

Sustainable Urban Wastewater Treatment

Optimisation of Energy Use, Opportunities for Renewable Energy Generation and Resource Recovery

Steve Palmer – Atkins Water and Environment



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WHY CONSIDER ENERGY USE OPTIMISATION AND CHANGES TO URBAN WASTEWATER TREATMENT ?

SUSTAINABLE DEVELOPMENT:

“Development that meets the needs of the present without compromising the ability of future generations to meet their own needs” [BRUNDTLAND COMMISSION, 1987]

SUSTAINABILITY IS AN IMPORTANT FACTOR IN THE FUTURE DEVELOPMENT OF ANY CORPORATE ENTERPRISE

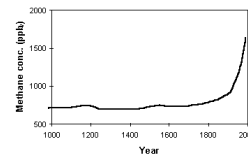
SUSTAINABILITY CONSISTS OF THREE DIMENSIONS:

- ECONOMIC DEVELOPMENT
- ENVIRONMENTAL PROTECTION
- SOCIAL RESPONSIBILITY

Industry requires energy; climate change issues mean that adherence to sustainable development obliges companies to maximise the use of renewable energy and minimise emissions of greenhouse gases (carbon dioxideand methane)

Striking the balance 2006
Wessex Water has published its latest sustainability report *Striking the balance* charting its pioneering progress to becoming a fully sustainable company. [more info ...](#)

Water company's cars fuelled with biopower
Wessex Water has taken delivery of the first of the next generation of environmentally-friendly cars which run on bioethanol. [more info ...](#)



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WHY CONSIDER RENEWABLES?

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Shell predicts two decades of rising energy prices

By Michael Harrison
07 June 2005

Worldwide energy prices are set to rise over the next two decades as individual countries become more concerned about ensuring security of supply and governments take a more pro-active role in dictating energy policy and regulating markets, according to the latest global outlook from the oil giant Shell.

❑ POWER COST INFLATION

❑ PERIOD OF PEAK OIL MAY BE CLOSE ACCORDING TO SOME AUTHORITIES

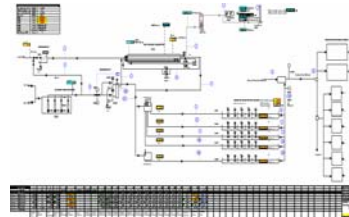
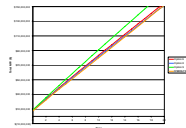
❑ U.K. MOVING STATUS FROM ENERGY EXPORTER TO ENERGY IMPORTER
...NOW.... with questions raised about total gas infrastructure capacity

❑ GEOPOLITICAL ISSUES INCLUDING NATIONAL SECURITY CAN AFFECT ENERGY PRICE

❑ OVER THE COURSE OF AMP4 ALONE POWER COST INFLATION HAS BEEN SIGNIFICANT; all indications are that it will get worse

❑ POWER COST INFLATION JUST AT PRESENT LEVELS CAN HAVE A PROFOUND AFFECT ON WASTEWATER INFRASTRUCTURE WHOLE LIFE COST

❑ e.g. TULARE, CA.



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Renewables include all resources - not just energy

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Residuals: Regulatory Implications

- Waste Management Licensing Regulations
 - Waste Management License requirements
- Landfill Directive
 - Increasing costs due to engineering and permitting requirements.
 - Significant restrictions on landfilling municipal biodegradable waste.
- Increasing Landfill Tax
- The challenge: maximise on site recovery of valuable resources from 'waste'

Transport Implications

- Increasing fuel prices
- Drive towards sustainability – reducing environmental footprint/impact
- Future
 - Sludge/waste hubs
 - Localised treatment/disposal
- The challenge: minimise or eliminate transport costs –especially for 'waste'

REQUIRED PHILOSOPHY IS TO TREAT 'WASTE' AS A UTILISABLE RESOURCE AS FAR AS POSSIBLE

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**WHY CHANGE URBAN ASSET DESIGN AND OPERATIONS?
Summary of Benefits**

- ❑ Development of a utility wide **Sustainable Energy Policy** beginning with and incorporating wastewater assets for water companies
 - ❑ Integrate energy balances analysis and reviews of wastewater assets with asset development planning; identification of opportunities for energy conservation integrated with identification of opportunities for renewable energy generation
- ❑ Meet Sustainable Development Criteria for Energy and Resources policy
- ❑ Better Control of Power Costs and Diversification of energy supply
 - ❑ Power cost inflation mitigation allows better control of **WHOLE LIFE COST** and **OPERATIONAL COSTS**
- ❑ Integration of residuals disposals and mitigation and reduction of residuals disposals costs integrated with integrated with power generation opportunities
 - ❑ Residuals rationalisation allows better control of **WHOLE LIFE COST** and **OPERATIONAL COSTS**

Issues

- ❑ Water supply and concomitant sewage treatment costs **1.2MWh/MI** (CIWEM, 2006)
- ❑ Residuals treatment and disposal is having a profound effect on wastewater treatment whole life cost
- ❑ Power cost inflation is having a profound effect on wastewater treatment whole life cost based on energy costs alone
- ❑ There are **triple Incentives** for exploiting opportunities for renewable energy generation in addition to reduction or elimination of net power demand:
 - ❑ Enhanced Capital Allowance
 - ❑ Tradable Renewable Obligation Certificates (ROCs)
 - ❑ Carbon Trading
- ❑ Energy conservation is a now key element in reducing wastewater treatment costs (U.S. E.P.A. Wastewater Management Fact Sheet: Energy conservation (2006))
 - ❑ For a 'standard' wastewater treatment facility treating municipal wastewater to Urban Wastewater Treatment Directive requirements plus nitrification by activated sludge – the power draw for aerobic secondary treatment is typically 10x the anaerobic digestion surplus gas yield


Issue Mitigation

❑ Reduce power demand in design provision and asset operations:

- ❑ Carry out energy audits and sustainability surveys- benchmark your existing systems and track energy costs
- ❑ Develop in house energy management training for operators
- ❑ Maximise options for low energy, high efficiency primary treatment to reduce aerobic secondary treatment costs
- ❑ Consider passive aeration system eg modern plastic media trickling filters versus high energy demand aeration options
- ❑ For Nutrient removal – preferential use of BNR
- ❑ Avoid chemical dosing where possible- consider other resources e.g. anoxic zones for alkali recapture and aeration demand reduction rather than N removal *per se*
- ❑ For activated sludge systems always install DO systems for aeration control: in future consider respirometric control of oxygen demand
- ❑ Consider VSDs against fixed speed pumps based on whole life NOT capital, cost
- ❑ Potential effects of Catchment per capita water reuse and reduced rate of return to sewer: more concentrated wastewater but reduced pumping costs

Issue Mitigation

❑ Exploit the Opportunities for Renewable Energy Generation

- ❑ Low head Water Wheels 
- ❑ Wind turbines 
- ❑ Solar panels on roofs 
- ❑ Maximise use of Anaerobic Digestion 
- ❑ Incineration of waste sludge always with CHP/Energy recover
 - ❑ Fluidised Bed Incinerators with CHP for Sewage Sludge Gasification
- ❑ Exploit the incentives for renewable energy generation
 - ❑ Enhanced Capital Allowance,
 - ❑ Tradable Renewable Obligation Certificates (ROCs)
 - ❑ Carbon Trading

Issue Mitigation

Utilise and Optimise Anaerobic digestion where ever possible:

- To reduce solids by 30% and thereby reduce transport costs
- Sludge processing to maximum dryness where possible to reduce transport costs, disposal costs and extend range of potential outlets
- Optimise digestion for gas production – by hydrolysis enhancement or sonication for secondary sludges in particular or introduction of plug flow digestion in general
- Optimise digester operations: optimise mixing
- Optimise digester operations: optimise sludge feed to at least 6% on average for properly mixed digesters
- Optimise digestion for gas production- maximise primary sludge capture (compared to primary, 100% SAS has to be fed at 7%DS at minimum to achieve a positive energy balance)

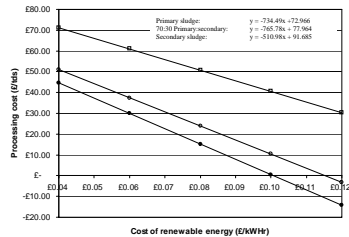
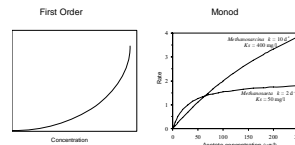


Figure 9. Influence of Renewable energy value on processing cost. Key: (●) 100% primary sludge; (◐) 70% primary 30% secondary sludge mixture; (◑) 100% secondary sludge.

Anaerobic Digestion Is a SEQUENCE of microbial reactions



- Hydrolysis is first order
- Acidogenesis and methanogenesis are governed by Monod kinetics
 - $\mu = \frac{\mu_{max} S}{K_s + S} - b$
 - $m =$ max growth rate (day⁻¹)
 - $S =$ essential nutrient conc (mg/l)
 - $K_s =$ half rate constant, = nutrient conc when $\mu = \mu_{max}/2$
 - $B =$ decay rate (maintenance energy) (day⁻¹)

From "Use of Plant Data to Predict the Influence of Sludge Quality on Anaerobic Digestion Costs" (with permission of Dr Bill Barber)

Issue Mitigation

Exploit the Opportunities for Renewable Resources

- Grit for re-useable bulking material
- VFAs from digestion for chemical feedstock/bio-plastics
- Water Reuse: Opportunities for local non potable use and site based reuse, including potable, from a microfiltration/UF/RO sidestream
- Phosphorus Recovery
 - Anaerobic batch P-recovery units for struvite etc also protect digesters,
 - Sludge will become a major source of P as 2070 approaches and world supply of P runs out
 - Sludge becomes a major source of P dosing for agricultural land instead of artificial fertiliser-perhaps simply as dried digested sludge pellets

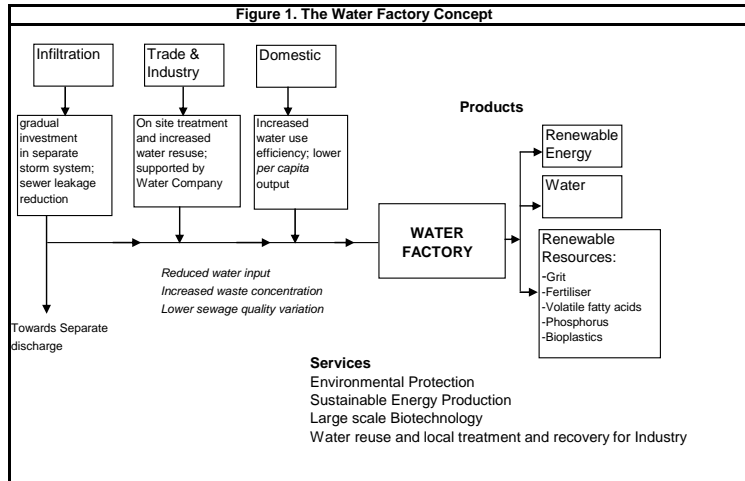


PHOSPHORUS RECOVERY TECHNOLOGIES:

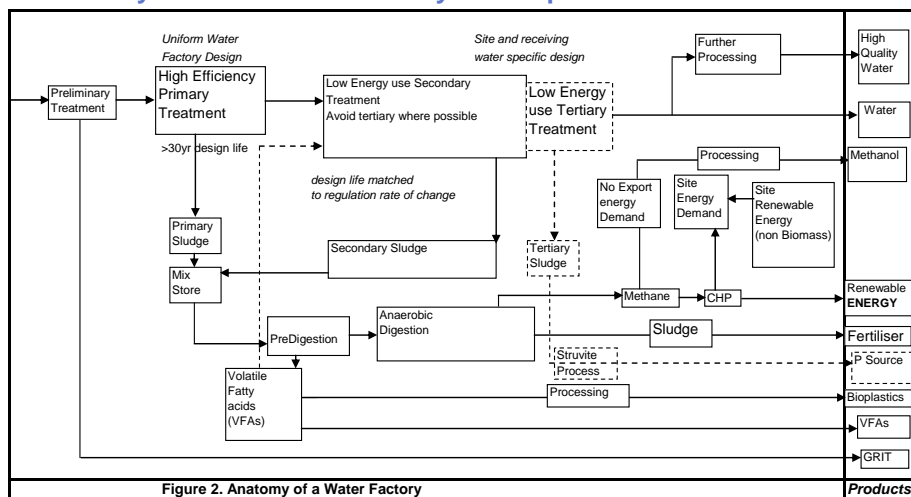
- PHOSMIX
- CRYSTALACTOR



Sustainable Urban Wastewater Treatment: The 'Resource Recovery Centre' / 'Water Factory' Concept

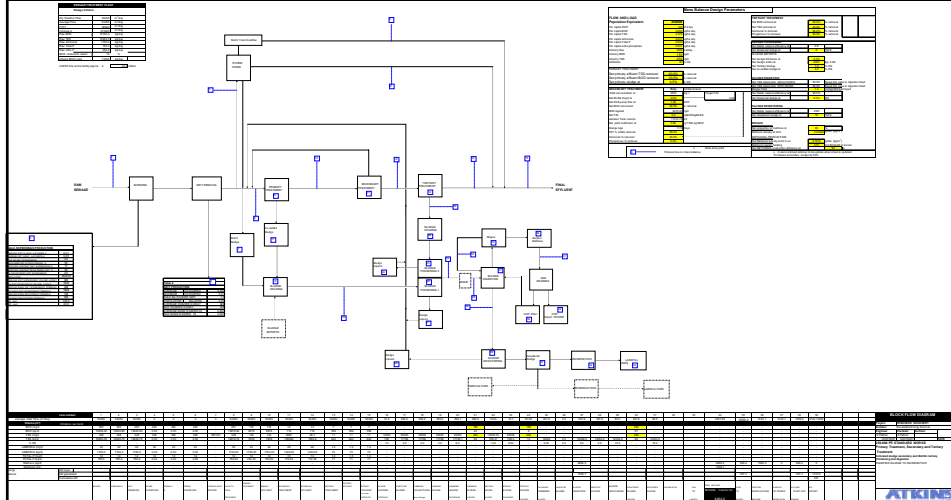


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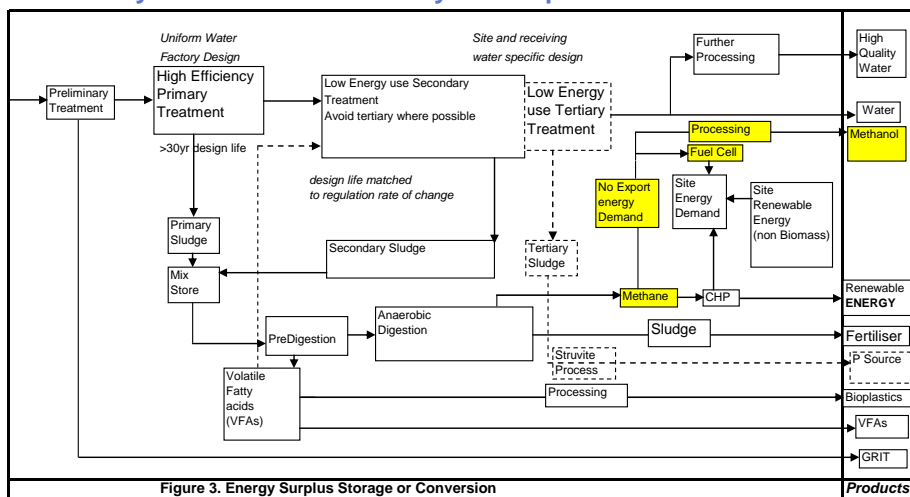


Figure 3. Energy Surplus Storage or Conversion

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**Sustainable Urban Wastewater Treatment: Synergies
- Other Business Development Opportunities**

Development of renewable power generation linked to better control of sludge disposal outlets

- For example: pilot project to set up local business for power generation linked to rural economy; joint venture between water company, local council, major energy company, venture capital, consultant
- Company to negotiate with farmers for use of agricultural land for 'power crops'; company owns and operates fermentation assets locally; also sells biofuel crops on to other biofuel (bioethanol) producers (e.g. BP)
- Farmers return land to use from food or set aside to power crop production:
 - Sugar Beet
 - Oilseed rape (biodiesel and bioethanol)
 - Wheat, barley,
 - Willow Coppice,
 - Crop range allows for minimum of 2 concurrent energy crops per year, sold to Company by farmers; also provides energy microgeneration opportunities locally
- Company also arranges for and leases sludge disposal as fertiliser to energy crop farmers
 - Energy crop production does not involve same resistance or perception issues as sludge to arable and cattle land
 - Expands and diversifies sludge disposal options for water company
 - Provides BATNEEC route for sludge disposal recycling Phosphorus