Low water levels aid plans for rehabilitation of Kariba Dam

By Tom Nevin

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In the months ahead, the Kariba Dam hydroelectric scheme must deal with the twin challenges of not holding enough water on the one hand and too much of it on the other.

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The capricious moods of the weather in the Zambezi River catchment leave everyone guessing. The flood plain is a huge swathe of mainly bush land carved by tributaries that deposit water into Africa's fourth-biggest river for its journey to the monstrous Lake Kariba, some 181-billion tonnes of water in extent. So far, the rainy season has been reasonable, but worryingly patchy. There's an upside, however.

Kariba was built on a gorge on the Zambezi River. The dam wall forced the rising waters to spill out of the gorge and back up over the land upstream creating a 250km long lake.

"Most of the storage is in the lake's upper levels and, even when most of the storage is depleted, the water levels are still quite a lot higher than the turbines," notes New Zealander Bryan Leyland, a global expert on hydroelectric schemes.

"I checked to see if they're running it down to levels that put the turbines at risk of cavitation or vibration," says Leyland.

"The rule of thumb is that the Francis turbines can operate down to 65% of the design head. At Kariba, the design head would probably be about 3m below the maximum level. As it is now, about 18m below full, the low level is not putting the turbines at risk. The problem might well be that, if the level goes any lower, air will be sucked into the turbine intakes."

Questions were put to the Zambezi Water Authority and Zambia's Institute of Engineering, but elicited no response.

The situation at both Kariba's north and south bank power stations is that despite exceptionally low water levels, Kariba Dam continues to generate electricity, thanks to a geological stroke of luck and engineers with the skills to take advantage of it. The 56-year-old, 1,600MW scheme hit the headlines two years ago, when reports circulated, eventually confirmed by the World Bank, that urgent intervention was needed to arrest erosion of the dam wall foundation and to replace faulty floodgates. Kariba's capacity will increase to 1,926MW when turbine upgrades are completed at the Zimbabwe south bank power station in 2019.

Kariba's geological configuration on the Zambezi on the borders of Zambia and Zimbabwe, while not unique in the world of hydroelectricity, is propitious in coping with limited water volumes to produce more energy than such low levels could normally allow, even though the maximum power output is reduced.

In generating hydro power, flow and head are the vital components. The flow is the volume of water that can be captured and redirected to turn the turbines and the head is the distance the water will fall on its way to the turbines. The larger the flow and the higher the head, the more energy is available for conversion to electricity.

Double the flow and double the power, double the head and double the power again. Where Kariba scores is that it can produce a decent amount of energy from dam levels as low as 12%. The power generator can get away with not having a large flow of water, because gravity will provide the energy boost.

"At Kariba, electricity output is a rare multiple of both flow and head - the height of the lake above the downstream river tailwater level," explains a British dam engineer familiar with the scheme. "It's a bit like the accelerator on your car. If you don't press the accelerator pedal to the floor, you don't go as fast because the engine is getting a limited amount of fuel. Similarly if you let out less water because river flows are low and/or the lake level is low, you get less power. This does not prevent the operation of the power stations because the turbines are designed for this condition.

"The work needed at Kariba is a bit more than an annual service, but like your car, it won't stop working three days after the next service is due."

He also weighed in over reports that Kariba might fail in three years. "That's a load of rubbish. No one could predict with accuracy that this would occur and I'm sure any dam engineer would tell you that."

A World Bank spokesman confirmed in an email interview that the rehabilitation programme has commenced. This includes the reshaping of the plunge pool and refurbishment of the spillways.

Procurement of the contractor for the plunge pool works has been concluded and is pending final approvals. The contractor is expected to be on site in the first half of 2017.

"Procurement of a contractor for the spillway works was launched in December 2016 with the pre-qualification, followed by the tender documents in the first half of 2017," he says.

"Work on the gates is expected to begin in 2017."

Kariba Dam has been central to regional energy security and economic development since it was commissioned in 1960.

"A catastrophic failure of the dam would result in devastating regional flooding and significant loss of life," said the World Bank spokesman. "An estimated 3-million people live in the area that could potentially be affected by such a devastating

event."

The $295m rescue operation is being funded by the European Development Bank ($100m), African Development Bank ($75m), World Bank ($75m) and Swedish government ($47m).

The rehabilitation programme is guided by the so-called independent Panel of Experts (PoE), the role of which is to provide an independent review and advice to the Zambezi River Authority (ZRA), Kariba's Zambia-Zimbabwe collective watchdog.

"The PoE has met on several occasions, most recently with a joint meeting of the ZRA, the financing partners and the various engineers," reports the World Bank spokesman.

"They continue to provide advice to ZRA and the financing partners and have endorsed the proposed approach to the rehabilitation works."

The region's peak rainfall months occur from March to May. However, unseasonably heavy falls, causing flooding in some parts of the Zambezi River catchment, have already been reported.

"The Zambezi River upstream from the Victoria Falls experiences a rainy season from late November to early April, and a dry season the rest of the year," notes the World Bank.

"However, the river's flood season is February to May with a peak in April."

He discounts fears that the current floods upstream could fill the dam up suddenly and that this could be a danger.

"The hydrology of the Zambezi River and specifically the upper catchment and midreaches flowing into the Kariba reservoir are heavily influenced by the Barotse system upstream. This large floodplain attenuates the flow and results in a lag time of about three months between peak rainfall and peak runoff. This, coupled with the large size of the reservoir, means that Kariba has the ability to absorb large flood events and prevent a sudden rise in water levels."

The very low level of the water in the dam is a boon for rehabilitation teams replacing seized floodgates' gates and apertures. It is also favourable for the reshaping of the plunge pool on the Zambezi River bed. The rehabilitation works themselves have no effect on power generation, although the current low water levels have reduced the available head and cut back on electricity generation.

"The risk of spilling from the dam is reduced due to the current water levels in the reservoir and for this reason, we do not anticipate work will be interrupted in the early stages of the project," says the World Bank.

"We expect work to be able to begin as soon as the contract has been awarded and the contractor mobilised."

Coincidental to Kariba Dam's rehabilitation is an ongoing programme to beef up electricity generation from both the Zimbabwe south bank power station and its companion installation on the Zambia north bank. Zimbabwe has six turbines producing a total of 666MW.

China's SinoHydro is installing a further 300MW capacity at a cost of $533m funded by China Bank.

SinoHydro also added a further four turbines to the Zambia power station to boost output by 360MW for a total capacity of 960MW. The upgraded facility was commissioned in December 2013.

On completion of the south bank upgrade in 2019, Kariba's total capacity will be 1,926MW.

Source: Business Day