Evidence

Renewable energy potential for the water industry

Report: SC070010/R5

Resource efficiency programme

Evidence Directorate

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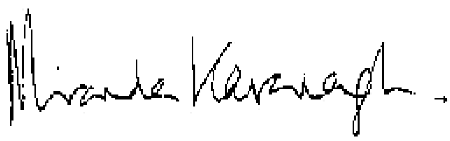

Miranda Kavanagh
Director of Evidence

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1 Executive summary

Key Messages:

1. The water industry uses up to three per cent of total energy used in the UK[42].
2. The industry is regulated to meet increasingly stringent water quality and reliability standards, but limited competition hinders innovation in energy use[3].
3. The industry provides 8.5 per cent of energy from renewable energy generation but must, in common with other sectors, contribute to the UK target of 15 per cent by 2020[10].
4. Over 90 per cent of current renewable energy generation is through sludge combustion and digestion. This is where innovation and potential lies, through better treatment and emerging technologies such as fuel cells and co-digestion.
5. Hydropower and wind power have been proven at the megawatt scale by water and waste companies, but require suitable local conditions and are not supported by Ofwat unless directly related to the appointed business.
6. By 2020 the water industry could increase renewable generation to produce a quarter of energy from renewable sources.
7. To achieve this, support must be provided by partners and government to encourage technology development and investment and remove legislative barriers.

The water industry is an energy intensive and closely regulated business that provides an essential service to the UK population. It is driven by increasingly stringent quality, reliability, economic and sustainability requirements. Competition in the industry is created through regulation by Ofwat with only limited direct retail competition.

There is an increasing requirement to ensure sustainability within the industry, which is challenging when considering the current energy intensive processes that ensure water quality and reliability standards are met.

The UK Government has targets to provide 15 per cent of total energy from renewables by 2020[10]. The advantages identified in government energy strategies are a reduction in greenhouse gases and greater security of supply as fossil fuels diminish. Major drivers are the renewable obligation order and climate change levy, along with increasingly stringent waste processing legislation that both helps and hinders energy production from waste. Currently the water industry uses around three per cent of the UK energy demand[42] and generates 8.5 per cent of that from renewable sources. A Department for Environment, Food and Rural Affairs (Defra) backed voluntary target of 20 per cent renewable energy generation[15] has been agreed with water companies through Water UK; this supports the existing regulatory structure with a definite target to aspire to.

Consultation with water companies revealed great differences in renewable energy generation between companies. Water-only companies are limited to hydro and wind power, with little success due to funding problems and planning uncertainty. Water and waste companies can demonstrate examples of wind and hydro power with an additional track record of using sludge for direct combustion and anaerobic digestion to meet disposal standards and provide heat and power.

The industry has a number of emerging technologies and innovations moving from research to prototype and full-scale applications, as summarised below:

Technology	Innovations	Large-scale examples
Anaerobic digestion	Two-stage treatment with thermal, enzymic, acid or pressure pre-treatment	Cambi plant at Ringsend sewage treatment works (STW), Blackburn STW and Barnfield STW are all full-scale sites
	Fuel cells where methane undergoes an electrochemical reaction to directly produce electricity and heat without combustion	One MW plant in Renton USA[21] and 250 kW unit in Moosburg, Germany[22] are both operational full-scale prototypes
	Biogas export is the distribution of methane-rich gas directly into a local gas network for use in place of conventional gas	Biogas export is in widespread use in Scandinavia with an example being the Varberg works in Sweden that exports two million cubic metres a year
Co-digestion	Mix of sewage with food and other organic wastes to increase output and minimise landfill	Europe and South Korea mix food wastes with sewage waste to increase gas production in shared digesters on a large scale
Sludge combustion	Use of pyrolysis and gasification advanced treatments to maximise energy and product output	Beckton STW uses conventional combustion whilst advanced techniques are being developed for other wastes as in the Compact Power unit in Avonmouth
Hydropower	Use of reverse Archimedes screw pump and other low head units to widen applications	Two 90 kW Archimedes screw turbines have been installed by Yorkshire water at their Esholt STW[43]
Wind power	Use of treatment works land to install large-scale turbines	Yorkshire Water and Anglian Water have installed MW scale turbines on a number of their sites

Innovations in the water industry

Constraints include limitations on funding for process-related sources like solar, wind and river hydropower, as well as Ofgem’s rebanding of sewage gas, regardless of technology used, as an established technology. Outside of funding issues, planning and operational difficulties can be encountered through waste legislation that prevents digestion of non-sewage waste, as well as stringent requirements for biofuels and grid access issues for energy export.

In response to these constraints the water companies, Government and regulatory bodies must combine to unite research, development and testing of innovative technologies whilst engaging in discussions to develop a flexible approach to legislation, funding mechanisms and planning processes. The Environment Agency can provide opinion and guidance on many issues, particularly river hydro schemes, but also on waste and environmental legislation and the environmental value of renewable generation.

Through best practice and collaboration on technology development, water company targets of 20 per cent energy generated from renewables could be exceeded and aspirational targets of 50 per cent on specific wastewater sites could become practical by 2020. Many water and waste companies predict exceeding 20 per cent generation as early as 2010; this will be achieved through wider use of emerging technology and shows good potential for use on a wider scale without further technological development.

2 Introduction

As global concerns on climate change increase and security of fossil fuel supplies decrease, our commitment to renewable energy generation becomes more focussed. Issues on sustainable energy supply affect all parts of society and every opportunity to contribute must be identified.

The water industry uses up to three per cent of the UK's total energy[42] and, like other energy intensive industries, has an opportunity to exploit renewable energy for sustainability and commercial benefits.

This report was commissioned by the Environment Agency to generate recommendations on how renewable energy generation can be increased in the UK's water industry.

The aims of the study were to:

- Define the current situation in the industry through a literature review and discussions with water companies.
- Conduct a review of the renewable energy market to identify and discuss political and technical issues relevant to this study.
- Carry out a Strength Weakness Opportunity Threat (SWOT) analysis for applicable renewable energy technologies in the context of the current and expected water industry regulatory framework.
- Describe the main constraints on and drivers for greater renewable energy generation.
- Develop recommendations to boost renewable energy generation.

3 Methodology

Consideration of how the water industry relates to the renewable energy industry is a complex task. The study was split into three distinct areas, each requiring different methods as outlined and discussed below.

Current situation

A renewable energy questionnaire was sent to all regulated water companies in England and Wales. Full details of this consultation and responses are covered in Section 5. In addition, literature review and industry knowledge was used to inform wider considerations in this study.

Policies and technologies

A review of recent government guidance, strategies and consultations make up the majority of the policy review and technology developments. Specific technology details use market knowledge and a targeted review of evidence to indicate current and future characteristics. Responses from the water company consultation were used to steer the focus of research.

Each identified technology category is presented in a data sheet, with additional sheets for extraction techniques where required, and provides the following information:

- **Overview** – A brief description of the technology and its use in the water industry.
- **Relevant activity** – Describes the current level of use in the industry as well as research and policy activity.
- **Innovations** – Gives details of any identified improvements to current methods that represent best practice or demonstration projects.
- **SWOT analysis** – Covers the strengths, weaknesses, opportunities and threats to renewable technology relevant to potential growth in the industry.

Potential for growth in renewable energy generation

The potential for growth depends on many factors, each subject to change, such as:

- Levels and forms of financial support for renewable energy production.
- Development of technologies to boost performance and reduce costs.
- Political and social support of renewable energy that affects the feasibility of renewable energy projects.
- Regulatory barriers and support for renewable energy.

There will also be local barriers to implementation of technologies such as:

- Geographic and topographic features that will affect wind and hydropower availability.
- Land availability for area intensive sludge processing.
- Onerous planning permission due to local features such as sites of special scientific interest or high population densities.

Taking this into account along with the responses received in Section 5, an estimate of energy production potential in 2020 was made.

4 Background

The water industry is a well-established and carefully regulated business with unique considerations. This section provides a concise background to issues in the industry that may affect renewable energy uptake.

Regulatory framework

An illustration of the regulatory framework's structure with key bodies is given below. The primary purpose here is to indicate the scope of responsibility of various bodies.

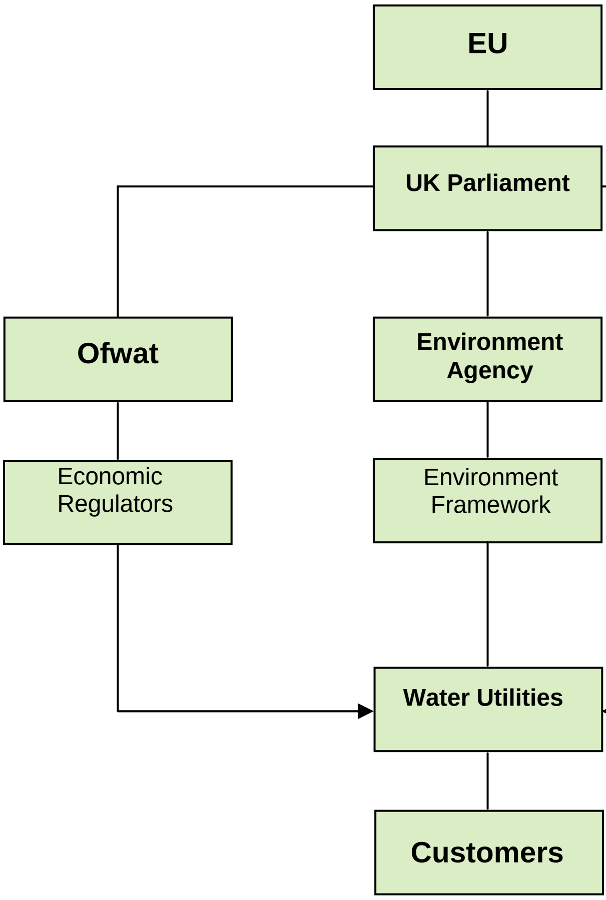


Figure 4.1 – Water industry regulatory structure.

The structure is a complex and rigid system to ensure water quality, environmental protection, reliability, value for money and customer service standards are met. In addition, there is an increasing requirement to ensure sustainability within the industry, which provides challenges to the energy intensive processes that ensure water quality and reliability standards are met.

Within the regulatory system, renewable energy targets are subsidiary to the main focus of reliable delivery of high quality water to customers and watercourses. However, Ofwat is taking steps to include renewable energy generation in its business. Generation levels are required to be reported from the PR09 period forward[27]. Ofwat has also made clear its thoughts on funding mechanisms for renewable generation in

PR09 guidance[28], which states that funding will only be made available for activities directly linked to the regulated business.

UK energy targets

The most relevant documents on renewable energy are the UK Government's Energy White Paper 2007[9] and the Renewable Energy Strategy[10] set for publishing in 2009. Both of these documents stress the importance of renewable energy in meeting our biggest energy challenges of:

- tackling climate change by reducing emissions here and abroad;
- ensuring our energy supply remains secure.

The UK has committed to two separate but related targets: a reduction in carbon dioxide emissions by 80 per cent compared to 1990 levels under the Climate Change Act 2008[20] and the production of 15 per cent of our total energy from renewable sources by 2020 as our contribution to the EU Renewable Energy Target[10].

Renewable energy policy review

This section provides a brief overview of existing and proposed support mechanisms.

Existing

Renewable Obligation Order is the primary funding source for renewable energy in the UK. Renewable obligation certificates (ROCs) are awarded for each MWh of eligible electricity produced. The order requires all electricity suppliers to provide a percentage of their electricity from renewable sources. This percentage is incremental to encourage continued growth. Where the supplier does not generate sufficient renewable energy, a 'buy out' payment is made; it is this fund of money that is made available for the purchase of ROCs. The income generated is in addition to any value for the sale of electricity.

Climate Change Levy is an additional charge placed on fossil fuel-sourced electricity that can be avoided through the use of renewable energy. Avoidance of this levy provides financial support for the production of renewable energy.

Future

Renewable Heat Incentive will be introduced under powers in the Energy Act 2008[8]. The exact details of the scheme will be consulted upon in 2009 and likely be finalised in 2010; however, it is assumed that a financial value will be placed on all scales of measurable heat from renewable sources[18]. The scheme is also likely to include direct bio-methane injection as an eligible source.

Carbon Reduction Commitment is a climate change and energy-saving scheme that allows organisations to save money in line with the amount of carbon emissions they reduce. It is an emission-trading scheme that will be compulsory subject to qualifying criteria based on annual energy usage[12]. The scheme will begin in April 2010.

Competition

The recent review of competition in the water industry by Professor Martin Cave[3] provides an overview of the current and likely future situation, with additional views expressed by the Department for Environment, Food and Rural Affairs (Defra)[14] and the Council for Science and Technology[6]. Currently, competition is provided solely by the regulatory system and funding structure and there is only a limited direct competitive market. Only commercial customers likely to use over 50 megalitres of water a year in England and 250 megalitres in Wales are able to choose their supply in accordance with the Water Supply License regime, aside from unserved developments or those customers that can secure and inset license.

The Cave review consultation concluded there is a case to open up the market to commercial consumers regardless of consumption, but with minimal benefit to freeing the household market.
In terms of boosting renewable energy, there are two areas of interest within competition, namely:-

- **Innovation** – Where companies can gain competitive advantages in resource efficiency, cost and environmental performance by introducing renewable energy technologies.

- **Social perception** – In cases where there is little differentiation between costs or service customers, particularly commercial, are likely to select water providers with better 'green' credentials.

The Cave review and others conclude that in the regulatory competitive environment, where Ofwat judges and scores the relative performances of water companies, there is a tendency to aspire to achieve parity. This system has no incentive to exceed the performance of competitors by any great margin.

Research and development expenditure in the UK water industry is just 0.29 per cent[3]; 40 per cent behind the combined utilities sector and far below the UK average of 1.7 per cent[11].

A voluntary renewable energy target for the water industry has been announced and endorsed by Defra[15]. This represents measurable regulation and limited competition for the deployment in renewable generation within the industry.

5 Current situation

Scope of consultation

As part of this study, a consultation questionnaire was circulated to all regulated water companies that covered aspects of their business relevant to renewable energy. All questions referenced performance in the 2007/2008 operational year. The questionnaire was split into five sections, as described below:

A. **General information** – Covering energy use and serviced population of the company.

B. **Current renewable energy production** – Current energy production along with technologies used and details of any innovative or best practice examples

C. **Renewable energy targets** – Queried whether internal targets had been set and whether there was an accompanying strategy to plan, implement and monitor actions to achieve the target. Details of how existing capacity is managed to maximise output was also requested.

D. **Constraints** – Companies were invited to identify barriers to greater renewable energy production as well as actions by all parties that could help to mitigate them.

E. **Additional information** – This section was an open invite to add comments or supporting information relevant to the consultation but not explicitly requested.

Limitations

As with all consultations, there are limits to what can reasonably be asked and many factors that affect the respondents' ability to adequately answer questions. The main identifiable issues that should be taken into account when reviewing the results are:

- Questionnaires were issued during the PR09 response period, a time when the water companies' resources were engaged in statutory activities.
- The questionnaire focussed solely on the 2007/2008 operational period and as such did not enable a review of trends in an individual company's progress.
- Water-only and water and waste companies have inherently different characteristics and resources, most notably the availability of sludge as a renewable energy source in wastewater operations. This limits the ability for useful comparisons between the groups.

Responses

In this section, key points from the 14 responses received are summarised and presented under the questionnaire headings described above. Full details of the companies consulted and those who returned a response are shown in Appendix A.

A. General information

This section lists the required energy consumption and population equivalent served by each water company; this data is used in combination with figures under section B to make comparisons between companies' performance.

Combining Water UK Sustainability Indicator data[41] and the overall breakdown by technology collected under section B of the questionnaire shows that the UK water industry has the following energy breakdown:

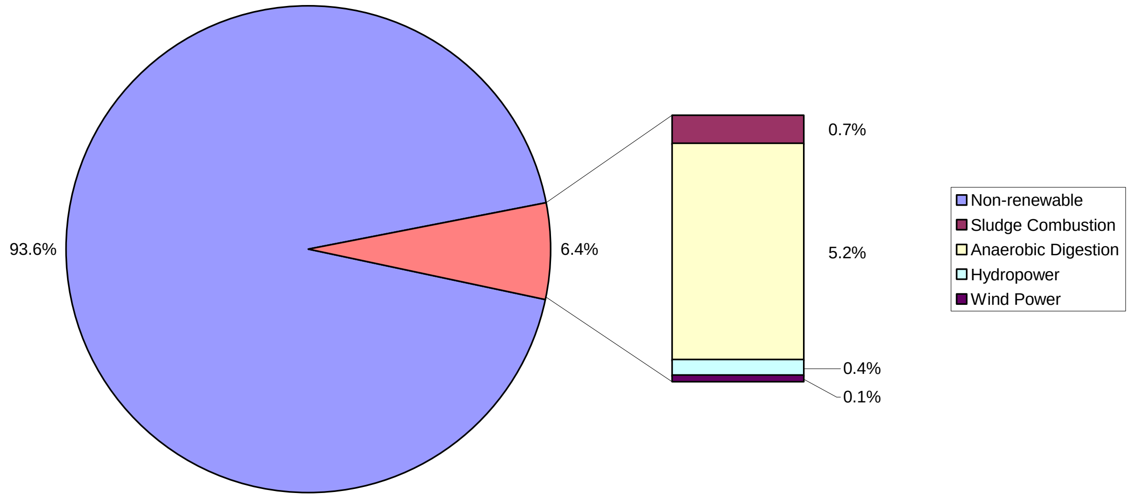


Figure 5.1 – Industry-wide energy use.

B. Current renewable energy production

Questionnaire responses gave indications of renewable energy production in 2007/2008, which is given in Figure 5.2 below*. This graph indicates the predominance of sludge-based technologies in the energy mix and also the variance in scale of deployment in hydro and wind power.

* Where responses have yet to be received from water companies, data on claimed renewable obligation certificates[28] was used to define renewable energy generation by technology. Population equivalent data was taken from the company's strategic direction statement or website.

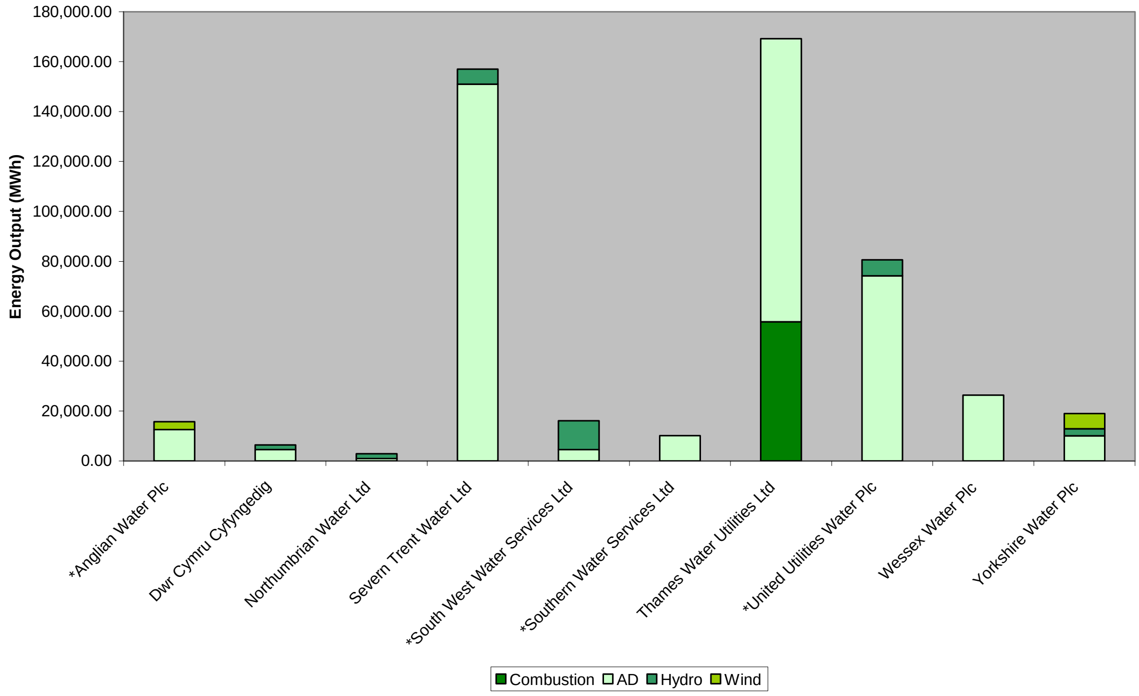


Figure 5.2 – Renewable energy output by water company.

Most notable in the graph is the omission of the water-only companies. The responses received gave no evidence of renewable generation deployment. Despite water-only companies' difficulties in producing renewable energy, many water and waste companies have found solutions that are not dependent on sludge as a fuel.

Figure 5.3 further reviews the renewable deployment by indicating generated energy per population equivalent served. This allows a fairer comparison of how well each company uses its resources.

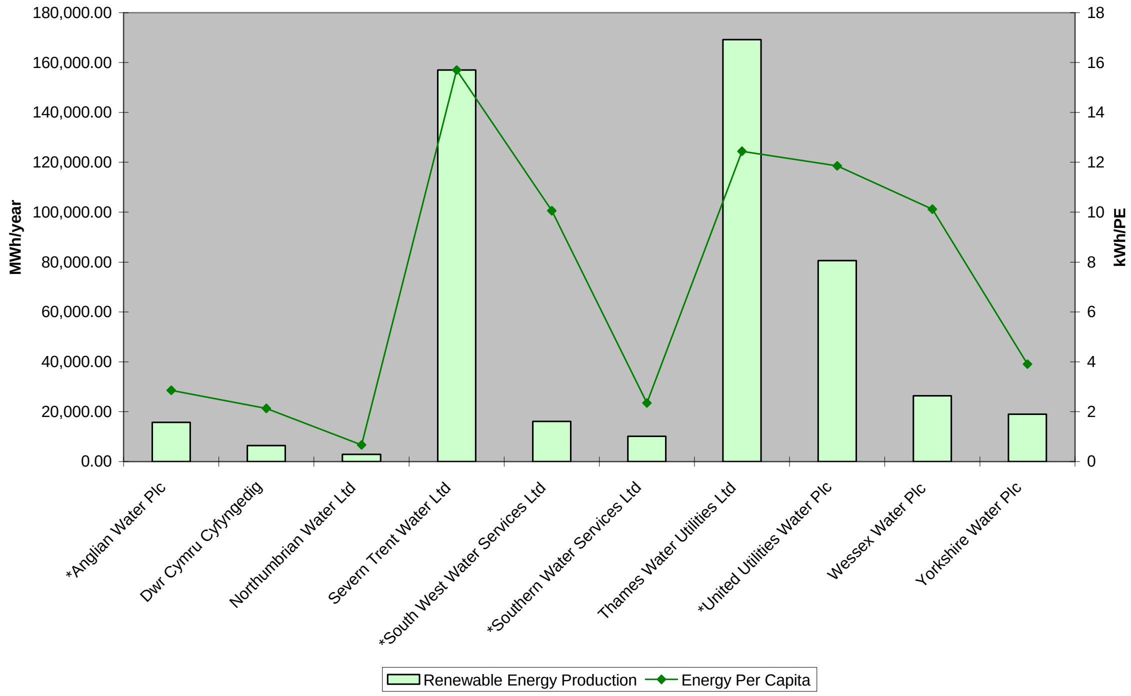


Figure 5.3 – Renewable energy output total and per pe served.

Additional observations

- **Export of energy** – Responses indicated that the majority of energy produced on site is subsequently used in the process rather than being exported to the grid.

- **Best practices** – These included the use of advanced anaerobic digestion equipment, specialist contractors to manage wind turbine performance, training for energy staff and detailed monitoring of energy production systems through SCADA and telemetry systems.

- **Novel technologies** – These include the use of thermal, pressure, enzyme- and acid- based advanced anaerobic digestion processes, as well as hydropower and wind power, to directly power processes. Comments indicated a lack of incentive to employ advanced technologies due to the need for short payback and lack of support from regulatory bodies.

- **Research and development** – A number of hydropower and wind power feasibility and monitoring studies have been carried out. Other activities revolve around investigation and prototyping of advanced sludge processing systems. In most cases there are plans to follow through on studies subject to favourable results and certainty of funding sources.

C. Renewable energy targets

In all cases, there are plans to increase renewable energy use through on-site generation or through procurement in many of the water-only company cases.

A general aspiration is to achieve 20 per cent of energy use from renewable sources by 2020 in line with the Water UK and Defra-endorsed voluntary target[15], but a few companies have specific targets, as shown in Figure 5.4 below.

Company	Quoted target	Predicted achievement
Bournemouth & West Hampshire Water Plc	20% by 2020	By procurement
Northumbrian Water Ltd	20% by 2020	20% by 2014
Severn Trent Water Ltd	20% by 2020	30% by 2013
South Staffordshire Water Plc	20% by 2020	18% by 2010
Sutton & East Surrey Water Plc	20% by 2020	By procurement
Thames Water Utilities Ltd	20% by 2020	18% by 2010
Wessex Water Plc	20% by 2020	50% by 2020
Yorkshire Water Plc	20% by 2020	10% by 2010

Figure 5.4 – Categories of energy use.

This increase is expected to come from advanced sludge processing on a wider scale and use of wind and hydropower where site conditions and funding permit. Water-only companies expect to procure a larger portion of renewable energy, despite carrying out studies and showing intent to make use of hydro and wind power where a financial case can be made.

D. Constraints

Constraints were common for most respondents and covered the following issues:

- **Ofwat funding –** A major hurdle for water companies is the position of Ofwat on technologies that qualify as part of the appointed business. Under this system only sludge-derived or hydro-derived energy can be included in bill pricing for funding by customers.

- **ROC banding –** The recent arbitrary banding of anaerobic digestion and sewage gas as being valid for 2 ROCs and 0.5 ROCs per MWh respectively seems to differentiate funding levels between identical technologies[24].

- **Waste regulations –** Regulations on disposal of sludge, incineration of non-sludge waste, introduction of animal waste and environmental pollution from combustion together present complex issues.

- **Grid access –** Complications and costs are incurred in upgrading grid supply equipment.

- **Carbon accounting –** Defra guidelines currently state that where ROCs are claimed for renewable generation, no claim should be made for reductions in carbon accounting.

- **Planning permission –** The complicated nature of renewable energy installations may be unfamiliar to water companies and as such increases investment risk.

- **Commercial risk –** Again, the relative uncertainty of renewable energy generation creates an inflated risk that is subsequently passed to shareholders and business decisions.

The following were suggested as mitigating actions:

- **Ofwat funding –** Ofwat could take a more flexible approach to funding renewable energy generation, including wind, and support its desire to improve sustainability with regulatory incentives and restrictions.

- **ROC banding –** Government should review recent banding in the light of required investment in sewage digestion, which is similar to higher banded non-sewage digestion.

- **Technology development –** The industry is open to collaboration, particularly on anaerobic digestion and Defra's task group is considered a positive step to uniting development.

- **Waste regulations –** Waste regulations are an intrinsic part of the water industry, but conditions are seen as overly onerous. Greater flexibility in regulations is necessary to unlock potential and this can be justified by the positive environmental impacts of renewable energy. There is also potential to make use of spare processing capacity for co-digestion schemes that would offer both environmental and cost benefits.

- **Carbon accounting –** The requirements of renewable energy production and carbon reduction are heavily linked but policy is often in opposition on these matters. A more holistic approach would provide greater clarity and reduced risk on investment decisions.

- **Planning permissions –** Planning authorities must build on recent moves to help deploy small-scale renewables and account for the environmental benefits of renewables by simplifying the process where possible.

- **Environment Agency support –** The Environment Agency is well placed to mediate many waste and environmental issues and guide discussions to a fair conclusion. The industry would like the Environment Agency's clear opinions on co-digestion, waste regulation and the benefits of renewable energy production. Partnerships in the development of river hydropower schemes have been requested.

E. Additional information

The water companies' PR09 submissions and strategic position statements were made available in many cases.

6 Technology review

Overview

The energy potential for any industry is fundamentally influenced by the availability of resources. Selection of the best technology ensures that this resource is exploited to the greatest benefit of the user. There is no reason to consider wind power where there is no wind and no reason for a 2MW turbine where the user is a single residence with no grid supply.

There are multiple examples of advanced technologies, sludge-fuelled and others, in operation and achieving marked operational efficiency. The premium for these technologies will fall as uptake increases, but the long-term advantages are clear. For now, these technologies are the minority but companies have plans to apply technologies on a larger scale across the UK.

Water industry energy use

The technological challenge for the industry lies not just in producing as much energy as possible but in making the best use of the energy available. A major issue in the energy future of the UK is creating a more dynamic and 'smart' link between demand and supply. A key portion of this process is in understanding how energy is used. Once this is understood, the best form of supply or combination of systems can be chosen to provide the required level of supply security.

The table below indicates categories of energy use within the water industry by plant or process:

Category	Process description	Examples
Continuous	Runs nearly 24 hours per day to meet the required demand.	Telemetry, programmable logic circuits (PLC), some mixers and base load aeration.
Process critical intermittent	Is called to run by process conditions (start and stop sensors) and failure to run is detrimental to the system within a short time.	Flow to treatment or storm pumps and aeration blowers.
Intermittent with storage	Is called to run by process conditions (start and stop sensors) but there is inherent storage in the system that makes a time lag between trigger conditions and reaction acceptable.	Drainage/liquor return pumps, inlet screens and sludge pumping.
Batch	Runs for a set number of operations within a longer total cycle.	Mixing, sludge dewatering and timed unblocking cycles of pumps.
Non-critical	Not related to process or health and safety requirements. Could be described as an optional extra.	Additional welfare provisions beyond legal requirements such as site wide lighting rather than task directed.

Figure 6.1 – Categories of energy use.

Moving next to the nature of renewable energy generation; technologies can be divided into deployable, predictable and unpredictable as follows:

Category	Description	Examples
Controllable	These technologies can be automatically adjusted within reasonable limits to match supply and demand.	All biogas and combustion-based technologies where the gas or other fuel is stored and increasing the feed rate can allow reaction to demand within reasonable limits.
Predictable	There will be long-term trends for these technologies that allow a minimum output to be confidently predicted.	Hydro and solar which exhibit daily, monthly and annual trends that can be predicted to give an expected minimum output to a known confidence level.
Unpredictable	The output from these technologies will vary dramatically over a short time period.	Wind, where output can vary from zero to maximum within a few minutes due to excessively low or high wind speeds.

Figure 6.2 – Categories of renewable energy generation.

Combining these demand and supply analyses into one table, it is possible to match renewable energy production to demand on site, assuming suitable sizing. Using a simple traffic light system:

Green can be taken as a reliable and secure option.

Yellow will meet demands with a high level of reliability, provided it is suitably sized and the resource is well known.

Red will meet and exceed predicted output the majority of the time, but will also regularly fall below nominal output without warning and requires full standby capacity.

Category	Deployable	Predictable	Unpredictable
Continuous			
Process critical intermittent			
Intermittent with storage			
Batch			
Non-critical			

Figure 6.3 – Supply and demand matching.

Figure 6.3 thus indicates the ability to maximise on-site use where this is financially attractive. Where conventional power supplies are available, there are two ways to view their relationship with renewable energy:

- The conventional power supply can be used to backup an unpredictable supply.
- The availability of renewable energy to meet site demands could partly negate the need for upgrades to site power supplies or standby generation.

The table below lists the technology categories identified in the water utility consultation and a general renewable energy review feasible for the industry. It defines variants of that technology in terms of extraction methods and the resource required to apply that technology. The table shows why waste and water companies are at an advantage over water-only companies, given the additional 'fuel' available to them. The table also shows that regions or sites with high wind speeds or large rivers nearby are advantaged in their capacity to produce power from renewable sources.

Technology	**Energy**	**Resource**			
Categories	**Extraction**	**Influent**	**Sludge**	**Effluent**	**Land**
Anaerobic Digestion	Gas combustion				
	Fuel cells				
	Gas export				
Sludge Combustion	Conventional				
	Gasification				
	Pyrolysis				
Hydropower	Dam hydro				
	Low head				
	Run of river				
Wind Power	Free standing				
	Building integrated				
Solar Power	Photovoltaic				
	Thermal				

Figure 6.4 – Renewable technologies and resources.

Each identified technology category is presented in a data sheet with additional sheets for extraction techniques where required on the following pages.

Anaerobic Digestion

Overview

Anaerobic digestion (AD) is a biological process that generates biogas naturally when methanogenic bacteria break down organic matter in environments with little or no oxygen. This gas can then be burned to generate both heat and electricity.

'Conventional' AD is an established technology in wastewater treatment that is widely used to stabilise sludge and generate power. It makes up an overwhelming majority of current renewable energy production in the water industry.

Anaerobic Digestion at Reading STW

Relevant Activity

Current Application	Primary contributor in waste side of business with over 65MW[35] installed capacity receiving ROCs in 2007.
Research	Wide range of activity in industry and academia[7].
Policy	Defra 2009 *Anaerobic Digestion – Shared Goals* document[14] and ongoing funding support through schemes such as the Waste & Resource Action Programme WRAP and Environmental Transformation Fund (ETF).

Innovations

The focus for AD development is in boosting gas quality, volume and pathogen destruction efficiency and reducing residual digestate. Much benefit can be gained from greater process control through better maintenance and monitoring. The primary method is multistage treatment of sludge prior to gas production which enables optimisation of each distinct digestion reaction, examples include:

- Thermal hydrolysis processing - Cambi plant, Teeside[2]
- Enzymic hydrolysis processing - Blackburn STW
- Acid gas hydrolysis processing - Barnfield STW
- Pressure-related pre-treatment - Cellruptor process

Strengths	Weaknesses
• Proven underlying technology • Additional benefits of sludge conditioning and volume reduction • Fuel source indigenous to business activity leading to logistic and regulatory advantages • Predictable and controllable energy supply • Opportunity to use waste heat	• Performance dependent on sludge characteristics • Electrical efficiency of about 39% that reduces during part-load operation • Emissions can be corrosive and include undesirable gases such as sulphur dioxide • Large area footprint compared to other gas combustion technology
Opportunities	**Threats**
• Ability to retrofit better process controls and additional pre-treatment stages to plant • High level of ongoing research that has resulted in successful demonstrations	• Recent re-banding of ROC eligibility to value sewage gas combustion at 0.5 per MWh compared to non-sewage AD at 2 per MWh

globally • Variety of funding sources available to assist further development and implementation • Likely drop in costs as technologies mature • Additional savings in digestate post-treatment	• Carbon accounting requirements prevents claiming carbon credit if ROCs are sold • Fuel cell technology may overtake AD • Alternatives to digestion exist that are simpler and cheaper to implement and operate

Co-digestion

Overview

Co-digestion is the anaerobic digestion of more than one waste stream. The process is identical to conventional anaerobic digestion and the biogas produced can be burned to generate heat and electricity.

The sludge stream of the water industry could be mixed with any biological waste from domestic or industrial sources. The co-fuel could include food waste, paper or any other high liquid content waste mix. The major limiting factor is legislative restrictions on mixed waste systems.

Holsworthy Biogas Plant, Devon

Relevant Activity

Current Application	None identified in UK water industry, extensive use abroad.
Research	Wide range of activity in industry and academia.
Policy	Defra 2009 *Anaerobic Digestion – Shared Goals*[14] document stated the need to investigate best use of co-digestion in the water industry.

Innovations

Co-digestion is a system that has been used extensively for over 20 years in countries such as Germany[16] and Scandinavia. Innovations in pre-treatment and monitoring that apply to anaerobic digestion are equally valid here. Where much knowledge has been gained is the effects of varying waste streams on gas output characteristics.

Co-digestion has been used in the UK since the first plant was installed in 1998 at Holsworthy[19], Devon to treat a mix of animal manure and food waste; the unit has a 2.7 MW capacity. A key example of co-digestion in the wastewater industry is the recently upgraded Youngyun WWTW in Ulsan, South Korea[32].

The greatest opportunity for innovation is in new policy to simplify the process of planning, consenting and operating a co-digestion site. Collaboration will then be required with the wider waste industry.

Strengths	Weaknesses
• Proven underlying technology • Benefits of waste volume reduction • Greater output compared to conventional AD • Greater calorific value of other waste streams • Predictable and controllable energy supply • Opportunity to use waste heat	• Performance and emission content entirely dependent on waste make-up • Need for uniform loading rate of digester and logistics of supplying suitable waste stream • Large area footprint compared to other gas combustion technology
Opportunities	**Threats**
• Opportunities for greater economies of scale in the industry • Commercial advantage in linking with other	• Recent re-banding of ROC eligibility to value sewage gas combustion at 0.25 per MWh compared to non-sewage

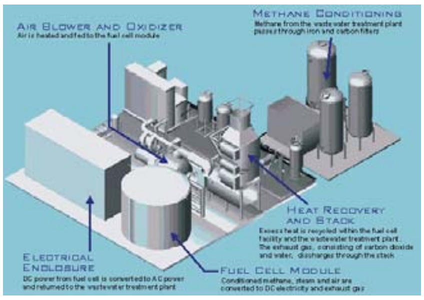
waste-processing organisations • Linking in with landfill reduction requirements and incentives	AD at 2 per MWh • Complication of ABP legislation • Increased permitting requirements under Environmental Permitting Regulations • Need for waste management license • Development of AD processing in waste sector

Anaerobic Digestion with Fuel cells

Overview

Fuel cells can use any gas high in hydrogen, which includes methane, to operate a DC generating system. The simple application for the water industry is to feed biogas from an AD process into a fuel cell. The cell is able to run as a combined heat and power (CHP) system to provide heat and electricity.

This concept is being tested at several sites in the USA and Europe. It is hoped that the fuel cell system will boost efficiency and reduce emissions over standard combustion techniques.



Renton Fuel Cell System

Relevant Activity

Current Application	Only prototype applications but up to 1 MW in capacity
Research	1997 Study by CH2M Hill for King's County[4]
Policy	

Innovations

Fuel cells are devices that use hydrogen (or hydrogen-rich fuel such as methane) to create electricity by an electrochemical process. A single fuel cell consists of an electrolyte sandwiched between two thin electrodes (a porous anode and cathode).

The potential for fuel cells as highly efficient heat and power generators is widely known. The major difficulty is in the cost-effective production of a hydrogen-rich fuel. The water industry is fortunate to produce methane on a large and economical scale. Several prototype plant are in existence, including:

- 1MW Molten Carbonate Fuel Cell (MCFC) in Renton, USA[21]
- 170kW Phosphoric Acid Fuel Cell at Columbia Boulevard STW[37&29]
- 250kW HotModule Fuel Cell in Moosburg, Germany[22]

Strengths	Weaknesses
• Potential for greater overall efficiency of energy conversion compared with standard methods • Sludge conditioning and waste reduction benefits of AD • Near zero pollution levels • Predictable and controllable energy supply • Opportunity to use waste heat	• Untested fuel cell technology compared to standard combustion cycles • Need for biogas cleaning prior to fuel cell injection to protect electrodes • Production of DC electricity needs extra electrical equipment for AC conversion • Higher costs on new technology
Opportunities	**Threats**
• Displacement of conventional combustion through increased efficiency and cleanliness • Accelerated long-term technology due to high level of research into fuel cell technology in multiple sectors • Import of hydrogen-based fuels should wider	• Recent re-banding of ROC eligibility to value sewage gas combustion at 0.25 per MWh compared to non-sewage AD at 2 per MWh • Need for long-term testing to prove reliability and operational costs

network be set up	• Potentially longer payback periods initially

Anaerobic Digestion Gas Export

Overview

Anaerobic digestion produces methane, which is a valuable gas fuel. There are a variety of uses for this fuel source other than combustion on site. The biogas is processed to synthetic gas by a variety of technologies to ensure quality standards are met for transmission and integration.

Germany, Sweden, Switzerland and the Netherlands have all practised the injection of processed biogas into local gas networks.

Varberg WWTW, Sweden

Relevant Activity

Current Application	None in UK, extensive in EU
Research	Biogas and Others in Natural Gas Operations (BONGO)[1]
Policy	Renewable Heat Initiative (Potential)

Innovations

Higher quality synthetic gas is made possible through advanced AD processes to increase gas output and purity. There is a requirement for further cleaning and separation to mimic natural gas properties. The identification of possible incentives for gas export under the Renewable Heat Initiative is a major step towards realising gas export.

Gas to date has only been injected into local gas networks at low pressures and has been successful. Injection into the main grid would incur complications of higher pressures and hence increased risk but may become feasible over time.

A number of facilities have been in long-term operation, these include the recently upgraded Varberg wastewater treatment works in Sweden[31]. There is also the option of conversion to vehicle fuel.

Strengths	Weaknesses
• Technology proven in EU • Sludge conditioning and waste reduction benefits of AD are retained • No combustion on site and so no emissions at source • Predictable and controllable supply of gas • Simple and efficient way of transporting fuel to population centres where site is rural	• Requirement for upgrade of gas quality to meet grid quality standards • Loss of significant portion of heat capture for use on site • Additional monitoring and safety mechanisms required • UK not familiar with technology or operational requirements
Opportunities	**Threats**
• Direct replacement of natural gas supplies to meet heat requirements • Accelerated learning from EU • Additional funding from potential renewable heat initiative • Use established gas network for distribution	• Recent re-banding of ROC eligibility to value sewage gas combustion at 0.25 per MWh compared to non-sewage AD at 2 per MWh • Need for testing to prove reliability and operational issues • Spread of distributed heat networks would reduce heating requirement

Sludge Combustion

Overview

Basic combustion of dewatered sludge is a mature technology with an established water industry history, although advanced processing such as pyrolysis and gasification are emerging technologies.

Beckton STW

In conventional technology the sludge is fed into a fluidised bed incinerator and incinerated at a temperature of about 850°C. Energy is recovered through a number of heat exchangers used to dissipate heat from the incineration to other heat-requiring steps in the process. Thames Water is the primary user of this type of combustion technique.

Relevant Activity

Current Application	Conventional technology established with advanced methods at prototype level
Research	Variety of advanced combustion techniques such as Compact Power[5] and Energos[17]
Policy	Higher renewable obligation certificate banding of advanced combustion technologies

Innovations

There are a number of reasons to further investigate advanced combustion techniques for sludge products. These could be combined with anaerobic digestion or carried out separately after dewatering. Both gasification and pyrolysis techniques are combustion under controlled conditions to enable a range of reactions to occur. Along with the capacity to produce electricity and heat, there is also the ability to form oils, gases and char materials. The exact mix of end products can be controlled to meet a range of demands that include gas and oil as bio-fuel.

Several pilot schemes at sewage treatment plants have suffered problems, including a gasification scheme at Anglian Water's plant in Wellingborough and a pyrolysis scheme at the Water Corporation's plant in Perth, Australia[23]. However, in parallel to water industry development a number of advanced combustion schemes are developing in other waste areas such as the Compact Power[5] unit in Avonmouth and the Energos[17] system of the Isle of Man.

Strengths	Weaknesses
• Conventional combustion is a mature technology • Significant waste reduction possible • Inert end products • Predictable and controllable energy supply • Opportunity to use waste heat	• Potentially hazardous emissions • Requirement for energy intensive pre-treatment process to produce dry fuel • Requires high fuel loading rates to enable continuous combustion which is limited by logistics of fuel supply

Opportunities	Threats
• Advanced techniques can produce a range of valuable products	• Continued concerns over hazardous byproducts due to large number of

• Possible combination with AD to create 100% inert final waste • Accelerated development through increasing ROC support and general waste processing research	simultaneous reactions • Where co-firing is required the increasing fossil fuel costs will affect long-term viability • Fuel cell use may become predominant due to low emission status

Hydropower

Overview

Conventional hydro-electric schemes rely on water which drops from one level to another. This drop is created naturally or artificially (via a dam or weir). Water is then diverted through a dedicated channel to the turbine to generate electricity.

The water industry theoretically has the opportunity to generate electricity from process flow streams, river flows adjacent to owned land and at dams. Works invariably neighbour a watercourse or river that could be harnessed using shared infrastructure.

Esholt 180kWArchimedes Screw Hydro

Relevant Activity

Current Application	Over 9MW of installed capacity in UK
Research	Low head turbines becoming viable and potential determined[30]
Policy	-

Innovations

Hydropower is considered a mature energy source and can be up to 90% efficient on larger schemes. The challenge for the water industry is to use cutting edge technology to harness small amounts of flow and head that may be available in the process. A further issue is overcoming reliability and capacity limits on the waste side where the water has solid contents.

The development of Archimedes screw hydro turbines overcomes low head and blockage concerns. An 180kW example is currently undergoing commissioning at Esholt by Yorkshire Water[33].

There is an opportunity for the industry to use land adjacent to rivers to develop run of river schemes, or act as landowner to enable third party development.

Strengths	Weaknesses
• Proven technology • Reliable and robust • Reasonably predictable and consistent energy delivery • Identified as relevant to core business activity and so qualifies for billed funding • Available for use on water or waste treatment sites	• Highly dependent on geographical conditions, which gives an advantage to some companies • Likelihood of blockage affecting process security • There is a need for bypass facilities in the case of failure, which adds cost to schemes and where available room for installation is small, can be preclusive
Opportunities	**Threats**
• Development of low head and non-blocking turbines opens up new opportunities for exploitation • As major landowners that are required to be adjacent to a watercourse for discharge, there is opportunity to install river hydropower, whether through third party or individually	• Process security and reluctance of designs and operations to accept additional points of blockage and failure • Potential for network flooding or consent failure if in process hydro fails • Development of hydro on adjacent rivers by other users that will preclude development • Abstraction licence requirement

Wind

Overview

Wind is set to make up the most significant proportion of the 2020 renewable energy mix. It is a well developed technology backed up by better knowledge of wind resource availability and predictability.

The water industry has taken advantage of wind resource at a number of locations but recent guidance by Ofwat has ruled that it is not part of the industry's prescribed business. As such, no direct funding will be made through billing.

Typical 2MW and 15kW Turbines

Relevant Activity

Current Application	Over 5MW installed, with 6MW given planning approval
Research	Established and proven technology
Policy	

Innovations

There is very little innovation accessible to the water industry for wind power. It would be advisable to consider leasing of land to enable third party development.

There is also scope for more careful consideration of smaller scale or vertical axis turbines as these technologies mature and become more efficient and reliable.

The following examples exist:-

- One 1.3MW turbine at Hull WWTW[43]
- Two 1.3MW turbines at Loftsome Bridge WWTW[43]
- 1.2MW installed capacity at Mablethorpe STW

Strengths	Weaknesses
• Proven technology • Reliable and robust • Non-polluting technology • Low area footprint once installed • Available for use on water or waste treatment sites	• Complicated planning procedure • High potential for complaints from nearby residents • Availability of wind resource is dependent on geography • Not considered part of regulated business

Opportunities	Threats
• As knowledge of resource availability increases this will help maximise energy use • Use of active demand management to account for wind variability • As major landowners there is opportunity to install wind turbines whether through third party or individually	• Lack of Ofwat funding support • Public opposition to development • Less desirable for grid export

Solar

Overview

Solar power is directly available as heat or electricity using solar thermal or photovoltaic units respectively.

Photovoltaics (PV) generate electricity when exposed to the sun's radiation (insolation). A photovoltaic panel consists of a number of individual cells, daisy-chained together within the panel that generate DC electricity.
In solar thermal, water is circulated through the collector and via a coil within a heat exchanger or a hot water cylinder (domestic) to provide heating and hot water.

10kWp roof photovoltaic system

Relevant Activity

Current Application	Minor installations on buildings or remote stations
Research	Ongoing to reduce manufacturing costs
Policy	Grant funding[13]

Innovations

Under governments grant schemes, a number of installations have been given grant funding. These range from individual household installations to schools, social housing and a number of prominent buildings. They offer a clearly visible indication of renewable energy production.

Remote locations are also ideally suited to PV installations and there are thousands of PV systems currently in operation in the UK, meeting small power requirements in applications such as telemetry and monitoring systems.

The main use in the industry is in providing low levels of power with battery backup through PV cells for telemetry systems. The low energy density in the UK climate makes it difficult to generate at scale cost-effectively.

Strengths	Weaknesses
• Useful at remote locations • Different technologies can provide heating and power needs • Proven technology • Reliable and robust • Non-polluting technology • Available for use on water or waste treatment sites	• Low energy density • Technology is still expensive per kWh which provides long payback periods • Prone to vandalism in exposed areas, which limits reliability
Opportunities	**Threats**
• As technology develops the capital costs will likely fall to assist potential payback periods and the general economic case • Use at remote locations is desirable in lieu of a grid connection • Step changes in energy use may make low outputs more suitable to demands	• Higher energy density technologies • Lack of Ofwat direct funding

7 Analysis of Results

Constraints

The major constraints to greater deployment of renewable energy in the water industry are:

Ofwat funding – A major hurdle for water companies is the position of Ofwat on technologies that qualify as part of the appointed business. Under this system only sludge-derived or hydro-derived energy can be included in bill pricing for funding by customers. In the case of water-only companies, this leaves just hydro as a supported technology.

If you consider that the UK Renewable Energy Strategy[10] identified wind as the major contributor to 2020 targets for renewable energy generation across all industries, this hampers the water companies' potential.

ROC banding – The recent arbitrary banding of anaerobic digestion and sewage gas as being valid for 2 ROCs and 0.5 ROCs per MWh respectively seems to differentiate funding levels between identical technologies. Although anaerobic digestion and standard combustion of sludge has occurred for many years in the industry, water companies still face the same challenges to install, operate and improve upon existing systems as faced in other waste-processing sectors.

Upgrade of existing systems to CHP or additional mechanical or biological pre-treatment is not complex. However, to conclude that other sectors are not able to share water industry knowledge of the processes to ensure an even technological field is unusual.

As the main financial incentive for renewable energy, the downgrading of ROC awards directly affects the financial viability of renewable generation and is at odds with any commitment to meet national and wider targets.

Waste regulations – This relates directly to the possibility of co-digestion or other combined treatment of non-sewage waste using spare processing capacity in existing treatment works. The paths to accreditation of plant and regulation for end product quality requirements make application under environmental permit and animal byproduct regulations difficult. Equally, biofuel combustion requires a Waste Incineration Directive permit, which complicates the use of waste as a fuel.

There are also issues around the disposal of sludge to land that require additional processing and greater land or transport requirements.

GridAccess – The ongoing Transmission Access Review[25] has identified difficulties and disproportionate burdens for integration of small to medium scale renewable generation into the grid. Where UK energy policy identifies a desire to meet renewables targets, steps should be put in place to facilitate this fairly.

Carbon accounting – Defra guidelines currently state that where ROCs are claimed for renewable generation, no claim should be made for reductions in carbon accounting. This seems an illogical step because renewable energy generation causes a reduction in carbon emissions. This confusion only acts to dampen enthusiasm for investment in emerging technologies.

This exclusion also applies to the incoming Carbon Reduction Commitment that water companies will be legally bound to.

Planning permissions – Where applications are made for changes to the environment, it is fully justified that permission should be sought. However, the planning system gives little credit to the 'green' aspects of renewable generation in applications. The complicated nature of renewable energy installations may be unfamiliar to water companies and as such boost investment risks.

Economic stability – This heading covers both the current investment environment and lack of certainty in the energy market. ROCs go some way to providing security, particularly with the renewed commitment until 2035[24], but renewable energy requires support to be economically favourable. Renewable energy is not a low risk option and so fluctuations in the economy will have a major effect on its uptake over the coming years.

Specialist knowledge – The water industry is a highly specialised technical area, and each company has different methods and built-up knowledge. Renewable energy, even sludge-based technologies as they move to new and advanced processes, is an entirely separate specialist area. Lack of knowledge increases risks and reduces the likelihood of implementation.

This, in part, links to lack of funding for some technologies where in-house knowledge or professional services could be procured to boost investment confidence. There is an additional need for collaboration within the industry to ensure knowledge-sharing and development of best available technologies.

Drivers

The main positive drivers for renewable energy in the water industry can be split into four categories:

Incentives – These are the direct appointed benefits by the public sector and include the items summarised in Section 4. The primary vehicle is through financial subsidy in the renewables obligation and climate change levy.

Commercial – As a private industry, any investments must make commercial sense. Outside of the incentives mentioned above, this comes from:

- Reductions in heat and electricity bills through self-generation, which made up 11 per cent of the industry's operating expenses in 2007/2008[26].
- Reduction in waste transport costs through on-site sludge processing and volume reduction. Sludge treatment and disposal costs amount to nine per cent of total operating expenditure[26].
- Additional revenue stream through production of valuable products in the waste stream.
- Income through leasing of land to third party developers for renewable energy projects.
- Additional revenue through processing of non-sewage waste streams.

Quality – The industry is closely regulated for the quality of effluent and sludge produced. Any improvement in these outputs is of direct benefit to the business.

The water industry is also monitored for customer satisfaction and a perceived improvement in service is a driver for investment. As social support for renewable energy increases so will the public appreciation of those bodies actively promoting it.

Environmental – Effective waste management and reduction of pollution of all kinds are measurable environmental targets. Renewable energy delivers these as follows:

- Reductions in carbon dioxide emissions.
- Reduction of biogas emissions through alternative technologies and higher gas quality.
- Supply of additional waste-processing capacity to other industries such as food waste in co-digestion technologies.

Potential for growth in renewable energy

The water companies in many cases showed promising moves to increase renewable energy generation over the coming years. Recognising that the current situation is one where advanced technologies are emerging but not widespread, it seems reasonable to take the following steps in estimating an overall industry potential by 2020:

- Current best performance on a per capita generation basis for each technology is taken as the benchmark for average performance in 2020. Consultation responses indicated that widespread use of many technologies is planned within the next five years.
- Taking the current best as the average of 2020, a simple scaling of the industry average provides the baseline potential.
- The next step is to add a growth allowance for technological advancements and accelerated use of best practice through improved knowledge-sharing forums.
- Details of values used are given in Figure 7.1.
- The total energy requirement is assumed to be constant between now and 2020 due to the conflicting requirements of higher water standards and reductions in carbon. However, water efficiency and carbon reduction targets could help boost energy generation as a proportion of use.

Technology	Current Best (mega watt hours per capita)	Average (mega watt hours per capita)	Growth
Anaerobic digestion and sludge combustion	15.1	5.17	20%
Hydro	0.94	0.46	10%
Wind	1.25	0.14	20%

Figure 7.1 – Potential estimate assumptions.

Figures 7.2 and 7.3 compare current and potential 2020 levels of renewable energy production. Sludge combustion and anaerobic digestion have been combined into sludge processing in Figure 7.3 due to difficulties in predicting technology choice of the industry.

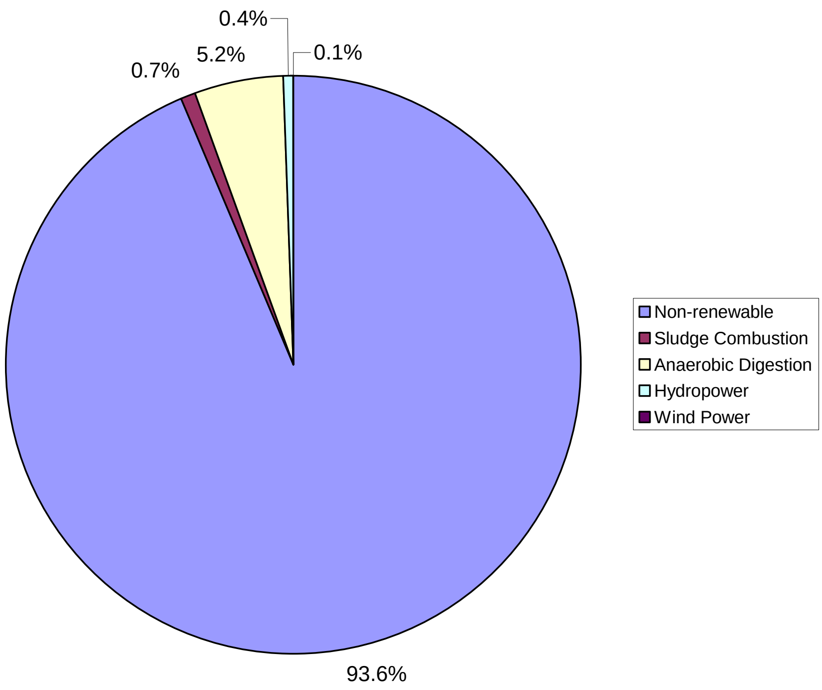


Figure 7.2 – 2007 energy mix.

Figure 7.3 shows a major increase in the proportion of renewable energy generation. As mentioned above, water companies' strategic direction statements and water resource management plans set targets for reductions in energy and water use. These reductions should help to boost renewable generation capacity.

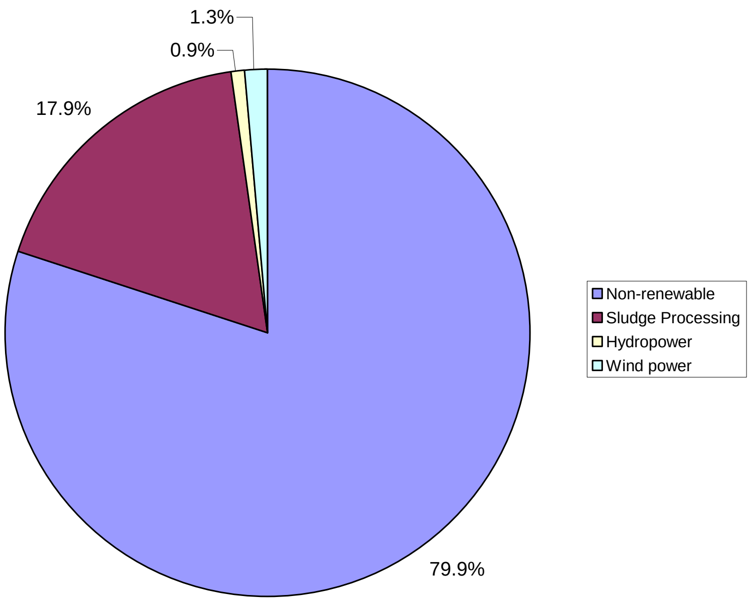


Figure 7.3 – Potential 2020 energy mix.

Self-generation may exceed the base target of 20 per cent generation by 2020. However, much of this burden must fall upon water and waste companies due to the availability of sludge; in light of this, it is promising to see that these companies aspire to meeting 20 per cent before 2020.

Water-only companies have inherent constraints on their energy potential through lack of sludge as fuel and associated infrastructure for co-digestion and similar schemes. However, with support there is potential for MW-scale deployment through wind and hydro. Examples of water and waste companies' deployment of these technologies can act as a blueprint for such installations.

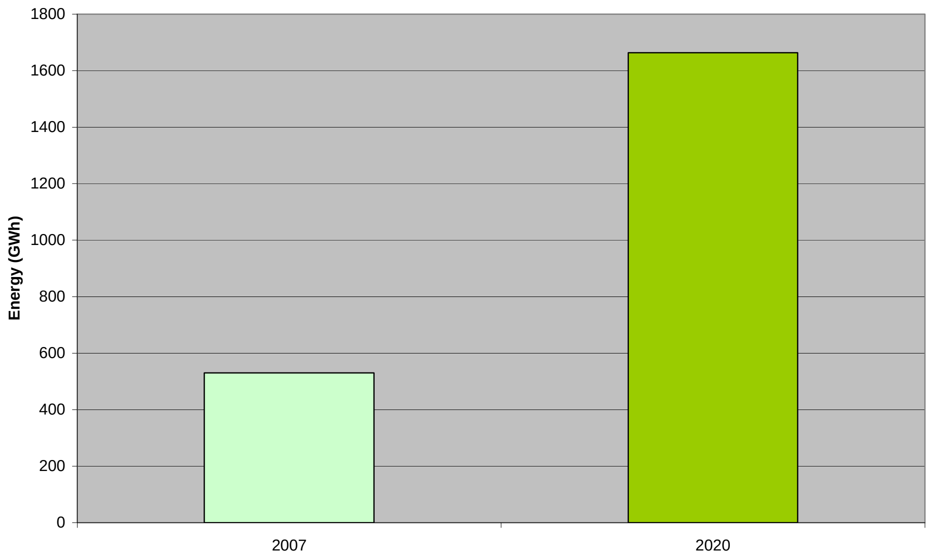


Figure 7.4 – Renewable energy output.

Figure 7.4 shows the potential for growth in water industry renewables between now and 2020. Renewable energy could grow by over three times its current level through emerging technologies. A reduction in energy use of 20 per cent will result in a further five per cent increase in renewable energy generation.

8 Conclusions

The water industry is a closely regulated and complex business that provides an essential service to the UK population. It is driven by increasingly stringent quality, reliability, economic and now sustainability requirements. Competition in the industry is created through regulation by Ofwat, with only limited direct retail competition in current systems.

As a result of the necessity for cleaner water and greater service reliability, the energy demand of the industry is on the increase. The ability to meet increasing demands sustainably is not simple.

Consultation with water companies revealed an industry with extreme differences in renewable energy generation between companies. Water-only companies are limited to hydro and wind power as options, with little success due to funding and planning uncertainty. Conversely, the waste water industry has a significant track record of using sludge for direct combustion and anaerobic digestion to meet disposal standards and provide heat and power on site. Despite water-only companies' difficulties in producing renewable energy, many of the water and waste companies have implemented such solutions successfully.

Conventional techniques prevail due to reliability and maturity of technology but the need for greater efficiency is driving novel technologies forward. A range of prototype and full-scale plants use advanced sludge processing, novel hydropower and on-site wind capture to meet demands, with varying levels of success. The industry manages to produce 8.5 per cent of its total energy from renewable sources, with the vast majority sourced from water and waste companies. A useful tool to increasing this will be in gleaning experience from European and global developments in biogas extraction and use, along with the general advancement of renewable energy technology.

The UK Government has targets to provide 15 per cent of total energy from renewables by 2020. The advantages identified in government energy strategies are a reduction in greenhouse gases and greater security of supply as fossil fuels diminish. To facilitate this, the major drivers are the renewable obligation order and climate change levy, along with increasingly stringent waste processing legislation that both helps and hinders energy production from waste. The water industry is well placed to benefit from renewable energy support due to the availability of land, water and sludge as renewable sources. However, it is necessary to understand, manage and develop capability in renewable energy generation.

Constraints include limitations on funding for process-related sources like solar, wind and run of river hydro, as well as Ofgem's rebanding of sewage gas, even advanced processing as an established technology. Waste legislation that prevents digestion of non-sewage waste and difficulties in accessing the grid to export energy are additional barriers.

However, full use of resources will yield economic savings, environmental benefits and broadening of potential revenue streams through sludge-based products such as biogas, bio-oils and inert waste matter.

Through best practice and a collaborative approach to technology development, water company targets of 20 per cent energy from renewables could be exceeded and aspirational targets of 50 per cent on waste sites could become practical by 2020.

In addition, water companies' strategic direction statements and water resource management plans indicate targets for reductions in energy and water use. These reductions will help to boost the significance of any renewable generation increases.

9 Recommendations

Water companies

- Short and long-term plans for implementation of all available renewable technologies should be prepared.
- Research and development should be targeted at advanced sludge processing and novel hydropower concepts.
- Open communication and collaboration within the industry will benefit all and increase confidence in technologies.
- Water-only companies' commitment to procure 20 per cent of their energy from renewable sources presents an opportunity for an innovative funding mechanism. With the correct framework, this could be targeted solely at the water industry by way of a voluntary fund for research tasks or joint project development.
- Investment in knowledge of renewable energy systems should be encouraged to reduce operational and investment risk.

Regulating bodies

- The requirement for energy intensive processes to meet consent standards is in opposition to sustainability. A fair and balanced approach to comparing risks associated with water quality and carbon emissions should be employed where possible.
- Renewable energy should be seen as a genuine alternative to conventional power in all senses and credit given to environmental benefits when considering investment plans.
- Long-term views on energy and environmental benefits must be considered, reaching beyond a single asset management plan (AMP) period; the UK is working towards 2020 and 2050 goals that must be mirrored at all levels of regulation.
- Research vehicles must be encouraged to progress renewable technologies within the industry, using regulatory power to enable collaboration.
- The Environment Agency should continue to act as a source of informed opinion, guidance and facilitation of discussion on issues such as river hydro schemes, waste legislation and environmental permitting.
- Any use of land to encourage renewable energy and associated benefits should be defined as central to the water industries responsibility.

Government

- A review of sludge processing technologies should be carried out. The water industry is well positioned to use waste products for energy and investment is required to ensure improvements in energy production and environmental benefits of sludge processing.
- Research vehicles such as the Technology Strategy Board, Engineering and Physical Sciences Research Council and the Energy Technologies Institute must be encouraged to progress renewable technologies within the industry, using government bodies to assist the process of knowledge sharing.

- The value of renewable heat should be enforced through political measures to develop benefits such as those achieved in Europe through district heating schemes.
- The renewable obligation order is the primary legislative driver for renewable energy uptake and care must be taken to ensure the system is fair. The technologies proposed for advanced anaerobic digestion of sludge are identical to those using other fuels but the level of funding is considerably different. The Government and water companies must discuss and agree a fair banding system for renewable obligation certificates.
- Support for co-digestion as a means of applying the waste hierarchy must be provided where possible; Defra is well placed to consider this.
- Wherever possible, maximum value must be extracted from sludge products for the benefit of the UK economy and to further reduce residual waste.

Appendix A – Consultation record

Company	Returned Questionnaire	Water & Waste	Water Only
Anglian Water Plc	N	Y	
Bournemouth & West Hampshire Water Plc	Y		Y
Bristol Water Plc	Y		Y
Cambridge Water Plc	Y		Y
Cholderton & District Water	N		Y
Dee Valley Water Plc	N		Y
Dwr Cymru Cyfyngedig	Y	Y	
Essex & Suffolk Water	Y		Y
Folkestone & Dover Water Services Ltd	N		Y
Northumbrian Water Ltd	Y	Y	
Portsmouth Water Plc	N		Y
Severn Trent Water Ltd	Y	Y	
South East Water Plc	N		Y
South Staffordshire Water Plc	Y		Y
South West Water Services Ltd	N	Y	
Southern Water Services Ltd	N	Y	
Sutton & East Surrey Water Plc	Y		Y
Thames Water Utilities Ltd	Y	Y	
Tendring Hundred Water Services Ltd	Y		Y
Three Valleys Water Plc	Y		Y
United Utilities Water Plc	N	Y	
Wessex Water Plc	Y	Y	
Yorkshire Water Plc	Y	Y	
Total	**14**		

List of Acronyms

BERR	-	Department for Business, Enterprise and Regulatory Reform
CHP	-	Combined heat and power
DECC	-	Department of Energy and Climate Change
DEFRA	-	Department for Environment, Food and Rural Affairs
ETF	-	Environmental Transformation Fund
PLC	-	Programmable logic circuit
PR09	-	Pricing Review 2009
PV	-	Photovoltaic
ROC	-	Renewable Obligation Certificate
STW	-	Sewage treatment works
SWOT	-	Strengths, Weaknesses, Opportunities and Threats
WRAP	-	Waste & Resource Action Programme
WTW	-	Water treatment works
WWTW	-	Waste water treatment works

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