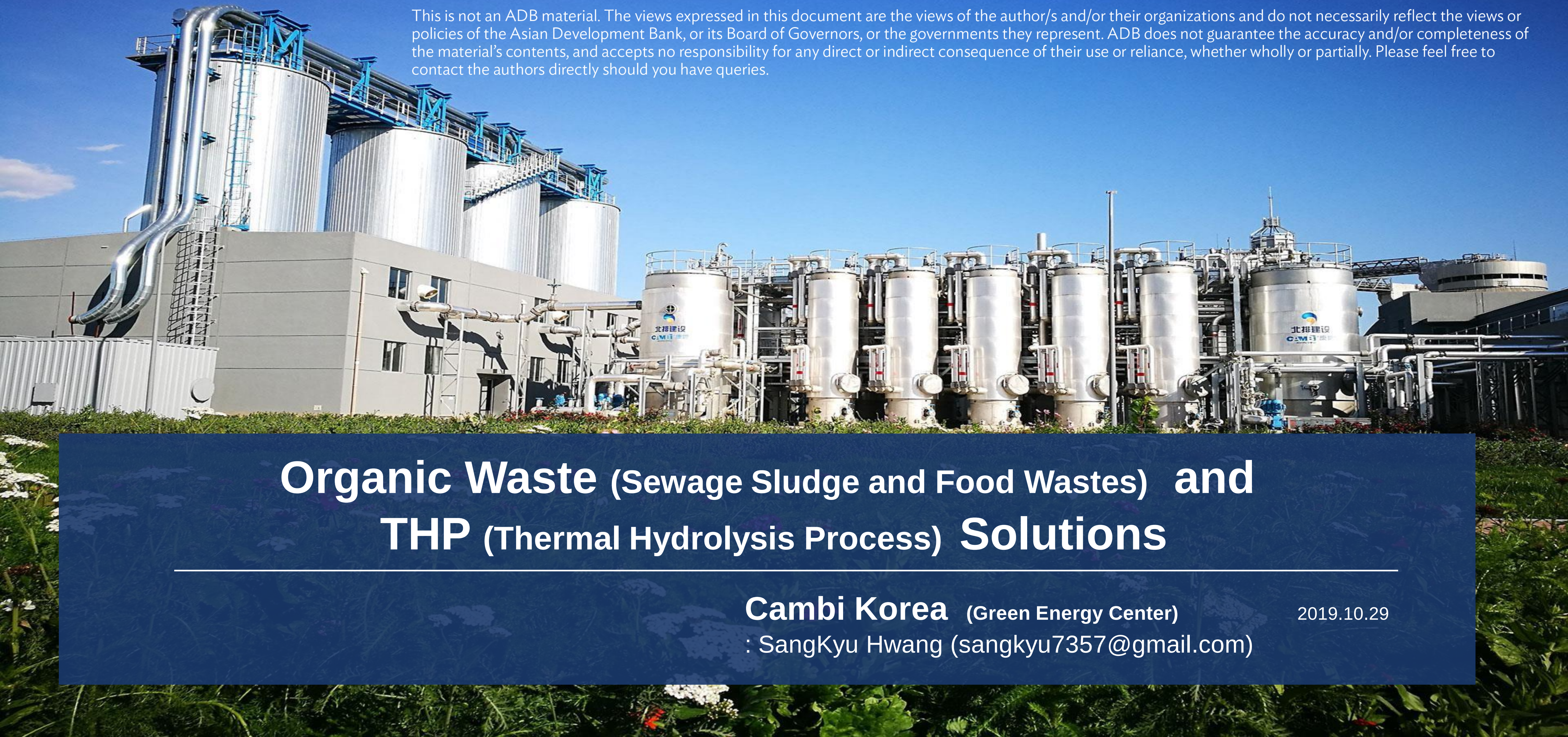
Sewage Sludge and Food Wastes Problems



Organic Waste (Sewage Sludge and Food Wastes) and THP (Thermal Hydrolysis Process) Solutions

Cambi Korea (Green Energy Center)

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2019.10.29

Issue Areas of Organic Wastes

Sludge:

State of the art Thermal hydrolysis processes to treat sludge

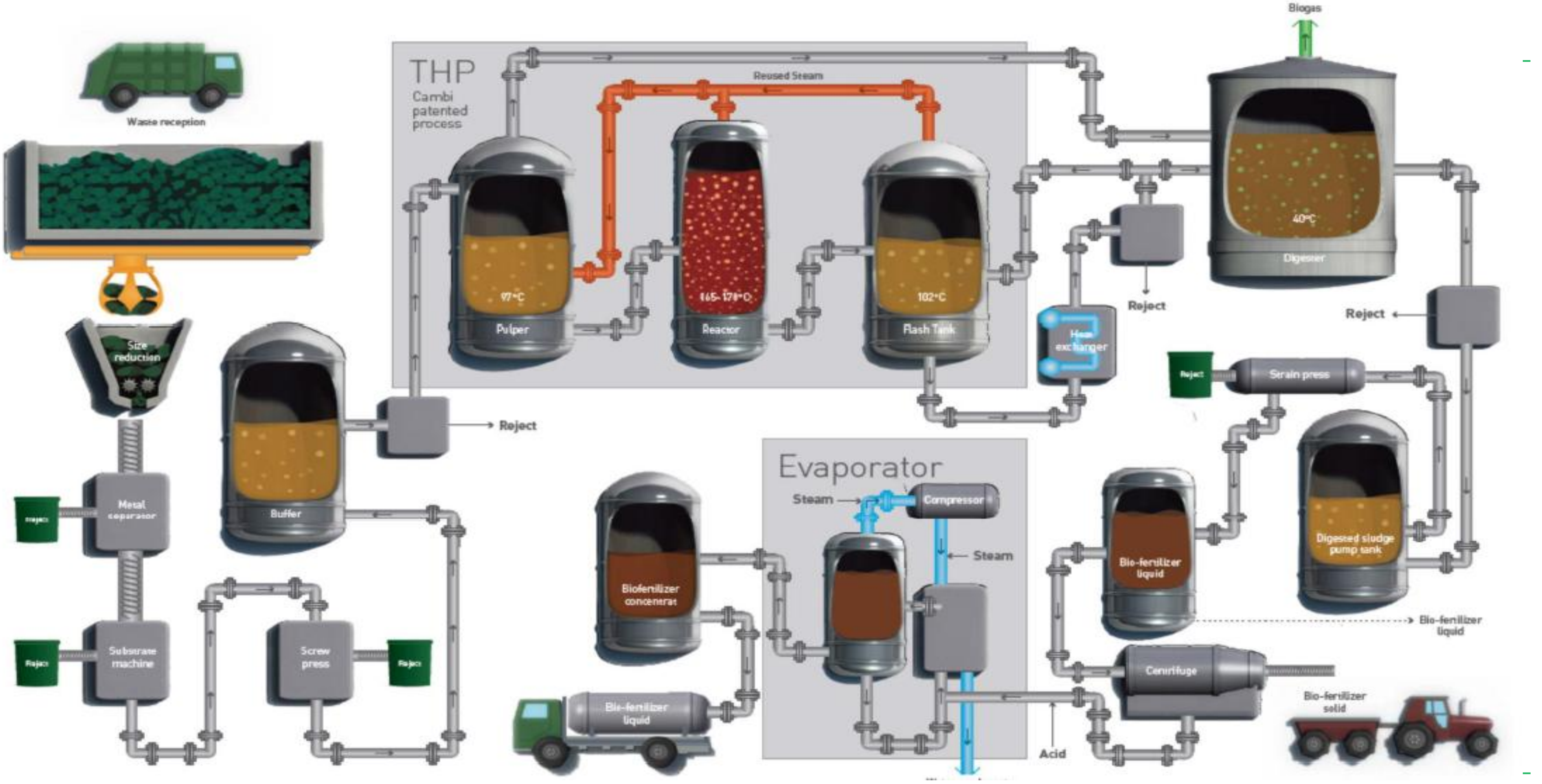
Food waste and co-digestion:
Biogas plants based on thermal hydrolysis, producing biogas & biofertiliser

Food wastes

Depending on the level of impurity and sources of the products, food waste/OFMSW (organic fraction of municipal solid waste) feedstock may be required the following pre-treatment technologies for the purification:

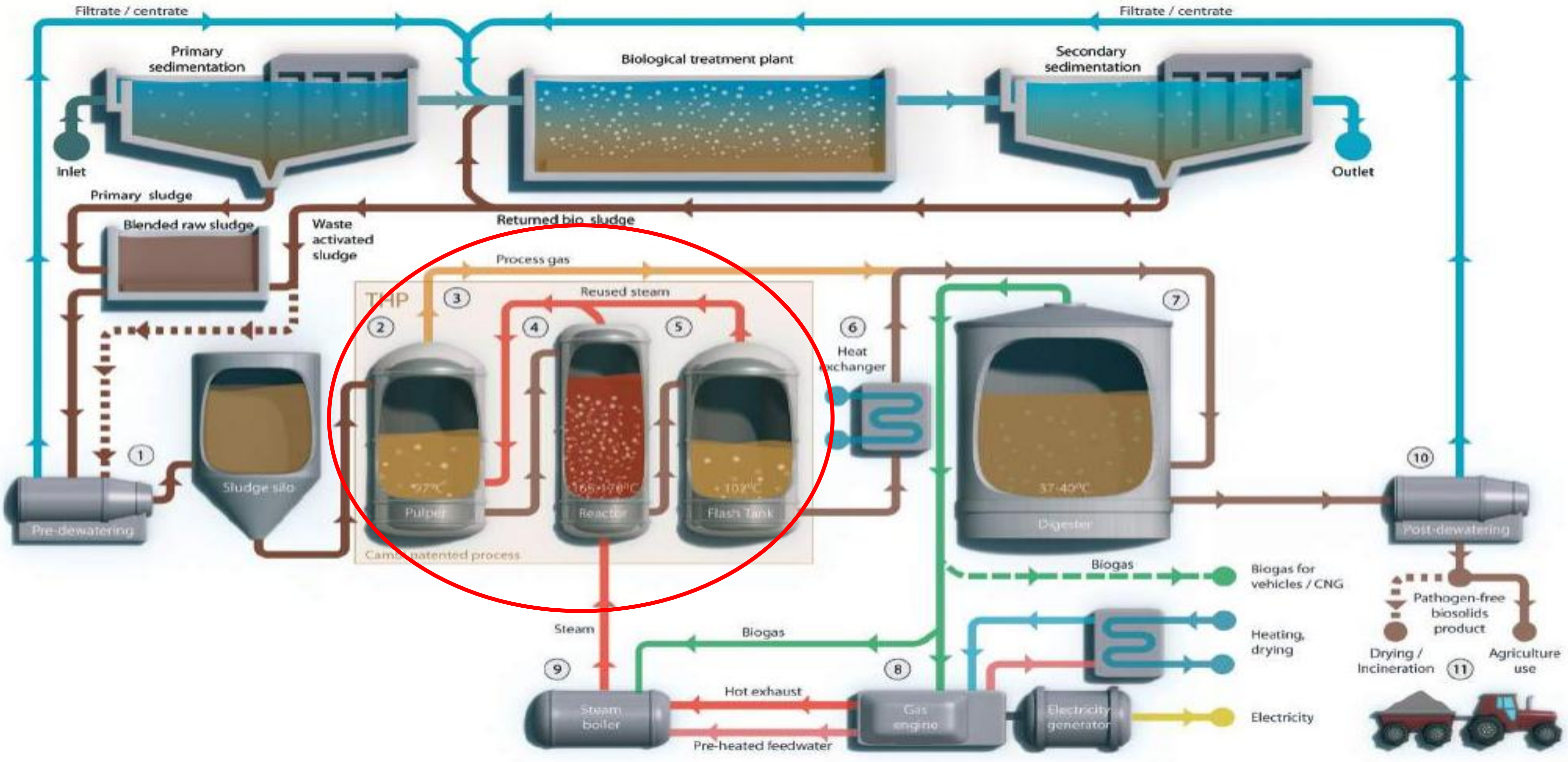
- Receiving and manual sorting
- Bag opener
- Shredders
- Screw Cutter
- Milling
- Rotating Drums
- Rotating Trommels
- Screens
- Magnetic separators
- Sterilizer
- Pulper
- Hydrolyser
- Homogenizer

Food Water Treatment and Biogas Production



Sewage Sludge

Sewage Water Treatment and Sludge problems



FROM WASTE TO WORTH USING ADVANCED ANAEROBIC DIGESTION

THE CAMBI SOLUTION TURNS
PROBLEMS INTO PRODUCTS:
FROM WASTE TO WORTH

“THP” has more than 25 years experience

1989 (first trials with steam explosion)

1992 (Cambi is founded)

1994 (contract with HiA S)

1998 (Chertsey/ JV with Th ames Wat er, UK)

2000 (large- scale THP, Dublin)

2005 (co- dig estion of food wa ste)

2011 (biowaste plant in Oslo)

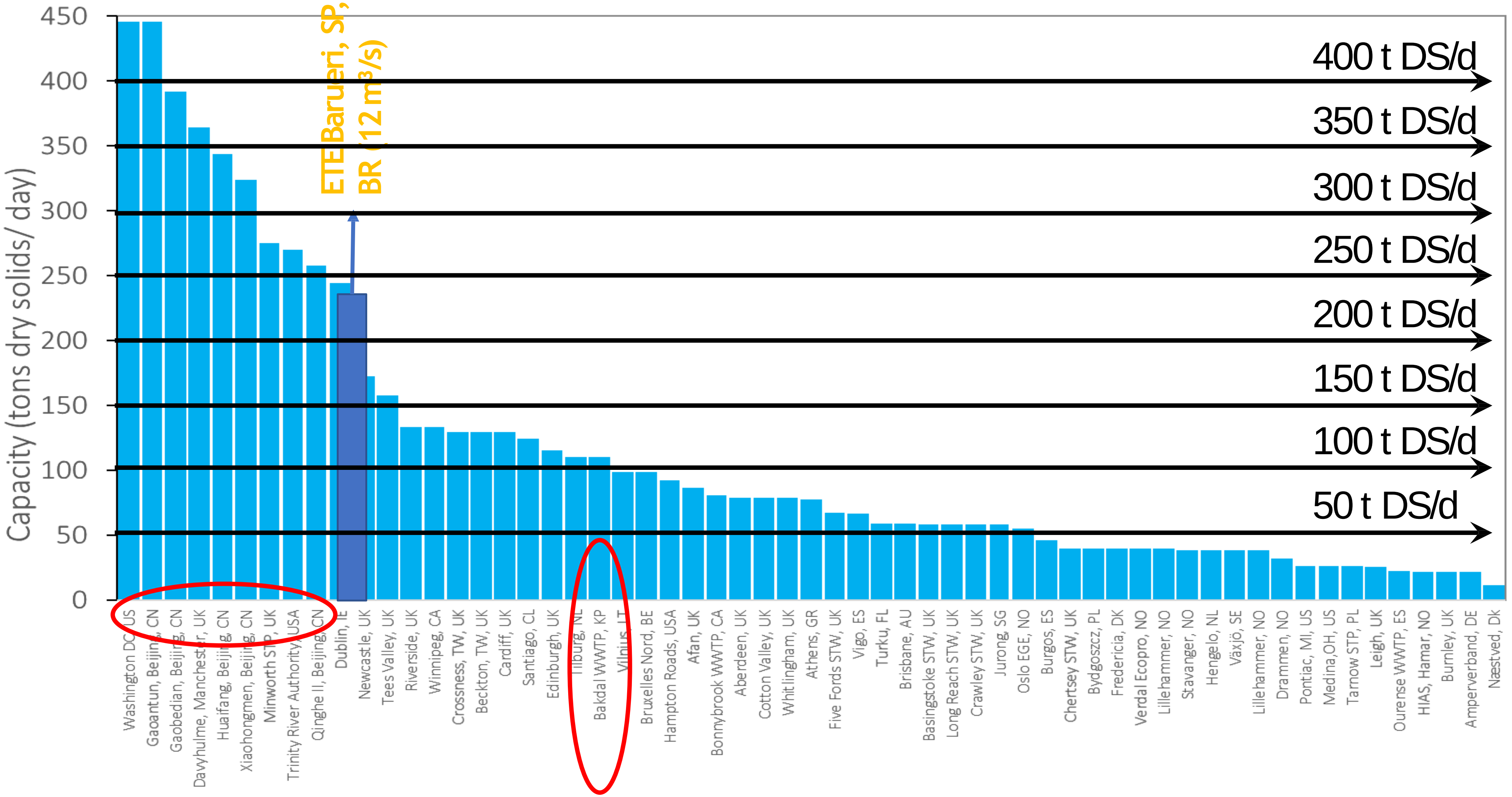
2011 (Washington DC contract)

2014 (China market t akes off)

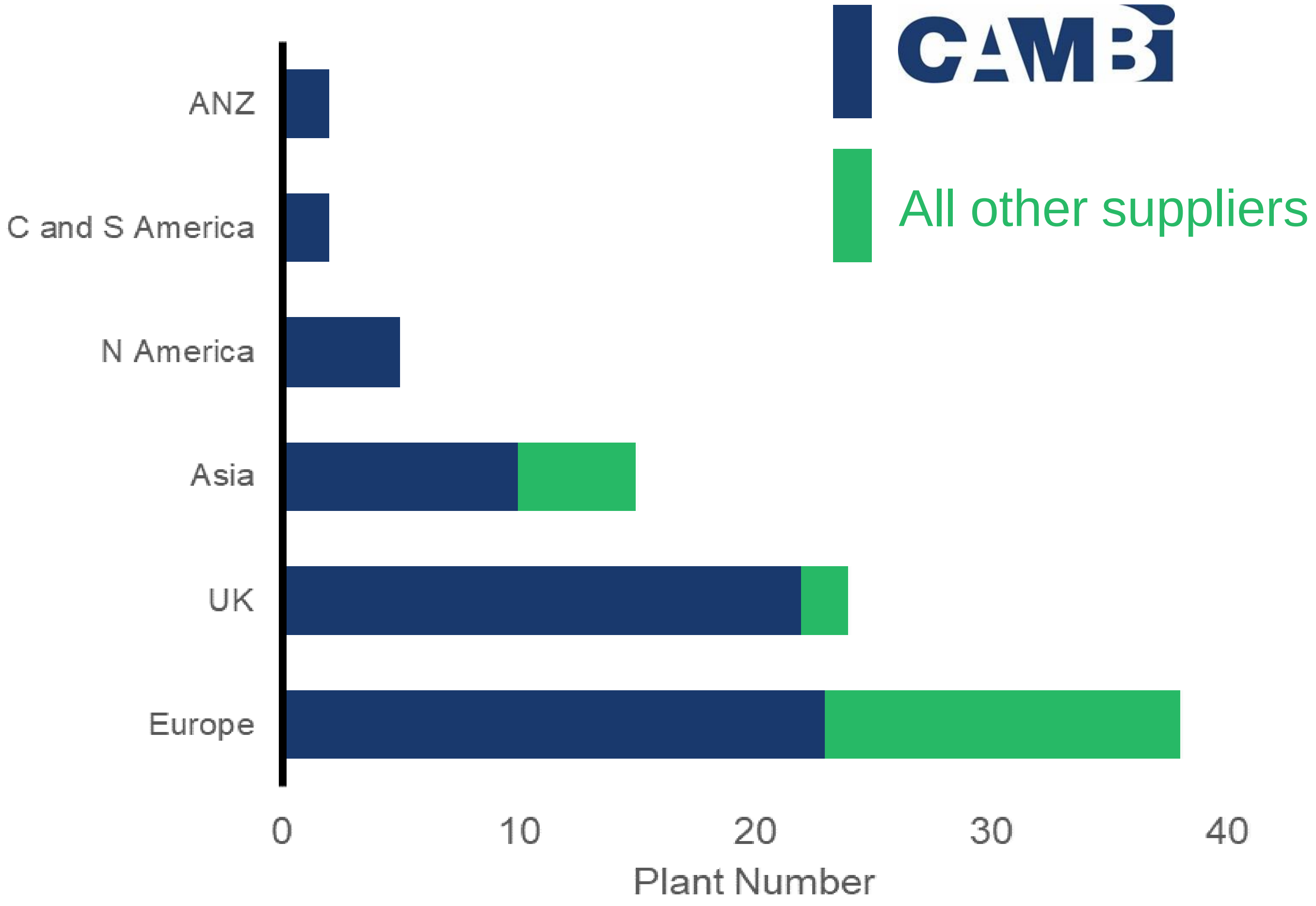
2017 (US market takes off)
Anyang, Korea

65	50	15	75M	6,955
Plants	Operational	In Design	Population equivalents	US ton dry solids/d

Today, thermal hydrolysis is a standard technology

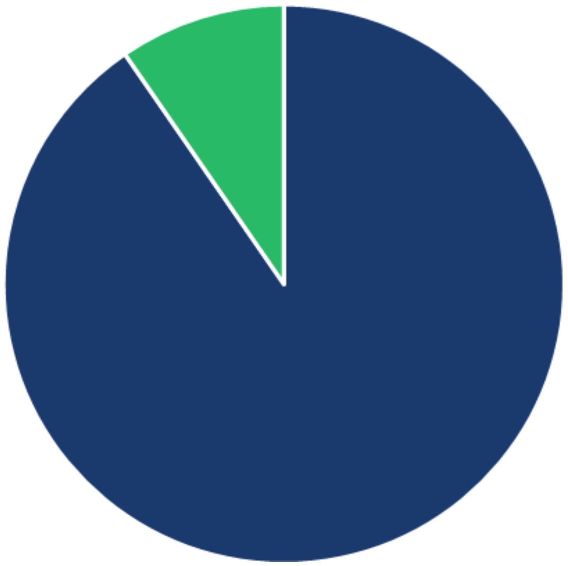


Thermal Hydrolysis Globally



Between 80 and 90 facilities

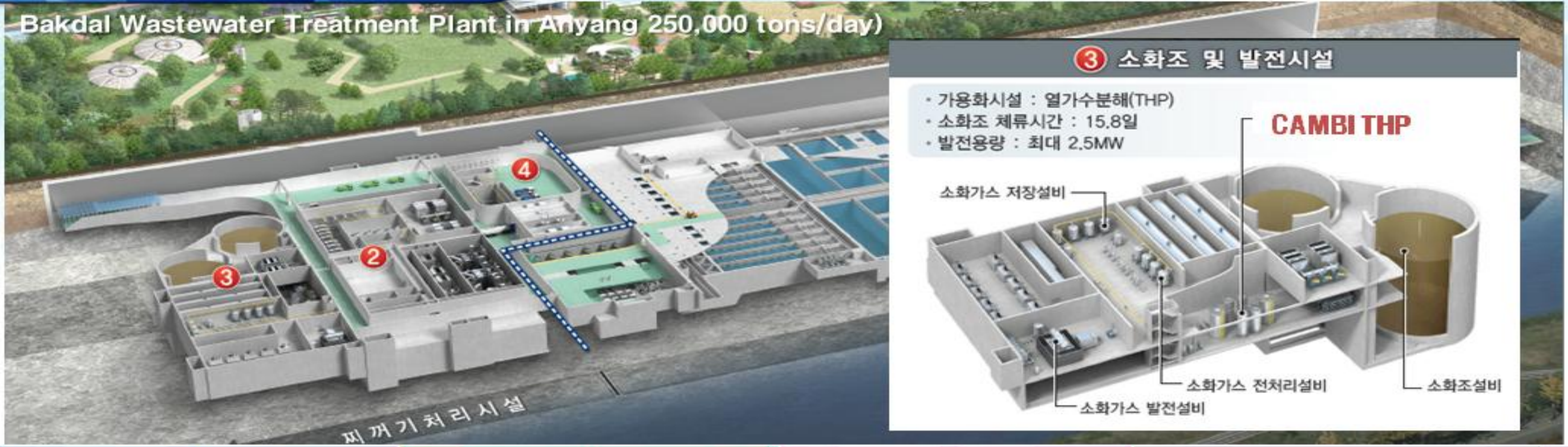
Market Share by installed capacity



Over 2 million tonnes dry solids processed annually

Example : Anyang Sewage Wastewater Treatment Plant

Status of Domestic Operation



Classification	Existing	THP	Remark
Treatment Capacity	630㎥/day (DS 10%)		• Use CAMBI's excellent technology and experience of operation → Maximize treatment efficiency of digester and minimize retention time
Days of Retention in Digester (HRT)	30.5 days	15.8 days	
VSR	40.2%	59.3%	
Amount of Digestion Gas Generated	6,110N · ㎥/day	18,000N · ㎥/day	
Content of Methane Gas (CH_4)	CH_4 55%	CH_4 62.8%	
Amount of Cake Generated (Moisture Content %)	187㎥/day (80%)	98.2㎥/day (73%)	
Electricity production (MW)	-	1.6 MW	

Note) The data is based on current operation performance.

More than 20 years of continuous operation for the first Cambi THP plant at HIAS WWTP, Hamar

The Normal Operation Actual Certificate

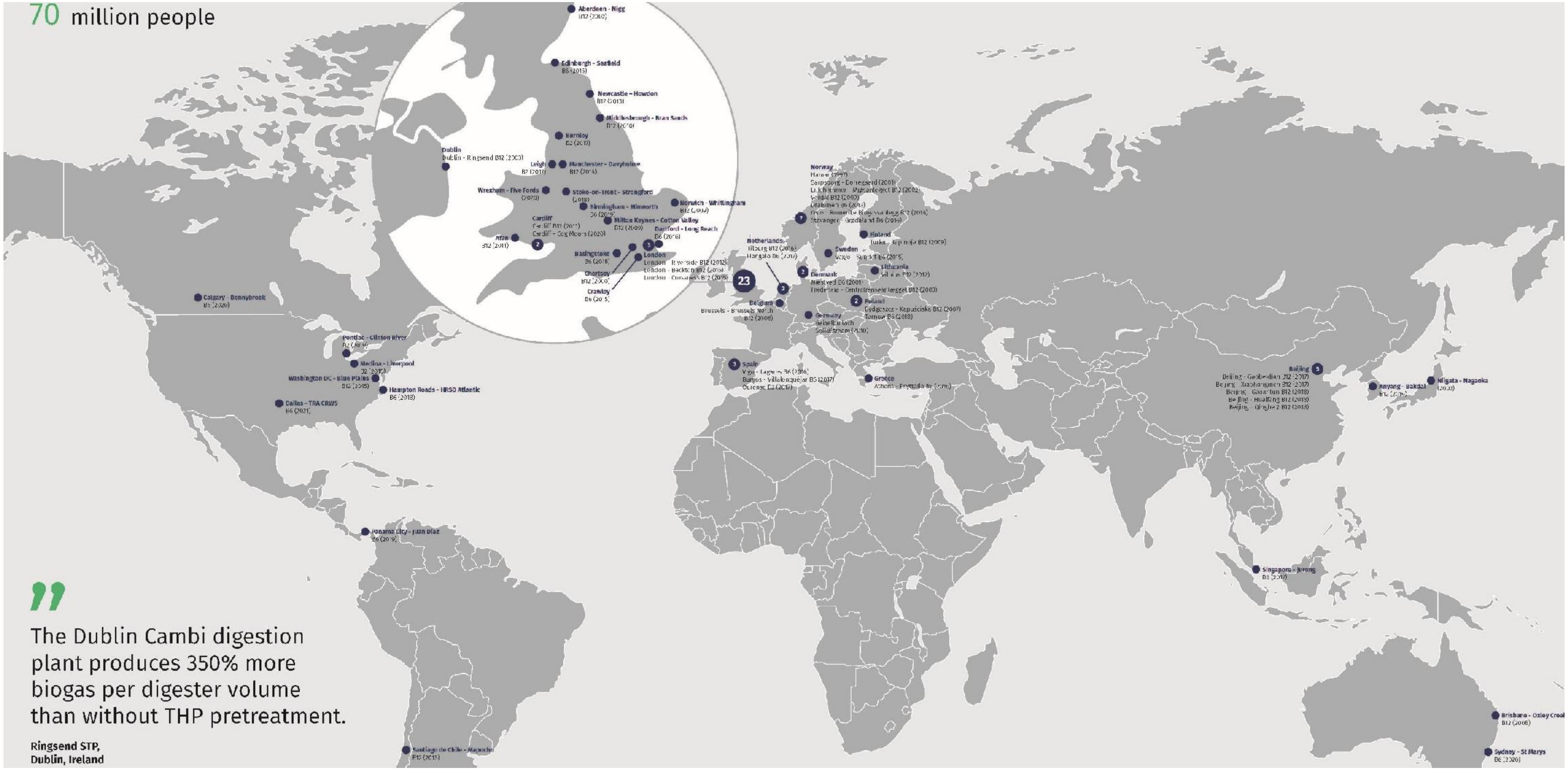
1. Plant Operation Start Date	Date of 1 Sept 1995	
2. Annual Operation Hours Record	Operation Year	Operation Hours
	1995-2014	350 d/y, 24 h/d
	2011	358 d/y, 24 h/d
	2012	358 d/y, 24 h/d
	2013	358 d/y, 24 h/d
	2014	358 d/y, 24 h/d
3. Trouble Outbreak Situation, if happened	Name of Equipment	CambiTHP
	None (only normal maintenance)	None
4. Plant Modification	2005: Expansion with additional digester, by Cambi 2006-2007: Expansion with additional THP reactor and a flashtank, by Cambi.	

5. Operating results
- Name of Project : Hias Wastewater Treatment Plant, Hias IKS (water and waste management company), Hamar, Norway
- Equipment type : Cambi Thermal Hydrolysis
- Design capacity : 19 t dry solids (DS)/day
- Actually treated capacity: 11 t dry solids (DS)/day
- Substance Type : Sewage Sludge
- Volatile Solid Reduction Rate : 63%
- Dry Solids concentration in dewatered cake: 38% DS

This is to certify that the above statement is true

May 08, 2015 Thorbjørn Netteland Operations Manager (signature)	May 08, 2015 County Governor of Hedmark (signature)

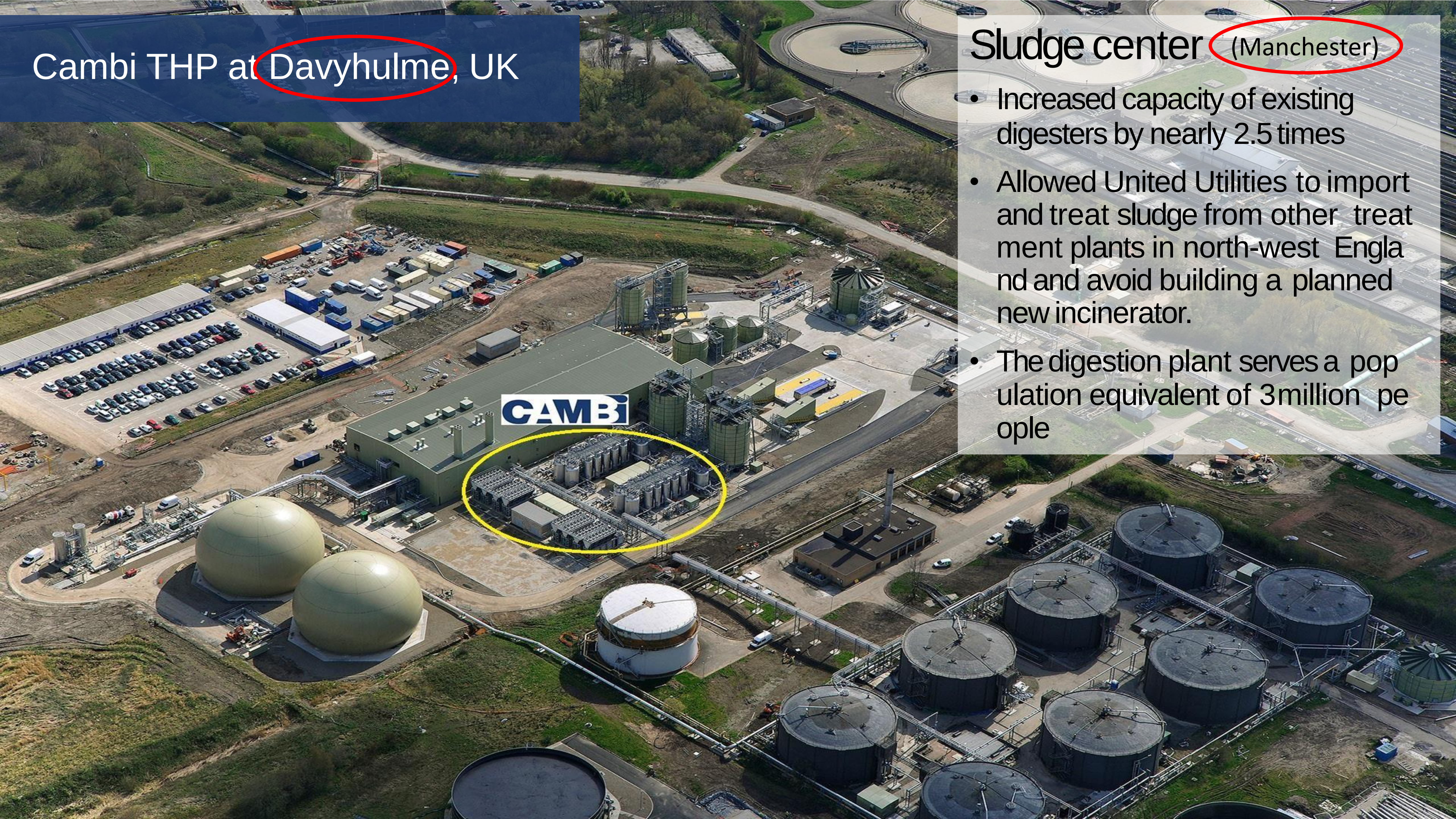
References


70 million people
Aberdeen - Nigg
B12 (2002)
Edinburgh - Seafield
B5 (2015)
Newcastle - Howdon
Middlesbrough - Bran Sands
Burnley
B2 (2017)
Dublin
Dublin - Ringsend B12 (2000)
Leigh
B2 (2017)
Manchester - Davyhulme
Wrexham - Five Fords
(2020)
Stoke-on-Trent - Strongford
(2018)
Birmingham - Minworth
Norwich - Whittingham
B12 (2009)
Milton Keynes - Cotton Valley
B12 (2009)
Cardiff
Cardiff - Cog Moors (2020)
Dartford - Long Reach
Afan
B12 (2011)
Basingstoke
B6 (2018)
London
London - Riverside B12 (2012)
London - Beckton B12 (2015)
London - Crossness B12 (2015)
Chertsey
B12 (2000)
Crawley
23
Norway
Sarpsborg - Domsgaard (2001)
Verdal B12 (2002)
Stavanger - Grødaland B6 (2016)
Finland
Sweden
Lithuania
Netherlands
Tilburg B12 (2016)
Denmark
Poland
Bydgoszcz - Kapuściska B12 (2007)
Tarnow B6 (2018)
Belgium
Brussels - Brussels North
B12 (2008)
Germany
Geiselbullach
Solidstream (2010)
Spain
Burgos - Villalonquéjar B5 (2017)
Ourense B2 (2017)
Greece
Calgary - Bonnybrook
Pontiac - Clinton River
Medina - Liverpool
Washington DC - Blue Plains
B12 (2015)
Hampton Roads - HRSD Atlantic
B6 (2018)
Dallas - TRA CRWS
B6 (2021)
Panama City - Juan Diaz
Santiago de Chile - Mapocho
Beijing
Beijing - Gaobeidian B12 (2017)
Beijing - Xiaohongmen B12 (2017)
Beijing - Gaoantun B12 (2018)
Beijing - Huaifang B12 (2018)
Beijing - Qinghe 2 B12 (2018)
Anyang - Bakdal
Niigata - Nagaoka
(2013)
Singapore - Jurong
Brisbane - Oxley Creek
B12 (2008)
Sydney - St Marys
B6 (2020)
”
The Dublin Cambi digestion plant produces 350% more biogas per digester volume than without THP pretreatment.
Ringsend STP,
Dublin, Ireland

Cambi in the UK

- UK industry is fully privatized
  - On stock exchange
  - Shareholders and dividends
  - United Utilities (UU) in 2018
  - Revenue £ 1750 million (US$2300 million)
- Governed by financial regulator OFWAT
- OFWAT control rates which can be charged

Cambi THP at Davyhulme, UK



Sludge center (Manchester)

- Increased capacity of existing digesters by nearly 2.5 times
- Allowed United Utilities to import and treat sludge from other treatment plants in north-west England and avoid building a planned new incinerator.
- The digestion plant serves a population equivalent of 3 million people

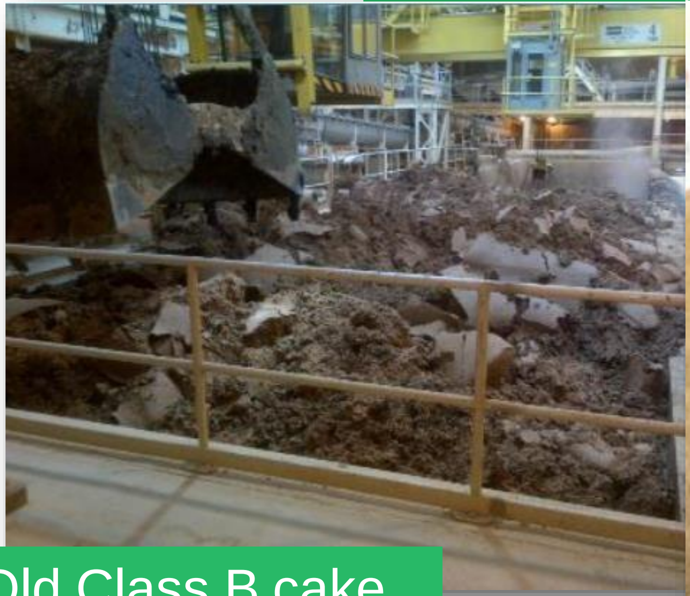
Cambi THP at Blue Plains WWTP in Washington DC (USA) – 4 million p.e.

- PLANNED TRADITIONAL DESIGN
  - 8 digesters = 174 000 m^3 designed originally

- CAMBI SOLUTION
  - 4 digesters = 58 100 m^3 (1/3 of traditional)
  - Saved $200 million CAPEX vs traditional
  - Saved >$20 mill in OPEX/year
  - Generate 13 MW (net 10 MW) of clean, renewable power from the CHP

Cambi THP at Blue Plains WWTP in Washington DC (USA) – 4 million p.e.

Cake production [wet basis]	
Before	After



Old Class B cake

New Class A cake

Bloom packaging
http://bloomsoil.com/

FIVE CAMBI PLANTS IN BEIJING
4.2 million m³/d = 48,6 m³/s , 6000 t of wet sludge/day

GAOBEIDIAN WWTP

GAOANTUN WWTP

HUAIFANG WWTP

XIAOHONGMEN WWTP

QINGHE II WWTP

FIVE CAMBI PLANTS IN BEIJING
4.2 million m³/d = 48,6 m³/s , 6000 t of wet sludge/day

CAMBI

Beijing Drainage Group (BDG) for Huaifang Water Reclamation Plant (HWRP) project for winning the IWA Gold Prize for category Exceptional Project Execution and Delivery at the International Water Association - World Water Congress 2018 at Tokyo – Japan. (16-21, September, 2018)

Madam Lin, the Chairman of BDG group: “The success of this award belongs to BDG and Cambi's cooperation, we thank the two companies for their collaborative efforts to work together”.

CAMBI THP PLANTS IN BEIJING with Norwegian Minister (2017.7.10)

CAMBI Converting food waste to biogas and fertilizer in 6 cities from Norway to South Korea

Why thermal hydrolysis?

It changes the properties of sludge at a fundamental level (non-reversible reduction in viscosity)

- Allowing higher loading rates to digesters
  - Minimize or eliminate spending on digester upgrades
  - New digestion plants are significantly smaller

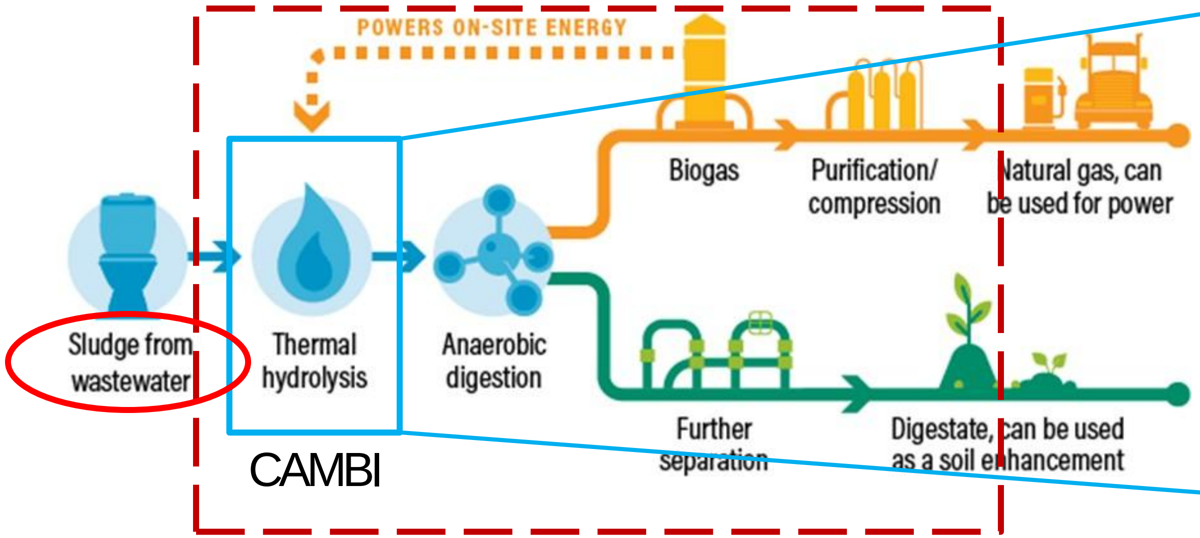
- Improving dewaterability
  - Less Biosolids exiting plant
  - Lower energy requirements for downstream processing

In addition

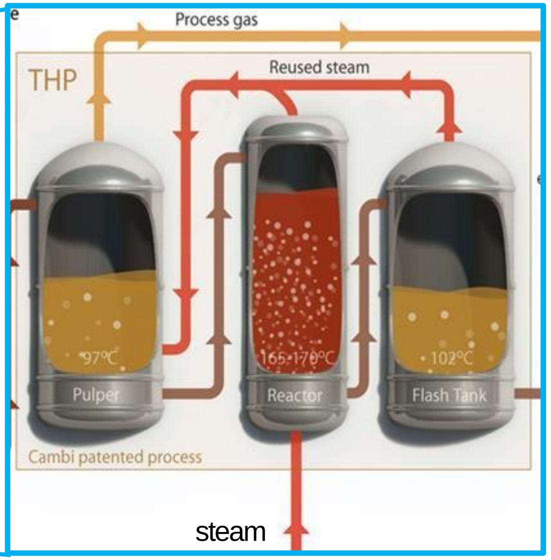
- Sterilization – Class A Biosolids without regrowth
- Improved digestion performance increases biogas production
- Minimized foaming potential
- Friable, minimum odor homogenous cake easy to spread on standard agricultural equipment
- Reduced carbon footprint

Where is CAMBI in a wwtp ?   (Sludge treatment)

Wastewater-to-Energy System



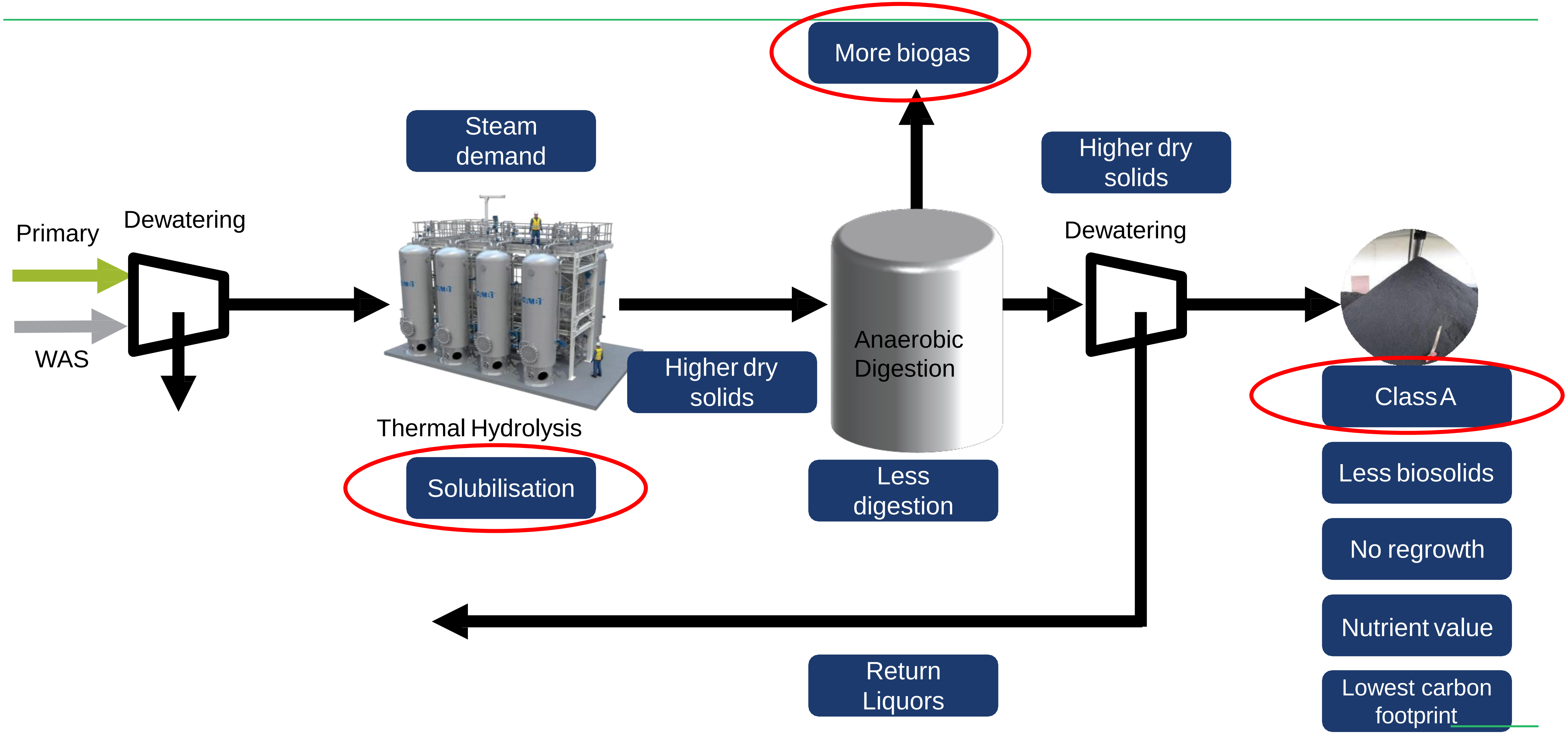
CAMBI Solutions



CAMBI Thermal Hydrolysis Process

Source: World Resources Institute, 2017

Influence of thermal hydrolysis on overall process



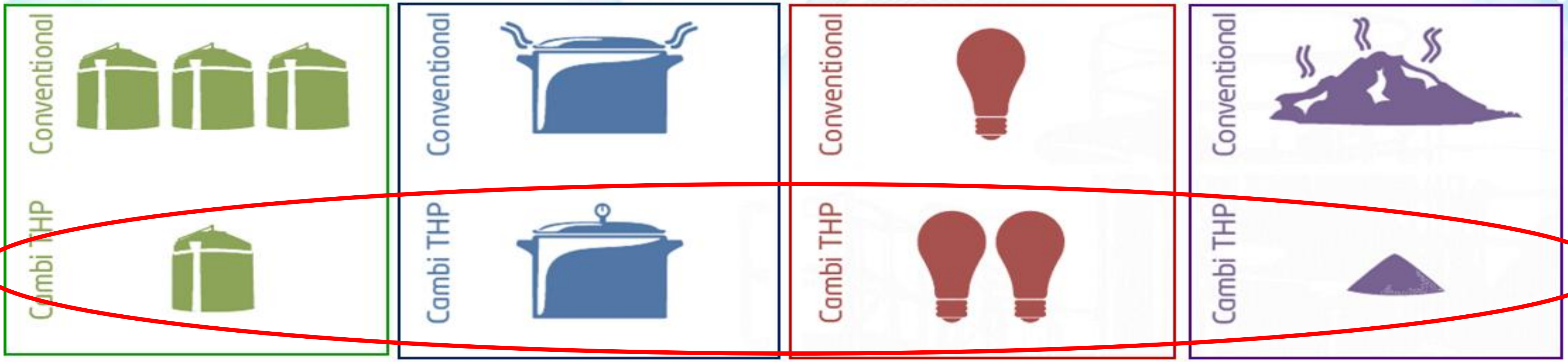
Comparison

Conventional	Parameters	Cambi
3-6%	Digester Feeding DS%	9-12%
20-25	Digester HRT (d)	15-18
Big	Digester volume	Small
Low	Digester Loading rate	High
33-37	Digester Temp (°C)	38-42
6.5-7.5	Digester pH	7.5-8.0
30-45%	Organic VSR%	50-65%
Low	Biogas production (m3/tDS)	High
High	Biogas H_2S	Low
20%-25%-30%	Dewatered Cake DS%	30%-35%-40%
Class B (partial)	Biosolids hygienization	Class A (pathogen Kill)
More	Viscosity	Less

CAMBI

Excellency of Technology

Improved Digestion Efficiency	Highly-efficient Energy Sterilization in Sealed Container	Increased Biogas Production (Renewable Energy)	Reduced Final Dewatered Sludge



Improved Digestion Efficiency	Highly-efficient Energy Sterilization in Sealed Container	Increased Biogas Production (Renewable Energy)	Reduced Final Dewatered Sludge
• Increase digestion efficiency by using cellular hydrolysis at high temperature and pressure • Reduce investment cost to 1/3 of that of conventional digester	• Thermal hydrolysis in completely sealed container – Collect odor-generating substances at gas compressor • Remove pathogens with operation at 165 ℃ and 6 bar or higher	• Increase bio-gas production by hydrolysis more efficiently • Boost biogas production with high VSR (more than 30%)	• Increase dewatering rate (30% DS) • Lower the amount of final cake drastically (more than 50%) • Use final cake as soil conditioner (in USA, Europe, etc.)

Account for 87% of the global market including Europe, Americas and China with great efficiency and reliability (No. 1 of World THP technology)

Carbon Footprint (Aecom/MOHURD China study)

Table 2 Carbon Footprint of Sludge Technical Routes

Reference Number	Technical Route	Carbon Footprint[a]
1	Thermal hydrolysis, anaerobic digestion, biogas utilization, heat drying (10% moisture content), coal substitution (e.g., in a power plant or cement kiln)	(500)
2	Anaerobic digestion, biogas utilization, landfill with landfill gas utilization	0
3	Thermal hydrolysis, anaerobic digestion, biogas utilization, land application	200
4	Anaerobic digestion, biogas utilization, compost, land application	450
5	Anaerobic digestion, biogas utilization, land application	950
6	Heat drying(10% moisture content), coal substitution	1,300
7	Composting, land application	2,400
8	Heat drying, gasification, energy recovery	4,750
9	Lime stabilization, land application	4,900
10	Heat drying, incineration, heat recovery	5,900
11	Landfill with landfill gas utilization	6,200
12	Anaerobic digestion, biogas utilization, landfill without landfill gas management	6,300
13	Heat drying (65% moisture content), land application	7,600
14	Heat drying (40% moisture content), land application	10,000
15	Landfill without landfill gas management	30,000

( ) = negative.

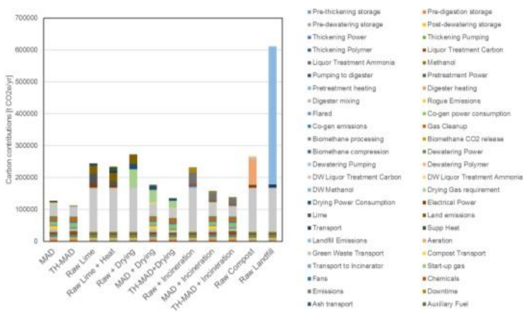
[a] Based on a typical urban wastewater treatment plant treating 100,000 cubic meters/day, producing 80 tons/day of dewatered sludge with 80% moisture content; carbon footprint indicated as tons of carbon dioxide equivalent/year.

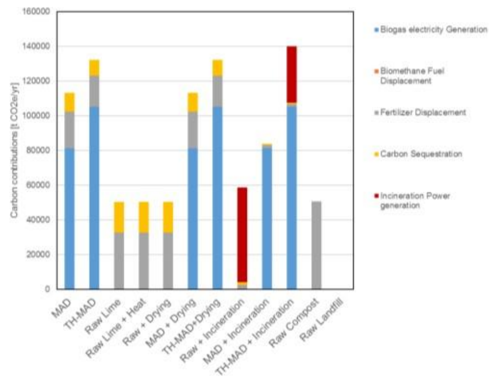
Source: East Asia Department, ADB.

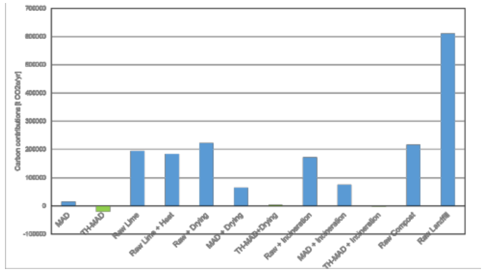
Impacts on carbon footprint

- Highest Volatile solids destruction → More renewable energy
- Highest Volatile solids destruction → Less sludge → Less Transport and downstream processing
- Better dewaterability → Less water in biosolids cake → Lower energy requirements for thermal systems
- Better dewaterability → Less sludge → Less transport to land
- Better quality of product → Less land required for reuse → Less transport

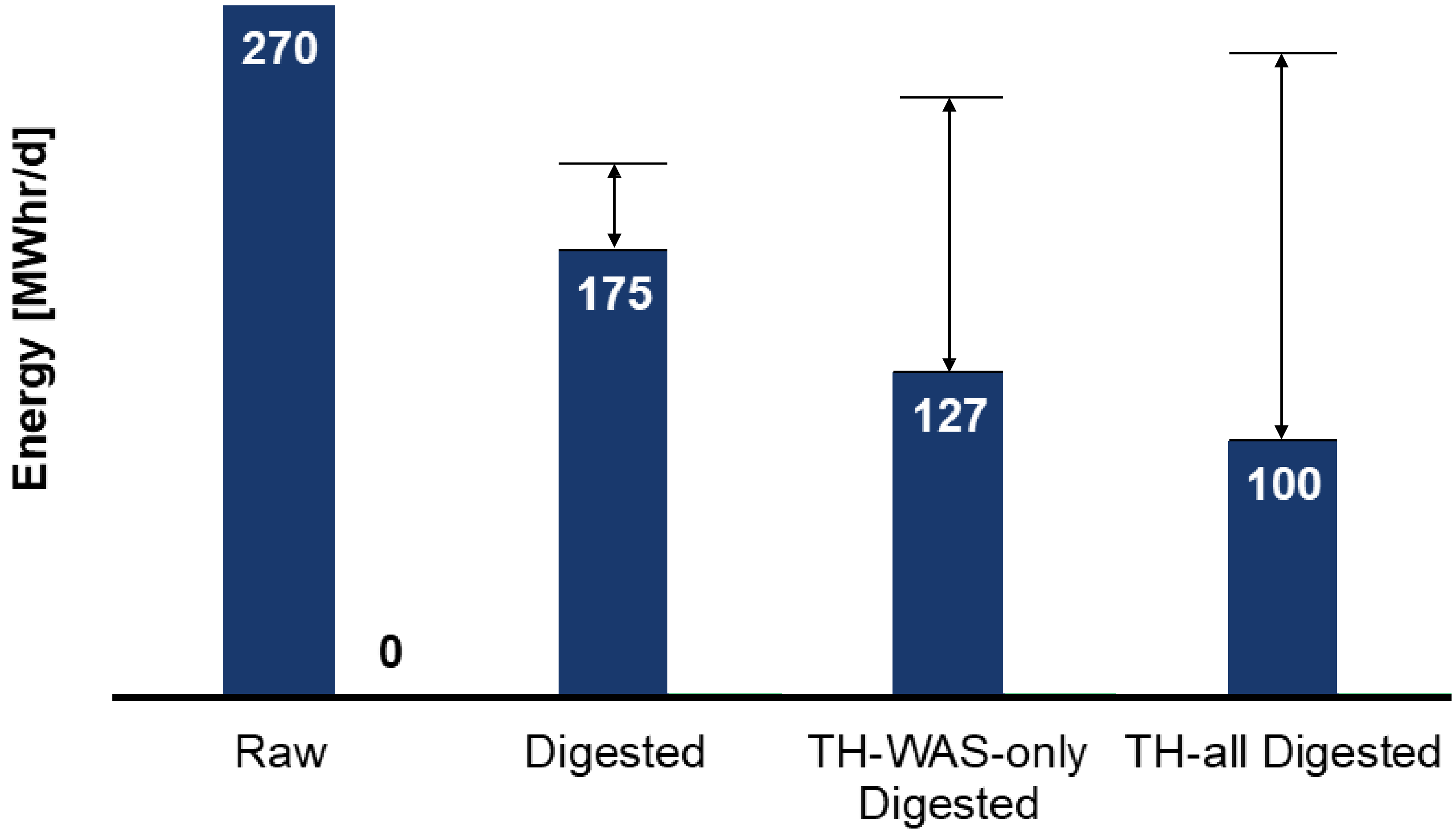
→ Lowest operating carbon footprint







Optimising sludge drying



Need *less* energy for drying

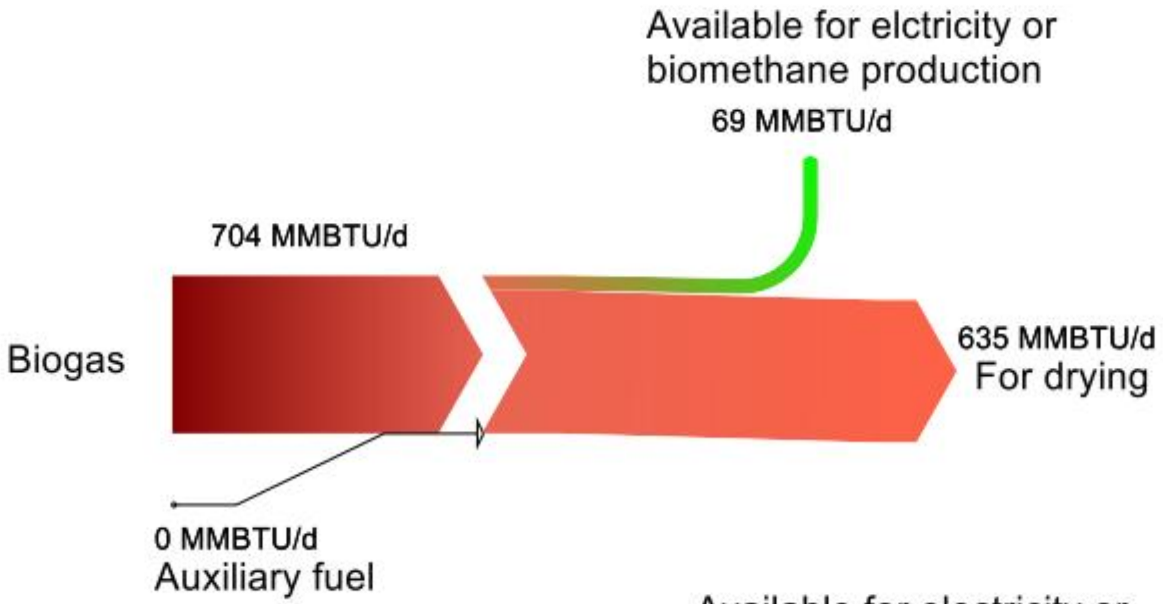
More energy from biogas

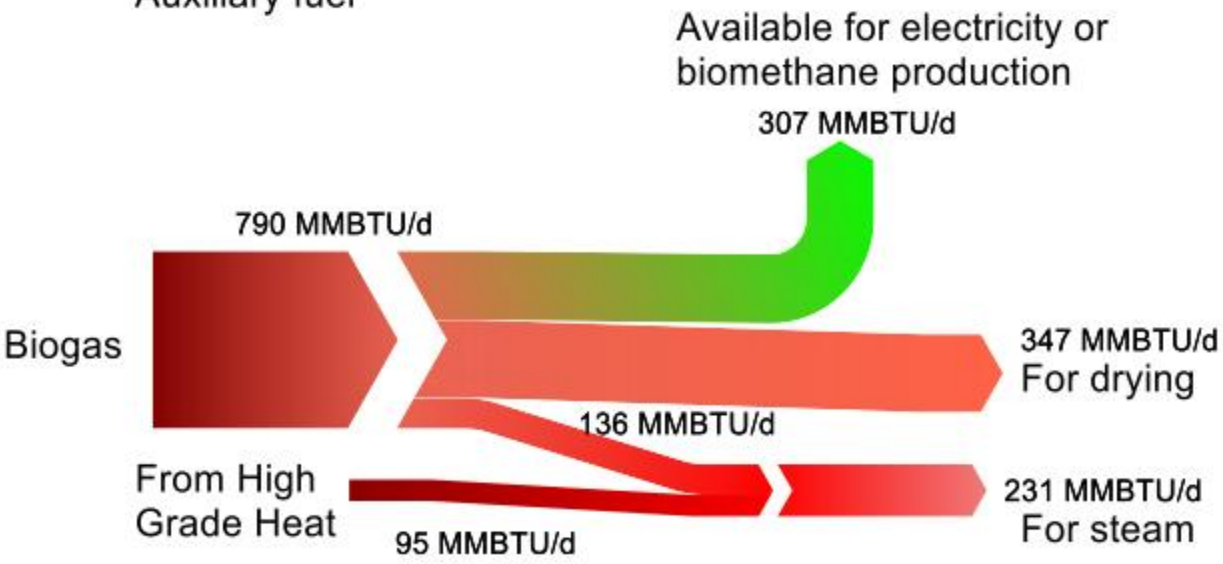
Much greater excess of energy

Key: Energy required for drying | Energy available from biogas

Basis: 100 tons dry solids/d

Summary - Theory





Without thermal hydrolysis

- Nearly all consumed by drier leaving little for other uses

With thermal hydrolysis

- Nearly 20% more energy in biogas
- 45% reduction in drying energy demand
- Over 4 times more biogas can be diverted to co-generation

Case Study

To consider:

Electric Energy or upgrade to Biomethane	Dry sludge using waste energy from CHP
Pathogen free solids to agri culture	Carbon footprint credits

THANK YOU FOR YOUR ATTENTION…

CAMBI® THERMAL HYDROLYSIS PROCESS FOR ADVANCED ANAEROBIC DIGESTION OF SLUDGE AND FOOD WASTE

- INCREASED RENEWABLE ENERGY
- REDUCED BIOSOLIDS VOLUME
- INCREASED BIOSOLIDS QUALITY (CLASS A)
- COMPACT ANAEROBIC DIGESTION