

Cambambe I

A partnership to power Angola



“Voith wholeheartedly supports Angola and its people in rebuilding after three decades of civil war. We have been a resource for development efforts in Angola since the 1950s and resumed commercial relations there in 2001. We know the country and understand the people and their needs very well. Our commitment to Angola is more than just building hydropower plants.”

Christer Parkegren, CEO, Voith Hydro, subsidiary Heidenheim.

Global cooperation for sustainable development

Today in Angola, the rehabilitation of the Cambambe hydropower plant is being realized. The initiative will endeavor to supply the urgent needs of the metropolitan area of Luanda and to extend electricity to the north central region of Angola. This hydropower project began in 2008, with Voith supplying the complete turbine technology, related equipment and services. The project was successfully completed in December 2012.



Local market near Cambambe.

Operated by Empresa Nacional de Electricidade (ENE), the Cambambe plant resides on the banks of the Kwanza River on the border of the Kwanza Norte and Bengo provinces in Angola. First installed in 1963, the facility was damaged during the political instability in the last decades.

In recent years, Angola has placed hydropower at top of its energy agenda, estimating the total potential of hydro energy at approximately 18 GW. The government is planning to invest 17 billion US\$ through 2016 for the rehabilitation of power

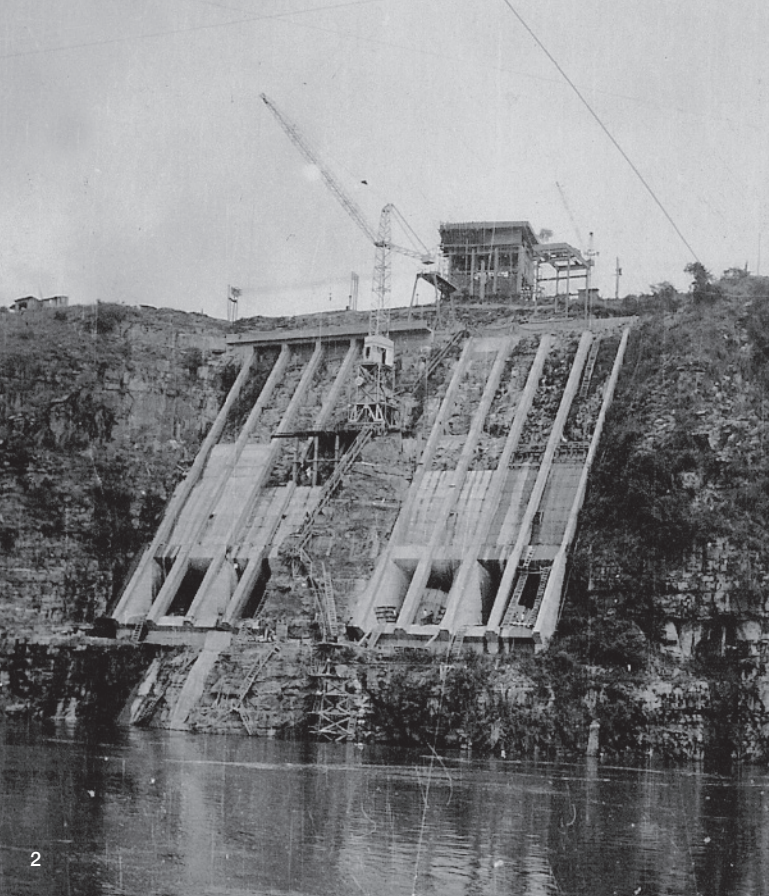
plants and construction of new hydropower projects. The aim is to increase the existing capacity of 1 200 MW to 5 000 MW.

As an environmentally friendly technology, hydropower represents sustainable development for Angola and will be a base for both local and national development. In addition, the generation of renewable energy will reduce emissions of greenhouse gases and mitigate local pollution caused by emissions from burning fossil fuel.



Angola – a reference for revitalization and modernization

After decades of instability, Angola is paving the path for the future. The country is investing massively in infrastructure like roads, airports, water and energy and preparing itself for consistent development.



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Angola – a West African pearl



- 1 960 km length: The Kwanza river is the longest river in Angola.
- 2 Construction of the original plant.

Promising future

Angola's economy is undergoing a period of transformation. Its vast mineral and petroleum resources have helped spur annual economic growth at a two-digit pace since the 1990s. From 2001 to 2010, Angola had the world's highest annual average GDP growth, at 11.1%. The country is rich in diamonds, oil, gas and copper as well as forest.

Getting power to the people

Much of Angola's infrastructure, including power plants and grids need to be rebuilt and expanded. The demand for electricity is booming due to the amazing growth of the economy

and the fast increase in population. Therefore, generation and distribution systems have to be built to ensure a reliable supply of electricity and to increase the access rate.

The Angolan government is making a multi-billion investment in energy projects such as Cambambe hydropower plant to overcome these shortfalls. The energy initiatives will not only provide access to electricity, improve the quality of living, and promote socioeconomic harmony but will also support economic development and local job creation. The Cambambe hydropower plant is poised to play a significant role in this effort.

Vision for Cambambe finally set in motion

In 2008, Voith was contracted to supply the complete turbine technology, related equipment and services for the Cambambe I hydropower plant. The emphasis of the project was on the rehabilitation of four existing turbine generator units.

The Cambambe hydropower plant, located 180 kilometers east of Luanda, initially entered operation in 1963. It was originally designed with a total installed power of 260 MW generated by four turbine units and operated at reduced fall. Original plans called for the construction of a second powerhouse and the dam heightening.

When the rehabilitation project was initiated in the mid-2000s, two of the original turbine units were still in operation, one was under major overhaul, and one was entirely out of operation. Therefore, the primary goal of Cambambe I was to replace the four turbines to increase power generation capacity and extend operation of the plant for further decades.

Choosing the right supply partner

As an industry leader in the production and supply of hydropower generators, turbines and associated control systems, and with its long-term experience in Angola, Voith Hydro was

the right choice as a supply partner for Cambambe. Voith's products and services range from engineering to commissioning, from automation to after-market services as well as manufacturing and project management. Voith was contracted to supply the electro-mechanical equipment and systems for the turbines rehabilitation, as well as to dismantle and erect all related equipment.

Environmental integration

Empresa Nacional de Electricidade (ENE) assembled a team of expert suppliers who from the start worked together to anticipate and address the challenges that would arise as a result of the surrounding conditions. In preparing for the given African environment, the necessary physical infrastructure was put in place, including paving roads and building camp-style lodging for the workers. The camp consists of stone houses that will be turned over to the local people when the projects are completed.





Voith modernizes turbines, governors and offers specialized expertise

During the planning and design phase Voith identified the best-fit technology for Cambambe I. Based on the goal of revitalizing the plant's outdated equipment and maximizing power generation capacity, the decision was made to design a state-of-the-art hydraulic for the Francis turbines combined with digital and hydraulics governors from Voith.

Type of Francis turbines

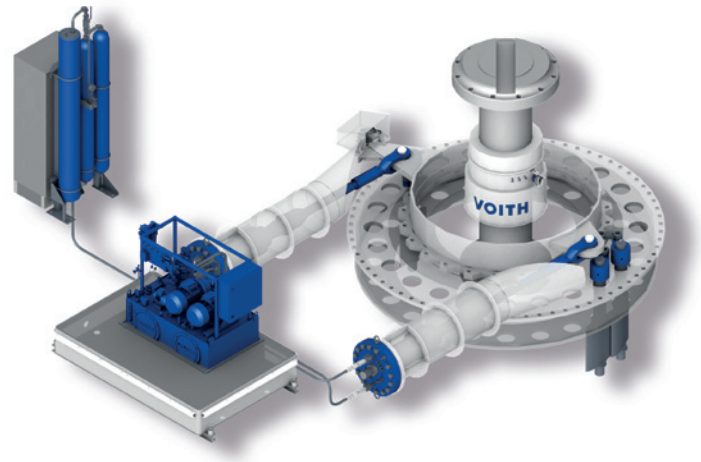
Nominal rated output per unit	67 MW
Rated net head	106 m
Rated speed	231 rpm
Runner diameter	2.98 m
Nominal rated flow	72.2 m ³ /s

Large and powerful Francis turbines

Driven by the latest hydrodynamic research and continuously optimized for high performance, the Francis turbine makes up well over half the turbines manufactured by Voith. They are among the world's largest and most powerful turbines and are in service around the globe.

Francis turbines are used primarily for medium heads up to 600 meters and large flows. Voith has successfully commissioned Francis turbines with runner diameters of up to 9 meters and with outputs of up to 800 MW. Their special hydraulic characteristics enable relatively high-speed compact units, right up to the highest power outputs.

For Cambambe I, Voith supplied four 67 MW Francis turbines with a total capacity of 268 MW. Each turbine was installed sequentially, leaving the other turbines to remain operational in order to supply the region with electricity.



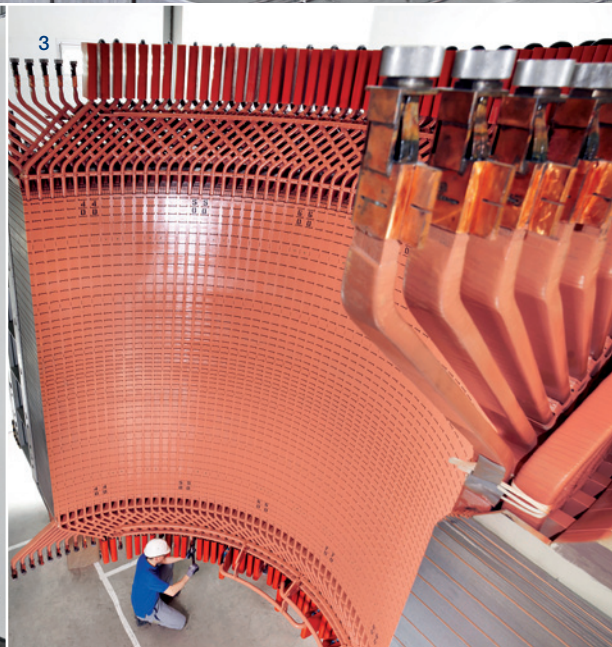
Complete design of the regulating system with 3D-CAD

Turbine governor system: reliable control elements for maximum safety and availability

The ability to control a hydropower unit and the quality of the provided electric power largely depend upon the performance of the turbine governor system. Voith HyCon digital governors combine cutting-edge technology with concepts that have proven their reliability and performance under all operation conditions over many years. Because of its modular and flexible design, it can be customized to satisfy the requirements of every type of turbine.

The importance of interfacing the control system to the machine is frequently underestimated. The electrohydraulic converters to operate the servomotors that are the main control elements for the hydropower conversion processes are individually designed for each power unit. Our wealth of experience in hydropower engineering helps us to create the required level of reliability and control accuracy.

For Cambambe I, Voith delivered an optimally aligned turbine governor package that includes all equipment for outstanding control performance of the Francis turbines. It included the digital governor, oil supply and pumping groups, pressure tanks, main valves for the oil supply, regulating valves and last but not least the hydraulic control elements.



Successful partnership builds strong foundation for the future

With the project in Angola, Voith Hydro demonstrated why an integrated, full-line supplier is essential to a project of this magnitude. Offering hydropower equipment, technology and services around the world, Voith's portfolio of products covers the entire life cycle of new and existing hydropower plants – large, medium and small. Its stand-alone solutions include plant automation, as well as lifetime services for all types of hydropower equipment.

As part of Voith's global network, each local facility operates under the same cutting-edge platform and is equipped with consistent best-in-class processes and tools. This network also ensures that Voith can meet special customized requirements – from project planning and equipment manufacture to commissioning and plant maintenance.

With branches and production facilities for electrical and hydraulic machines and components in Europe, Asia, North and South America, Voith is close to its customers and all major hydropower markets.

Voith's customers in Angola were very pleased with the results of Cambambe I. The new plant equipment was up and running on schedule and has performed optimally as expected. Voith representatives are available for ongoing service and maintenance of the equipment.

Contracted for Cambambe II

Thanks to the competence to supply not only turbines but also perfectly fitting generators, as well as broad experience and capability in structuring financing, Voith received the order for equipment supply for the Cambambe II project.

Ultimately, the Cambambe plant with the expansion under construction will generate enough power to provide the people of Angola with clean, renewable electricity throughout the country, helping them to enrich their lives. The plant also supports the economic growth of Angola and the overall development of this promising country.

Key Milestones

2005	Initial contact with Voith for the rehabilitation of the complete water-bearing portion of Cambambe I.
2005 – 2007	Project team assembled.
2007 – 2010	Financing for the project completed, with Voith's support in structuring the financing.
2008	Voith chosen as contractor.
2011	Start of commissioning of the first unit.
2011 – 2012	Installation of all turbines completed.
Dec. 2012	All four turbines in operation.
June 2013	Expected official inauguration of the hydropower plant Cambambe I.

1 At the workshop of Voith Hydro Heidenheim.

2 Voith Standard Field Service Container with tools and devices for installation at site.

3 Mounting of a Voith generator.

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