Mega-dam in Ethiopia

The Grand Ethiopian Renaissance Dam will be, once completed, the largest hydroelectric power plant in Africa and the seventh largest in the world. The facility will add 6.45 GW to Ethiopia's national grid and also reduce the carbon footprint of the African nation. The megaproject is also highly controversial as Egypt contests the project, stating it will limit its water supply from the Blue Nile.

By Lucien Joppen

Ana E. Cascão (2016)

The Grand Ethiopian Renaissance Dam (GERD) goes a while back, like most mega-projects. The eventual site (see map) for GERD was identified by the United States Bureau of Reclamation in the course of the Blue Nile survey, which was conducted between 1956 and 1964 during the reign of the Ethiopian emperor Haile Selassie. Due to the coup d'état of 1974, however, the project failed to progress. The Ethiopian Government surveyed the site in October 2009 and August 2010. In November 2010, a design for the dam was submitted.

On 31 March 2011, a day after the project was made public, a USD 4.8 billion contract was awarded without competitive bidding to the Italian company Salini Impregilo, and the dam's foundation stone was laid on 2 April 2011 by the Ethiopian prime minister Meles Zenawi.

Changes in design

Meanwhile, the design for the gravity dam has changed several times between 2011 and 2017, affecting both the electrical and storage parameters. Originally, the hydropower plant was to receive fifteen generating units with 350 MW nameplate capacity each, resulting in a total installed capacity of 5,250 MW with an expected power generation of 15,128 GWh per year.

Its planned generation capacity was later increased to 6,000 MW, through 16 generating units with 375 MW nominal capacity each. The expected power generation was estimated at 15,692 GWh per year.

In 2017, the design was again changed to add another 450 MW for a total of 6,450 MW, with a planned power generation of 16,153 GWh per year. That was achieved by upgrading 14 of the 16 generating units from 375 MW to 400 MW without changing the nominal capacity.

Extreme floods

As for the storage parameters, originally the dam was planned to be 145 m high with a volume of 10.1 million m^3. The reservoir was planned to have a volume of 66 km^3 and a surface area of 1,680 km^2 at full supply level. The rock-filled saddle dam beside the main dam was planned to have a height of 45 m, a length of 4,800 m and a volume of 15 million m^3.

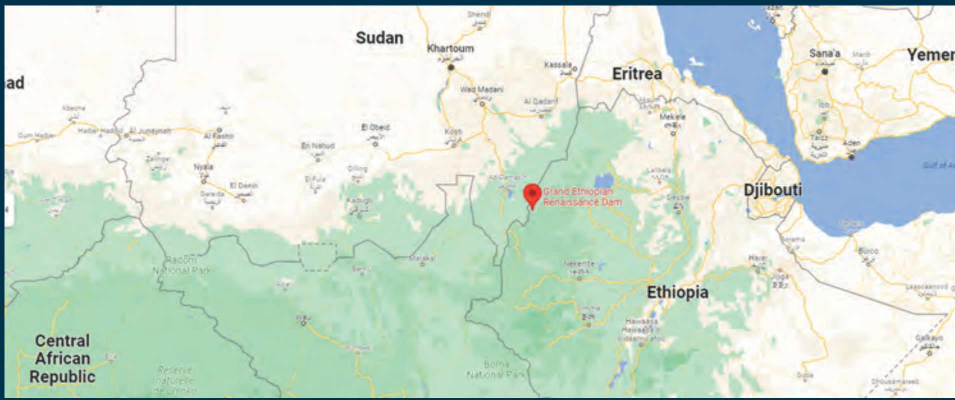
In 2013, an Independent Panel of Experts assessed the dam and its technological parameters. After the Panel made its recommendations, the dam parameters were changed to account for higher flow volumes in case of extreme floods: a main dam height of 155 m (plus 10 metres) and a dam volume of 10.2 million m^3 (plus 0.1 million m^3). The outlet parameters did not change, only the crest of the main dam was raised. The rock saddle dam went up to a height of 50 m (plus 5 metres) with a length of 5,200 m (plus 400 meters). The volume of the rock saddle dam increased to 16.5 million m^3 (plus 1.5 million m^3).

Key components

The design of the dam, carried out by the Italian engineering consultancy firm Studio Pietrangeli, revealed that the above dimensions have changed again in some cases. Studio Pietrangeli presented its concept at a conference in Morocco in 2017. The consultancy mentioned in detail the key components of the project: the river diversion system, the roller compacted concrete (RCC) main dam, a concrete faced rockfill (CFRD) saddle dam, a system of three spillways, two steel-lined bottom outlets, sixteen penstocks, two outdoor power houses, one 500 kV switchyard on right bank and six 500 kV transmission lines and one 400 kV transmission line. When comparing these technical parameters with the aforementioned recommendations, it seems that the dimensions have changed yet again.

Difficult to predict

One study (Mulat and Moges, 2014) concluded that under normal and wet flow scenarios of the six-year filling period, GERD has no significant impact on downstream water uses. "The agricultural water requirement from HAD (Aswan high dam) which is a concern in Egypt could not be affected under these scenarios. The reduction in the storage volume of HAD never reached its minimum operation level. (…) If the worst case scenario of six years consecutive drought would occur, or if the flow is reduced by 10 per cent or more from the long term mean annual flow, then the planned six-year filling of GERD is insufficient to fill the reservoir without affecting downstream water uses."



The GERD is located 700km northeast of the Ethiopian capital of Addis Abeba, in the Benshangul-Gumaz region.

For all the studies, potential consequences downstream are difficult to predict as many factors come into play, such as rain fall and flow in the basin during filling or the speed of the filling process of the GERD-reservoir. In the coming years, the effects of GERD for the downstream countries will become clearer.

The river diversion system, designed to discharge up to 14,700 m^3 /s, includes four culverts (octagonal section 7.5x8.3m) for discharging during the dry season up to 2700 m^3 /s (December to June) and a temporary stepped spillway for dam overtopping during the wet season. The first stage of river diversion envisaged the excavation of a channel, 1100 m long and 120 m wide, on the right bank to allow the construction of the dam in the 30 m deep gorge at river thalweg and of the culverts on the left bank.

Sixteen penstocks

Furthermore, the studio designed an RCC main dam with a maximum height of 175 m and a total volume of RCC of about 10.2 million cubic meter and a CFRD saddle dam (60 m high and 5 km long, with an embankment volume of 17 million m^3).
A system of three spillways (main service gated spillway, free-flow crest spillway and side channel un-gated spillway) is designed to safeguard the project against maximum floods. Two steel-lined bottom outlets (6 m diameter), embedded in the dam body, allow the control of reservoir level and the discharge during plant outage periods. Sixteen penstocks (8 m diameter) are embedded in the dam body. Two penstocks at lower elevation are dedicated to early generation during reservoir impounding.
Two outdoor power houses are located at the main dam toe on the right and left riverside housing ten Francis turbine units and six Francis turbine units respectively, with 375 MW each totalling 6,000 MW installed capacity.

Controversy

Anno 2021, the GERD's construction has passed the ¾ mark. The filling process of the dam reservoir has already started and is expected to continue until 2026. Currently, the second filling has been completed, as announced by the Ethiopian government in July 2021. By now, the reservoir contains sufficient volume to generate hydroelectric power. Egypt and Sudan opposed this unilateral move before reaching a legally binding agreement on filling and operating the dam.
This is where the controversy comes in. Since the conception of the megaproject, both Sudan and Egypt have objected against the scale of the dam, arguing this will impact the water supply to their countries, both impacting society, agriculture and energy production.
Previously, there have been talks between the parties but as for now nothing has been resolved. In fact, in the summer of 2021 the dispute seemed to escalate as Egypt threatened to carry out military action if Addis Ababa initiated the second filling.

Fundamental differences

Luckily, this hasn't happened. However, it seems that there is no resolution in the short term. From various press reports, it looks like Ethiopia and Egypt/Sudan have a fundamentally different approach for a negotiation about how much water Ethiopia is allowed to 'take out' of the Blue Nile for GERD.
Ethiopia wants to base negotiations on the Nile River Cooperative Framework Agreement (CFA), signed in 2010 by six Nile basin countries (Ethiopia, Uganda, Kenya, Tanzania, Rwanda and Burundi). The CFA was intended to address Nile water quotas that were determined in an agreement from 1959 and to shift control over the Nile River from the downstream to the upstream countries. Egypt and Sudan, who did not sign the CFA, want to keep the 1959-agreement intact.
Meanwhile, several studies have been conducted on the impact of GERD on downstream water supply for agriculture and hydropower, in particular the Aswan dam.

Ball and butterfly valves (see image) are the most common-used types in hydropower. The valves are controlled by a counterweight and hydraulic cylinder and they belong into the group of safety valves. Those valves are mostly used at hydropower plants, in front of the turbine. As the flow conditions vary per hydropower station, these valves are designed and manufactured tailor-made. Very often are these valves, both butterfly valves and ball valves, supplied with other devices, such as dismantling joint and parts of the pipeline serving as an additional measurement. Both can be also equipped with by-pass of the main pipeline, connected for the medium pressure sensor in the pipeline or in the entrance of the pipeline. An anchor frame is another accessory, concreted into the floor of the control room to accommodate a safety valve.

Source: ARMATURY Group

Note: ARMATURY Group was not involved in GERD-project.