

ENERGY FROM WASTEWATER – A FEASIBILITY STUDY

GUIDE FOR:

- 1. TECHNOLOGY DEVELOPERS AND RESEARCHERS**
- 2. INDUSTRY AND WASTEWATER GENERATORS**
- 3. POLICY MAKERS**

Report to the
Water Research Commission

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WRC Report No. TT 400/09

JULY 2009

Obtainable from

Water Research Commission
Private Bag X03
Gezina, 0031

The publication of this report emanates from a project entitled *Energy from Wastewater – A Feasibility Study* (WRC project o. K5/1732)

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ISBN 978-1-77005-848-4
Set No. 978-1-77005-846-0

Printed in there public of South Africa

A GUIDE FOR TECHNOLOGY DEVELOPERS AND RESEARCHERS

This guide is based on a study funded by the Water Research Commission with the purpose of determining the feasibility of developing technologies for energy recovery from wastewater. A full technical report is available for further reference (WRC report no 1732/1/09).

The availability of clean, renewable fuels is well recognised to be core to sustainable economic growth. The use of wastewater as a renewable energy resource has been poorly exploited to date particularly in developing countries such as South Africa. Wastewaters as renewable sources of energy are valuable to supplement and/or replace non-renewable sources, reduce the environmental burden of conventional power generation and provide the added benefit of enhanced waste processing.

The study reviewed the available literature and surveyed international and national practice in energy recovery from wastewater in order to identify the most significant potential for new research and innovation. A survey of potentials for energy from wastewater in South Africa served to identify which types of substrates are available in significant amounts. The project also included a set of case studies that show what factors to consider in developing energy from wastewater projects. Workshops were held to provide opportunities for consultation with stakeholders in the fields of wastewater treatment and technology development, in order to determine areas where technical and application problems might exist (WRC report no 1732/1/09).

This guide makes recommendations relevant to the R&D sector regarding recovery of energy from wastewater. It also seeks to provide information about directions which would be useful to South Africa's research community by identifying areas where R&D are needed, and by highlighting areas to which the WRC might direct funding in future.

Conclusions and recommendations:

- The three major classes of **wastewater with the greatest potential** for energy recovery are:

Sewage, both for existing centralised WWTP and decentralised (non-sewer connected) household sanitation needs

Animal husbandry wastewaters

Food and beverage processing wastewaters.

This conclusion was based on the loads (COD and volumes typically present) and the energy determined to be potentially available from them. Any research into energy from wastewater should primarily focus on these three wastewater types.

- **Anaerobic digestion** (AD), producing biogas, is clearly the most common and best understood technology available for treating wastewaters. It is a mature technology, applied widely both internationally and nationally at various scales. Thus, there is limited need for further fundamental research in this area, especially with regards to larger, commercial-scale opportunities. Smaller, community or homestead-scale systems require demonstration-type research projects in order to build capacity and to identify typical problems.

AD biogas could be implemented in South Africa but there is a need for applied research to establish the effective integrated operation with different waste streams. Research is needed to monitor the performance and understand the stability of anaerobic digesters with particular reference to microbial ecology.

- The efficiency of **wastewater treatment plants** (WWTPs) was highlighted as a problem area and applied research in this area might facilitate improved performance with the integration of wastewater treatment with energy recovery. The improved characterisation of wastewater streams and an investigation into the impact of specific large volume or high load wastewaters produced by industries would help understand and improve the efficiency of WWTPs. The characterisation of waste streams can also inform urban developers of more integrated planning options that take into consideration the energy from wastewaters.
- **Algal ponding technology to produce biodiesel or biomass** has significant potential, but has not been demonstrated on a large scale. Technical constraints include limitations with respect to productivity and product recovery. While algal ponding has been demonstrated as a feasible technology, there is a need for research to improve productivity and lipid recovery for algal biodiesel systems.

- **Fermentation to produce ethanol** is limited in its applicability to wastewaters. It is very substrate specific and is not readily applicable to very dilute waste streams. However, there is potential for development of ethanol production using low carbohydrate-containing wastewaters by addition of other wastes or mixing with other waste streams. The value of the integrated use of mixed wastewaters would require research to optimise these systems.
- **Microbial fuel cells** represent new technology with potential for an effective method to generate energy directly from wastewater, but this is an area where much research and development is needed before scale-up to industrial scale is established and implementation can be achieved. There is an exciting potential to build South African capacity in new technologies, such as microbial fuel cells, to develop applications relevant and specific to South African wastewaters.
- **Waste heat recovery** involves heat integration and requires analyses of processes and their relationships to their location. There is significant scope for research and development in the field of industrial ecology to characterise processes and to provide direction with respect to implementation.

There is a particular need to identify industries requiring only low grade heat (especially in the emerging biotechnology sector) and to provide information and guidance on the location of such activities in appropriate industrial environments, where sufficient amounts of low- to medium grade waste heat are freely available.

- **Research capacity** is of concern nationally, and the following observations were made:
 - The research community has strong expertise in fermentation
 - South Africa does not have good skills and expertise in gasification and advanced thermal technologies
 - In the field of biogas, applied research is needed into technology development and skills rather than fundamental research.
- There is a need for **research collaboration and information-sharing** between research groupings, government research agencies and municipal practitioners to facilitate effective data collection for use in research, analysis and calculation of potential benefit.

A GUIDE FOR THE WASTEWATER SECTOR (INDUSTRY, MUNICIPALITIES, SERVICE PROVIDERS, SUPPLIERS)

This guide is based on a study funded by the Water Research Commission with the purpose of determining the feasibility of developing technologies for energy recovery from wastewater. A full technical report is available for further reference (see WRC report 1732/1/09).

The availability of clean, renewable fuels is well established to be core to sustainable economic growth. The use of wastewater as a renewable energy resource has been poorly exploited to date, particularly in developing countries such as South Africa. These renewable sources of energy are valuable to supplement and/or replace non-renewable sources, reduce the environmental burden of conventional power generation and provide the added benefit of enhanced waste processing.

The study reviewed the available literature and surveyed international and national practice in energy recovery from wastewater in order to identify the most significant potential for new research and innovation. Workshops were held to provide opportunities for consultation with stakeholders in the fields of wastewater treatment and technology development in order to determine areas where technical and application problems might exist (see WRC report 1732/1/09, Appendix).

This guide makes recommendations relevant to practitioners in the field of wastewater treatment and seeks to provide information useful to parties seeking to exploit the opportunities available for recovery of energy from wastewaters by developing or applying appropriate technologies.

Conclusions and recommendations:

- The **recovery of energy from wastewaters** in South Africa will not cover South Africa's national energy needs, but it can provide up to 10 000 MW. This may consist of small (<1 MW) and distributed projects that enable local energy security (off-grid power).
- **Biogas technology** is the most appropriate technology available for application at both large and small scale because:
 - It can be applied to wastewaters containing dissolved or suspended substrates and using separate or combined wastes
 - It can be located in municipal, industrial or agricultural plants
 - Its application is well-established internationally, but it is not yet widely used in South Africa.

Biogas production has important potential value in WWTPs, since it can be used to provide essential on-site power (for instance for sewage pump stations etc, and during load shedding periods).

There are significant potential spin-off benefits from the production of biogas from wastewater:

- Cleaner water outflows
- Sanitary and health benefits
- Savings on waste disposal costs
- Freeing up of COD discharge capacity
- Storage of biogas for load shedding or peak demand periods.

Technologies ancillary to biogas generation, such as gas conditioning, gas engines or micro-turbines are available internationally, but not necessarily in South Africa. This means that whilst technology can be imported and installed at some cost, there is usually no local maintenance and repair capacity.

- **Algal ponding** to generate biodiesel from wastewater has not yet been convincingly demonstrated in at large scales. It should be noted that there is more value in growing algae itself than the production of biodiesel as a value-added product. For example, algal ponds can provide a downstream method for polishing treated wastewaters and can be used to generate biomass for other energy from wastewater technologies.
- **Energy integration** through the location of companies in industrial parks is an important and frequently missed opportunity. For example, the availability of excess low-grade heat may be an attractive opportunity in the collaborative development of business consortia and the establishment of an industrial park.
- Since South Africa has little history of recovering energy from wastewater, there is an urgent need for **demonstration plants** to be established to prove the technologies.
- **Barriers** to implementation of these technologies include the general perception that regulatory issues and governmental red tape make it difficult to obtain the necessary permissions (such as a license for electricity generation).
- **Access to finance** was identified as an obstacle for development of energy from wastewater projects. It is noted that there are a number of ways in which finance can be accessed including:

Municipal Infrastructure Grants

The South African renewable energy subsidy scheme

Grants or loans for detailed feasibility studies

Export credits for the import content of the plant

Various carbon trading mechanisms (including CDM of the Kyoto Protocol)

Long-term finance

Soft loans

Cash flow buffers

Start-up funds

Eskom's demand side management program.

- The **local capacity** for applying energy from wastewater technologies is limited and there is a severe need for training personnel with the technical skills needed to develop energy from wastewater technologies.

A GUIDE FOR POLICY MAKERS

This guide is based on a study funded by the Water Research Commission with the purpose of determining the feasibility of developing technologies for energy recovery from wastewater. A full technical report is available for further reference (WRC report 1732/1/09).

The availability of clean, renewable fuels is well established to be core to sustainable economic growth. The use of wastewater as a renewable energy resource has been poorly exploited to date, particularly in developing countries such as South Africa. These renewable sources of energy are valuable to supplement and/or replace non-renewable sources, reduce the environmental burden of conventional power generation and provide the added benefit of enhanced waste processing.

The study reviewed the available literature and surveyed international and national practice in energy recovery from wastewater in order to identify the most significant potential for new research and innovation. The conclusions from these surveys are summarised in the project Essence Report (WRC report TT 399/09). The project also included a set of a case studies carried out in order to further explore some energy from wastewater possibilities and identify the barriers, risk and drivers of energy from wastewater processes.

Workshops were held to provide opportunities for consultation with stakeholders in the fields of wastewater treatment and technology development in order to determine areas where technical and application problems might exist.

This guide makes recommendations relevant to policy makers in a range of sectors of local and national government, to service providers and funding organisations.

Observations and recommendations:

- **Anaerobic digestion** (AD) for the production of biogas is by far the most prominent available technology as a means of energy recovery from waste, and there are approximately 50 small scale biogas projects in South Africa. There are some recent large scale AD projects that have essentially been made possible through the Clean Development Mechanism (CDM) and the sale of Certified Emission Reductions (CER). While AD is not necessarily a complete solution to wastewater treatment there are significant benefits to be derived from biogas generation including:

- On site production of heating and/or cooking for households

- Reduction of pressure on natural resources (such as wood)

- Production of sludge fertilisers which can be applied to cultivated land.

The scope to integrate “energy from wastewater” goals with effective sanitation (MDG 2015) is large. In particular, the free basic alternative energy policy (FBAE 2007) could be linked to voluntary installation of AD biogas systems.

There exists no standardised agency for the implementation of small household AD. A standard implementation agency is required to ensure uniform standards of design and construction. Such an agency should have improved access to financing government grants or loans, as well as the Clean Development Mechanism (CDM) and Certified Emission Reductions (CER) (e.g. BSP in Nepal). Based on a recent report “South African Domestic Biogas Feasibility Study” (2007), the Department of Minerals and Energy is currently contemplating a detailed program for the implementation of approximately 20 000 rural household AD.

- There is a desperate need for **skills development and capacity building** to provide sufficient technological expertise to support the roll out and maintenance of energy from wastewater projects.
- Support for **demonstration projects** would assist in the development of skills and the acceptance and uptake of appropriate energy from wastewater solutions.

Barriers:

- It was observed that there is a serious **lack of effective data collection and maintenance** for wastewaters. Obtaining data on the performance and operating capacity of wastewater generators across the country proved to be extremely difficult and many offices reported that records were not being maintained due to a lack of human resource capacity.
- The **cumbersome regulatory issues** have lead to the lack of success in implementation of existing processes. For instance, at the Cape Flats WWTP in Cape Town, biogas is generated on site and used to dry sludge to pellets. These pellets can be used as a fuel for generating energy. However, the policy that no income generating secondary industries are allowed on state owned operations (e.g. municipal WWTP), makes it difficult to financially benefit from this.

Local government authorities may also be limited in by the Municipal Finance Act (MFMA) which imposes constraints on public-private partnerships (such as the requirement that every project should go out to tender and is limited to three years unless approved by council).

- The **national electricity tariff structure** is not conducive to energy recovery; there are no special feed-in tariffs, green energy tariffs or peak tariffs.
- There is a **lack of human capacity and a severe skills shortage** in the wastewater sector. Policy is needed to support skills training and develop a national capacity to implement new technologies in energy recovery.
- A **clear commitment is needed by government** for targeting renewable energy, including policy and legislation to establish mandatory targets for renewable energy, incentives and investment opportunities boosted with private-public partnerships or preferential pricing policies. Essential services (WWTP operation, schools, and hospitals) and the needs of communities not serviced by sewage and electrical infrastructure should preferentially be targeted.