UKWIR Energy Efficiency Research Project CL 11
A Compendium of Best Practice and Case Studies

Final Document – Case Studies and Examples

Selection Criteria and Data Collection Guidance

Introduction

The Compendium of best practice in energy efficiency will be illustrated by Case Studies of various technologies, processes and plant. This document details the information that is required for the case studies and examples and explains how Black & Veatch propose this should be collected.

This document will be appended to the Priority Short List Report to help the project teams focus efforts on collecting relevant high quality data.

Scientific Base

In order to provide a sound basis for investment the information should be based on scientific principles so that results are quantified and any risks are known and can be managed. The information required for case studies establishes the background, the type and size of the process, the situation before and after any changes, the changes themselves and the results. If there is any doubt over the data or information, such projects may be shown as generic examples rather than as detailed case studies.

Information required

The information required to describe a project will vary from an example of a simple basic model up to a complex and complete case study.

In its simplest form, a generic energy saving project could be:

1 Starting point and problem or opportunity,
2 Actions, measured and repeatable,
3 End point and solution or measured energy efficiency gain.

An example of this could be:

1 A sewage activated sludge plant was using (X) kW/m^3 of treated effluent,
2 Dissolved oxygen controls were replaced with Ammonia controls,
3 The same plant on the same loads now uses 70%(X) kW/m^3,

hence the energy efficiency saving is 30% for the cost of a simple control change with a payback period of 3 years.

Usually problems and opportunities are more complex than this so the following table sets out the scope of information that would form a complete picture of an energy saving project. It is flexible to apply to any part of the water cycle matrix, from raw clean water or desalination, through to sewage effluent and sludge disposal. To cover special situations, electronic responses are encouraged so the boxes will expand as required and information will not be missed.

The table represents the comprehensive set of data necessary to fully evaluate an energy efficiency project. Ideally all questions should be addressed for a case study. However, for a few projects, there may be insufficient readily available data. This should not preclude this project being reported as an example of good practice, and if necessary follow up discussion with the utility may be necessary to evaluate the data provided.

The guidance notes in the right hand column in italics are for explanation. In the Case Study Proforma the boxes are left blank for answers to be entered electronically or onto a printed version (see last page of this Guidance Note).

Case Study Information Table

Ref	Enquiry Item	Response information, description and remarks
1	**Location:** Country, urban or rural:	*This information will allow regional and other issues to be accounted for in the Compendium.*
2	**Sector:** clean, waste or sludge:	*This description explains which part of the water cycle matrix is relevant.*
3	**Works Owner or Operator:** with financial set-up, regulatory or not.	*The works owner and operator may influence working attitudes to energy efficiency and information on local regulation of the water industry is important to understand how owners are incentivised.*
4	**Size:** flows and loads or population equivalent:	*Size: allows any scale issues to be accounted for including quality variations; e.g. seasonal.*
5	**Energy Provider:** with costs, incentives, taxes and conditions:	*The power is assumed to be electricity but the provider could be a private or public utility, perhaps even the works owner. It is important to understand energy costs, taxes or incentives and any special conditions such as peak power management tariffs (TRIADs in the UK).*
6	**Process:** physical, chemical, or biological description:	*This describes the process focus for the example: e.g. treated water pumping or sewage aeration.*
7	**Component:** all or part of the works:	*Examples may be a single component such as a pump, grouped components such as an aeration system, or a whole works.*
8	**Specific energy problem:** including quality or consent details:	*This is the specific issue that caused the project, whether it was a rise in prices, a focus on energy lost, or a local initiative based on metered power. If relevant please quote the raw water problem or discharge consent.*
9	**Process/Plant changes:** mechanical, electrical or controls:	*Process/Plant changes are details of any plant alterations, refurbishments or renewals which have contributed to energy savings.*
10	**Civil/Physical Changes:** to water/effluent quality, civil works, or process:	*Civil/Physical Changes implemented to achieve the energy efficiency objective in terms of water or effluent quality and a description of any civil works or process changes.*

11	**Operational Changes:** skill levels, procedures and maintenance routines:	*Operational procedures, training and priorities can affect energy efficiency so any changes should be detailed here.*
12	**Risks and Dependencies:** risk assessment of project and changes.	*Risk matrix covering project activities and the changes to the works from operational and strategic viewpoints.*
13	**Implementation:** design, build, procurement, installation and commissioning:	*If the project was changing instruments, or a software routine or building a complete new works or section, the scope should be described here with an indication of costs and programme to show the cost-effectiveness of the change and the time for planning the cycle of investment*
14	**Energy Efficiency gains:** kWh or kWh/m3 before and after implementation.	*The actual energy efficiency gains should be highlighted here preferably in kWhours. If other units are used please note them with any conversion factors and baselines.*
15	**Cost / Benefit analysis:** financial appraisal or payback time.	*Implementation costs balanced against intended benefits including energy efficiency gains; can be simply expressed as payback time.*
16	**Project review:** could it be improved or developed?	*A project review will usually uncover areas where the project implementation could have been improved, and may show further steps that can be taken to improve the works or process. These may be limited by funds, knowledge, peoples' skills or technology.*
17	**Confidence grade:** on data provided.	*The CC's view on the repeatability of the case study input and output data as reported.*

Case Study Selection Criteria

The Compendium will be a global reference document for best practice so it is important that representation is as complete as possible across the following typical subject areas:-

Scope;	to cover incremental and significant changes,
Process;	to cover all important parts of the water cycle matrix,
Geography;	to cover flat and steep catchments and various environments,
Climatic;	to cover regions with cool, temperate and tropical conditions,
Regulatory;	to cover public, private, regulated and non-regulated utilities,
Scale;	to cover large and small works in rural and urban areas,
Technology;	to cover simple low-tech and complex high-tech solutions,

It is possible that some case studies will cover more than one of the above aspects so a case study for each may not be necessary. For clarity, and to avoid repetition, it may be better to illustrate the main principles with one or two comprehensive case studies and cover variations by quoting specific parts of others or by using less detailed examples.

This project's objectives will be best delivered if all participants can provide sufficient level of detail for their examples.

Case Study Presentation

There will be a lot of information in the Compendium so it is essential to present it in an inviting and interesting way with some uniformity. The following is an example of current thinking of the final report presentation. It is likely to evolve as we gather case studies.

Each subject area will be introduced with a Fact Sheet explaining the basics of the technology to middle management or senior engineer level personnel. Further details will be referenced in the appendices for experts or project implementation managers. The Fact Sheet will be followed by a Case Study showing best practice selected according to criteria established for the Compendium. This may be reinforced by examples showing comparative projects using variations as discussed above to increase the coverage of the case study. All case studies and examples will be fully referenced in the appendices in as much detail as permitted by the available data.

Example of a Fact Sheet and Relevant Case Study

The example below is of a control change on an aeration section of an Activated Sludge Plant. It is a UK site in the Incremental Changes section of the Wastewater matrix.

Activated Sludge Plant (ASP) Aeration Fact Sheet

Aeration typically takes 65% of a Sewage Treatment Works energy demand

Description of Process

Aeration efficiency is influenced by the following factors in a typical works:-

- *Blower inlet air conditions,*
- *Blower condition, wear, seal, bearing and lubrication system maintenance,*
- *Control system accuracy, response time, instrument cleaning and calibration,*
- *Air distribution system sizing, pipes, control valves and flow measurement,*
- *Diffuser condition, type, internal cleanliness and size of bubbles,*
- *Depth of aeration tank, and diffuser floor coverage,*
- *Strength of mixed liquors, upstream treatment, homogeneity,*
- *Matching of different components in the system.*

The control system should allow for varying sewage strengths and diurnal flow variations through its variation of and response to instrument settings. It is important for energy efficiency that the parameters and set points match the effluent consent.

Potential Interventions **}** To be completed with case study data

Range of Potential Savings **}** To be completed with case study data

Case Studies (in Appendix ZZ) **}** List of related case studies

Wastewater - Aeration - Case Study Example

An Activated Sludge Plant was altered from Dissolved Oxygen to Ammonia control with a secondary priority to balance flows between three lanes by adjusting penstocks.

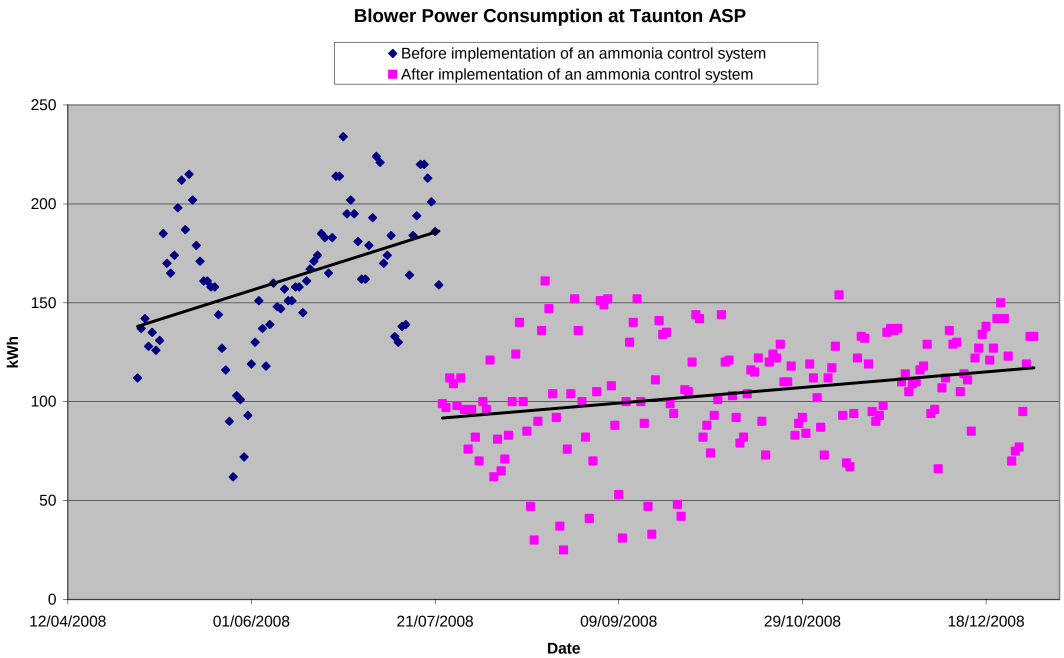
Taunton WwTW Activated Sludge Plant – Wessex Water – UK

Ref	Enquiry Item	Response information, description and remarks
1	**Location:** Country, urban or rural:	UK, rural
2	**Sector:** clean, waste or sludge:	Waste Water
3	**Works Owner or Operator:** with financial set-up, regulatory or not.	Wessex Water; EA regulated
4	**Size:** flows and loads or population equivalent:	7131kg/d BOD and 20,727m3/d
5	**Energy Provider:** with costs, incentives, taxes and conditions:	WPD, triad applicable
6	**Process:** physical, chemical, or biological description:	Biological, secondary aeration treatment
7	**Component:** all or part of the works:	Consists of 3-lane ASP
8	**Specific energy problem:**	Focus on optimising process leading to less aeration
9	**Process/Plant changes:** mechanical, electrical or controls:	Installation of ammonium control which regulates DO input according to ammonium measured in last pocket of each lane
10	**Civil/Physical Changes:** to water / effluent quality, civil works, or process:	Ensure equal flow split to each lane by re-calibrating penstocks
11	**Operational Changes:** skill levels, procedures and maintenance routines:	None particular but probes require maintenance
12	**Risks and Dependencies:** risk assessment of project and changes.	-
13	**Implementation:** design, build, procurement, installation and commissioning:	Materials cost £25k and £5k to install
14	**Energy Efficiency gains:** kWh & kWh/m3	**~ 480,000kWh PA**
15	**Cost / Benefit analysis:** financial appraisal or payback time.	-
16	**Project review:** could it be improved or developed?	Level of saving dependent on attitude to compliance risk
17	**Confidence grade:** on data provided.	Highly transportable and adaptable.

Observations:

Wessex Water have not included a cost / benefit analysis but if electricity costs £0.07/kWh, the payback period is less than one year. The motivation appears to have been energy cost saving so it was successful.

The chart below was an output from an automatic data gathering system but the lines through the plotted points are drawn by hand (by B&V). Various interpretations are possible and trended data over a longer period would give a more robust saving number.



Observations:
The above example has not been reviewed for final submission to the Compendium and there may be some questions to complete the scientific aspect of the results. For example, how much of the apparent gain is due to realigning the controls to Ammonia rather than Dissolved Oxygen and how much is due to balancing the flow between the three lanes. This is an inevitable compromise when doing practical trials on a works when actions need to be done in parallel to avoid multiple shutdowns against laboratory trials when only one parameter should be changed between each trial run.

Case Study Pro forma

A blank form is appended to this document for Case Study data collection.

Coverage of the Water Cycle Matrix

It is important that there are case studies covering all parts of the water cycle matrix where it is envisaged that there are major gains in energy efficiency to be made. A simplified matrix is therefore included below. Detailed coverage will be required in key areas such as:-

- Raw water and clean water distribution pumping,
- Membrane pumping and waste stream hydraulic recovery,
- Sewage treatment aeration,
- Sewage sludge digestion CHP.

To cover regional and other variations the Continental Coordinators are encouraged to explore areas inside and outside the green boxes in order to extend the usefulness of the Compendium. This will apply in areas such as:-

- Conservation as well as leakage reduction,
- Catchment transfer and aquifer recharge,
- Desalination: thermal and membrane technologies,
- Enhanced and tertiary treatment,
- Disinfection including ozone and Ultra-Violet treatment,
- Process optimisation including sludge disposal,
- Matching non-biogas renewable energy generation to process plant energy demand.

Please Note That:

1. The matrix may be UK centric and Continental Coordinators are encouraged to impart a regional bias through case studies in relevant areas. These variations will be included and discussed in the Compendium.

2. The data “Current Energy Usage Estimate (%)” will be converted into Pie charts in the final report. We expect to be able to produce a number of charts including

- Energy use and potential efficiency gains,
- by Company/country,
- by Region (CC)
- Global (for the Executive Summary)
- by Water Supply, Waste Water and Sludge where the data are available.

This will reinforce the observations on regional and other variations thus making the Compendium more useful to local practioners around the world.

WATER CYCLE ENERGY SAVING MATRIX				Green boxes show priority areas				
		Raw Water	Treatment	Distribution	Sewerage	Treatment	Disposal	Re-use
Current Energy Usage estimate (%)		25	10	65	25	60	15	
Demand Management	Conservation							
	Leakage Reduction							
Pumping	Optimise Gravity Flow							
	Transfer Pumps							
	Catchment Transfer							
	Aquifer Recharge							
Treatment	Screens / Preliminary							
	Sedimentation / PSTs							
	Aeration / Mixing							
	Filtration SSF / RGF							
	Intermediate / RAS Pump							
	Filtration GAC							
	Protection Membrane							
	Desal. Membrane/Therm							
	Disinfection / UV							
	Ozonation							
	Enhanced / Tert Treatmt.							
	Optimise Ops/Process							
Sludge	Sludge Thick/Dewatering							
	Sludge Digestion							
	Sludge Drying							
	Disposal to Land							
Building Services								
Generation	Mini Hydro-Turbines							
	Wind Turbines							
	Biogas / Cogeneration							
	Incineration							

The matrices that follow are included to allow estimates to be made on how much energy can be saved through efficiency measures in various parts of the water cycle. Four matrices cover clean and waste water for incremental and significant changes, and the fifth covers sludge, building services and renewable energy.

We expect that the estimates will range from verbal estimates with little evidence up to full analyses with referenced data and realistic forecasts. Both approaches are valid but the information should be annotated to describe the basis of the estimate.

Clean Water Energy Saving Matrix – Incremental Improvements				
		Raw Water	Treatment	Distribution
Current Energy Usage estimate (%)		25	10	65
Demand Management	Conservation			
	Leakage Reduction	5	5	5
Pumping	Optimise Gravity Flow	5		5
	Transfer Pumps, Ops	10		10
	Transfer Pumps, Plant			5
	Catchment Transfer			
	Aquifer Recharge	10		
Processes	Aeration			
	Mixing			
	Sedimentation			
	DAFF			
	Filtration SSF / RGF		10	
	Intermediate Pumping			
	Filtration GAC		10	
	Protection Membrane			
	Desal.Membrane/Therm		10	
	Disinfection			
	Sludge dewater/ disposal			
	Ozonation		10	
	Enhanced Treatment			
	Optimise Ops/Process			

Waste Water Energy Saving Matrix – Incremental Improvements				
		Sewerage	Treatment	Disposal
Current Energy Usage estimate (%)		25	60	15
Pumping	Optimise Gravity Flow	5		5
	Transfer Pumps, Ops	10		
	Transfer Pumps, Plant	10		
Processes	Primary / Settlement			
	Aeration, Blowers		10	
	Aeration, Others		10	
	Nutrient Removal			
	Nitrate Return Pumping			
	RAS Pumping		5	
	Tertiary Treatment			
	Intermediate Pumping		5	
	Membrane Treatment		10	
	Disinfection (UV)		10	
	Odour control			
	Optimise Ops/Process			

Clean Water Energy Saving Matrix – Significant Improvements				
		Raw Water	Treatment	Distribution
Current Energy Usage estimate (%)		25	10	65
Demand Management	Conservation			
	Leakage Reduction	10	10	10
Pumping	Optimise Gravity Flow	5		10
	Transfer Pumps, Ops	10		10
	Transfer Pumps, Plant			5
	Catchment Transfer			
	Aquifer Recharge	10		
Processes	Aeration			
	Mixing			
	Sedimentation			
	DAFF			
	Filtration SSF / RGF		10	
	Intermediate Pumping			
	Filtration GAC		10	
	Protection Membrane			
	Desal.Membrane/Therm		50	
	Disinfection			
	Sludge dewater/disposal			
	Ozonation		20	
	Enhanced Treatment			
	Optimise Ops/Process			

Waste Water Energy Saving Matrix – Significant Improvements				
		Sewerage	Treatment	Disposal
Current Energy Usage estimate (%)		25	60	15
Pumping	Optimise Gravity Flow	20		20
	Transfer Pumps, Ops	10		
	Transfer Pumps, Plant	10		
Processes	Primary / Settlement			
	Aeration, Blowers		15	
	Aeration, Others		15	
	Nutrient Removal			
	Nitrate Return Pumping			
	RAS Pumping		15	
	Tertiary Treatment			
	Intermediate Pumping		15	
	Membrane Treatment		15	
	Disinfection (UV)		20	
	Odour control			
	Optimise Ops/Process			

The matrix below combines sludge treatment with building Services and Renewable Generation opportunities. Apart from maintenance on digester and sludge thickening plant energy savings will only be achieved through significant investment.
We have not estimated current energy usage as the data is not widely available because reliability has been more important than efficiency.

Sludge, Building Services and Renewable Energy Improvements				
		Raw water /Sewage	Treatment	Distribution /Disposal
Sludge	Sludge Mixing/Pumping		10 to 80	
	Sludge Thick/Dewatering			
	Sludge Digestion		20	
	Sludge Drying			
	Disposal to Land			
Building Services				
Renewable Generation	Mini Hydro-Turbines	5		5
	Wind Turbines			
	Solar thermal / PV			
	Biogas / Cogeneration		20	
	Incineration			

Appendix – Case Study Pro forma

Title of Case Study

(Brief description of component and change, location).

Ref	Enquiry Item	Response information, description and remarks
1	**Location:** Country, urban or rural:	
2	**Sector:** clean, waste or sludge:	
3	**Works Owner or Operator:** with financial set-up, regulatory or not.	
4	**Size:** flows and loads or population equivalent:	
5	**Energy Provider:** with costs, incentives, taxes and conditions:	
6	**Process:** physical, chemical, or biological description:	
7	**Component:** all or part of the works:	
8	**Specific energy problem:** including quality or consent details:	
9	**Process/Plant changes:** mechanical, electrical or controls:	
10	**Civil/Physical Changes:** to water / effluent quality, civil works, or process:	
11	**Operational Changes:** skill levels, procedures and maintenance routines:	
12	**Risks and Dependencies:** risk assessment of project and changes.	
13	**Implementation:** design, build, procurement, installation and commissioning:	
14	**Energy Efficiency gains:** kWh & kWh/m3	
15	**Cost / Benefit analysis:** financial appraisal or payback time.	
16	**Project review:** could it be improved or developed?	
17	**Confidence grade:** on data provided.	

Observations: