Direct dry cooling in the power sector

Matimba, South Africa

water scarcity impact

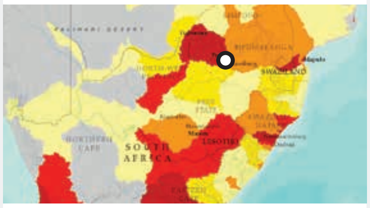
Reduced withdrawal	●
Reduced consumption	●
Improved water quality	
Increased productivity	●
Net basin benefit	●

volumetric impact
62 500 000 m³/yr

capital cost
confidential

estimated unit cost of water
not available

Water Stress
Matimba, South Africa ○



Arid & low water use | Low (<10%)
Low to med (10-20%) | Med to high (20-40%)
High (40-80%) | Extremely high (>80%)
No data available

Water Stress Map:
Gassert, F., M. Landis, M. Luck, P. Reig, and T. Shiao. 2013. "Aqueduct Global Maps 2.0."

Confidence level
Low Medium High

Water Scarcity Impact Key
Main Minor

Credits
We wish to acknowledge the assistance of Eskom staff in the preparation of this case study.

Project Overview

Water resources are under considerable pressure in South Africa however they are critical for the production of electricity. Eskom, South Africa's and the African continents leading electricity supplier is a government owned utility that provides electricity to almost 95% of all end users in South Africa, and close on 60% of the entire electricity consumption on the African continent. Eskom's coal fired power stations are steam driven using highly purified water and there is an effort to recover and re-use water due to the high costs in production and water scarcity. Eskom have a zero discharge policy and water is only lost from the plants during the condensation of the spent steam and as ash slurry.
In the financial year of 2010/11, the Eskom fleet consumed a total of 327 000 000m³ of water during the power generation process. If innovative technologies for more efficient cooling using less water had not been implemented, this consumption would have been at 530 000 000m³.

Matimba Power Station in the Limpopo Province is an example where direct dry cooling has been implemented to reduce water consumption. Limpopo Province is one of South Africa's richest agricultural areas but also particularly dry and unable to meet its water needs from its local supplies. Matimba Power Station is the largest direct-dry-cooled station in the world, with an installed capacity of greater than 4 000MW. It makes use of closed-circuit cooling technology reducing water consumption to around 0.1 litre per kWh of electricity distributed.

Key Elements

- The main driver for this intervention was the medium to long-term water resource security. This is under threat due to conflicting demands for the right to use water, depleted environmental flows, population and economic growth and the implications of climate change.
- Installation of a direct dry cooling system to reduce water losses during the condensation of the spent steam.

Key Outcomes

- Water use in Matimba power station is in the order of 0.1 litres per kWh of electricity produced.
- In comparison wet cooling system power stations use 1.9 litres per kWh of electricity produced.
- Water savings of 62 500 000m³/yr.
- Reduction in average unit power output of 1% compared to a comparable wet cooling system.

Matimba, South Africa

Intervention Features

¬ Direct dry cooling for power generation

Project Levers

(1) Installation of a direct dry cooling system:

In a steam turbine, ultra-pure water in the form of superheated steam is the main component in driving the turbine and generator to create electricity. Like any significant input to a process, maximising the efficiency of usage of the primary inputs is key to driving down not only the operational cost of the process but also reducing the environmental footprint of the process. This is particularly applicable in the case of water as it is a scarce commodity.

To achieve condensation by reducing the steam temperature in a traditional wet cooling system, a cooling water system is employed that pumps colder water from outside, through a condenser via a nest of tubes, with the steam on the outside. As a result of the temperature difference between the water and steam, condensation is achieved. The warmed cooling water then flows out to a cooling tower where an upward draft of air removes the heat from the water and after cooling, this water returns to the condenser. It is during this cycle with the upward movement of air that a substantial amount of water is lost. Typically, wet cooling uses 1.9 litres of water per kWh of electricity produced.

In the direct cooling system, steam from the final stage turbine blades is channelled directly into radiator-type heat exchangers. The direct cooling system has no cooling towers. The heat is conducted from the steam to the metal of the heat exchanger. Air passing through the exchanger is supplied by a number of electrically driven fans. The air removes the heat, thus condensing the steam back into water which will be used once again to produce steam in the boiler.

Above: GEA Aircooled Systems

Matimba Power Station is the largest operational directdry- cooled station in the world with an installed capacity of approximately 4 000MW. Water use is in the order of 0.1 litres per kWh of electricity produced. This is 19 times less than the average water consumption of power stations that function with wet cooling systems and use 1.9 litres per kWh of electricity produced. Matimba uses approximately 3 500 000m^3 of water per annum whilst an equivalent wet cooled power station would use an average of 66 000 000m^3 per annum.

The dry cooling system requires 48 fans of 10m diameter for each of the six units. This corresponds to an auxiliary power of 72MW, approximately 2% of the station's total generating capacity.

Whilst financial data is not available for Matimba power station, a previous Eskom estimate indicates that the capital cost of the dry cooled system is 170% of an equivalent wet cooled system.

In line with its drive to reduce overall water consumption all Eskom new build power stations are dry cooled. The water saving achieved by this is significant. However, other factors that are associated with a move to dry cooling are listed below. These are a cost incurred when generating power with a much reduced water demand.

- Increased auxiliary power demand for cooling fans.
- Generation performance is sensitive to meteorological conditions, in particular ambient temperature and high winds, this can result in a less reliable generating capacity of between 10-15%.
- The annualised capital cost of a 500MW air cooled coal fire power plant is approximately $15.5m compared to a wet cooled station figure of $3.6m.