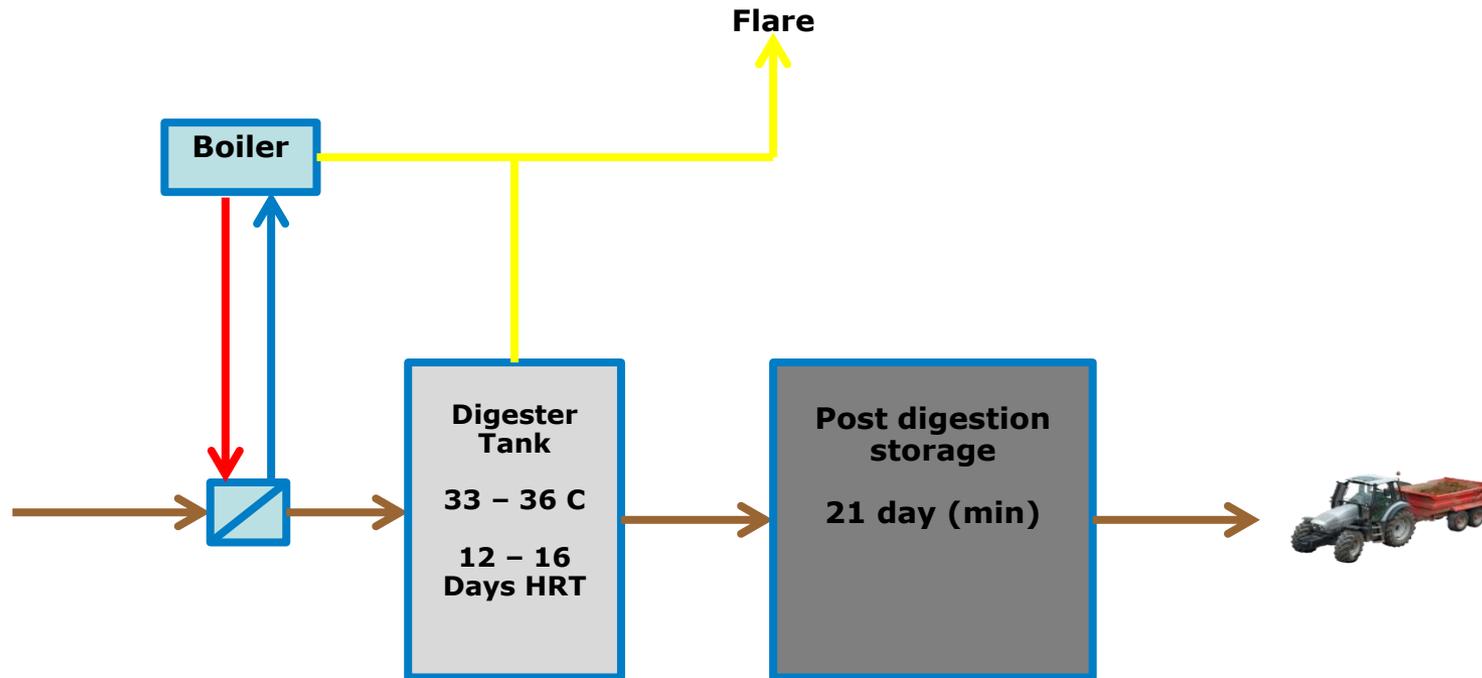
## Conventional

- Lime Stabilisation
- Conventional anaerobic digestion and liquid batch storage (21days)
- Conventional anaerobic digestion and cake storage (3 months)
- 2 stage digestion (acid phase + conventional anaerobic digestion)

## Enhanced

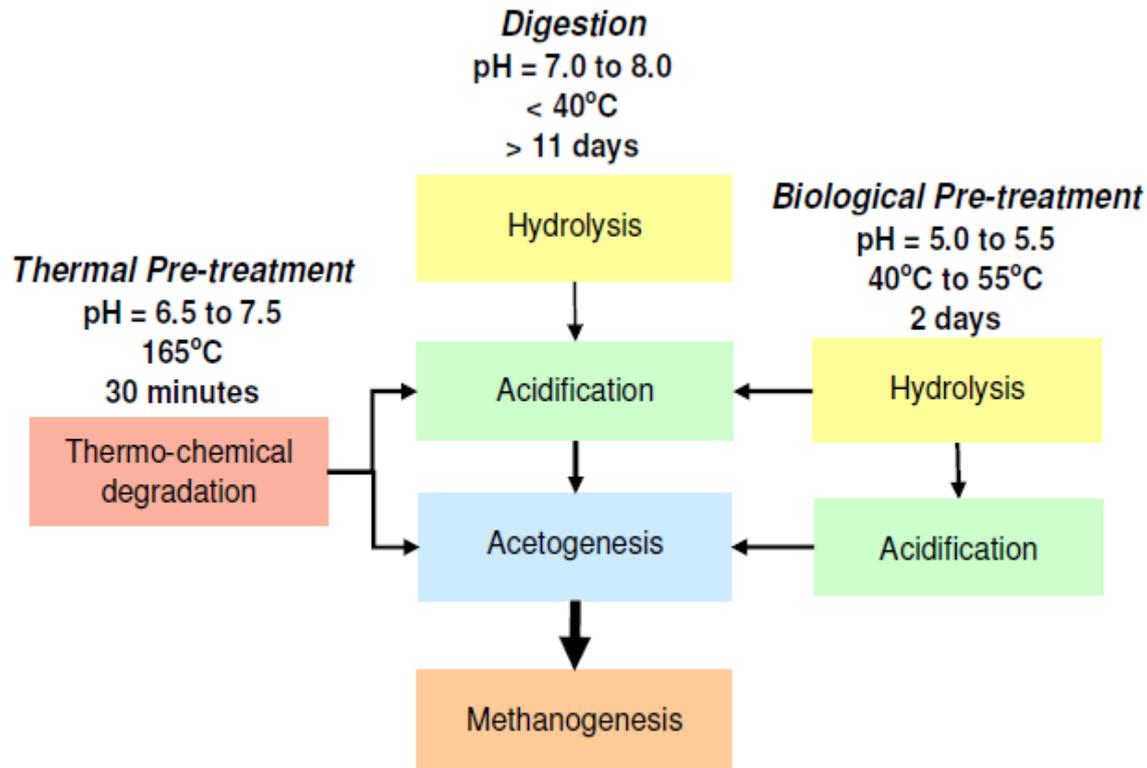
- Pasteurisation (70C for minimum 30 mins) and digestion
- Biological hydrolysis with pasteurisation and digestion
- Thermal hydrolysis and digestion
- Thermal drying of raw or digested sludge

# Typical Conventional AD System



HACCP Control for this system: Min digester HRT 12 days at >33C & min 21 day secondary batch storage

# Advanced Digestion Systems



- Conventional digestion is a four stage biological process
- Separation of stages 1-3 by biological or thermal hydrolysis improves the overall conversion efficiency by removing competing bacteria from the digestion phase
- Pre-treatment also allows for the sludge to be pasteurised to achieve an enhanced treated biosolids product

# Why Advanced Anaerobic Digestion?



- Can Produce both 'Conventional and Enhanced Treated' products suitable for recycling to agricultural land as a soil conditioner which provides a wider range of outlets as set out in the safe sludge matrix
- Higher levels of product acceptability, lower odours
- Higher conversion of organic matter, minimising quantity of product whilst maximising biogas yields
- Biogas utilised to produce heat and electricity using combined heat and power engines
- Reduced operating cost, maximised renewable energy production and reduced risk

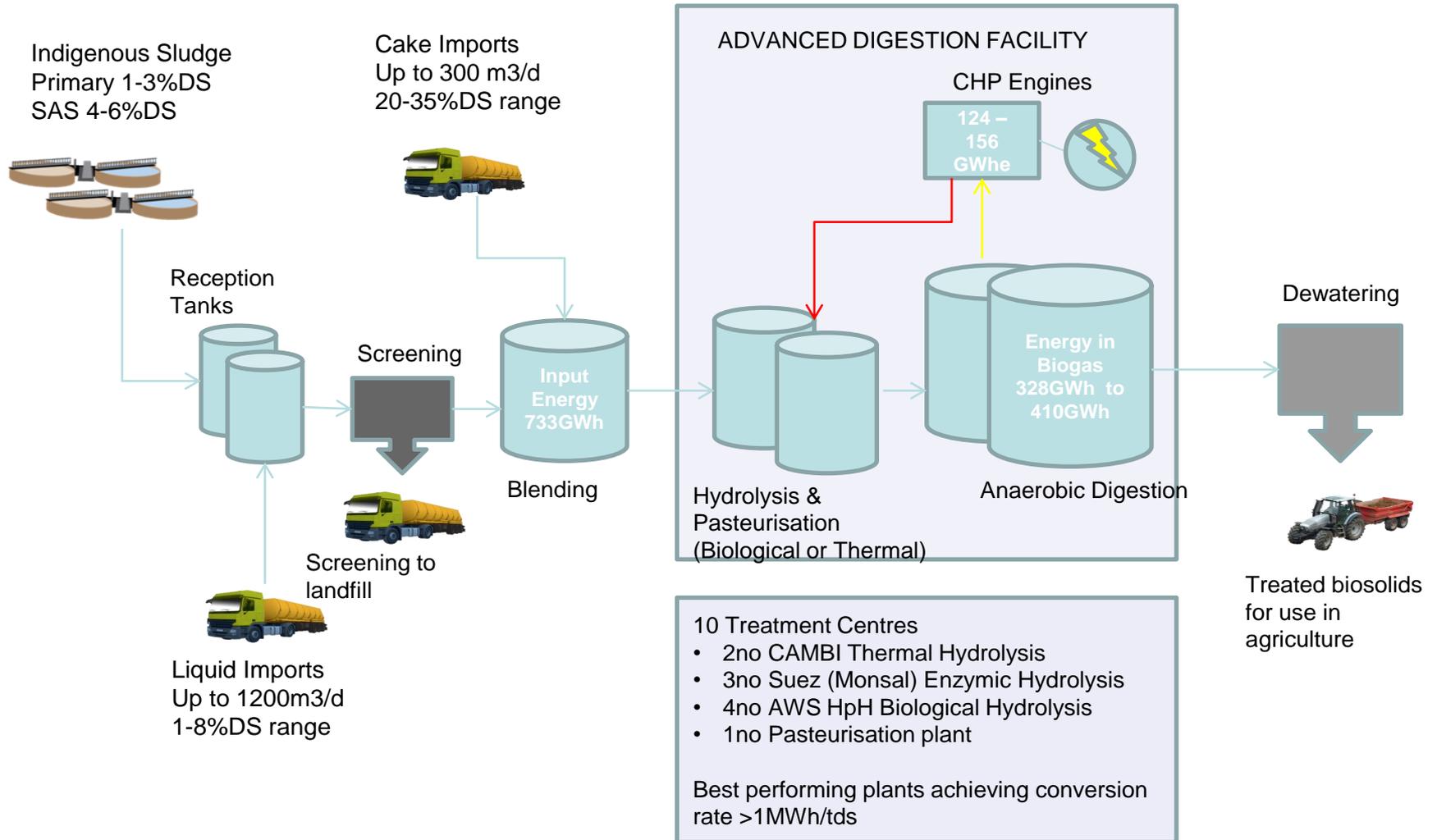
# Our Bio-resource Strategy



- Our strategy is to treat all sludge to the higher enhanced treated standard by 2020, minimising risks to agricultural outlets and reducing the volume of solids to be recycled
- Product recycled to agriculture as a soil conditioner providing valuable nutrients and organic matter to farmland
- Biosolids Quality Assurance Scheme (BAS) was introduced in 2015. Industry wide system, development was led by water companies and consulted key stakeholders from agriculture and the food processing industries. Objective applying an auditable quality standard for all biosolids recycled to agriculture
- Enhanced Digestion technology was a clear winner compared with alternatives as provides maximum solids destruction and reliably achieves enhanced treated quality
- Maximising solids destruction increases biogas yields and improves business case for renewable power generation and supports our wider renewable energy and carbon goals

# Bio-Resources Treatment

Typical Flow sheet used in Anglian Water



# Advanced Digestion Technologies used in Anglian Water



## Cambi Thermal Hydrolysis



*Cottonvalley STC*

### Cottonvalley (Milton Keynes)

- Commissioned 2008
- 20,600 tonnes dry solids per annum capacity
- 1.75MWe + 0.65KWe CHP engines

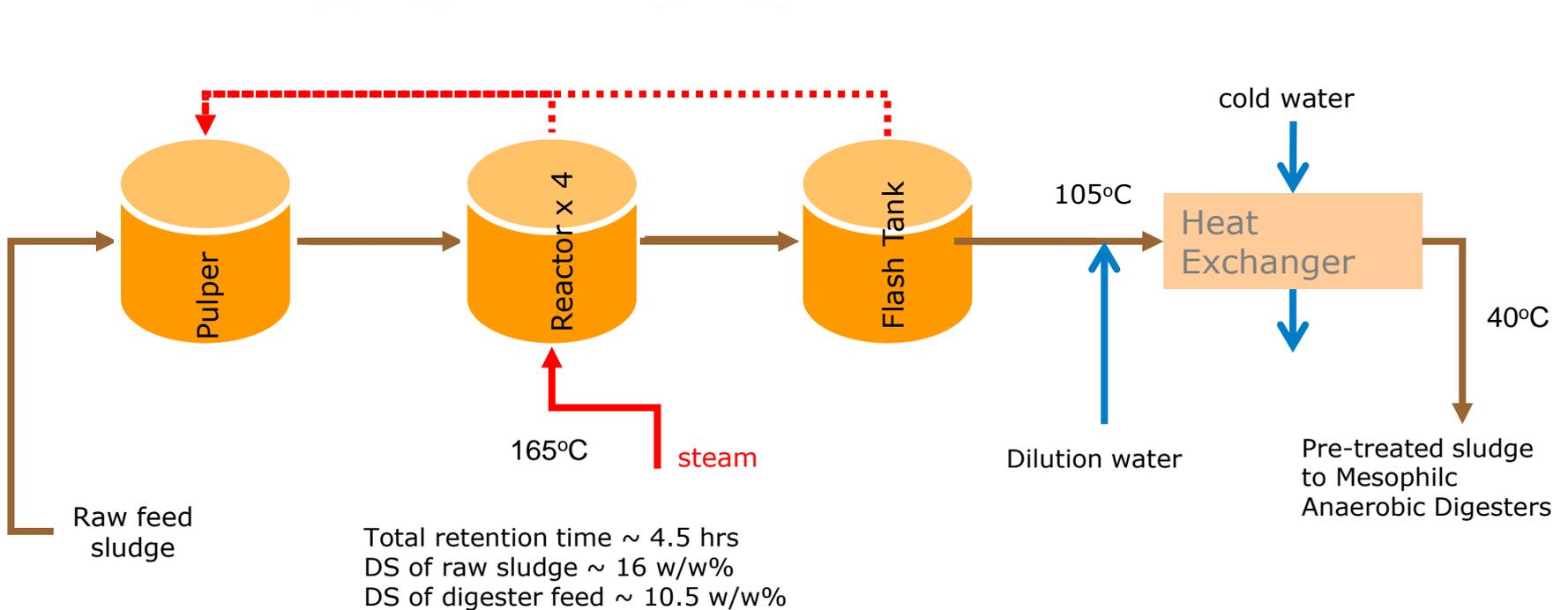
### Whitlingham (Norwich)

- Commissioned 2010
- 20,800 tonnes dry solids per annum capacity
- 1.75MWe + 1.2MWe CHP engines
- Sharon Liquor treatment plant

# Thermal Hydrolysis



steam recycled



HACCP control: Min reactor pressure 4 bar, min time 24 mins

# Advanced Digestion Technologies used in Anglian Water



## Suez Enhanced Enzymic Hydrolysis (EEH)

### Cambridge

- Commissioned in 2007
- 0.6MWe + 0.34MWe CHP engines
- 10,200 tonnes dry solids per annum capacity

### Kings Lynn

- Commissioned in 2008
- First EEH plant to use steam heating
- 19,000 tonnes dry solids per annum capacity
- 2no. 1MWe CHP engines

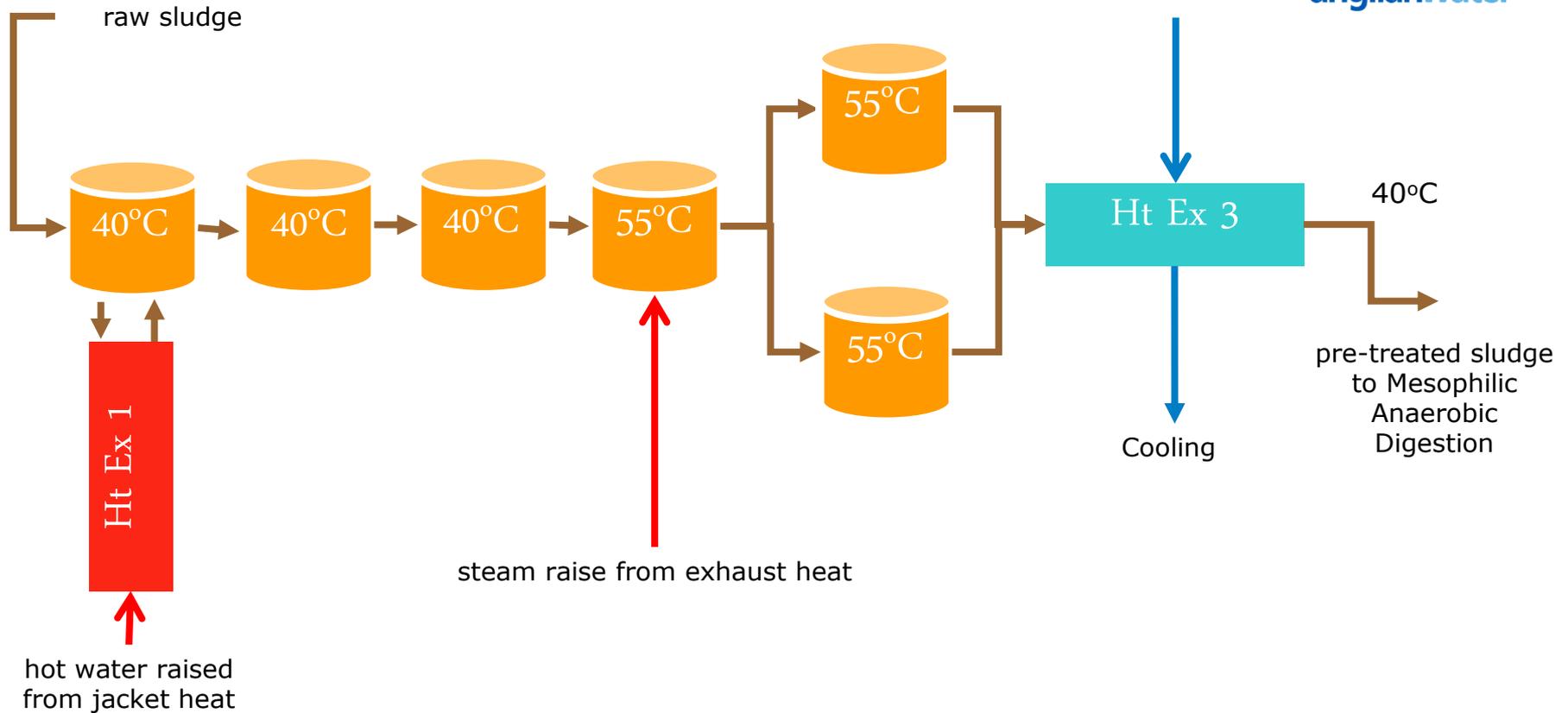
### Gt Billing (Northampton)

- Commissioned in 2010
- Largest STC operated by Anglian Water
- 36,500 tonnes dry solid per annum capacity
- 3no. 1.4MWe + 1.5MWe CHP engines



*Kings Lynn STC*

# Suez EEH Process



HACCP control: Min stage 2 temp 55C, min hold time 5 hours

# Advanced Digestion Technologies



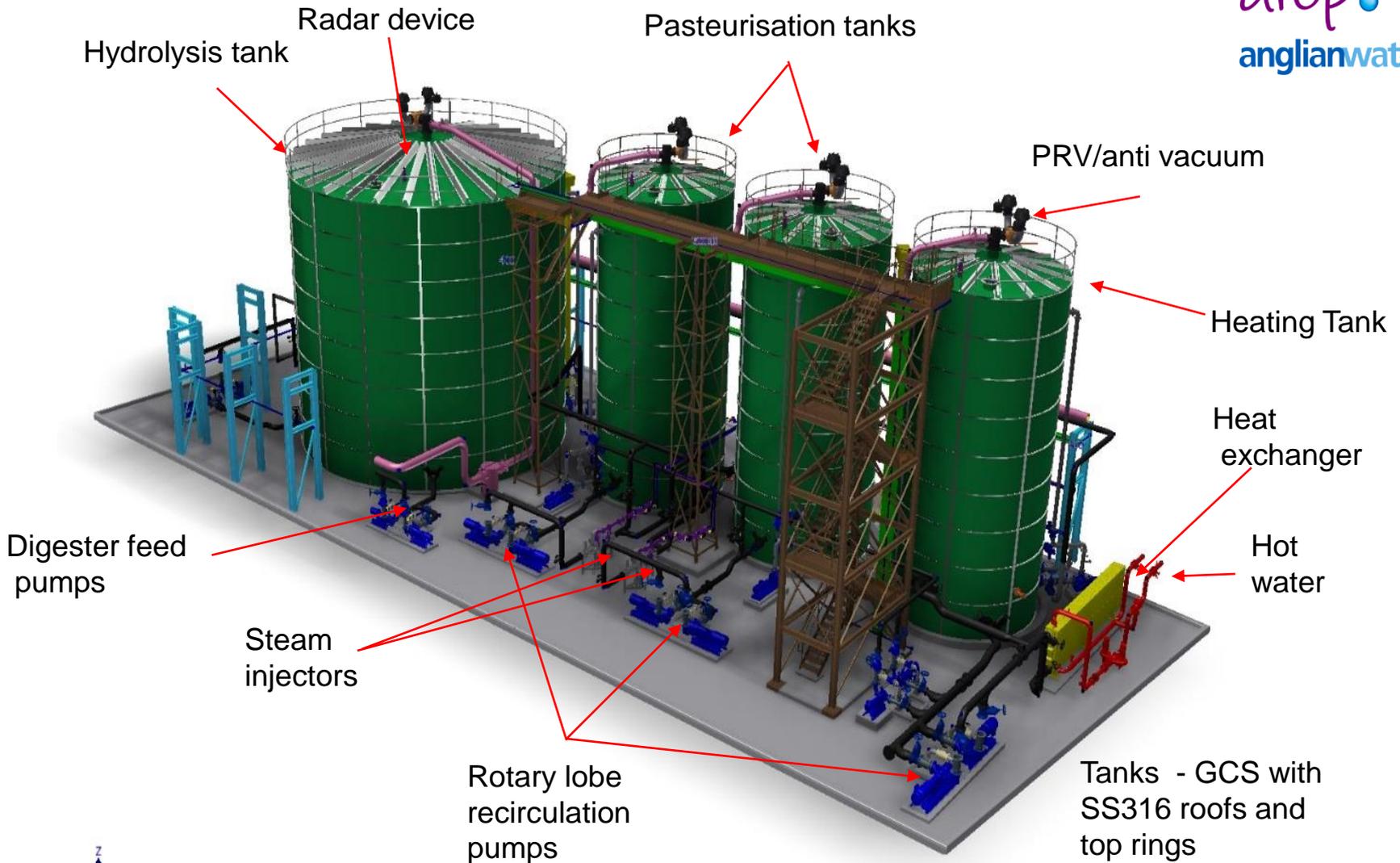
## Anglian Water - HpH Process

- New process developed by AWS and partners
- Patent awarded in July '16
- Biological hydrolysis process
  - Basildon 2013
    - 10,100 tonnes dry solids capacity
    - 2no. 0.6MWe CHP engines
    - AMTREAT Liquor Treatment
  - Cliff Quay (Ipswich) 2013
    - 14,800 tonnes dry solids capacity
    - 2no. 1.2MWe CHP engines
    - AMTREAT Liquor Treatment Plant
  - Colchester 2014
    - 14,900 tonnes dry solids capacity
    - 2no. 1.2MWe CHP engines
    - AMTREAT Liquor Treatment Plant
  - Pyewipe (Grimsby) 2014
    - 16,667 tonnes dry solids capacity
    - 2no. 1.2MWe CHP engines

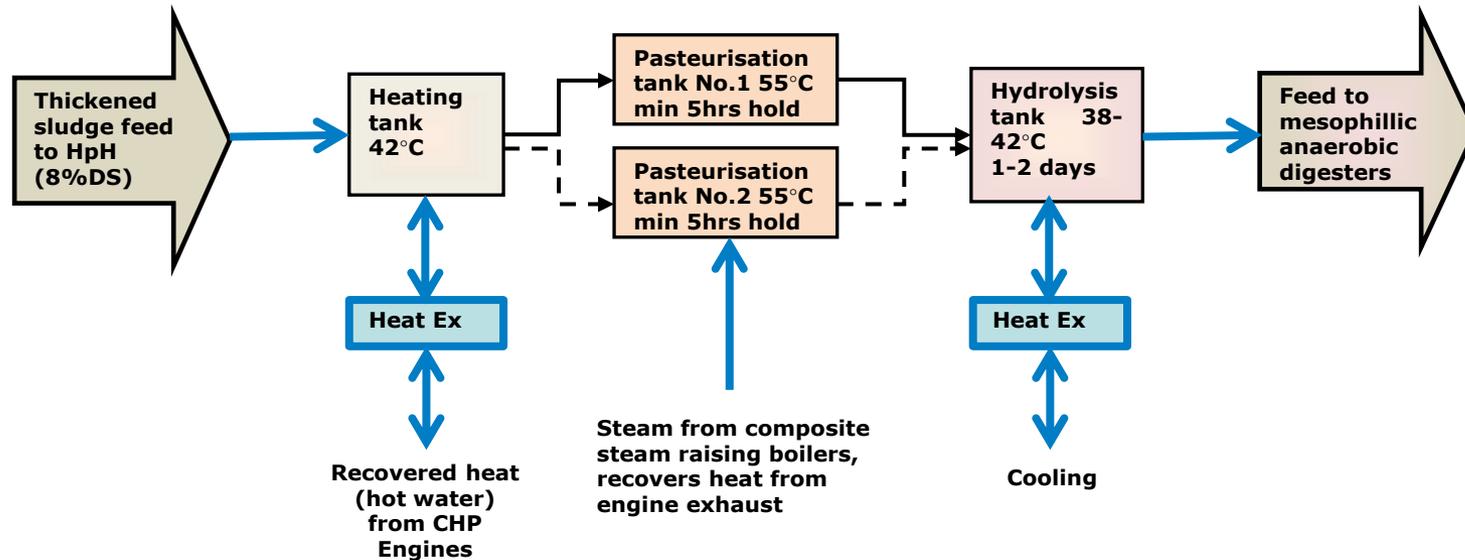


*Colchester STC*

# The HpH Process in Detail

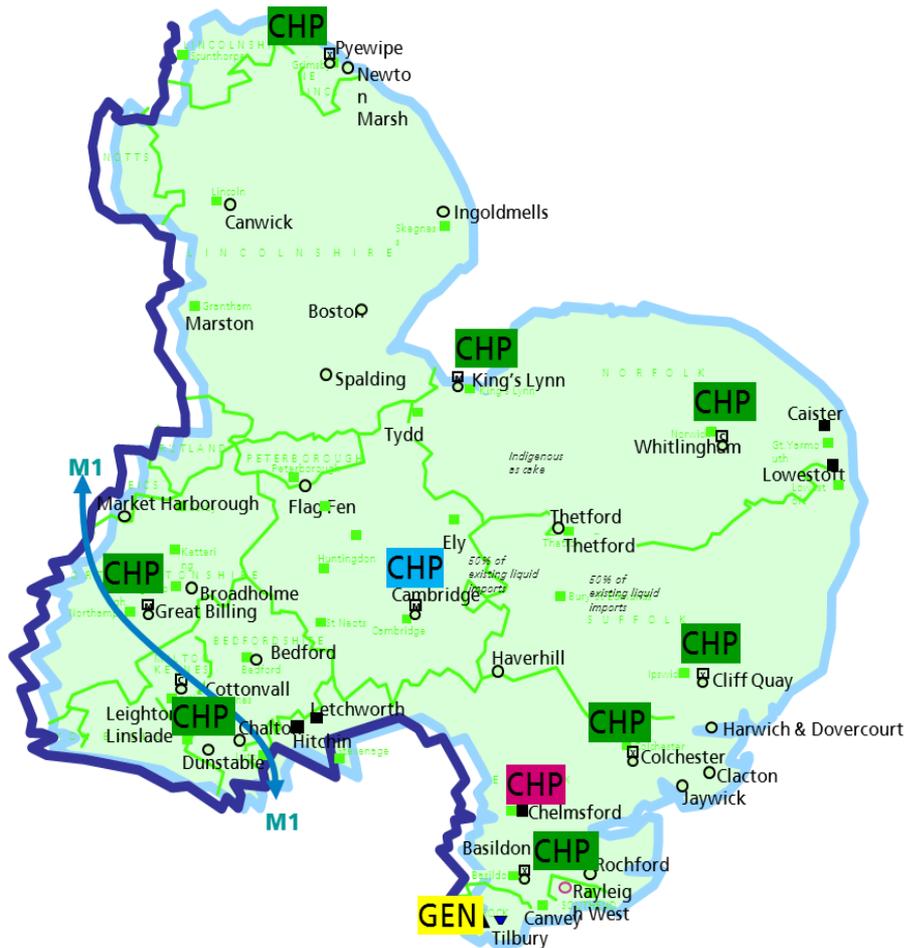


# HpH Biological Hydrolysis



HACCP control: Min stage 2 temp 55C, min hold time 5 hours

# Our Biogas CHP Sites



## CHP Fleet

### Pyewipe

2No. 1.2MWe MWM

### Kings Lynn

2No. 1MWe Jenbacher

### Great Billing

3No. 1.4MWe Jenbacher + 1No. 1.5MWe MWM

### Cottonvalley

1No. 1.75MWe Cummins + 1No. 0.65MWe CAT

### Whitlingham

1No. 1.75MWe Cummins + 1No. 1.2MWe MWM

### Cambridge

1No. 0.6MWe MWM + 0.34MWe MAN

### Cliff Quay

2No. 1.2MWe MWM

### Colchester

2No. 1.2MWe MWM

### Chelmsford

2No. 0.37MWe Perkins

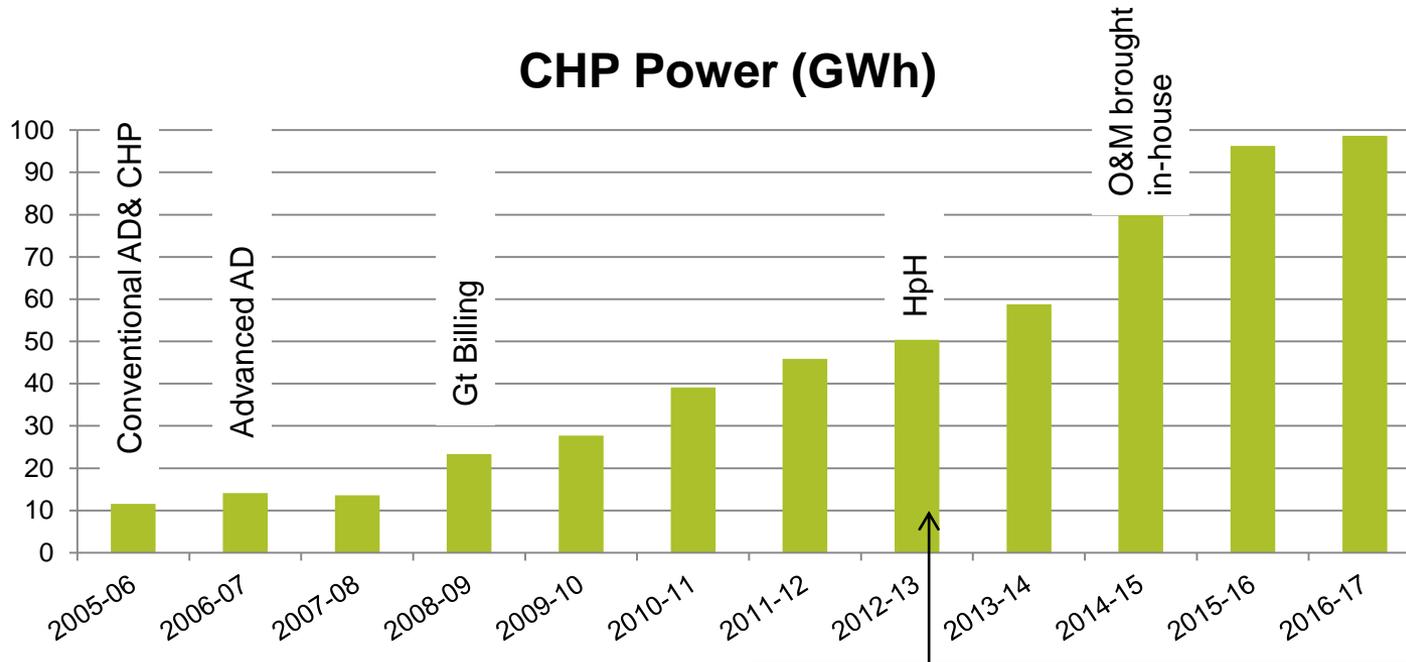
### Basildon

2No. 0.6MWe MWM

# Renewable Generation



## CHP Power (GWh)



# Plant Performance



- Use conversion rate, gross power generated per tonne dry solids of raw sludge treated (MWh/tds) as key performance measure
- Our top five sites have averaged a conversion rate of 1.05MWh/tds which is industry leading performance
- Best performing sites use biological hydrolysis technology (4No. HpH & Great Billing EEH)
- Targeting interventions to improve conversion rates on other sites
- Objective to get all sites operating consistently above 0.8MWh/tds

# Summary



- Bio-resource strategy is to move towards treating all of our raw sludge production to an enhanced treated standard by advanced digestion whilst maximising the generation of renewable power from the biogas produced
- 98.4GWh was generated from biogas in 2015/16 beating the our regulatory obligation and the targets set in the operational budgets
- £236M invested across nine sludge treatment centres since 2005
- Further investment planned to increase advanced digestion capacity to treat 100% of biosolids to enhanced treated standard
- Targeting a minimum of 105GWh/y power generation from biogas by 2020 with a further stretch target to generate 124GWh from our CHP fleet



love  
every  
drop.  
anglianwater