Eco-efficiency and LCA for sustainability assessment in wastewater treatment

Complementary tools?

Sustainability is :

Lack of definition! Lack of precision! Meaningless concept!

Environmentally effective

Economically affordable

Socially acceptable

Provides ideas! Shows leadership! Global commitment!

Balancing the needs of society and the environment

Preliminary study…….
What do we need for sustainable WWT

- Decision support data
- Minimal use of natural resources
- Minimal use of energy
- Focus on recycling or reuse
- Put into system context
- Include other stakeholders
- Consider different technology options
- Consider all impacts - local and global

Wastewater US, for example

- 16,225 plants
- 160 billion L wastewater/day
- 98% municipally owned
- 73% service population
- 4 billion L reclaimed
- 7 million tonnes sludge produced – 30-80% of electrical energy
- Chlorine and UV sterilisation comparable in energy use
- 50% sludge beneficially reused
- POTPs consumed 21billion KWH – private 2x this15.5 Tg CO_2, 145 Gg SO_2, 4 Gg $PO_{4,,,,,,}$
- 1% of total GHG emissions

>5% of all electricity globally used to treat “waste”water

Centre for sustainable systems, Uni of Michigan

What does sustainability mean in wastewater treatment

- WWT conventionally used to protect health and hide “unmentionables”
- Little concern for recovery of resources
- Sustainable issues not covered in training of engineers, planners, health officials, funding bodies
- Brundtland’s original definition – “not compromising future generations”
- *A sustainable urban water system should over a long time perspective provide required services while protecting human health and the environment, with a minimum use of scarce resources - Lundin*

- Providing a sanitary solution that does not diminish health of the anthroposphere and the natural environment. It should aim to minimise resource use and be socially, technically and “financially” viable, within the constraints of our present education and implementation institutions.
- Recognises importance of stakeholders – public, health officials, other government, farmers, engineers…….

What does WWT seek to achieve

- Organic pollutant removal
  - BOD, COD, odour, taste/taint, colour, trace contaminants
- Inorganic pollutant removal
  - Metals, salts
- Microbial pollutant removal
  - Harmful species, e.g. bacteria, viruses
- Acceptable water quality for??????

Sustainability Indicators

- An indicator is useful if it is of fundamental interest in decision-making, simplifies or summarises important properties, visualises phenomena of interest and quantifies, measures and communicates relevant information.
- Also useful

· to assess conditions and trends (sometimes in relation to goals and targets);

· to provide information for spatial comparisons;

· to provide early warning information;

· to anticipate future conditions and trends. (Gallopín, cited Lundin)

Measuring sustainability – some potential indicators

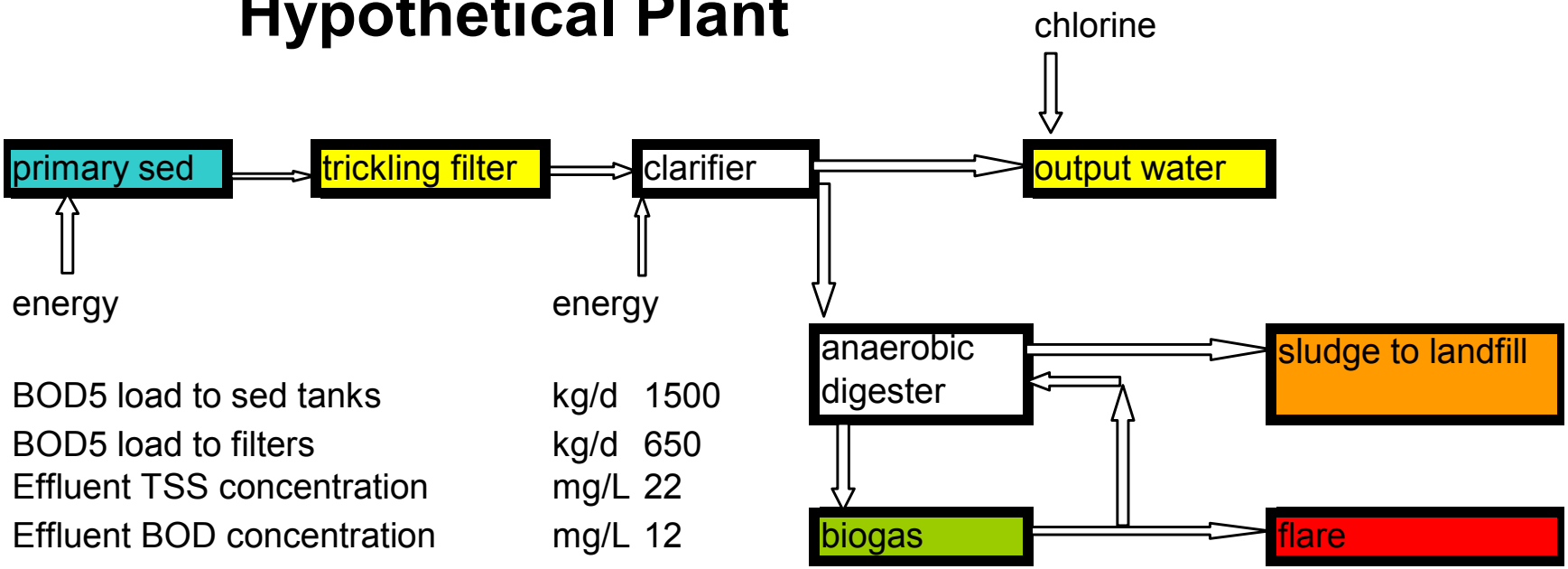
- Economic affordability
- Global warming, Ozone depletion, Toxicity (human, aquatic, terrestrial), Acidification, Nitrification
- Construction, operation and maintenance requirements
- Adaptability to social –cultural and institutional environment
- Biotic and Abiotic depletion, Dessication, Resource utilisation
- Scale and possibilities for integration

LCA

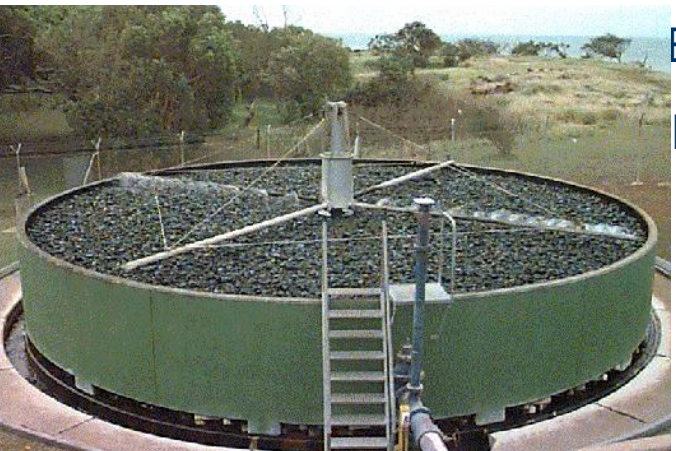
From Balkema

Carrying out eco-efficiency in WWT - the trickling filter plant

Hypothetical Plant



BOD5 load to sed tanks	kg/d	1500
BOD5 load to filters	kg/d	650
Effluent TSS concentration	mg/L	22
Effluent BOD concentration	mg/L	12



Effluent N = Influent N!

Effluent P = Influent P!

Eco-efficiency indicators – hypothetical trickling filter plant

		TF				
	$/kL			**$/PE**		
Electricity	0.12	0.18	KWh/kL	1.18	16.83	kWh/PE
Chlorine	0.001	0.000	kg/kL	0.08	0.004	kg/PE
Polymer	0.001	0.000	kg/kL	0.00	0.01	kg/PE
Zeolite	0.00					
Sludge	0.02	0.75	kg/kL	2.35	70.55	kg/PE
Fossil carbon		0.20	kg/kL		18.19	kg/PE
Costs	0.04	$/kL		3.66		
BOD removal	0.20	$/kg		1105.00	kg/day	
N removal	unknown					
P removal	unknown					

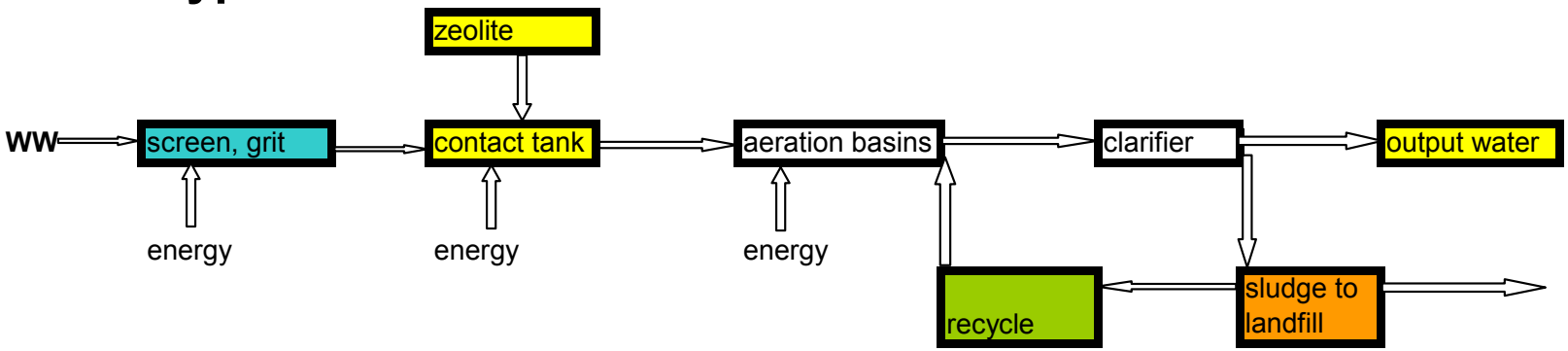
WBCSD

Product or service value

Environmental influence

Carrying out eco-efficiency in WWT - the Activated Sludge plant

Hypothetical Plant



BOD5 load to plant	kg/d	8500
Effluent TSS concentration	mg/L	5.5
Effluent BOD concentration	mg/L	2
Effluent N	mg/L	2
N removed	kg/day	1760

P removed ?

Eco-efficiency indicators – hypothetical Activated Sludge plant

	AS					
	$/kL			**$/PE**		
Electricity	0.26	0.36	KWh/kL	2.48	35.52	kWh/PE
Chlorine	0.00					
Polymer	0.004	0.01	kg/kL	0.04	0.06	kg/PE
Zeolite	0.06	0.01	kg/kL	5.72	0.01	kg/PE
Sludge	0.06	1.68	kg/kL	5.84	168.00	kg/PE
Fossil carbon		0.39	kg/kL		38.40	kg/PE
Costs	0.15			14.40		
BOD removal	0.56	$/kg		3581.60	kg/day	
N removal				1760.00	kg/day	
P removal	unknown					

Assessing eco-efficiency in WWT - the plants compared

	TF	TF	AS	AS	
	$/kL	$/PE	$/kL	$/PE	
Electricity	0.125	1.18	0.26	2.48	
Chlorine	0.001	0.08	0.00		
Polymer	0.001	0.00	0.004	0.04	
Zeolite	0.000		0.06	5.72	
Sludge	0.025	2.35	0.06	5.84	
Costs	0.038	3.66	0.15	14.40	
BOD remov	0.204	1105.00	0.56	8581.60	kg/day
N removal	unknown			1760.00	kg/day
P removal	unknown				

Carrying out eco-efficiency in WWT - the solutions TF

- Improve electric motor efficiency
- Improve transfer efficiency in TF bed
- Insulate digestor and install cogeneration facility
- Reduce Chlorine dosage?
- Improve polymer and dispersion – dewater sludge more
- Find uses for sludge
- Burn sludge?

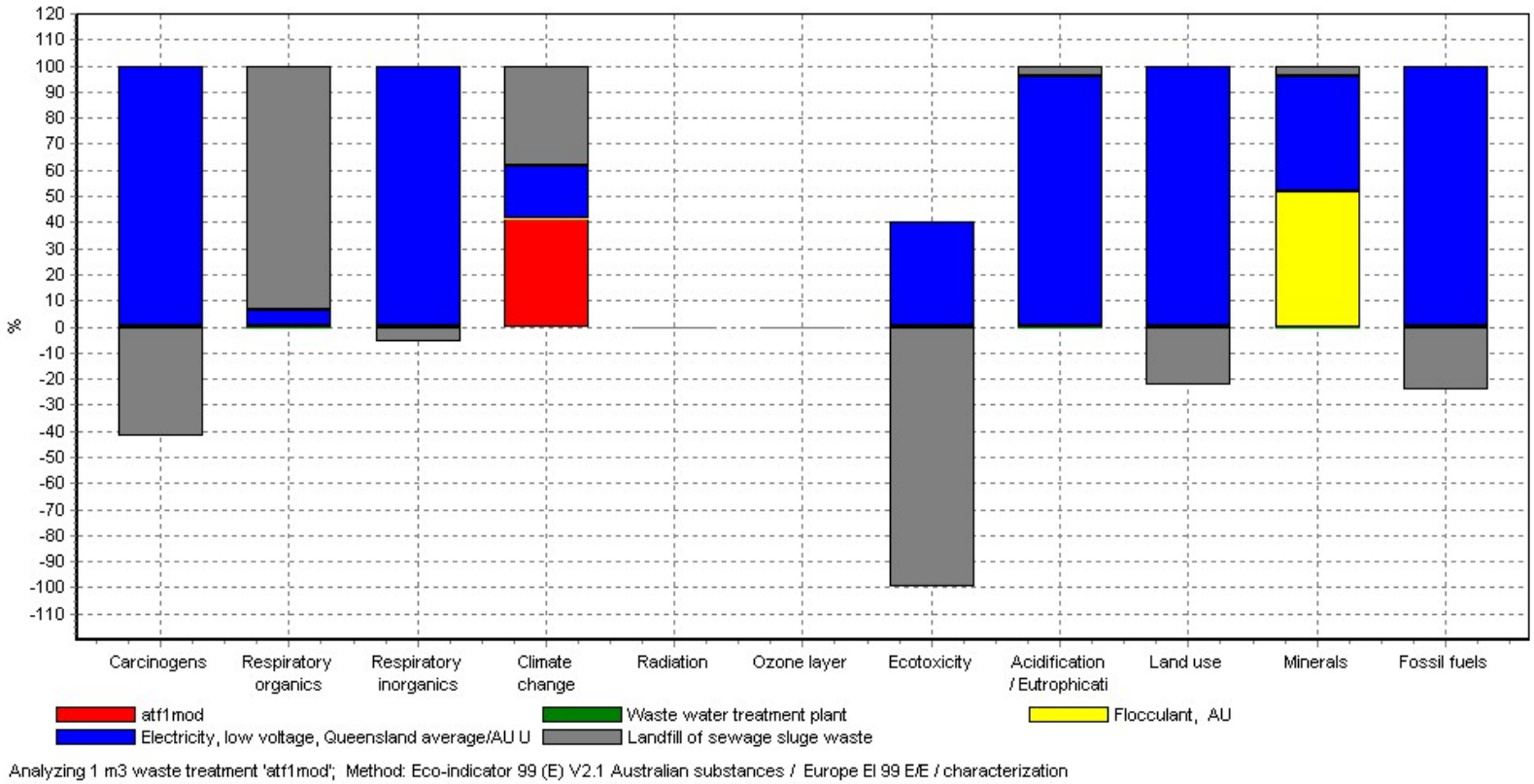
Carrying out eco-efficiency in WWT - the solutions AS

- Improve electric motor efficiency
- Improve blower/distributor efficiency
- Reduce zeolite dosage?
- Improve polymer dispersion – dewater sludge more
- Find uses for sludge
- Burn sludge

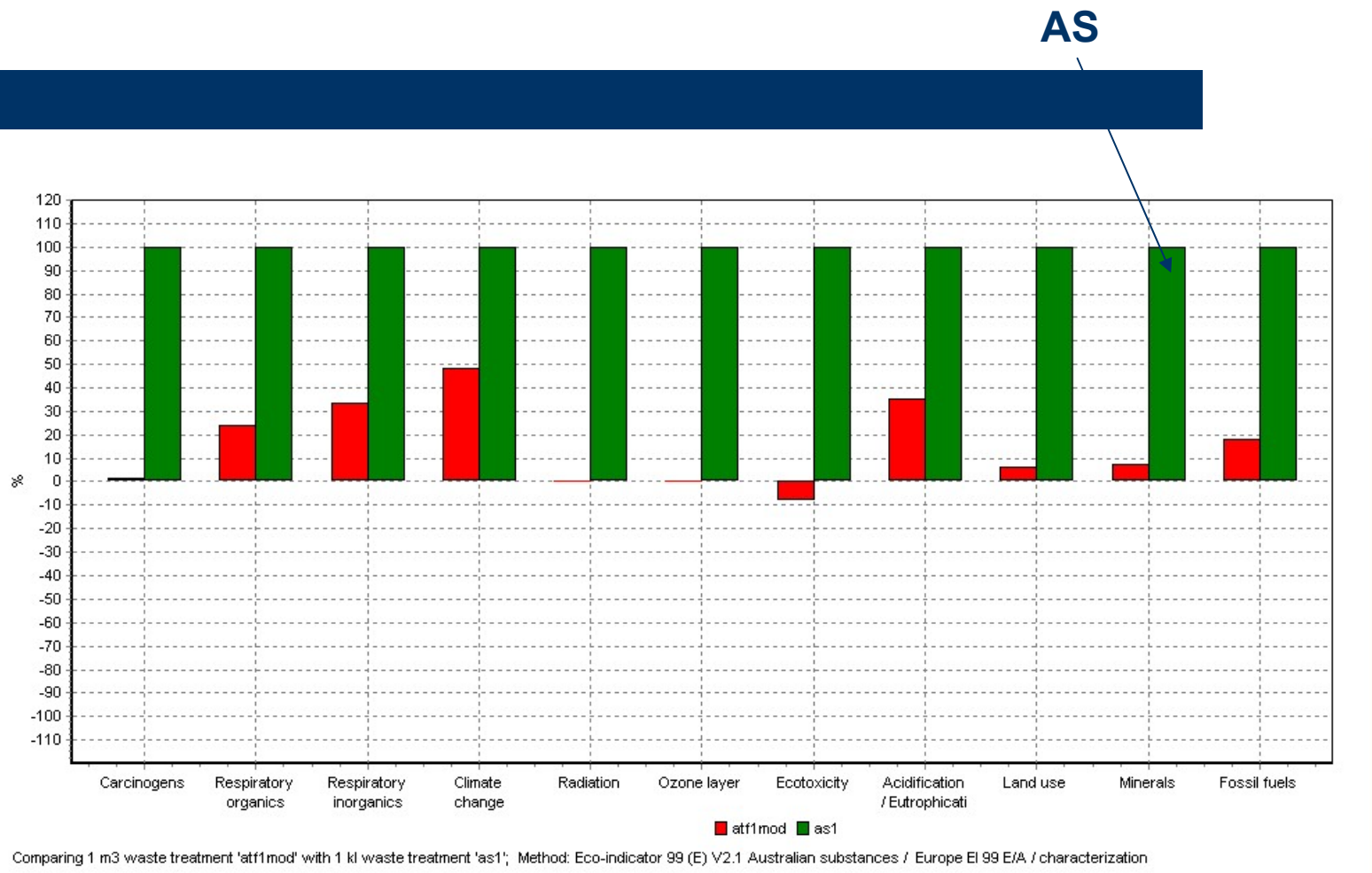
Carrying out eco-efficiency in WWT - generics

- Reduce flow – reduce paved areas (porous pavements, swales), green roofs, disconnect non-sanitary devices, install low water using devices (not part of our system!)
- Improve oxygen transfer in tanks
- Dewater more efficiently
- Better control equipment
- Improve all equipment efficiency

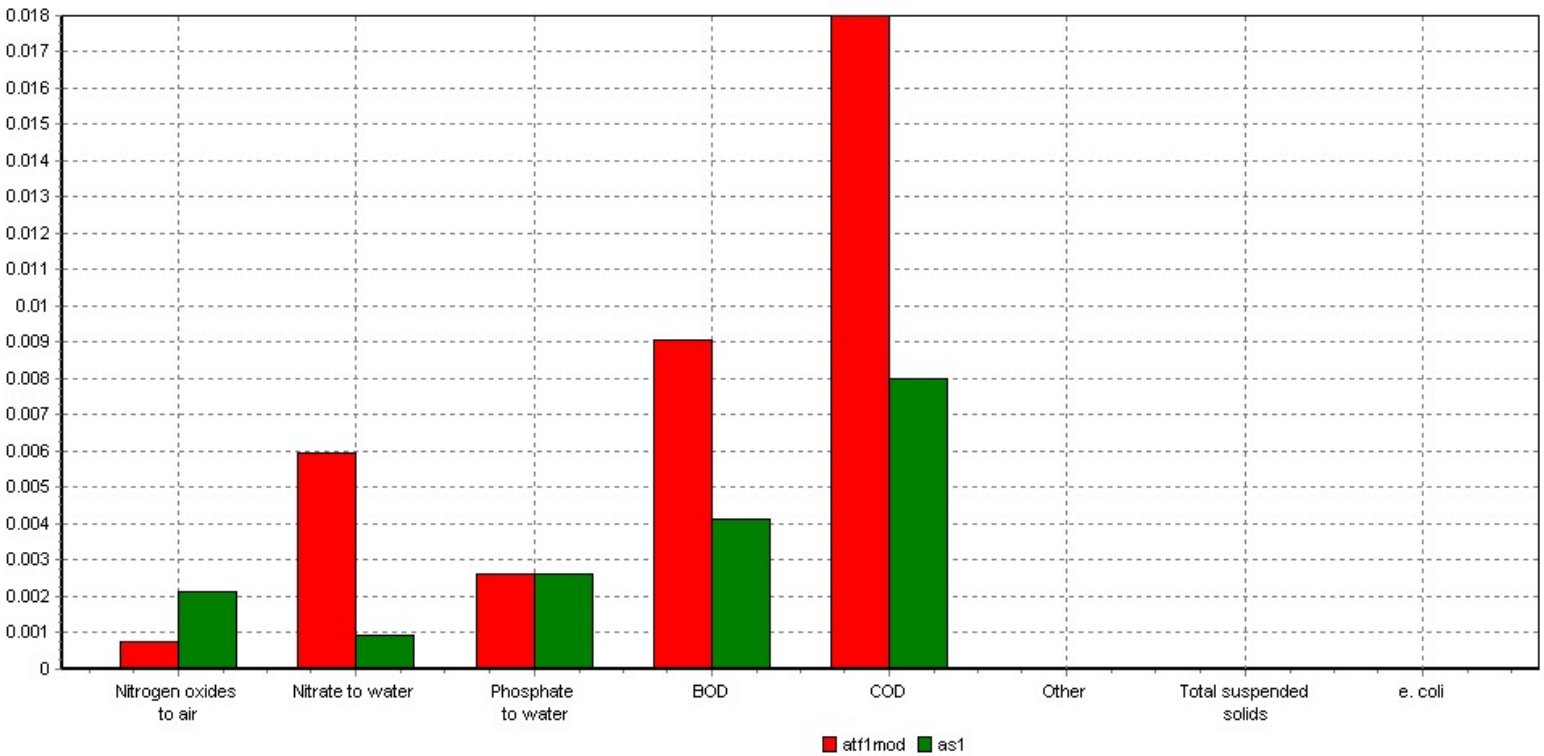
Streamlined LCA - TF



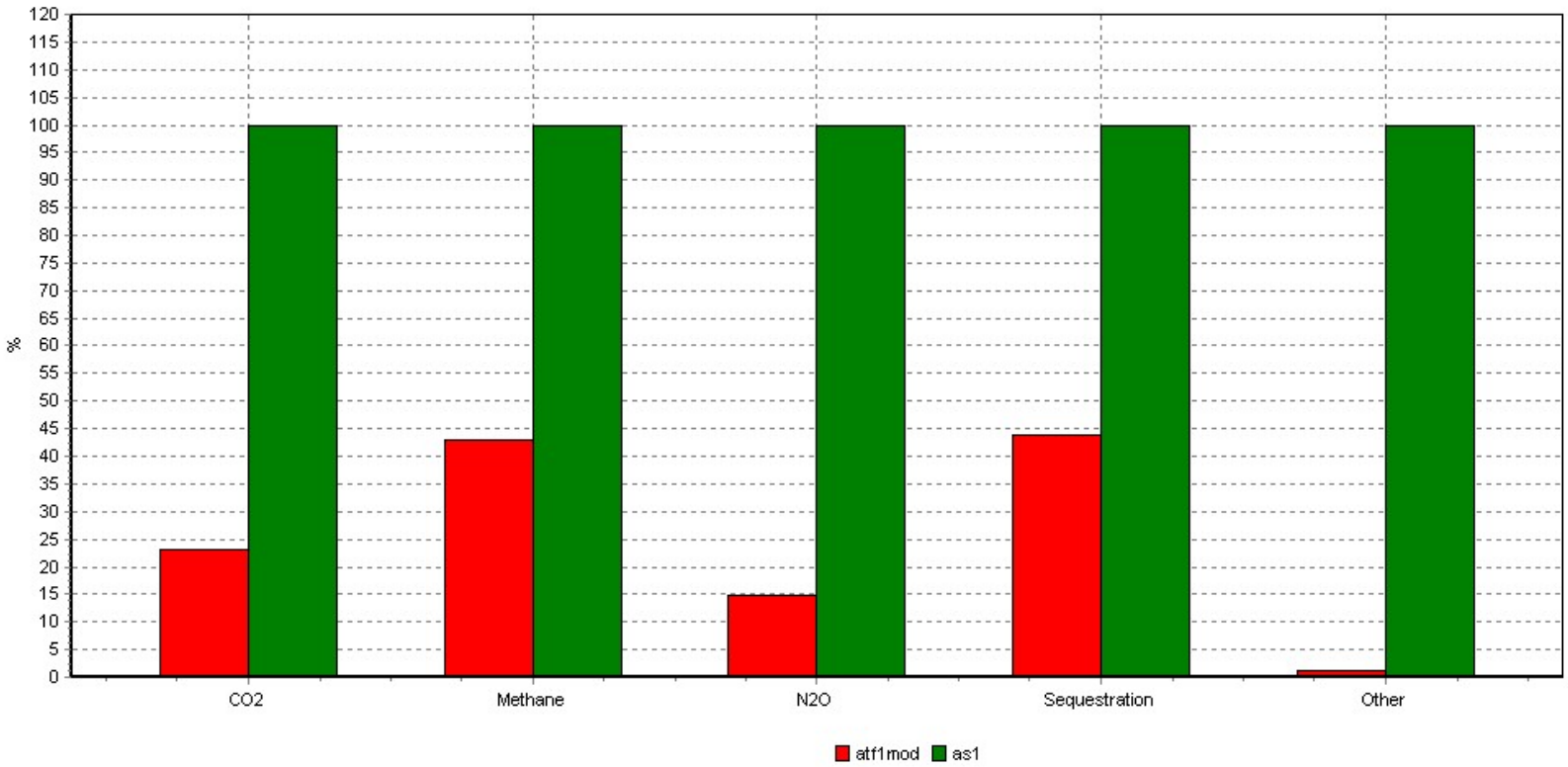
Streamlined LCA EI method



Nutrient impact model



Greenhouse Model



Comparing 1 m3 waste treatment 'atf1mod' with 1 kl waste treatment 'as1'; Method: Greenhouse Model - Single Point = kg CO2eq / Greenhouse kg CO2eq / characterization

LCA issues

- Little available data from local sources
- Diversity in unit processes – data needs
- Impacts from sludge landfill – need to be specific
- The boundaries – plant or system for optimal results?
- What is water for – discharge as waste, resource for recovery, resource for nature – real value??
- Sludge disposal, electricity use major areas

Streamlined process compared

Eco-efficiency

- Dollar values shown
- Output in terms of indicators, recommendations
- Non-standard methodology
- Plant based solutions
- Can be low data requirements
- Provides ideas for improvement

LCA

- Impact values derived
- Good graphical outputs – communication tool
- Global impact indicators
- ISO methodology
- Extensive data required
- Data quality stipulations
- Identifies hotspots

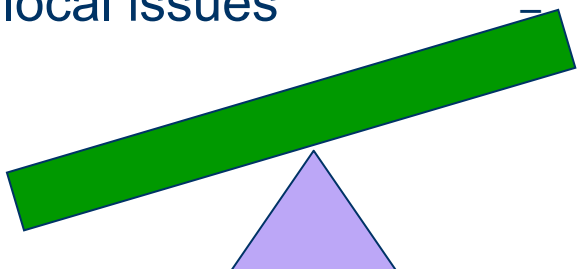
Sustainability measures? – useful, adequate, suitable??? – what do you think?????

EE assessment

- Indicates GHG
- Can indicate other environmental issues
- Indicates economic performance
  - Measures sludge production/disposal
  - Measures chemicals used
  - Measures total costs
- Interprets
- Plant scale / local issues

LCA

- Indicates impacts
  - GHG
  - Nutrients
  - Acidification
  - Ozone depletion
  - BOD
  - Ecotoxicity
  - Land use
  - Fossil fuels
  - Carcinogens
  - etc



Needs interpretation – excels at global issues