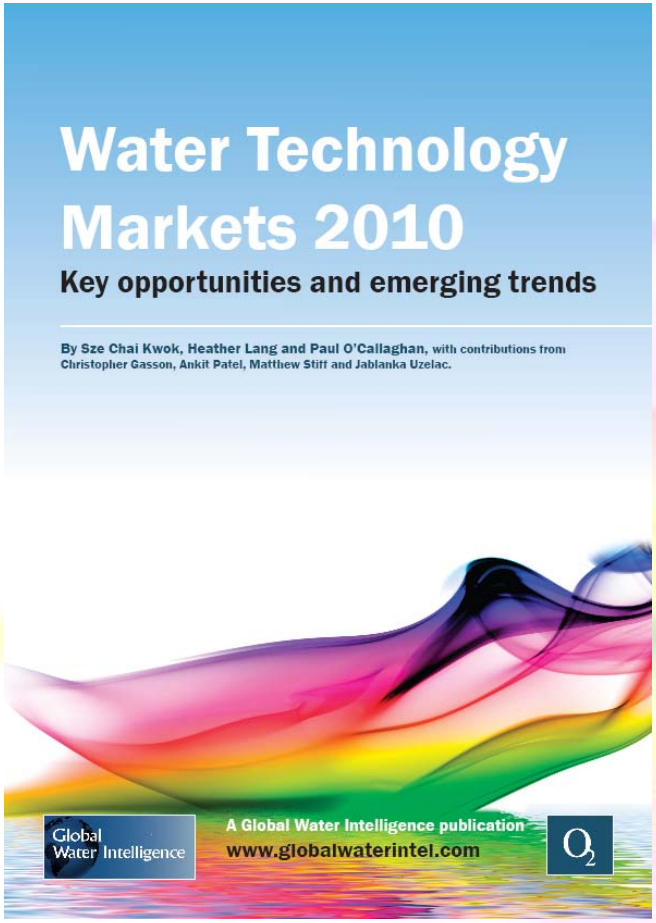

Untying the Wastewater Knot: Resource Recovery and Energy

Dr. Tim Evans, TIM EVANS ENVIRONMENT
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O_2 Environmental
Technology Assessment Group
Water Technology Market Experts

Details on BlueTech Tracker™:
info@o2env.com

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Where I'm coming from

- Soil Scientist trained UK and USA (Madison WI)
- Thames Water (UK)
  - Privatised 1989
  - 13 million pop
  - 300 WwTW
  - Created QA biosolids recycling for 60% of sludge
  - Helped grow business outside UK including USA

- Independent consultant 1999
  - to help clients to create cost-effective solutions for organic residuals (including biosolids, food wastes and wastewaters) that are sustainable and appropriate to their needs and local situations

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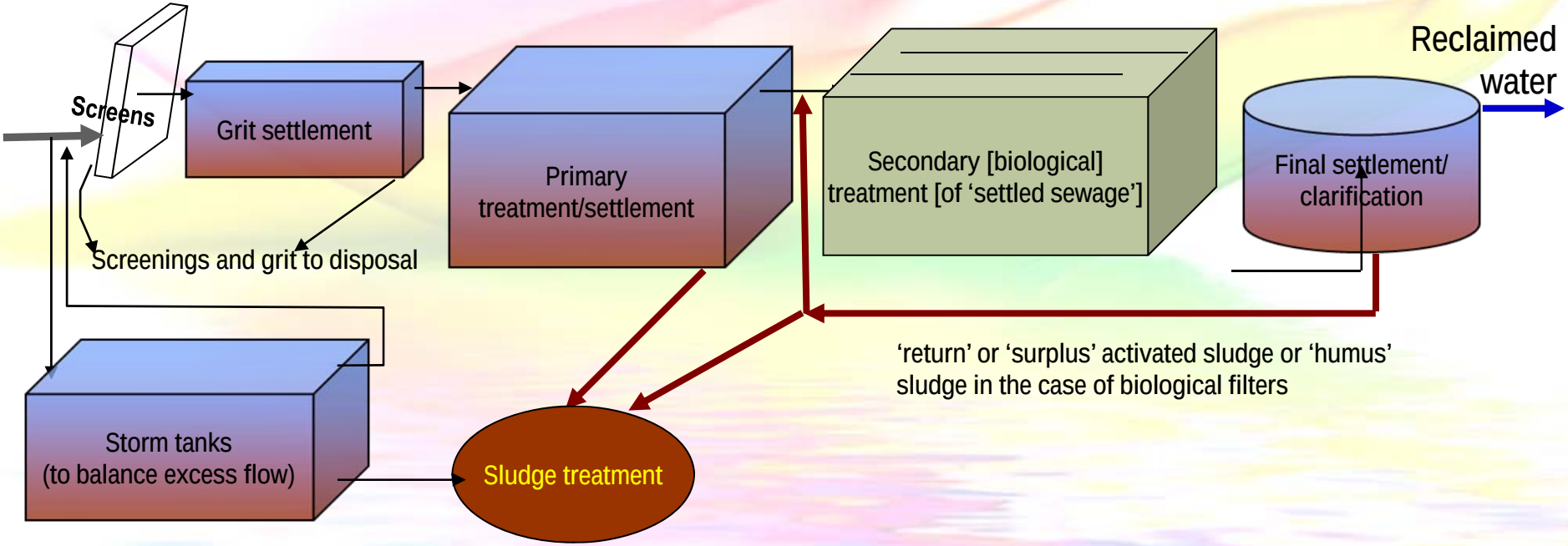
- I've used, operated, evaluated and been associated with a lot of the technology
- but all I sell is my [unbiased] opinion



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Drivers/opportunities that make markets

- Climate change
- Energy security
- Phosphate crisis
- Food security
- Water scarcity
- Aging infrastructure
- Biosolids
  - Fecal phobia and chemical phobia
- Cost

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Customers

- Publicly owned / Privatised / Contracted
- UK 100% privatised
  - 11 wastewater companies for 62 million population
  - Regional solutions and economies of scale
- USA mostly publicly owned
  - 10,000 operators for 294 million population
    - consulting engineers are pseudo customers – might not favour turnkey solutions that have little design work
    - DBO/PFI contractors are customers
- Engineers rush to be second
  - Engineers love to engineer

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Climate change

- More extreme weather events more frequently
  - Rising sea level
  - Loss of productive agricultural land - 50% more people + 70% more food
- Building bigger pipes underground is not the answer
- Green infrastructure (rain gardens, green roofs …)
  - Soaks up some rain and reduces speed of runoff
  - Reduces urban heat island
  - Less water in pipes means less to pump and less to treat
- Carbon reduction commitment
  - It's another selling point

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Energy security

(the theme of WEF R&B May'10)

- Linked to climate change
- Anaerobic digestion of sludge and other organic residuals gives continuous non-fossil energy
  - USA legacy of pancake digesters (wide & low)
    - narrow & tall are easier to keep mixed
    - egg-shaped – pretty but expensive
  - Retrofits to boost biogas
  - Thermal hydrolysis trebles treatment capacity, more biogas, better dewatering
    - 3x the feed = 4x the biogas but no increase in cake
    - Would enable co-digestion of other residuals without building more digesters

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Sludge to Energy Technologies

- *Established*
  - Sludge to Biogas — Anaerobic digestion +/- pre-treatment
    Biogas to electricity or biomethane
  - Incineration — Multiple hearth / Fluidised bed
    water removal is key
- *Novel*
  - Sludge to Syngas — Gasification – *e.g. KOPF*
  - Biogas Utilisation — *Microturbines / Stirling Engines/ Fuel Cells*
  - Sludge to Oil: — Pyrolysis *e.g. STORS [EnerSludge]*
  - Sludge to Fuel: — Carbonisation & Torrefaction *E-coal and E-Fuel*
  - Supercritical Water Oxidation: *Aquacritox*

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Food waste

- Food waste disposers
  - When 50% of households installed FWD, biogas increased 46% but sewage treatment costs did not change
- FOG (fat oil grease)
  - Problem for kitchens
  - Problem in sewers but
  - Great biogas potential

FOCUS: SEWER

SAN FRANCISCO FIGHTS FOG

A progressive program helps keep fats, oils and grease out of sewers, while a new technology turns it into high-quality fuel for use or sale

By Mike Larson

FOG can be a big problem in San Francisco — not the mist-kind that famously blankets the City by the Bay, but sewer-clogging fats, oils, and grease. FOG is a sticky problem for the San Francisco Public Utilities Commission (SFPUC), largely because of the many restaurants for which the city is known.

The men and women of SFPUC fight to keep FOG out of the city's 1,000 miles of combined sewers, which carry 80 mgd of wastewater. They clean out gooey plaque that causes blockages. They clean up FOG-caused sewage backups and overflows. They fix sections of sewer broken as a result of clogs and backups. And they try to convince residents and business owners to take steps to avoid dumping FOG into the system.

And now, the commission uses a new technology to convert grease collected from commercial grease traps into high-quality fuels. The technology produces ASTM-certified biodiesel fuel, a renewable, nontoxic fuel that can be used in any diesel application, from vehicles to household furnaces, without modifying the machinery.

It's all part of a new, comprehensive FOG-control program that the commission expects to help reduce sewer blockages, save on emergency responses and cleanups, and keep costs down for ratepayers.

Good food, bad clogs

Collection System Division manager Lee Harrison says his department handles about 9,000 work orders each year, about 4,000 of them related to sewer blockages, of which 44 percent are caused by grease. All told, the city spends about $3.5 million per year on grease-related blockages, and that

PROFILE: San Francisco, Calif., Public Utilities Commission

POPULATION SERVED: 1.5 million

AREA SERVED: 49 square miles

WASTEWATER FLOW: 80 mgd

EMPLOYEES: 482 (wastewater system)

INFRASTRUCTURE: 1,000 miles of combined sewer; 23,000 catch basins

ANNUAL BUDGET: $132 million

WEB SITE: www.sfwater.org

14 February 2012 msmag.com

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Biosolids

- Accounts for 45% of wastewater treatment costs
- Land application | thermal destruction | landfill
  - **Land application** 49% USA - 36% EU
    varies by State / country [68% in UK]
    - Vulnerable to odor / fecal phobia / chemical phobia
    - Supreme Court refusal to consider LA vs Kern County
  - **Incineration** 15% USA but legacy of multiple hearth incinerators that could not meet stringent air quality limits if EPA changes classification
  - **Landfill** 28% USA but even with landfill gas capture they leak and have large global warming potential

Treatment processes

- Sludge starts as 95% water so first step is dewatering
  - Water does not burn
- Murphy's Law "if something can go wrong it probably will"
  - Evaluate proposals with healthy scepticism
- HACCP Hazard Analysis and Critical Control Point
  - FMEA Failure Mode and Effect Analysis
- To reduce the capital cost companies sometimes
  - Undersize plants
  - Don't allow for downtime
  - Overstress components

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Phosphate crisis

- Today's phosphate mines will be exhausted by the end of the century at the current rate of use
- Estimates of future P reserves 200 to 400 years then …

*"…life can multiply until all the **phosphorus is gone, and then … an inexorable halt which nothing can prevent**…. We may be able to substitute nuclear power for coal, and plastics for wood, and yeast for meat, and friendliness for isolation - but **for phosphorus there is neither substitute nor replacement**."*

Isaac Asimov, "Asimov on chemistry" (June 1974) Doubleday Company, New York

- it deserves to be a policy driver – how will that affect technologies?

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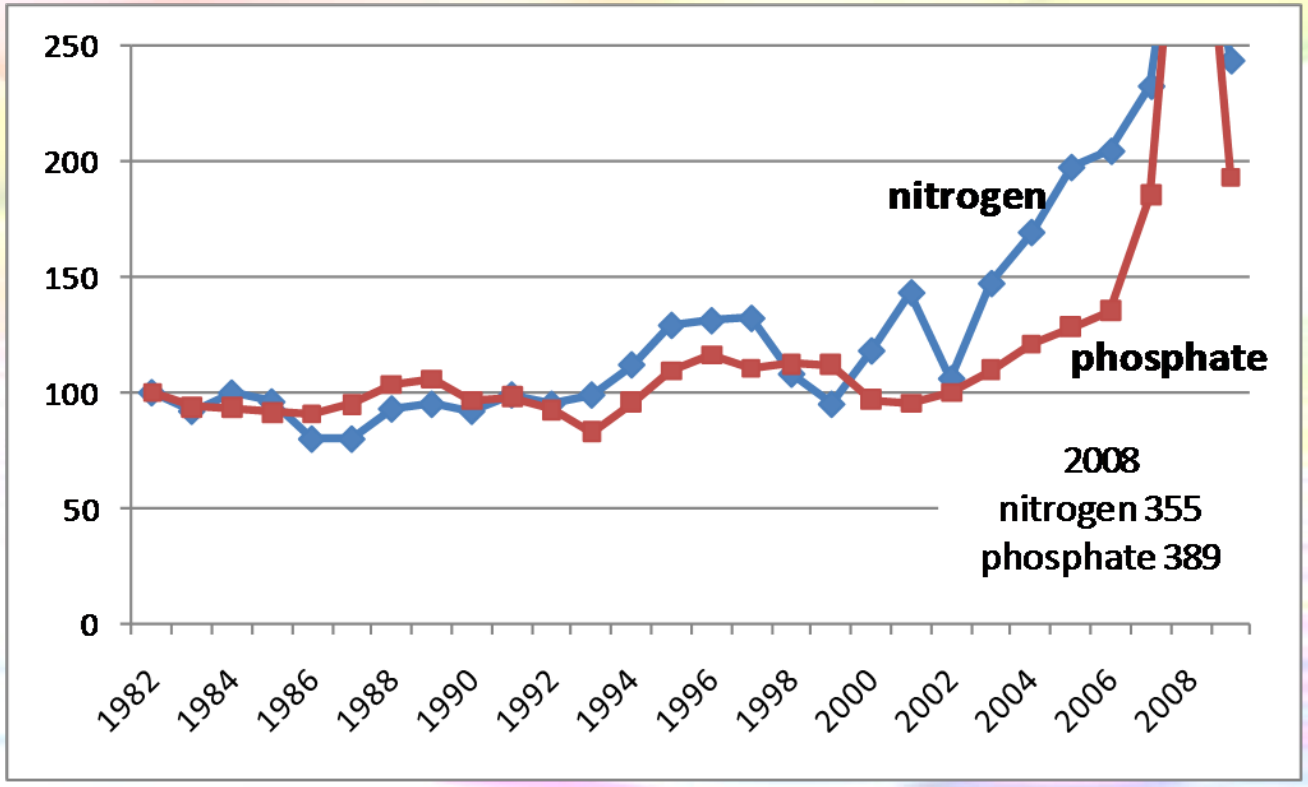
Fertilizer prices - index (USDA) 1982 = 100

- Fundamentals say prices will increase
- Security of supply
- Air is 80% nitrogen just need energy to fix it



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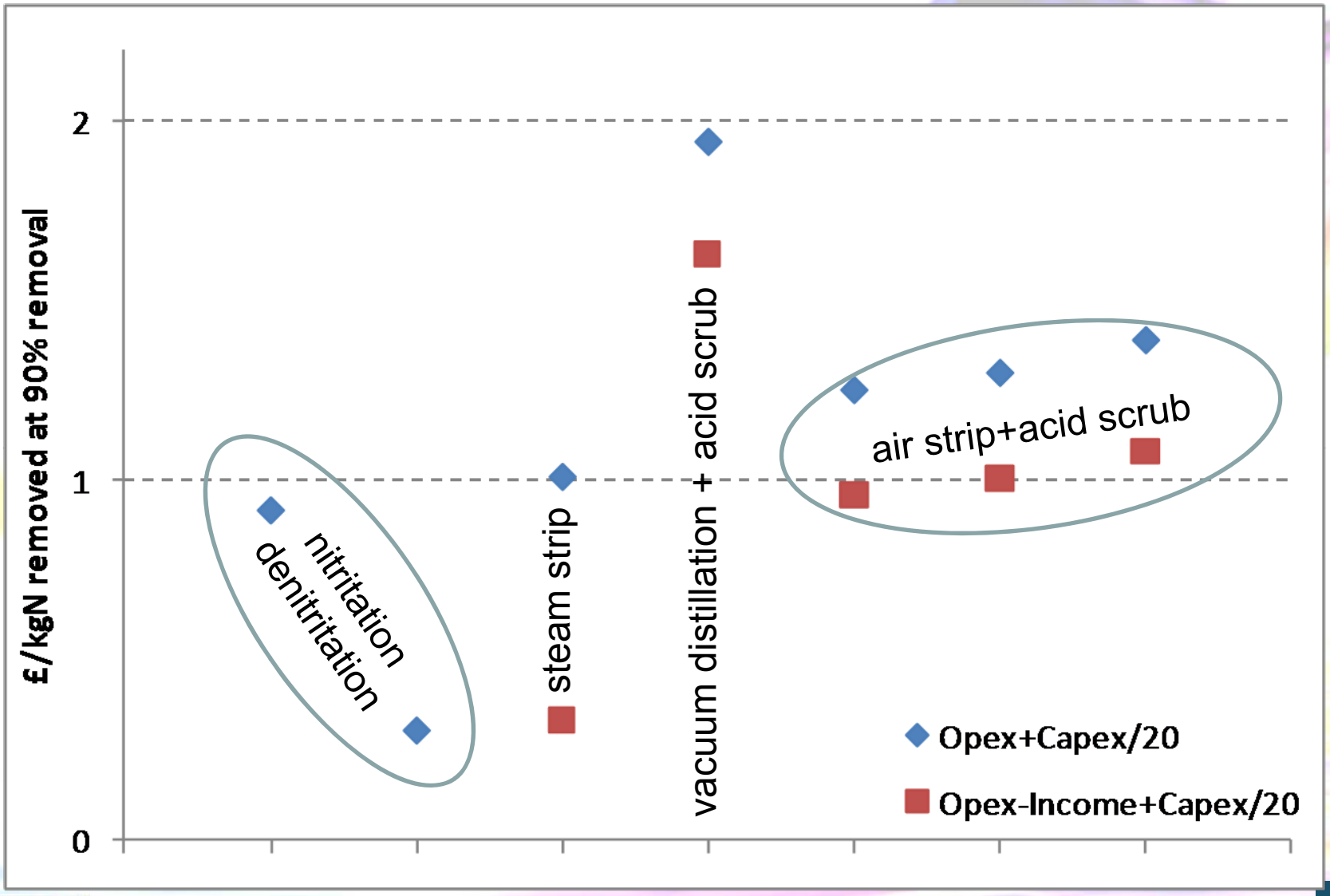
P in urban wastewater

- Wastewater treatment could capture 95% of P into sludge
- We have only thought about preventing eutrophication but in the future will P-recovery be the driver?
- Sweden recycle 60% of P in wastewater by 2015
  Germany aim to recover P
  – EU next?
- Dewatering liquor 25% of load on WwTW
- Struvite recovery (also N)

Sidestream N removal less expensive than conventional



Value of resources

Biosolids	USA	EU	
Biosolids MtDS/y	6.5	10	
Total nitrogen @5%N (Mt)	0.325	0.5	
Total N @ $1.008/kg	$ 330M	$500M	$0.8bn
Total P_2O_5 @7% (Mt)	0.455	0.7	
Total P_2O_5 @$0.936/kg	$430M	$660M	$1bn
Plus the same again going out in the treated water			
Biogas – electricity @$65/MWh	$1.2bn	$1.8bn	$3bn
Plus recovered water	55bn m^3	40bn m^3	$45bn

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Summary

- Multiple new drivers mean there are opportunities
- Multiple customers and geopolitical situations mean no one solution will sweep the board
  - Appraise with healthy informed scepticism
  - Are the fundamentals right?
  - Is it robust?
- The market is quite conservative and has the classic segmentation [chasm]
- Mix of evolution and revolution