Sewage Sludge –

Inevitable production of a renewable resource

Dr Bill Barber

23 February 2012 Geelong

Australian & New Zealand Biosolids Partnership

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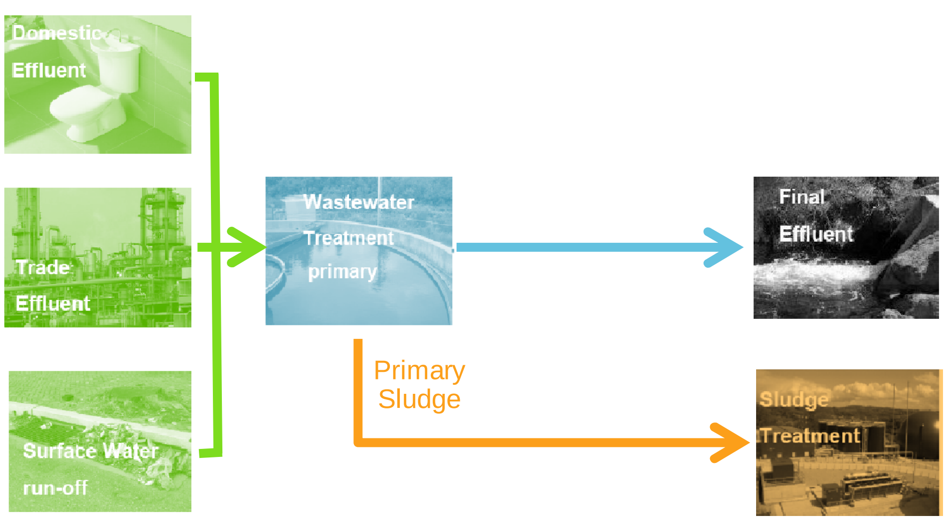
Traditional wastewater treatment



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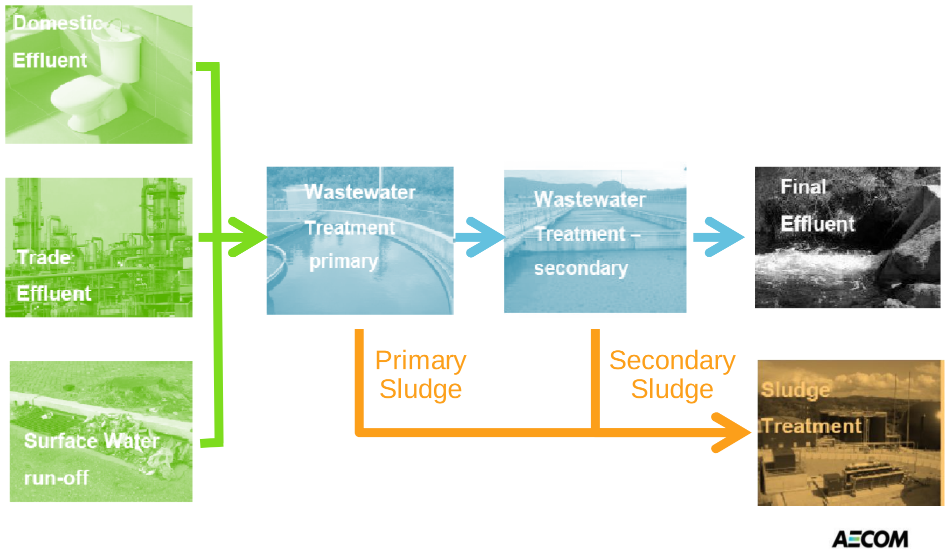
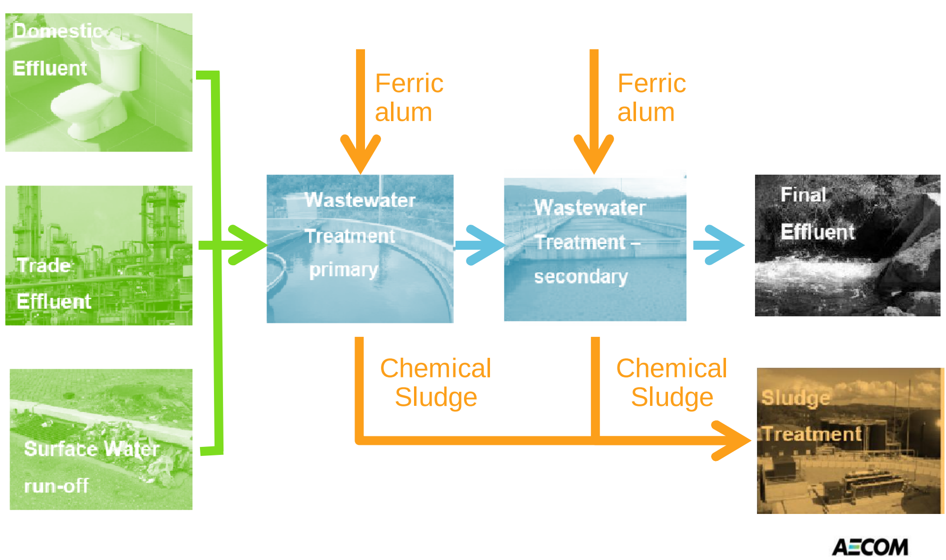
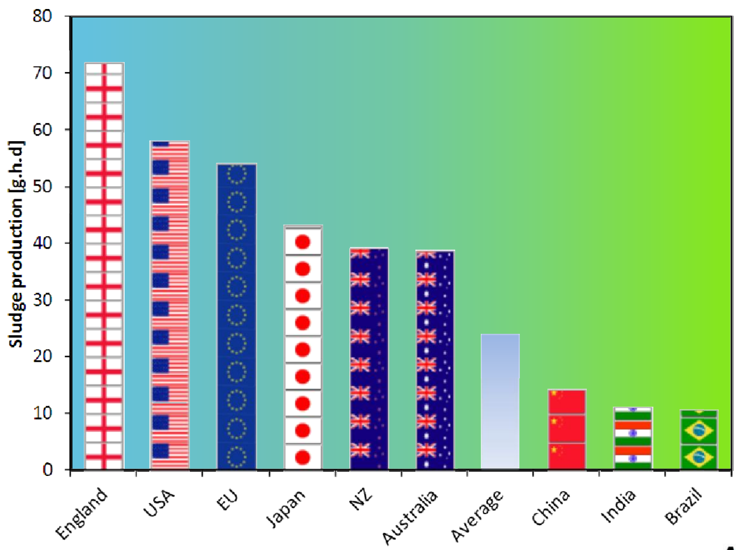
Stricter wastewater standards – Secondary Treatment



Nutrient removal – Chemical Dosing



World-wide Sludge Production



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World Sludge Production

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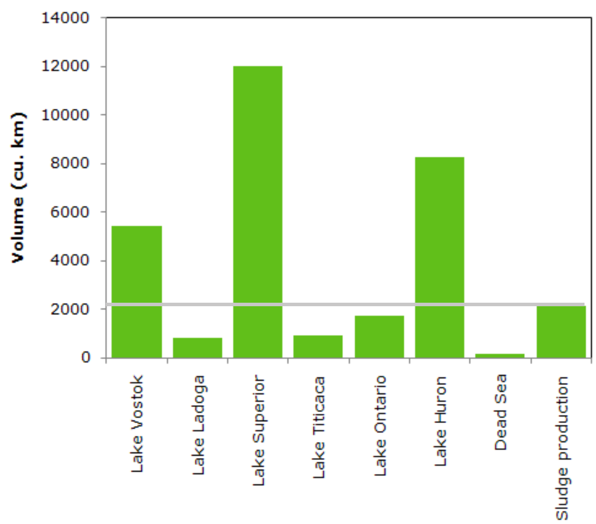
World Sludge Production



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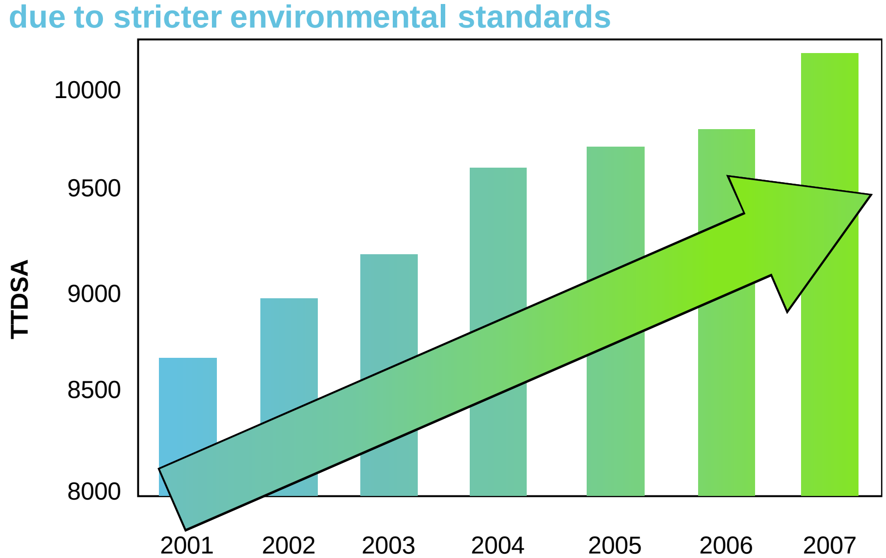
Increasing sludge production in Europe mainly due to stricter environmental standards



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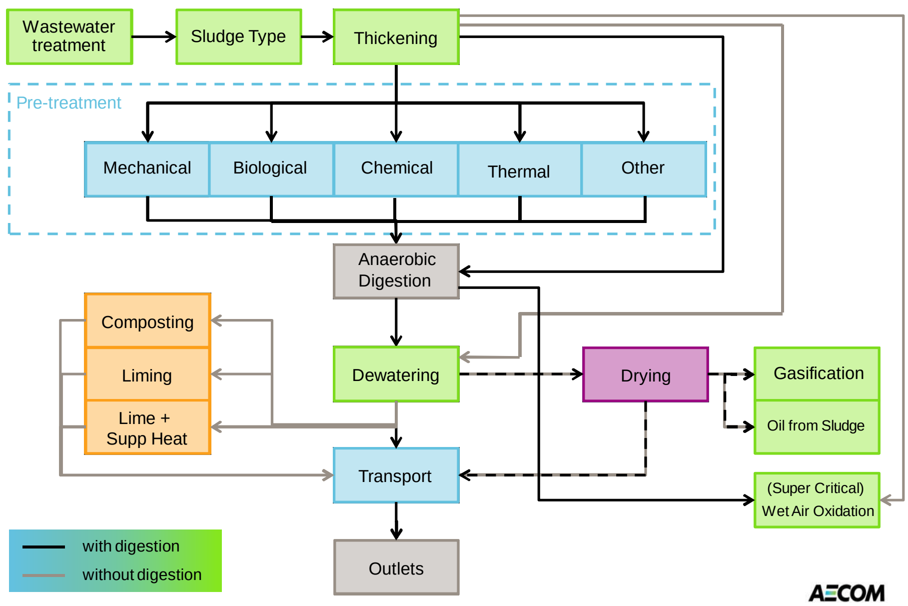
Sludge Processing



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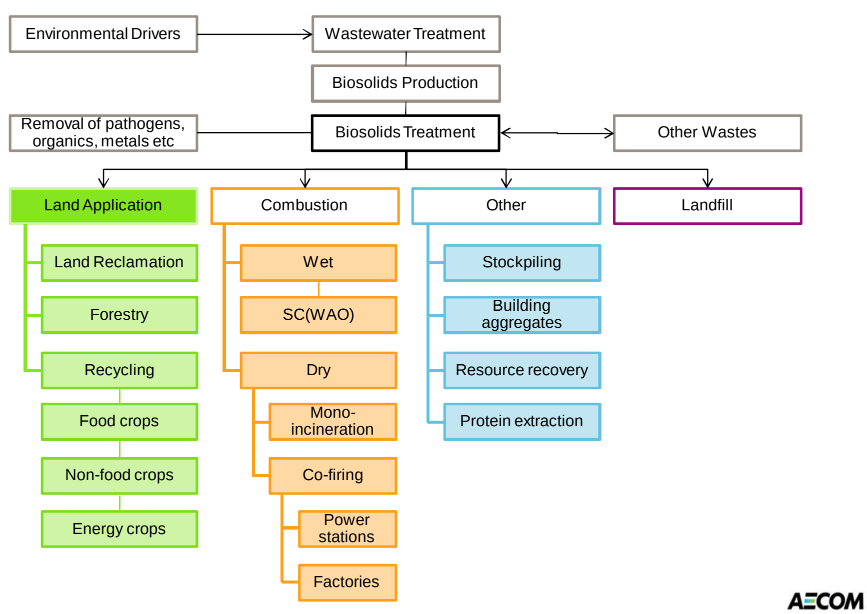
What can you do with it?



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What else can you do with it?


POOP BURGER: Japanese Researcher Creates Artificial Meat From Human Feces

by Lori Zimmer, 06/16/11

filed under: News, Poo Power!, Recycled Materials

Like 34k

Some hardcore carnivores have a hard time finding meat alternatives such as soy protein or tofu burgers to be palatable. But non-meat eaters may lose their appetite along with their carnivorous friends over this one – a meat alternative made from HUMAN EXCREMENT. Yep, you heard me correctly — Japanese scientist Mitsuyuki Ikeda has developed a "burger" made from soya, steak sauce essence, and protein extracted from human feces. Hit the break for a video explaining the process!

Would you eat a turd burger?

YES! WITH A SIDE OF FRIES PLEASE! 1,237 VOTES

NO WAY! MC DONALD'S IS BAD ENOUGH! 8,106 VOTES

NOT SURE, I'D HAVE TO SEE IT UP CLOSE FIRST. 1,152 VOTES


Japan scientist synthesizes meat from human feces

Story by Jeff Hughes
Japan scientist synthesizes meat from human feces

It's being called the "poop burger". Japanese scientists have found a way
human feces.

Somehow this feels like a Vonnegut plotline: population boom equals food
waste matter. Absurd yes, but Japanese scientists have actually discove
feces.

Mitsuyuki Ikeda, a researcher from the Okayama Laboratory, has develop
excrement. Tokyo Sewage approached the scientist because of an overa
explore the possible uses of the sewage and Ikeda found that the mud co

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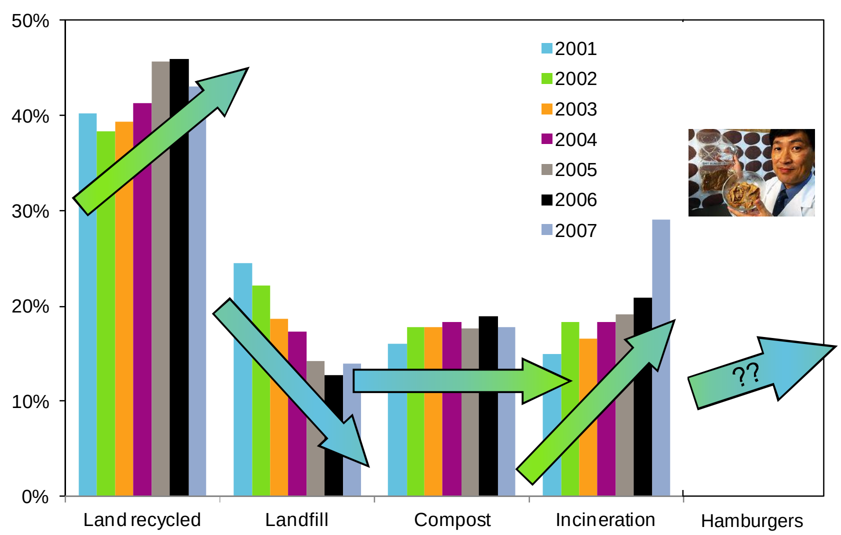
European Sludge Outlets



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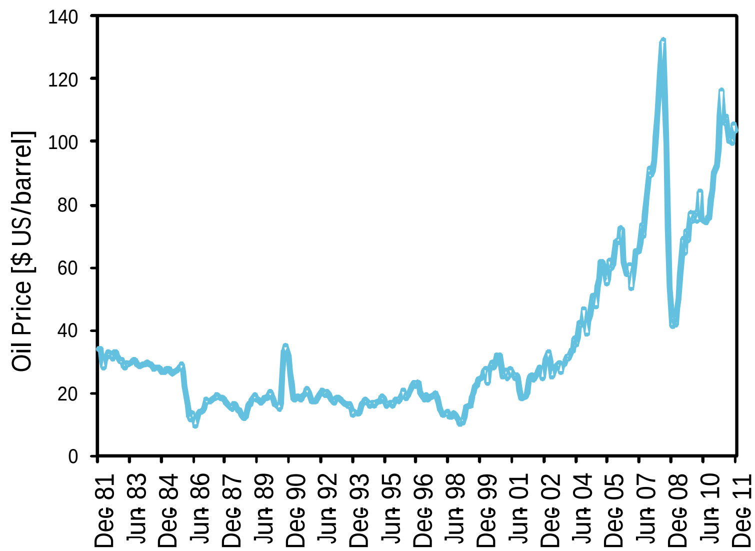
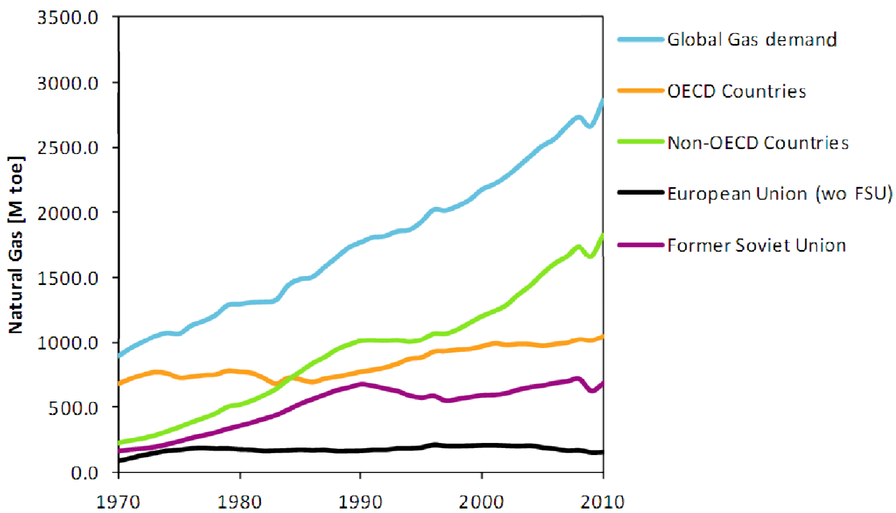
Energy Recovery

Australian & New Zealand Biosolids Partnership

Energy – Price



Energy – Security



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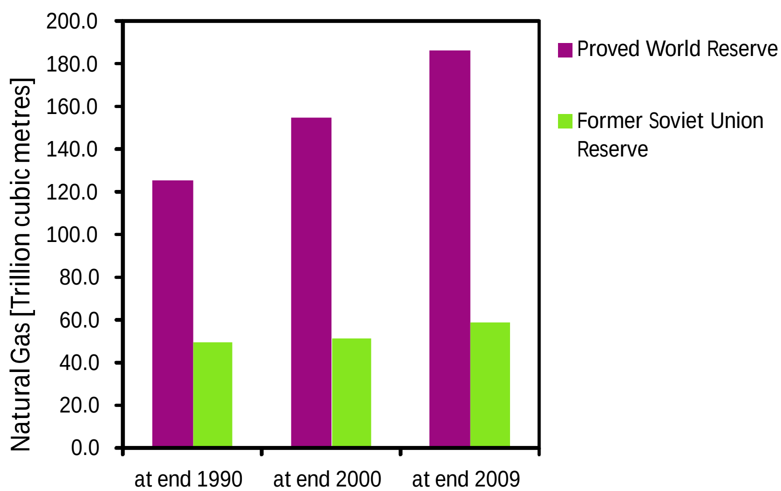
Energy – Security



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Russia shuts off gas to Ukraine

Russia has stopped all gas supplies to Ukraine after the collapse of talks to end a row over unpaid bills and prices.

Much of the EU's gas from Russia arrives via Ukraine

Russia's gas giant Gazprom said it turned off the taps at 0700 GMT, when its contract to supply Ukraine ended.

Ukraine insists it has paid off its debts to Gazprom, but Russia contests this. The two countries have also failed to agree on a price for 2009.

The EU urged Russia and Ukraine to resume negotiations and not to let the dispute disrupt supplies to Europe.

A similar row between Gazprom and Ukraine at the beginning of 2006 led to gas shortages in several EU countries.

Pipes across Ukraine carry about a fifth of the EU's gas needs.

The new holders of the EU presidency, the Czech Republic, urged the parties to "rapidly reach a successful outcome" to their dispute.

Europe's gas pipeline network

OPEN Enlarge Map

"All existing commitments to supply and transit must be honoured," it added.

Both Russia and Ukraine insist that gas supplies transported via Ukraine to the European Union will continue as

Russia turns off the taps again: Moscow slashes gas supplies to Belarus amid claims of £130m in unpaid bills

By MAIL FOREIGN SERVICE

Last updated at 4:28 PM on 21st June 2010

Comments (2) | Share +1 0

Russia cut gas supplies to Belarus by 15 per cent today pressing its neighbour to pay a £130 million debt and raising fears of disruptions in deliveries to Europe.

Relations between the two have soured since they failed to agree on unified customs rules and Belarus gave refuge to ousted Kyrgyz President Kurmanbek Bakiyev.

Russia supplies a quarter of Europe's gas needs and uses Belarus, which borders European Union member Poland, as one of two key transit routes for oil and gas to the continent.

Previous pricing disputes with Minsk led to oil supply cuts, with Poland and Germany being affected most.

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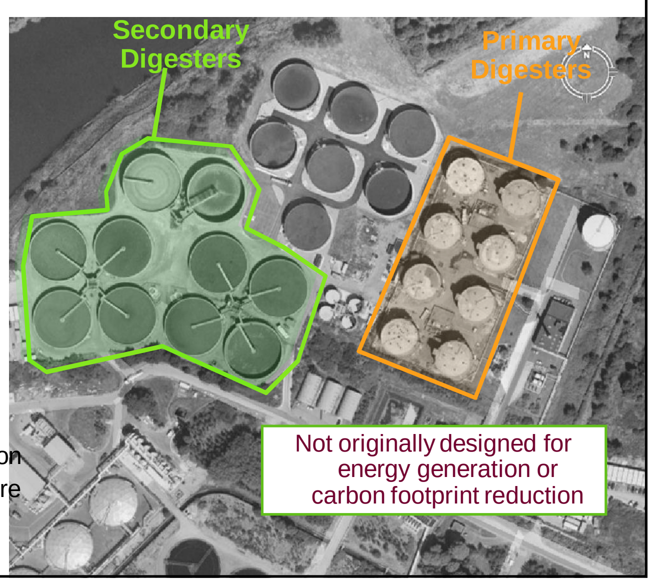
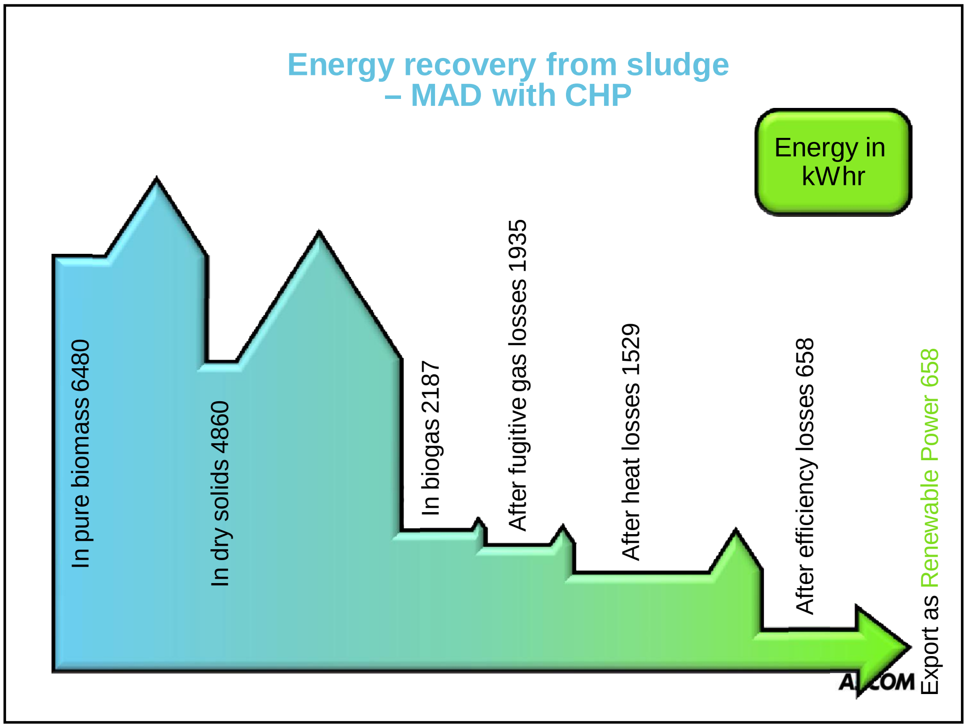
Anaerobic Digestion in the Water Industry Traditional Configuration

- Two stage process

- Primary digestion
- HRT ~ 16 d
- Covered
- Biogas collected and used in CHP

- Secondary digestion
- HRT ~ 14 d
- Uncovered
- For additional stabilisation
- Biogas lost to atmosphere




Energy recovery from sludge
– MAD with CHP
Energy in kWhr
In pure biomass 6480
In dry solids 4860
In biogas 2187
After fugitive gas losses 1935
After heat losses 1529
After efficiency losses 658
Export as Renewable Power 658
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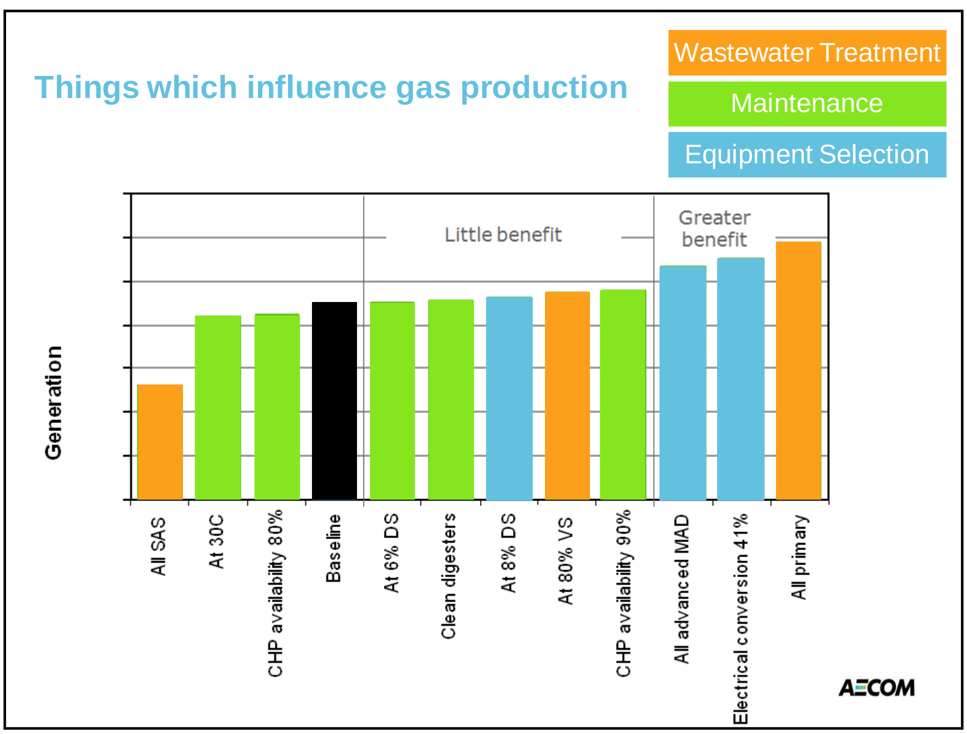
Things which influence gas production
Wastewater Treatment
Maintenance
Equipment Selection
Generation
Little benefit
Greater benefit
All SAS
At 30C
CHP availability 80%
Baseline
At 6% DS
Clean digesters
At 8% DS
At 80% VS
CHP availability 90%
All advanced MAD
Electrical conversion 41%
All primary
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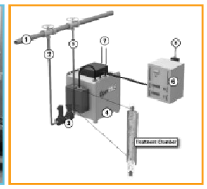
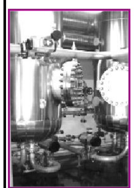
Water Industry
Advanced Anaerobic Digestion


Ultrasonics | High Pressure Shear | Electric Pulse

Chemical Lysis | Medium Pressure Maceration | Rapid Decompression

Thermal Hydrolysis | Acid Phase | Biological Hydrolysis

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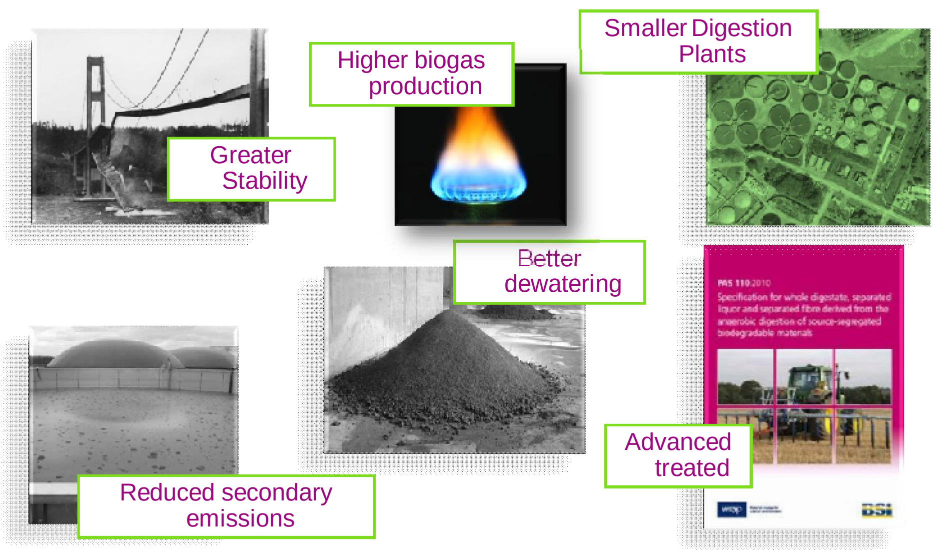
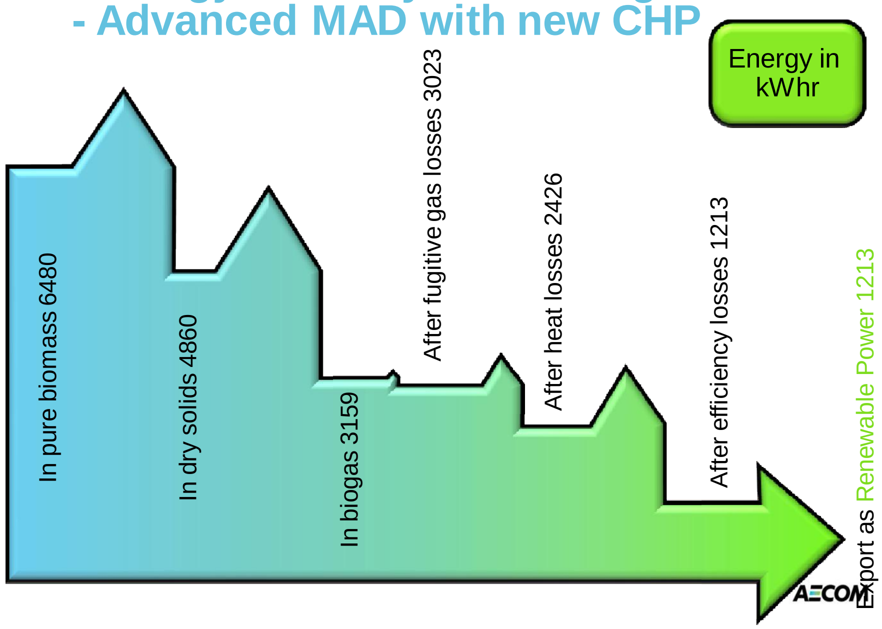
Benefits of Advanced Digestion



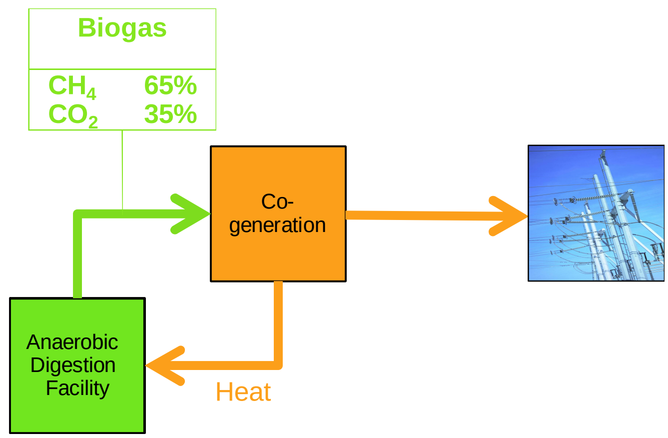
Performance

	Biological	Thermal	Acoustic	Pressure
Sludge	✓	✓	✓	✓
Organics	✓	✓	✓	✗
Standard	✓	✓	✓	✓
Advanced	✓	✓	✗	✗
Sterilisation (ABP)	✗	✓	✗	✗
High DS (OLR)	✗	✓	✓	✗
VS destruction	58%	62%	62%	70%
Complexity	✗	✓	✗	✓
Energy Demand	✓	✗	✓	✗
Dewaterability	✗	✓ (NH_3)	✓ (NH_3)	✗

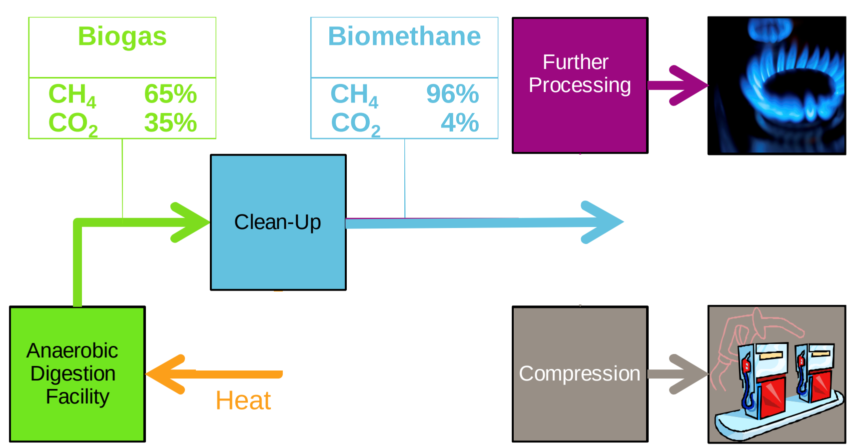
Energy recovery from sludge - Advanced MAD with new CHP



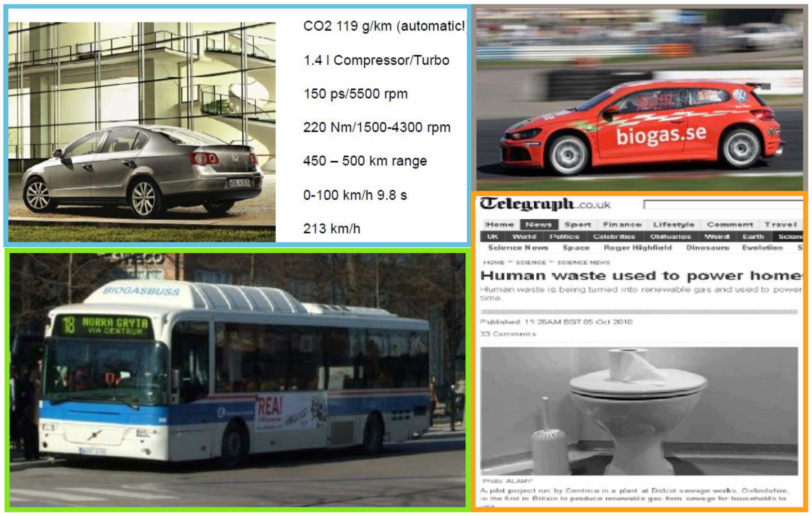
Alternative Biogas Uses



Alternative Biogas Uses



Alternative uses for Biogas



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Davyhulme

- Biogas to Grid
  - 4000 – 7000 m^3 biogas/hr
  - Pressure Swing Adsorption preferred technology to produce 96% CH_4 biomethane
  - 230 m^3/hr biogas cleaned
  - Injection to grid
  - Compression and vehicle use


Human waste used to power home

Pilot project to deliver renewable gas direct to grid

Peta Hodge
15th June 2009

Flush a loo in Manchester and you could soon be doing your bit to help the Government meet its renewable energy targets – thanks to a new £4.3 million initiative from United Utilities and National Grid that aims to deliver renewable gas direct to consumers for the first time.

The pilot project, based at United Utilities' wastewater processing plant at Davyhulme in Manchester, will upgrade the biogas that is produced when wastewater sludge is broken down by the process known as anaerobic digestion, removing the CO2 and trace

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Energy Recovery
Thermal

Australian & New Zealand
Biosolids Partnership

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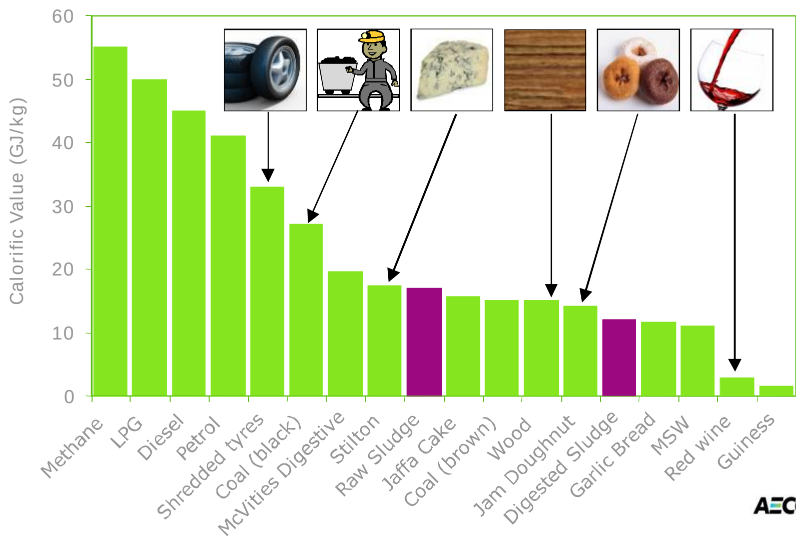
Calorific Value of Substances



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Thermal sewage sludge treatments

Benefits	Incineration	Drying	Co-combustion
	Total destruction	Proven at full-scale	Fraction of the costs and plant of incineration
	Energy recovery	High volume reduction	Commercially proven at full scale with both sludge and numerous refuse derived fuels (such as chicken litter)
	Fly ash may be recycled	Partial pasteurisation	Can take dewatered or dry cake
	Proven at full-scale	Storage and handling of product may be easier than sludge cake (especially if pelletised)	Reduces fossil fuel requirements
	Reduces reliance on landfill	Long storage times possible	Sludge burnt by company who have expertise in burning materials
		Larger range of disposal options than sludge cake	
		Increases calorific value of sludge prior to thermal destruction	

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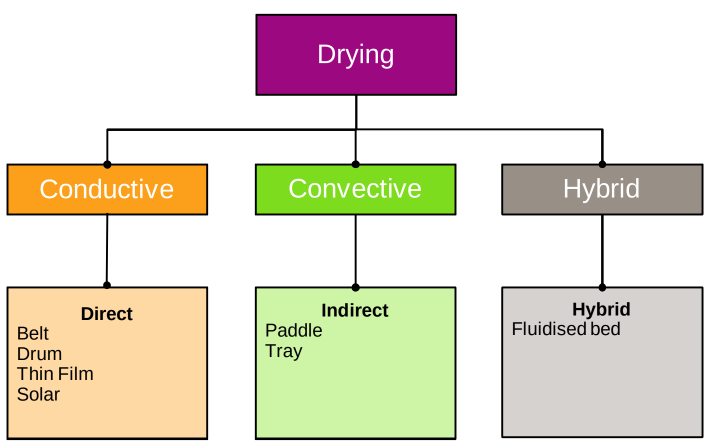
Thermal sewage sludge treatments

Disadvantages	Incineration	Drying	Co-combustion
	Planning	High capital and operating costs	Critically dependent on third parties
	Public Perception	Needs auxiliary fuel such as natural (or bio)gas	May result in tightening regulations at power station
	Very low on waste hierarchy	Potentially complex operation	Public perception
	Requires complex gas cleaning	Potential handling problems	Limited to power stations with advanced flue gas treatment facilities
	Removes phosphorous from ecosystem	Very sensitive to fluctuations in load (especially dry solids)	Methane build-up problems
	Produces a number of hazardous wastes	Issue with fibres and other materials	May be forced to dry cake
	High capital cost	With direct driers, production of gas which may require further treatment.	Competition from other refuse derived fuels
	High operating cost	Critically reliant on gas prices	Numerous take-overs of power station companies may disrupt long term contracts
		Rewetting of raw dried sludge has resulted in pathogen regrowth	Fluctuations in sludge quality may discourage power plant owners from accepting sludge

Drying Theory

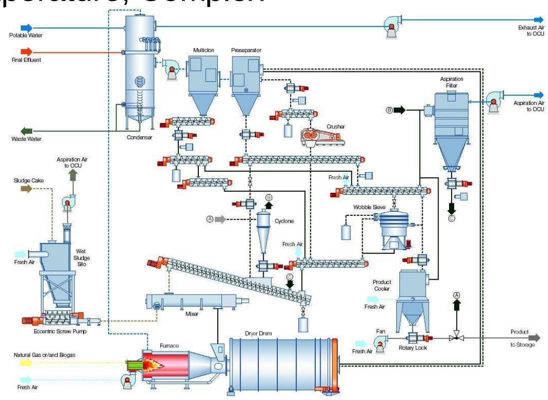
- Two falling rate curves
- 1 MW/t we (0.72 MW for water evaporation)
- 50 kWe/t we
- Pelletiser
- Operational breakdown
  - Energy 55%
  - Staff 30%
  - Maintenance 10%
  - Other 5%

Drying Technology



Direct Dryers: Rotary Drum Dryer

- Andritz, Siemens, Baker-Rullman
- Medium to Large
- High operating temperature, Complex
- Multipass Design
- High Pellet Quality



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In-Direct Dryers - Paddle Dryer

- Komline Sanderson, Fenton, Therma-Flite
- Small to Medium
- 180 – 230 °C
- Can use waste heat
- Single Pass Design
- No need for biosolids recycle

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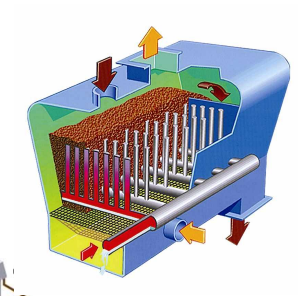
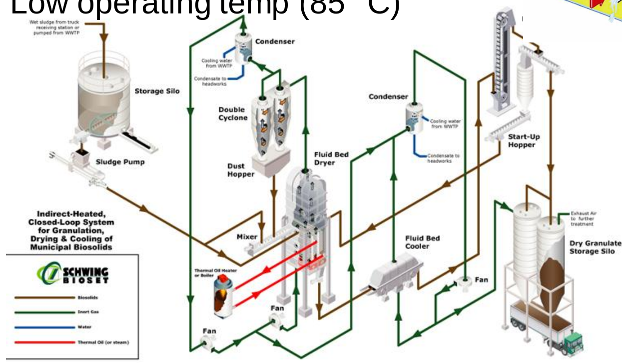
Fluidized Bed Dryer, Hybrid

- Andritz, Schwing
- Medium to Large
- Can use waste heat
- Low operating temp (85 °C)





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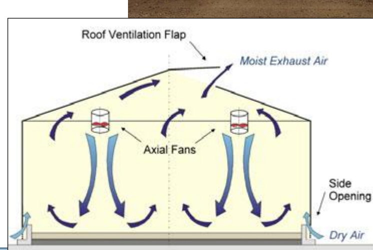
Solar Drying

- Veolia, Wendewolf, Parkson, Huber
- Large footprint, low energy
- 850 kg/m^2/yr in Europe
- 0.5 – 0.6 m^2/t we/yr
  - 1 – 3.5 kg we/m^2 /d
- Thickness 100 > 350mm
- Largest plant 150 MLD



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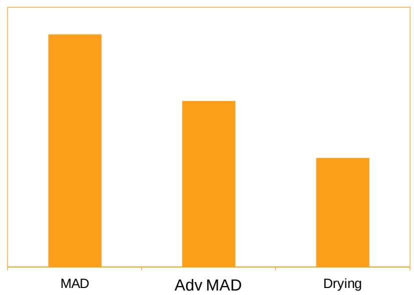
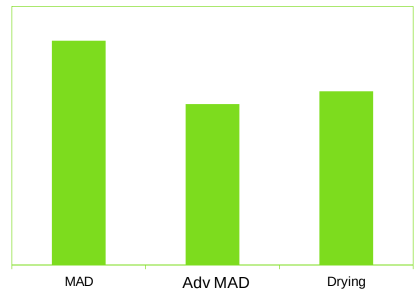
Economic and carbon analysis (long transport distance)

Cost



Carbon Footprint



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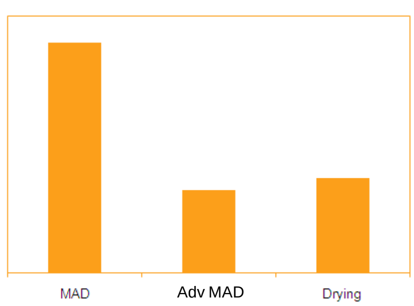
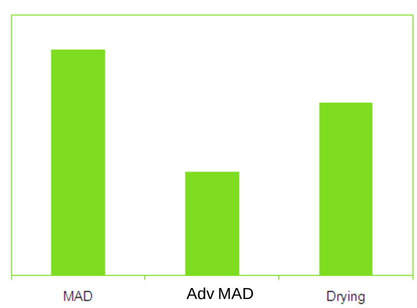
Economic and carbon analysis (short transport distance)

Cost



Carbon Footprint



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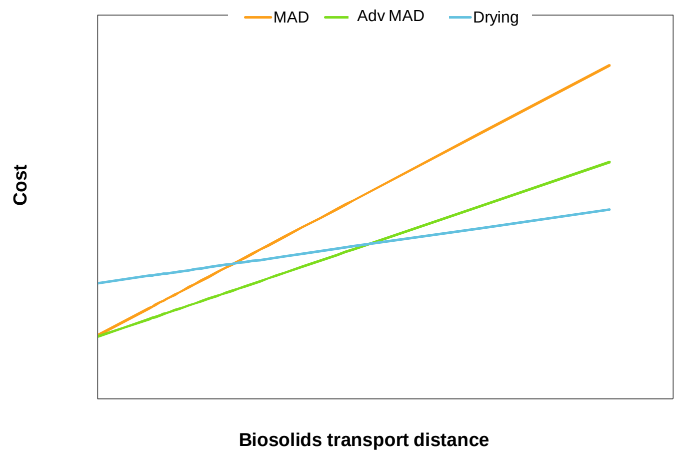
Impact of transport on processing costs



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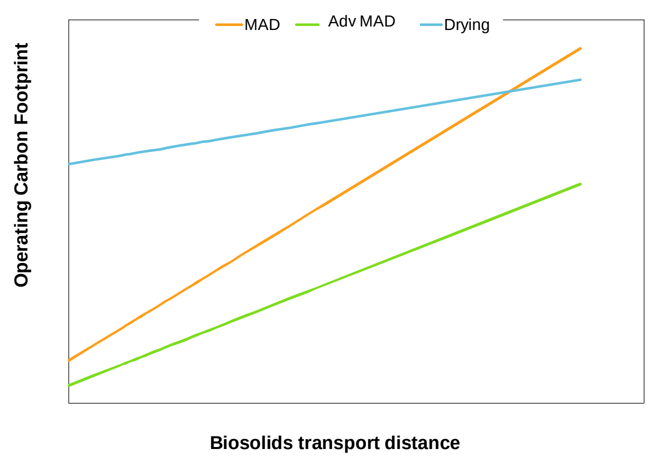
Impact of transport on carbon footprint



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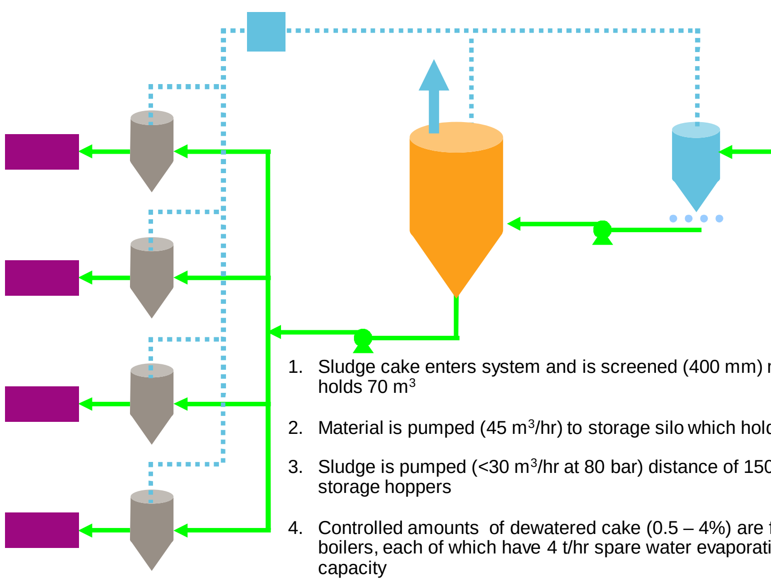
Heilbronn Power Station

Co-firing of sludge at coal-fired power station



1. Sludge cake enters system and is screened (400 mm) mesh. Silo holds 70 m^3
2. Material is pumped (45 m^3/hr) to storage silo which holds 240 m^3
3. Sludge is pumped (<30 m^3/hr at 80 bar) distance of 150 m to storage hoppers
4. Controlled amounts of dewatered cake (0.5 – 4%) are fed into 4 boilers, each of which have 4 t/hr spare water evaporation capacity
5. Methane and air are extracted from all areas containing sludge to prevent build-up of hazardous gases

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Sludge reception station

Sludge cake storage silo

Sludge cake pump

Nutrient recovery

AWA
australian water association

Australian & New Zealand
Biosolids Partnership

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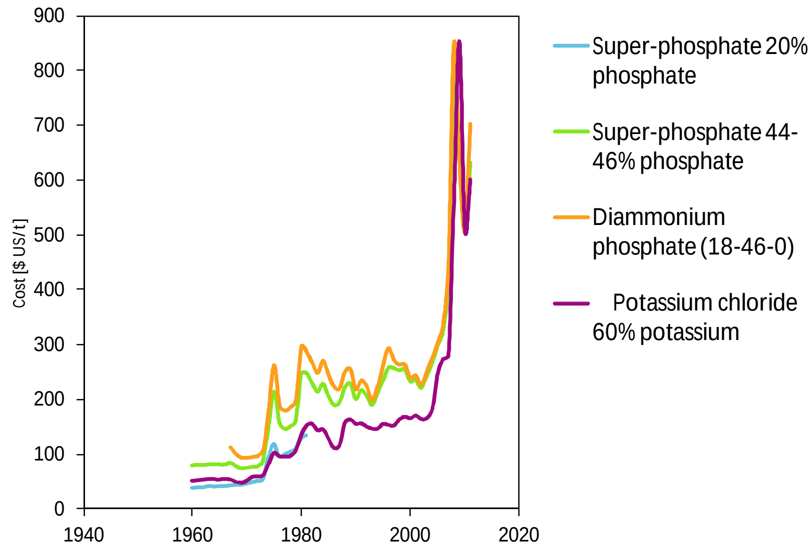
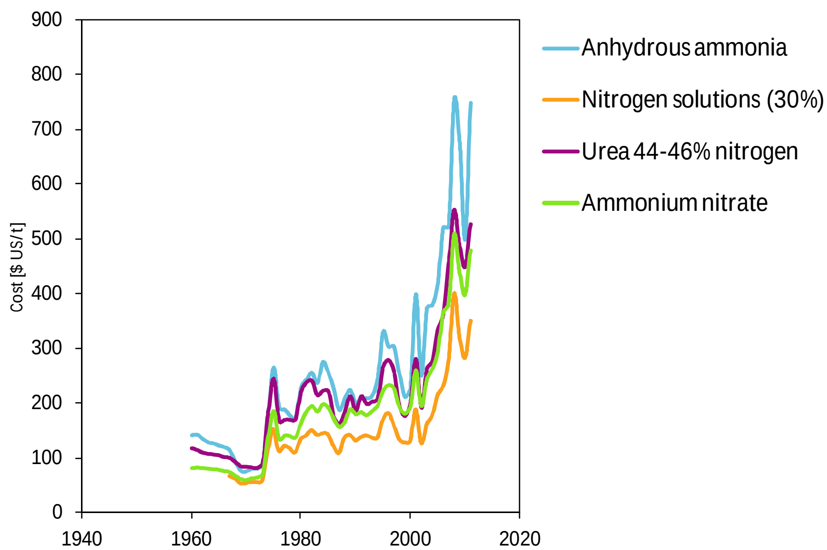
Fertiliser Costs – Phosphorus

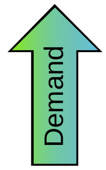


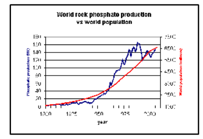
Fertiliser Costs – Nitrogen



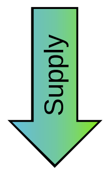
Phosphorous

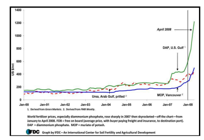
- World population increasing
  - Becoming urbanized
  - Changing food habits
  - Global demand increased 4.7 million tones in 3 years (equivalent to USA consumption)
    - 0.6 – 1.6 kg P/person.year





- Peak P predicted at 2035?
  - 50 – 100 years of easily mined P remain
  - >60% of all reserves in Morocco
  - China imposed P export tax (+110%)





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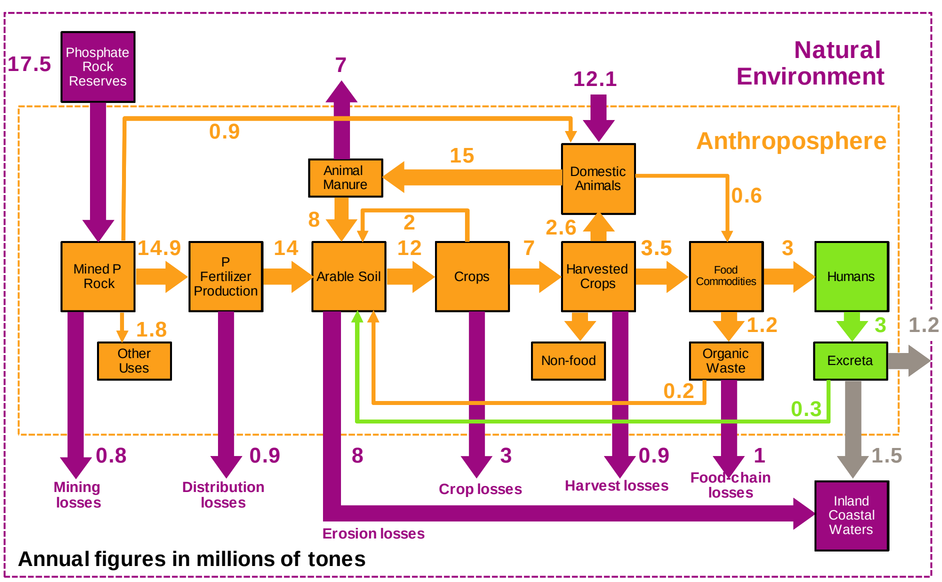
Phosphorous Balance



Adapted from Cordell *et al*., 2009. The story of phosphorus: Global food security and food for thought

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Phosphorus

- 90% of phosphorus consumed by humans is wasted
- If recovered, this phosphorus could meet 20% of current global demand
- Over half of this phosphorus is in sludge
  - Generally this is a nuisance at a sewage works
- This is lost during thermal processing
  - Incineration

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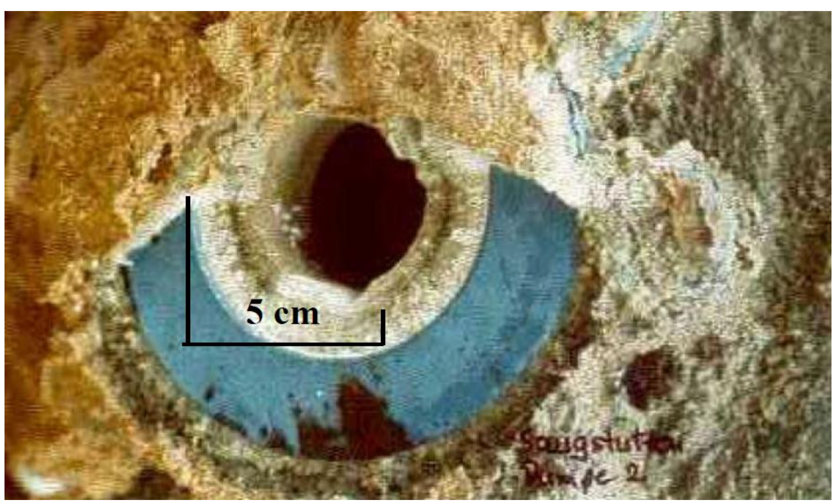
Struvite

$Mg^{2+} + NH_4^+ \ PO_4^{3-} + 6\ H_2O \rightarrow MgNH_4PO_4\ .6H2O$



Heizmann and Engel, 2006

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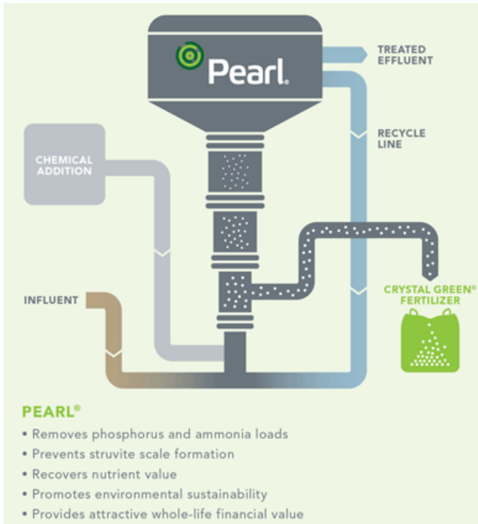
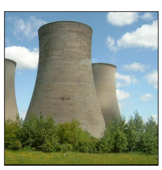
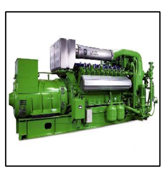
Phosphorus



Biosolids as a resource

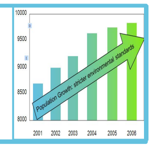
1 tonne sewage sludge

0.42 tonne oil equivalent	0.08 kW electricity	200 m^3 biomethane	50 kg N 25 kg P	15.3 oz troy
$305	$70	$25	$40	$26,000

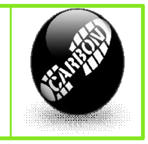
Summary

- Sludge production is increasing globally
  - Stricter legislation; Population increase; Greater urbanization
- It is also becoming increasingly difficult to treat



- Many ways which energy can be recovered from sludge
  - Anaerobic digestion; biogas upgrading; thermal recovery (mono- and co-firing as cake or dried material)

- Nutrient recovery becoming more important to address phosphorous requirements and to assist with carbon reduction



AECOM

Thank you

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AWA australian water association

Australian & New Zealand Biosolids Partnership

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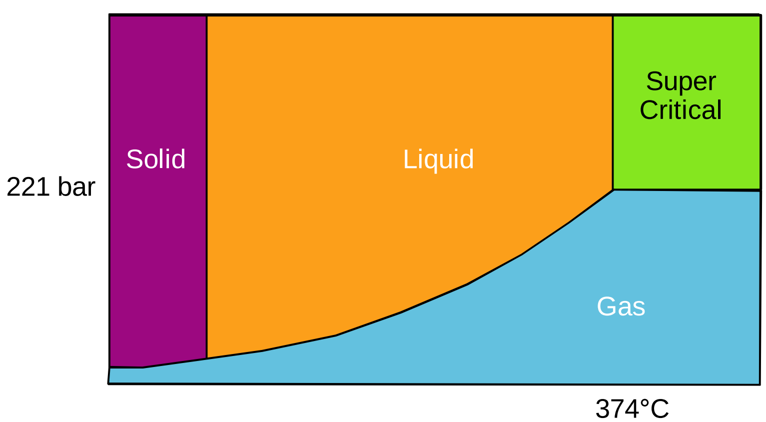
Case-study

Energy Recovery using *Super Critical Wet Air Oxidation (SCWAO) Alternative to Incineration*

Super Critical Wet Air Oxidation (SCWAO)



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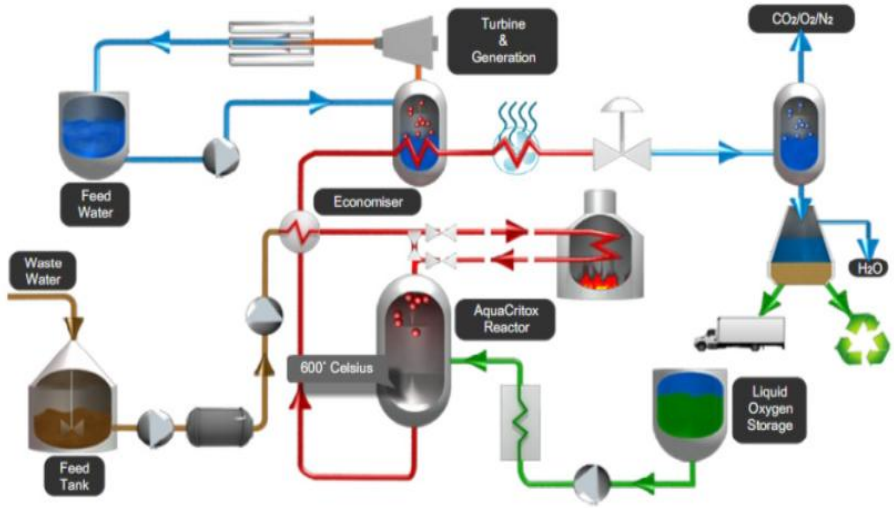
SCWAO



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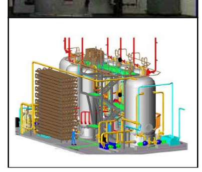
Bruxelles Nord – Thermal Hydrolysis with WAO

- 18000 TDSA
  - Operational 2006/7
- Mixed primary and secondary sludge
- Sub-critical oxidation
  - 50 bars
  - 250°C
  - Uses catalyst
- Less than 5% organics in solid residue
- Effluent contains 25% COD load



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