WATER RESEARCH COMMISSION

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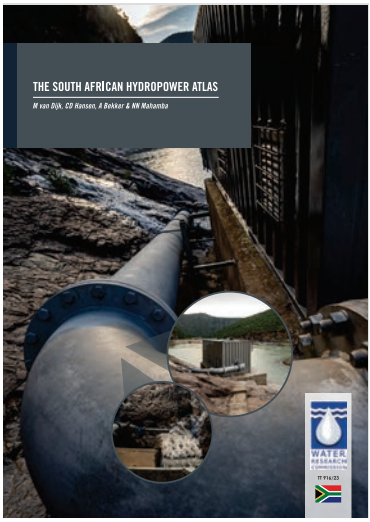
INTRODUCTION

Energy and water are intricately connected. All sources of energy (including electricity) require water in their production processes: the extraction of raw materials, cooling in thermal processes, in cleaning processes, cultivation of crops for biofuels, and powering turbines. Energy is itself required to make water resources available for human use and consumption (including irrigation) through pumping, transportation, treatment, and desalination.

Society's acumen on the conjoined management of water and energy resources has developed over time. The relationship, as defined today, stands as simple as the energy intensity in the water sector to water intensity in the energy sector. It is the amount of water needed directly or indirectly for exploration, extraction, generation and transmission of energy, and the amount of energy needed for extraction, transportation, distribution, collection, treatment and end use of water. The energy and water nexus was coined as a focused area of study under the entire nexus to develop an understanding of the interdependencies and complications of water and energy alone. The water for energy and energy for water dependencies revolve around many elemental issues ranging from water management systems and water infrastructure to sustainable energy and efficient systems.

An integrated development of the energy and water policies is of paramount importance and not in isolation from each other. With high risks that the energy sector is now exposed to, the importance of including water in its strategic plan is more essential than ever before.

HYDROPOWER



THE SOUTH AFRICAN HYDROPOWER ATLAS

WRC report No. TT 916/23

The electrification of urban areas in South Africa, including many informal settlements, reached its culmination during recent years. However, the electrification of rural areas has still a long way to go before most of the rural communities will be provided with reliable and sustainable electricity supply. The national electricity grid managed by the parastatal ESKOM has been experiencing problems due to various reasons, particularly since 2008. The further development of rural electrification presently is in the doldrums mainly due to the shortage in the generation capacity available to ESKOM which needs to be made available to the users already connected to the national grid. The increases in the price of electricity are starting to be felt by the urban- as well as the rural communities. The primary electricity infrastructure (i.e. coal-fired power stations, major supply lines and distribution of electricity within urban areas) is becoming rapidly insufficient and cannot sustain a supply against the demand for electricity from the existing and future users connected to the national grid. The research project's aim was to enhance the uptake of micro-hydro technology, making local stakeholders (private sector, financial sector, government entities, etc.) aware of the opportunities that this technology brings, and the efforts required to get this technology successfully implemented in South Africa. The report provides general information regarding the assessment of hydropower potentials and provides the information required regarding the feasibility of such projects.

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SCOPING STUDY TO EXPLORE HYDRO POTENTIAL IN THE NEARBY VICINITY OF BAAKENS RIVER AND THE LAKE

WRC report no. 3087/1/23

South Africa's primary electricity infrastructure (i.e. coal-fired power stations, major supply lines and distribution of electricity within urban areas) is rapidly becoming insufficient and cannot sustain a supply against the demand for electricity from the existing and future users connected to the national grid. The research project's aim was to enhance the uptake of micro-hydro technology, making local stakeholders (private sector, financial sector, government entities, etc.) aware of the opportunities that this technology brings and the efforts required to get this technology successfully implemented in South Africa. A municipal hydropower development tool was developed to assist municipalities with the identification and development of hydropower sites in their area. The tool was developed based on the pre-feasibility phase of the hydropower development process. As a case study, the sites within the Nelson Mandela Bay Municipality were identified based on a pre-feasibility analysis. A site-visit was conducted to enable a feasibility analysis to be conducted on all shortlisted sites.

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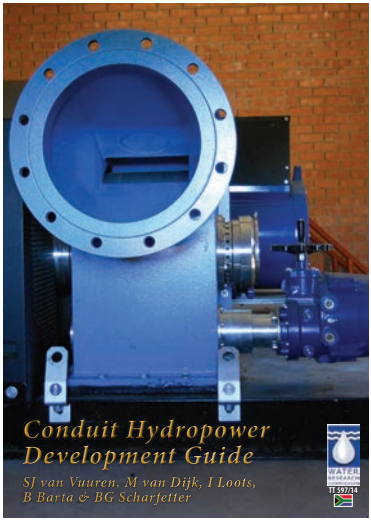

CONDUIT HYDROPOWER DEVELOPMENT GUIDE

WRC report no. TT 597/14

South Africa is facing an energy crisis which places additional importance on harvesting all available feasible renewable energies. Rolling power cuts have made all citizens aware of the fact that demand for electricity is grossly outstripping supply. South Africa is acknowledged to be not particularly endowed with the best hydropower conditions as it might be elsewhere in Africa and the rest of the world. However, large quantities of raw and potable water are conveyed daily under either pressurised or gravity conditions over large distances and elevations. An initial WRC scoping study highlighted the potential hydropower generation at the inlets to storage reservoirs. In South Africa there are 284 municipalities and several water supply utilities, mines, all owning and operating gravity water supply distribution systems which could be considered for small, mini, micro and pico scale hydropower installations. Most of these water supply/distribution systems could be equipped with turbines or pumps as turbines, supplementing and reducing the requirements for pressure control valves. The hydro energy may be used onsite, supplied to the national electricity grid or feeding an isolated electricity demand cluster. A Decision Support System (DSS) that facilitates the development process of a conduit hydropower plant was developed. The DSS assists in evaluation of the site, providing guidance on the data gathering procedure, describes the feasibility/economic analysis required, and guides the developer through the turbine selection and detail design aspects.

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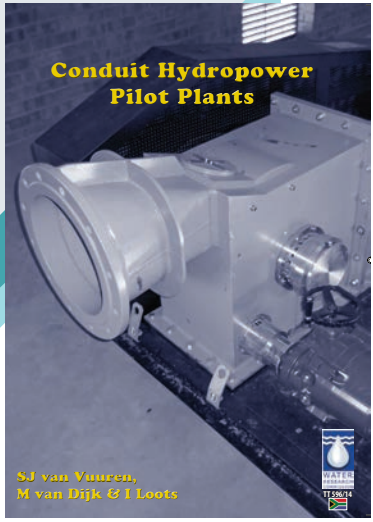

CONDUIT HYDROPOWER PILOT PLANTS

WRC report no. TT 596/14

There are basically five areas where there could be a potential to generate energy in the water supply and distribution system, namely dam releases into bulk supply lines; at water treatment works (raw water) – the bulk pipeline from the water source can be tapped; potable water – at inlets to service reservoirs where pressure reducing stations (PRS) are utilised to dissipate the excess energy; distribution network – in the distribution network itself where excess energy is dissipated (typically with pressure reducing valves (PRV)); and treated effluent – cases where the treated effluent has potential energy based on its elevation above the discharge point. The application to install hydroelectric turbines in a water distribution system is fairly new in South Africa and thus three pilot plants, one in Pretoria, one in Bloemfontein and one in Durban, were constructed showcasing several of the intricacies in the development process and to demonstrate the technologies. This research project indicated that it is feasible and technically possible to generate energy from distributions systems. The hydropower development guidelines assist in identifying locations, selecting the turbine and determining the feasibility thereof. To assist in the feasibility calculations, showing that it is a viable investment cost functions have been developed. The practical aspects are demonstrated with the three constructed, operational pilot plants installations.

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MITIGATING THE IMPACT OF ELECTRICITY DISRUPTION ON WATER SUPPLY – CASE STUDY OF THE CITY OF TSHWANE

Mitigating the impact of electricity disruption on water supply was investigated as a case study based in the City of Tshwane. This study explores the implications of electricity disruptions on water supply, describing the risks in detail and identifying options to mitigate the risks identified.
WRC report no. 2591/1/19
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THE WATER-ENERGY NEXUS IN THE CONTEXT OF CLIMATE CHANGE: INVESTIGATING TRADE-OFFS BETWEEN WATER USE EFFICIENCY AND RENEWABLE ENERGY OPTIONS FOR SOUTH AFRICA

Renewable energy is being promoted as one way of achieving sustainable energy provision in the country. However, some issues require close scrutiny in order to understand the water requirements of renewable energy production in the country. Due to the large gap that exists between water supply and demand, trade-offs in water allocation amongst different users and energy resources are critical. The aim of this study was to investigate trade-offs between water use efficiency and renewable energy in South Africa.
WRC report no. 2239/1/15
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LONG-TERM FORECASTS OF WATER USAGE FOR ELECTRICITY GENERATION: SOUTH AFRICA 2030

The study aimed to forecast water usage patterns associated with coal-based electricity generation; assess scenarios of water usage patterns based on cooling technology and power plant type; and propose projected water saving measures within distressed water management areas.

WRC report no. 2382/1/14

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SCOPING STUDY: ENERGY GENERATION USING LOW HEAD HYDRO TECHNOLOGIES

Low head hydropower generation refers to electricity generated from a relatively low pressure head normally found in rivers or irrigation canals, and is applicable to sites with less than 5 metres of head. In the execution of this study attention was firstly given to identify the available low head hydropower technologies, followed by the identification of sites where the technologies can be implemented and finally the discussion of specific sites where the technology can be implemented.

WRC report no. KV 323/13

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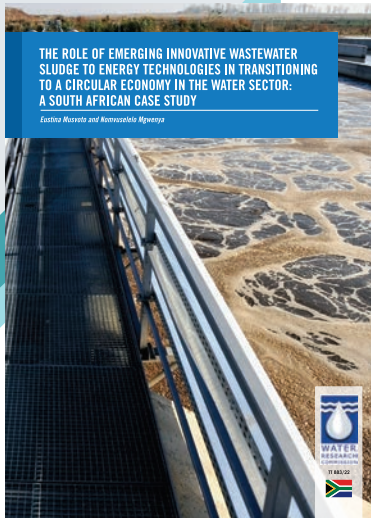
ENERGY RECOVERY AND EFFICIENCY AT WASTEWATER TREATMENT PLANTS



THE ROLE OF EMERGING INNOVATIVE WASTEWATER SLUDGE TO ENERGY TECHNOLOGIES IN TRANSITIONING TO A CIRCULAR ECONOMY IN THE WATER SECTOR: A SOUTH AFRICAN CASE STUDY

WRC report no. TT 883/22

Similar to other sectors, the benefits of transitioning to a circular economy (CE) in the water and wastewater sector have been demonstrated through both theoretical models and practical experience in those areas where partial circularity has been achieved. However, full transition still faces significant challenges and barriers. As in most countries, the current water and wastewater business cycle in South Africa is predominantly based on the linear economy approach. To address current and future water security challenges in a sustainable manner, there is a need to rethink the South African water and sanitation value chain and accelerate transitioning to a CE. Initiatives in South Africa have mostly been from the wastewater sector where research into some areas that support the CE (e.g., energy conservation and generation in wastewater management, wastewater effluent reuse) has been undertaken in recent years. This project evaluated the role of sludge to energy technologies in accelerating the adoption of CE principles by converting wastewater treatment plants into resource recovery facilities at the centre of that transition.

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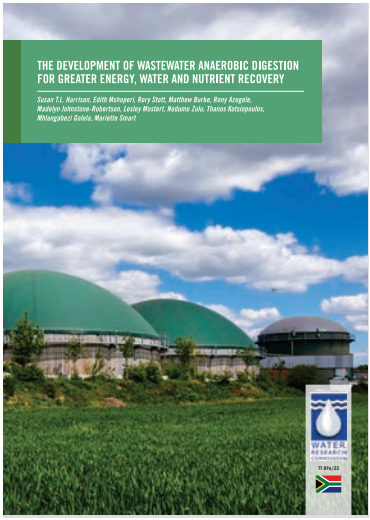

THE DEVELOPMENT OF WASTEWATER ANAEROBIC DIGESTION FOR GREATER ENERGY, WATER AND NUTRIENT RECOVERY

WRC report no. TT 896/22

Enhancing resource efficiency through the maximising benefit extracted from each natural resource used while minimising associated environmental burden is key for progress towards sustainable development. Anaerobic digestion (AD) is a bioprocess commonly cited to deliver towards such sustainable development owing to both its use in the upgrading of wastewater quality and the development of renewable energy. While there is potential for the integrated delivery of these targets, traditionally, AD processes have been targeted at either water treatment or renewable energy generation. This report addresses the potential for AD to deliver fit-for-purpose water while simultaneously valorising the waste components within the water stream to either energy or other products of value. To achieve this, the project aimed to re-evaluate AD design concerning volumetric biogas productivity and effluent quality and consistency, aiming to maximise space time utilisation of the AD.

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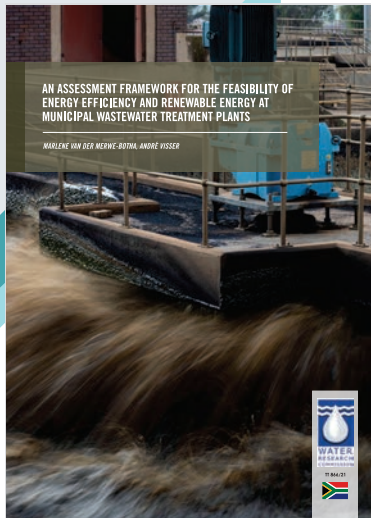

AN ASSESSMENT FRAMEWORK FOR THE FEASIBILITY OF ENERGY EFFICIENCY AND RENEWABLE ENERGY AT MUNICIPAL WASTEWATER TREATMENT PLANTS

WRC report no. TT 866/21

Energy awareness has been growing in all sectors of industry, both public and private, mainly as a result of factors such as increased electricity and fuel costs, interrupted power supply risks, as well as a growing environmental awareness and the impact of energy inefficiency. This awareness and the need for energy efficiency (EE) and renewable energy (RE) recovery (co-generation) prompted an investigation into the key drivers and factor that impact on the feasibility of EE and RE projects at municipal wastewater treatment facility, known for its significant energy conservation and generation potential. This project aimed to identify and assess the cross-functional aspects that impact on EE and RE at municipal wastewater treatment works from global and local perspectives; to develop and test a framework to assess EE and RE at three case sites; and to build a picture of how the learnings from this study could benefit the uptake of EE and RE at SA municipal plants.

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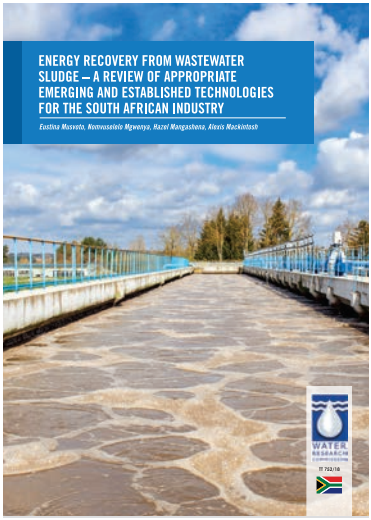

ENERGY RECOVERY FROM WASTEWATER SLUDGE – A REVIEW OF APPROPRIATE EMERGING AND ESTABLISHED TECHNOLOGIES FOR THE SOUTH AFRICAN INDUSTRY

WRC report no. TT 752/18

The historical approach to sludge management in South Africa has been mostly to implement strategies and practices that fulfil legislative and regulatory requirements. Although Department of Water and Sanitation regulations recommend beneficial use, there are very few wastewater treatment plants (WWTPs) that recover energy (and/or other valuable resources) from wastewater sludge. However, the electricity shortages in 2008 exposed the risk to wastewater treatment operations posed by an unreliable power supply and continuous increases in electricity prices, stimulating interest in technologies for recovering energy from wastewater sludge. In response, the WRC and its partners increased research funding into technologies to recover energy from wastewater, to provide detailed information on such technologies and decision support tools that can assist municipalities to evaluate these technologies. The project evaluated one innovative/emerging and two established sludge-to-energy technologies that have not yet been implemented in South Africa.

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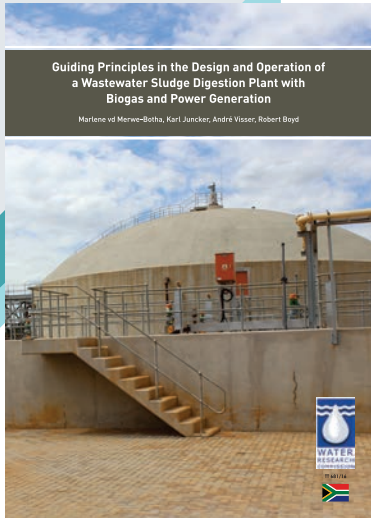

GUIDING PRINCIPLES IN THE DESIGN AND OPERATION OF A WASTEWATER SLUDGE DIGESTION PLANT WITH BIOGAS AND POWER GENERATION

WRC report no. TT 681/16

The South African industry is widely acknowledged for its excellence in process design. However, some disconnect have been identified between the work of the design engineer, the process manager and the process controller. Opportunity presents itself to align the work of the process designer, who considers design criteria but often exclude operational optimisation of the system, and the process manager, who may lack design knowledge but are well conversed with operation of the plants. This study aims to not only align and optimise the process design and operation, but also to unlock the opportunities presented by integrated- and advanced sludge treatment methodologies. One of the value adds of sludge treatment is the generation of energy, which is gaining interest as the price of electricity increases and interrupted supply impact on the ability of treatment facilities to meet regulatory targets. Anaerobic digestion, coupled with Combined Heat and Power (CHP) generation is becoming an attractive technology. The study explores the case of the City of Johannesburg's full-scale CHP installation.

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NUTRIENT AND ENERGY RECOVERY FROM SEWAGE: TOWARDS AN INTEGRATED APPROACH

WRC report no. TT 661/16

The transition to a low-carbon and resource-efficient economy has begun, also in South Africa. Wastewater is increasingly viewed as a 'water-carried waste', presenting opportunities for recovery of nutrients and energy, as well as water. Ecologically and economically more sustainable sanitation and wastewater management solutions are being explored and implemented. Among the sewage-borne resources, phosphorus is an important, non-substitutable nutrient for all life forms, particularly in the growth of plants, and is therefore essential in ensuring universal food security. Human activities have disturbed the natural phosphorus cycle and remain heavily dependent on mining of non-renewable rock phosphate. As a result, there is a particular interest in phosphorus recovery. This technology transfer report firstly explores phosphate recovery possibilities from wastewater, relative to its potential South African market and developments in wastewater treatment.

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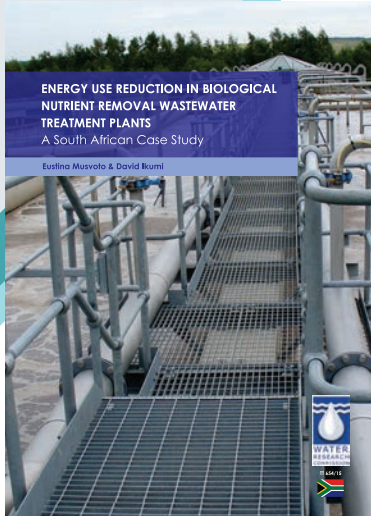

ENERGY USE REDUCTION IN BIOLOGICAL NUTRIENT REMOVAL WASTEWATER TREATMENT PLANTS – A SA CASE STUDY

WRC report no. TT 654/15

Wastewater treatment uses about 55% of the energy consumed in the South African water sector. The bulk of this energy (50-75%) is used for aeration at biological nutrient removal activated sludge plants, which are widely employed for municipal wastewater treatment in order to meet the Department of Water and Sanitation's strict final effluent discharge regulations. Focusing on aeration energy use reduction therefore yields the most savings in energy cost. This project was focused on aeration energy conservation in wastewater treatment. The project investigated feasible practical aeration energy conservation measures that can be implemented at biological nutrient removal activated sludge plants that not only result in energy use reduction, but also ensure final effluent compliance with discharge regulations; thus satisfying both the primary objective of wastewater treatment as well as energy conservation.

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ENERGY EFFICIENCY IN THE SOUTH AFRICAN WATER INDUSTRY: A COMPENDIUM OF BEST PRACTICES AND CASE STUDIES

WRC report no. TT 565/13

Energy will in future remain a high-cost item for municipalities and utilities which operate and maintain water and wastewater processes. Energy consumption will continue to increase as more people are provided with water and sanitation and new technologies are implemented to meet stricter effluent and potable water quality requirements. This project covered the principal activities of water and wastewater businesses and focused on the identification of current best practice, tools and technologies. The study evaluated both incremental improvements in energy efficiency through optimisation of existing assets and operations, and substantial improvements in energy efficiency from the adoption of new technologies. It also highlighted new processes, plant types and systems, which realise more substantial energy gains. Water and wastewater treatment plant surveys were conducted to document case studies and examples of best practice.

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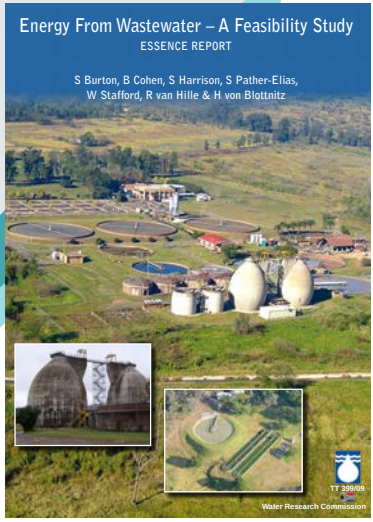

ENERGY FROM WASTEWATER – A FEASIBILITY STUDY (ESSENCE REPORT)

WRC report no. TT 399/09

The opportunity exists to improve the current wastewater treatment processes by applying new solutions and technologies that can also reduce energy inputs and/or generate energy for other processes. This study explored the various waste streams and assessed the feasibility of appropriate technologies that could be used to generate energy. The assessment considered the net energy generated from wastewater foremost while the conservation or reclamation of water, reduction in disposal of wastes (solid, liquid and gas) and the generation of by-products were considered as added benefits. The technical approaches to recovering energy from wastewater were outlined and the feasibility of applying various technologies and solutions explored. Local and international case studies were used to demonstrate working examples and frame their potential in the South African context. Specific case studies considered particular processes or waste streams and determined the practical and large scale application of energy recovery from these wastewaters. Lastly, community and industrial surveys were conducted to assist in formulating recommendations for industry (wastewater generators), researchers (industrial and academic research) and policy makers (government).

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ENERGY FROM WASTEWATER – A FEASIBILITY STUDY

This guide is based on a study funded by the WRC with the purpose of determining the feasibility of developing technologies for energy recovery from wastewater. 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.

WRC report no. TT 400/09

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WATER CONSERVATION THROUGH ENERGY CONSERVATION

Two separate but similar process integration techniques (thermal pinch analysis and water pinch analysis) have been developed to optimise the thermal efficiency or the water efficiency in industrial complexes. Combining these two techniques could result in significant energy and water savings in South African industries. The overall aim of this project was to promote both water and energy savings in the South African process industry through more efficient use of both process water and cooling and heating utilities.

WRC report no. 1368/1/07

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