

The Evaluation Of Technologies For Small, New Design Wastewater Treatment Systems

About me ...

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- ▣ School of Mechanical and Manufacturing
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- ▣ Final six months of PhD

“Economic and Environmental assessment of wastewater treatment – A Lifecycle Approach”

Background

- ▣ Research is funded by the Irish EPA as part of Horizon 20 /20 commitments
- ▣ Irish Water (IW) form a large part of the research steering committee
- ▣ Research is broken down into two strands:
 - Part a) LCA of wastewater treatment systems (WWTS) in Ireland
 - Part b) LCC of small WWTS in Ireland (500 - 2,000 PE)

Background

- ▣ > 87% of WWTS in Ireland are below 2,000 PE
- ▣ Many plants are old, overloaded and in need of significant capital investment
- ▣ There can be a culture of “regional tranching” of WWTS in Ireland

Main objective

- ▣ Enlighten toolkit users about the trade-offs between:
 - operation and capital expenditure, and
 - the economic and environmental costs

Specific objectives

- Carry out life cycle costing for a selection of systems
- Develop a decision support toolkit

Scope

- Toolkit should be able to be operated by both technical and non-technical users
- Toolkit should allow for variations in
 - Scale (500 – 2,000 PE)
 - Loading
 - Discharge limits
 - Temperature
 - Topography

Methodology

- ▣ Literature review
- ▣ Identification of feasible systems
- ▣ Data compilation
- ▣ Systems modelling
- ▣ Testing
- ▣ Validation

Systems

Systems	Abbv.	Family
Complete mix activated sludge	CMAS	Suspended growth
Anoxic/oxic	A/O	Suspended growth
Anaerobic/anoxic/oxic	A/A/O	Suspended growth
Extended aeration	EA	Suspended growth
Oxidation ditch	OD	Suspended growth
Sequence batch reactor	SBR	Suspended growth
Rotating biological contactors	RBC	Attached growth
Trickling filters	TF	Attached growth
Integrated fixed-film activated sludge	IFAS	Hybrid
Moving bed biofilm reactor	MBBR	Hybrid
Constructed wetlands	CW	Natural

Modelling

- ▣ Models were developed for:
 - Footprint
 - Energy requirements
 - Chemical requirements
 - Sludge production
 - Capital expenditure
 - Operational expenditure
 - Lifecycle costing (NPV)

Decision Support Tool (DST)

System Selection Support Tool

[DST homepage](#) | [Parameter Inputs](#) | [Process Information](#) | [Systems Comparison](#) | [Additional Parameters](#) | [Set up](#)

DST

*Wastewater Treatment System
Decision Support Tool*

User Guide

Technical Documentation

Let's Start!

V.3.0 2016

User input parameters

System Selection Support Tool

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Plant Loading

Average Influent Loading

BOD5 (mg/L)

COD (mg/L)

TSS (mg/L)

TN (mg/L)

TP (mg/L)

NH4 (mg/L)

PO43- (mg/L)

Hydraulic load
(m3/day)

Calculation method

Hydraulic load ☒

Agglomeration ☐

Agglomeration (PE)

Enter Plant Loading

Discharge Limits

BOD5 (mg/L)

COD (mg/L)

TSS (mg/L)

TN (mg/L)

TP (mg/L)

NH4 (mg/L)

PO43- (mg/L)

Chlorination ☒

Dechlorination ☐

Enter Discharge Limits

Sludge

On-site Sludge Treatment ☒

Dewatering

Stabilisation ☒

Enter

Surface area restriction

<= (m2)

Filter

Submit

Reset

Sludge disposal

- ▣ Three sludge disposal options included:
 1. No treatment – contractor disposal
 2. Mechanical dewatering (centrifuge)
 3. Sludge drying beds

The screenshot shows a software interface for configuring sludge disposal. On the left, there is a vertical column of dropdown menus and checkboxes. The main configuration area on the right is titled 'Sludge' and contains three sections:

- On-site Sludge Treatment**: A checkbox that is checked.
- Dewatering**: A dropdown menu currently showing 'Mechanical'. Below it, a list of options is displayed: 'N/A', 'Mechanical' (highlighted in blue), and 'Drying beds'. An 'Enter' button is located below the list.
- Surface area restriction**: A section with a label '< =' followed by a text input field containing '5000' and a unit dropdown set to '(m2)'.
- Filter**: A dropdown menu currently showing 'CAPEX'. Below it is a 'Submit' button.

At the bottom left of the interface, there is a button labeled 'imits'.

Additional parameters

System Selection Support Tool

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☐ [Unlock advanced features](#)

Cost Parameters

Electricity (€/kWh)	<input type="text" value="0.2"/>
Labour operator (€/hour)	<input type="text" value="20"/>
Labour engineer (€/hour)	<input type="text" value="28"/>
Labour helper (€/hour)	<input type="text" value="12"/>
Labour lab. tech (€/hour)	<input type="text" value="20"/>
Ferric chloride (€/Litre)	<input type="text" value="0.7"/>
Calcium carbonate (€/kg)	<input type="text" value="0.2"/>
Calcium hydroxide (€/kg)	<input type="text" value="0.5"/>
Chlorine (€/Litre)	<input type="text" value="0.5"/>
Methanol (€/Litre)	<input type="text" value="0.7"/>
Sludge disposal (€/m3)	<input type="text" value="20"/>
Replant wetlands (€/m2)	<input type="text" value="20"/>
Land cost (€/km2)	<input type="text" value="2200000"/>

Aeration parameters

Mean annual temperature (C)	<input type="text" value="10"/>
Alpha value	<input type="text" value="0.5"/>
Beta value	<input type="text" value="0.95"/>
Fouling factor	<input type="text" value="0.9"/>
Diffuser height (m)	<input type="text" value="0.5"/>
Fine bubble OTE (kgO2/kWh)	<input type="text" value="3.5"/>
Course bubble OTE (kgO2/kWh)	<input type="text" value="2.0"/>
Height above sea level (m)	<input type="text" value="118"/>

PE definitions

Hydraulic (L/person)	<input type="text" value="200"/>
Organic (g BOD/person)	<input type="text" value="60"/>

Preliminary treatment

Treatment type

Footprint

Clearance offset (m)

NPV

Systems lifetime (years)

Program outputs

System Selection Support Tool

DST homepage | Parameter Inputs | Process Information | Systems Comparison | Additional Parameters | Set up

Performance Data

System Option 9 - Energy filter

Anaerobic Anoxic Oxid

Previous

Next

Costing

Energy Efficiency

CAPEX (€)	4219000	(kWh/m ³)	0.31
CAPEX (€/PE)	421.90	(kWh/kg BOD)	1.77
OPEX (€/PE.year)	25.34	(kWh/g NH ₃)	
NPV (€*10 ⁶)	4.33	OPEX (€/m ³)	

Footprint

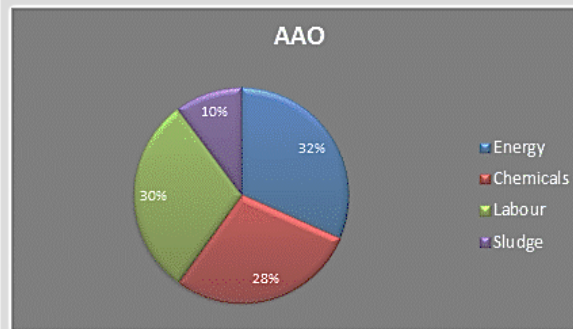
Area (m ² /PE)	0.06	Sludge (kgds/d)	638.08
Active area (m ²)	388.74		
Total Footprint (m ²)	600.18		

System Information

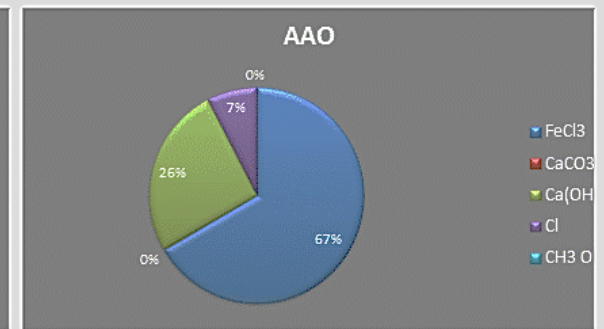
Save Data

Systems data

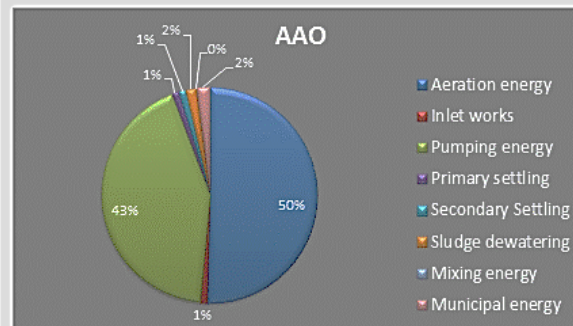
OPERATIONAL COST



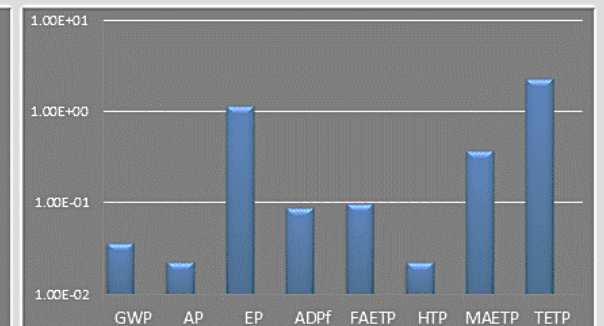
CHEMICAL COST



ENERGY DISTRIBUTION



LIFE CYCLE ASSESSMENT



Systems comparison

System Selection Support Tool

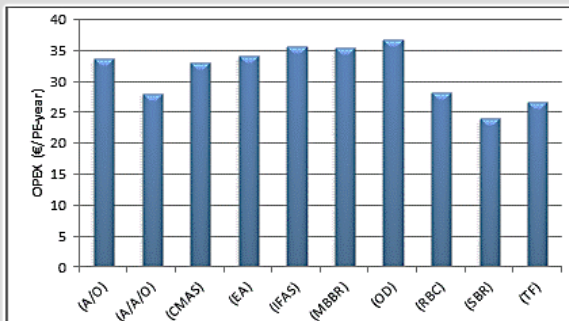
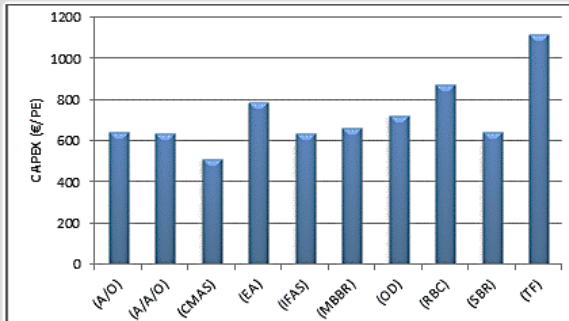
DST homepage | Paramter Inputs | Process Information | Systems Comparison | Additional Parameters | Set up

Systems comparison data

CAPEX

OPEX

Load Graphs

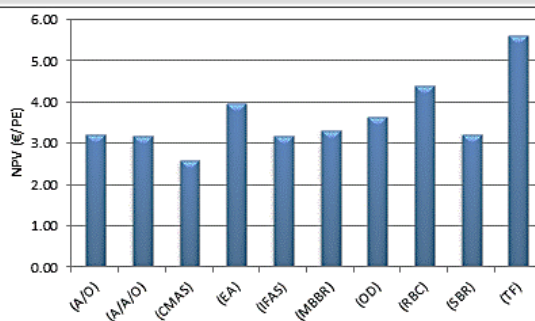
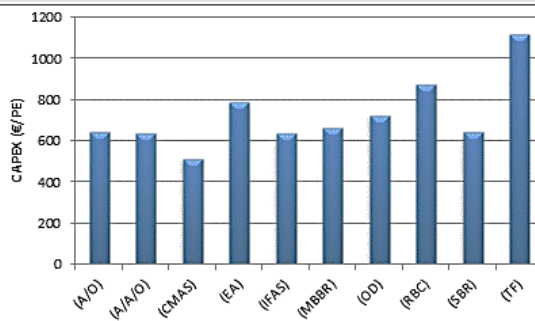


Systems comparison data

CAPEX

Net present value

Load Graphs

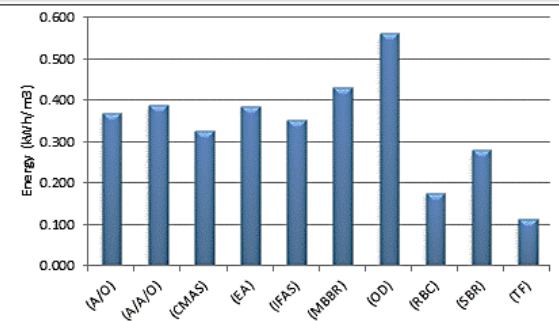


Systems comparison data

Energy - hydraulic

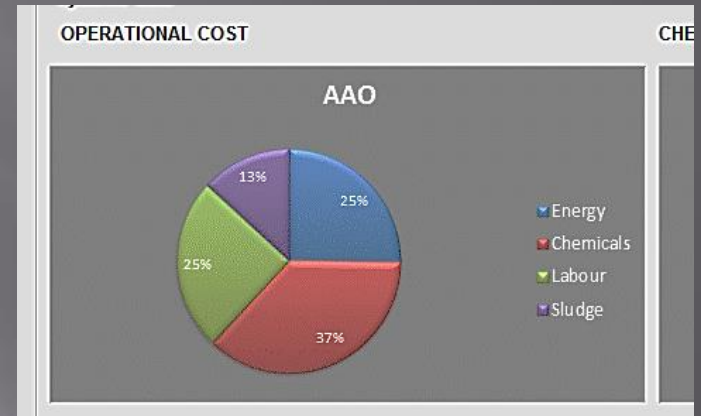
OPEX

Load Graphs



Preliminary findings - Labour

- ❑ Labour costs are subject to significant economies of scale
- ❑ Labour- hours, and required expertise estimations are often poorly calculated
- ❑ Underestimating labour requirements can lead to a decline in system performance and ultimately, system failure



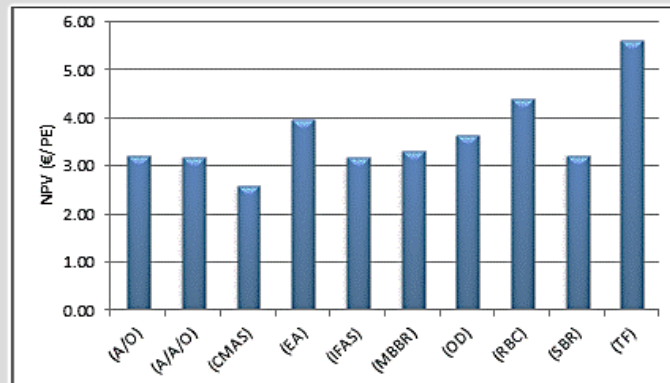
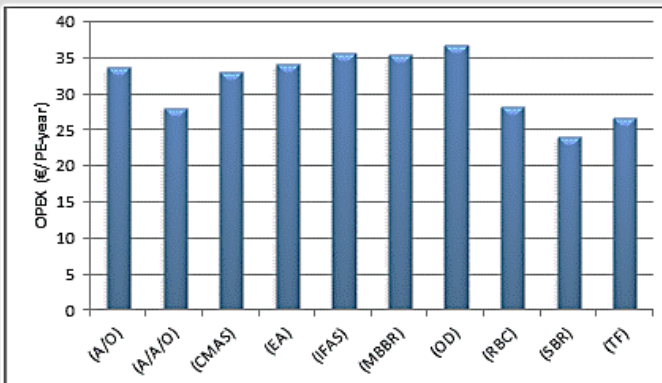
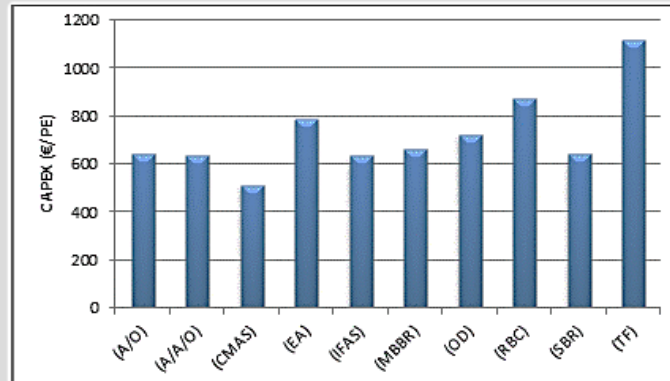
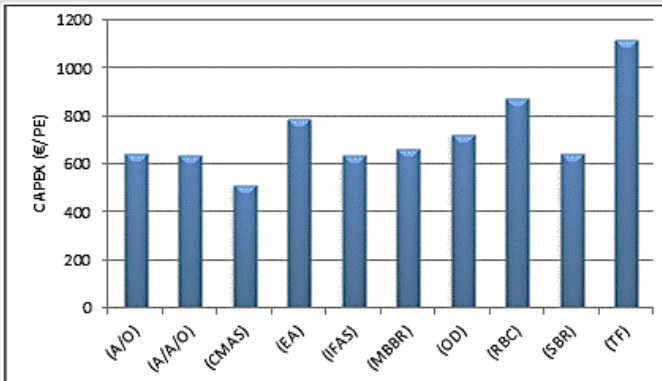
2000 PE



500 PE

Preliminary findings - CAPEX

- Capital expenditure dominates lifecycle cost



Limitations

- ▣ Capital expenditure estimations are prone to significant uncertainty
- ▣ Low energy estimations - based on first principles – not reflecting full economies of scale
- ▣ Oxygen transfer efficiency (OTE) assumptions need further analysis/parameterisation
- ▣ Specific component life times required

Further work

- ▣ A general address of assumptions
- ▣ Inclusion of a sensitivity analysis function
- ▣ Inclusion of LCA component of program
- ▣ More detailed capital expenditure breakdown
- ▣ Further OTE investigation needed
- ▣ Additional sludge treatment options

Thank you for listening

Questions?