

Unlocking water to energy opportunities in the water sector

Rajiv Paladh, Jason Holder, Andy Knox and Chantal Ramcharan-Kotze

This study explored the extent and potential of the water to energy (WTE) market in South Africa. The aim of the study was to attract potential investors to the water to energy market and unlock projects that could generate electricity through various water to energy technologies. This article thus summarises the findings of the study and outlines the way, water to energy studies could be successfully implemented.

Methodology

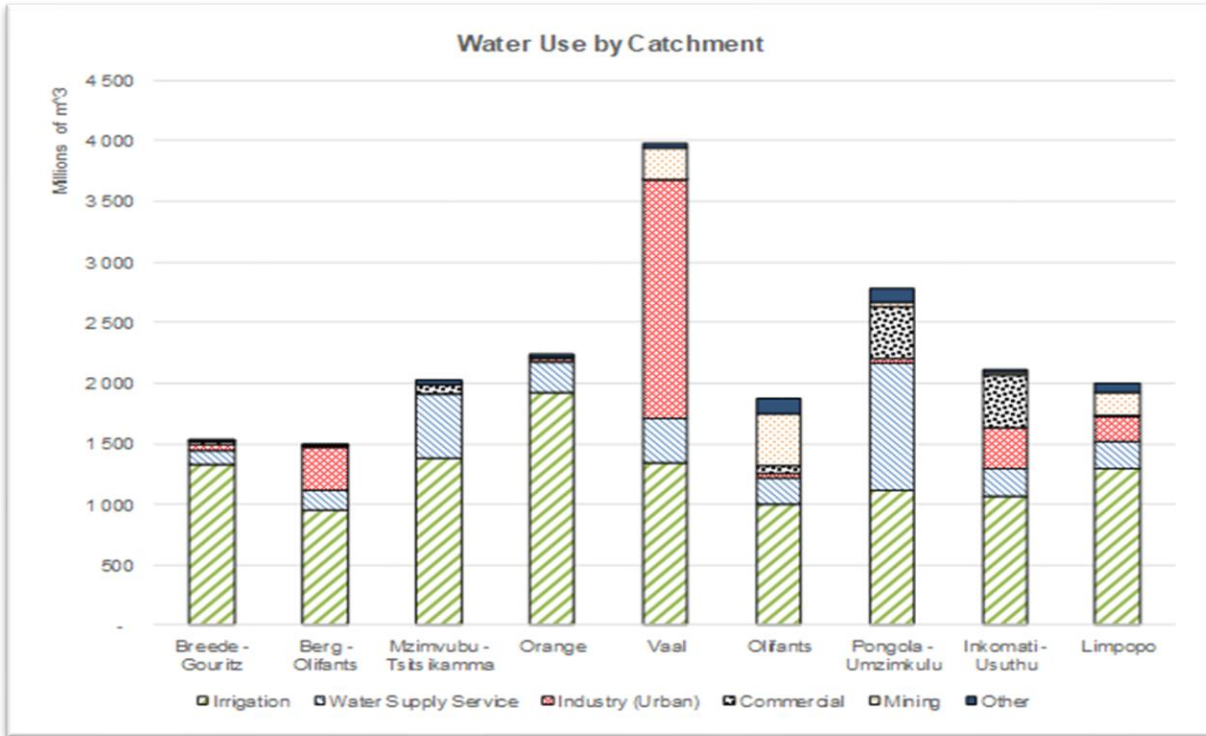
The study was completed in a phased manner that included a market segmentation exercise and market evaluation. Stakeholders were also engaged at various stages of the study for input and confirmation of the findings of the study.

A review of technologies that could extract the inherent energy within water was conducted. This was done to ensure that the technologies were sufficiently established to provide comfort to Investors that the technology could be reliably operated and provide the necessary energy to Customers. These technologies were evaluated using the Technology Readiness level framework, market readiness framework and a Multi-criteria decision analysis (MCDA) process.

A review of applicable water and electricity regulations, policies and plans indicated that there is a strong alignment between legislation and the implementation of water to energy technologies. This is evidenced by the Integrated Resources Plan 2019 (IRP2019) which confirms hydropower and biogas to be predominantly featured as part of the proposed energy mix by 2030.

The Water and Energy Market in South Africa

The diagram below provides an indication of the water users in different catchments. Water for agricultural use is the largest consumer followed by industry and water supply services.



A review of the key market segments for electricity consumers yielded the results presented in the table below.

Table 1: Market segments

Market segment	Comment
Industry and Mining	Industry generates the highest demand for energy in South Africa (52%). Industry and Mining are also amongst the highest water users in the country with the highest industrial water use located in the Vaal catchment.
Agriculture	Irrigation uses the highest proportion of water and consumes 6% of the energy within the country. This represents a potential market segment that has a relatively high water consumption profile across all catchments in the country, that has the potential for mini and small hydropower schemes.
Domestic	The residential market in South Africa accounts for 8% of energy but 15.7% of water being consumed by water supply services. This is seen to be for the provision of domestic water and sanitation services.
Municipalities	Municipalities are seen to have a key role to play in the provision of water services, as well as the provision of electricity to their customers.
Water Boards	Rand Water is listed as one of the 29 highest energy users in South Africa. The utility is also the largest Water Board in the country. It is possible that given the scale of operations, Water Boards may be well placed to benefit from Water to Energy interventions.

It is important to note that there appears to be a strong correlation between water and energy consumers. The table above also highlights that municipalities have an important role to play in both the provision of water and electricity services. Water Boards also have a relatively high energy consumption and an important role in the provision of bulk water supply.

Potential WTE projects

The table below provides an indication of the WTE projects that could be implemented in South Africa and the potential impact. The annual revenue generation was based on a tariff of R1.40 kWh and household consumption is assumed to be 20 kWh per day.

Table 2: Established technology and source

Application	Generation Capacity (MWh/annum)	MW	Equivalent no. of HH	Annual Revenue (ZAR)
Hydropower sets to existing (new) dam	500 000	71	69 444	700 000 000
Municipal/Water Utility Distribution systems (Hydropower)	375 000	54	52 083	525 000 000
Inter-basin Water Transfer Schemes (Hydropower)	300 000	43	41 667	420 000 000
Anaerobic Digestion at WWTW	190 232	27	26 421	266 325 024
Refurbishment/upgrading of existing plants in ownership of municipalities or DWA (Hydropower)	70 000	10	9 722	98 000 000
"Greenfield" Hydropower sites	5 000	0.71	694	7 000 000
		206	200 032	2 016 325 024

The application of hydropower and anaerobic digestion in rural applications that could benefit either rural communities or agricultural consumers were considered. However, anaerobic digestion in rural areas would require the introduction of an alternative feedstock as sludge would not generate the requisite volumes of biogas. Importantly, the physical location at which the electricity is generated and could be used is a critical consideration in rural applications. This impacts negatively on the capital requirements if the electricity generated is required to be transported over long transmission lines for consumption. The development costs associated with the smaller installations are also seen to be prohibitive.

Emerging innovations that are seen to have potential but would need further development to be considered for large scale investment are:

- Wave to Energy;
- Microbial Fuel Cell;
- Generating biofuel from wastewater sludge; and
- Thermal treatment of sludge.

The Combustion of wastewater sludge is an internationally mature technology, however, the MCDA confirmed that this technology had limited application in the South African water sector at this stage.

Bankability and risk

Projects need to be deemed bankable if they are to attract investment from funders. This includes the development of the strategic, financial, commercial and management case for each project. The diagram below indicates the key risks that would need to be overcome for the implementation of water to energy projects.

Risk	Conception	Design	Build	Operate & Maintain
Political	Political support Regulatory environment that supports the implementation of WTE projects			
Financial	Ensure projects are financially viable	Cashflow to fund project development	Necessary agreements to execute projects	
	Usually funded by the Developer	Certainty that the costs are accurate	Sufficient cashflow can be collected and used to service debt	
Operational	Necessary skills to execute each phase			

Figure 1: Bankability requirements/risk potential for water to energy projects

The diagram above also highlights the need for a ‘Developer’ or Project Sponsor to move a project from Concept towards Implementation and Operations and Maintenance. The Developer should be able to provide comfort to the Investor that the project can be successfully implemented and the ability to attract the right partners at each stage of the project development process.

Opportunities map and recommendations

The opportunities map is presented in the diagram below.

Technology	Water Services Authority	Water Boards	Agriculture	Mining
Anaerobic Digestion				
Gasification				
Combustion				
Hydropower				
Wave to Energy				
Microbial Fuel Cell				
Algae to diesel				

Key

	Opportunity to be targetted immediately
	Possible opportunity but further investigation is required
	Emerging innovation to be monitored
	Mature technology with limited application in South Africa

Figure 2: Opportunities map

The diagram above indicates that anaerobic digestion and hydropower provides clear opportunities for WTE projects. These could be implemented in partnerships with WSA and Water Boards. Anaerobic digestion in agriculture markets may have application but would require an additional feed stock beyond sludge. Hydropower in agriculture may also be possible but this is expected to be site specific and is discussed further below.

It is expected that most of the electricity generated by the WTE projects would be for onsite use or supply into the municipal grid. This reduces the risk of non-payment for the electricity generated from the WTE projects. This also reduces the requirements to engage with additional parties for off-take agreements and/or the use of transmission infrastructure.

The mining sector could contribute a potential 1 200 MW in Gauteng from mining applications. However, there is a need to confirm the practical application of hydropower solutions or energy recovery in mining applications. It is possible that this electricity could be used on site or supplied directly to industry or the electrical grid depending on the location of the project or operational state of the mine.

It is noted that Water Boards and Municipalities have been investigating the potential for hydropower applications and anaerobic digestion at various sites. These projects are seen to be at concept stage and need to be further developed.

It is therefore proposed that:

- Funding from DFI's is allocated towards the development of feasibility studies for the sites that have been identified as these may be outdated and would need to reflect current capital, operating and revenue;
- Project Preparation Funding should also be allocated to sites in the metropolitan municipalities and Water Boards to assist with the design components associated with Water to Energy projects;
- Consider the development of an office similar to the Independent Power Producer Office at the DBSA to assist municipalities with the implementation of water to energy projects;
- Political will is seen to be crucial in ensuring the success of WTE projects. Therefore political support and alignment will be required from all key stakeholders. This will have to be driven from Central Government by ensuring appropriate legislation, incentives and adequate funding for operations and maintenance are in place. Incentives will need to be aligned by the different institutions and staff that are involved in the projects; and
- Explore the potential to establish specialised units within institutions that can manage the operational and maintenance risks associated with WTE projects.

The potential impact of implementing the water to energy opportunities that have been identified are significant in that:

- It contributes to enhancing South Africa's electricity supply;
- It could assist municipalities in obtaining electricity at a lower price than that provided by Eskom;
- Job creation benefits through each phase of project implementation;
- Economic and environmental benefits through investment in renewable energy and reduction on the reliance of coal; and
- It stimulates innovation and the implementation of circular economy principles.