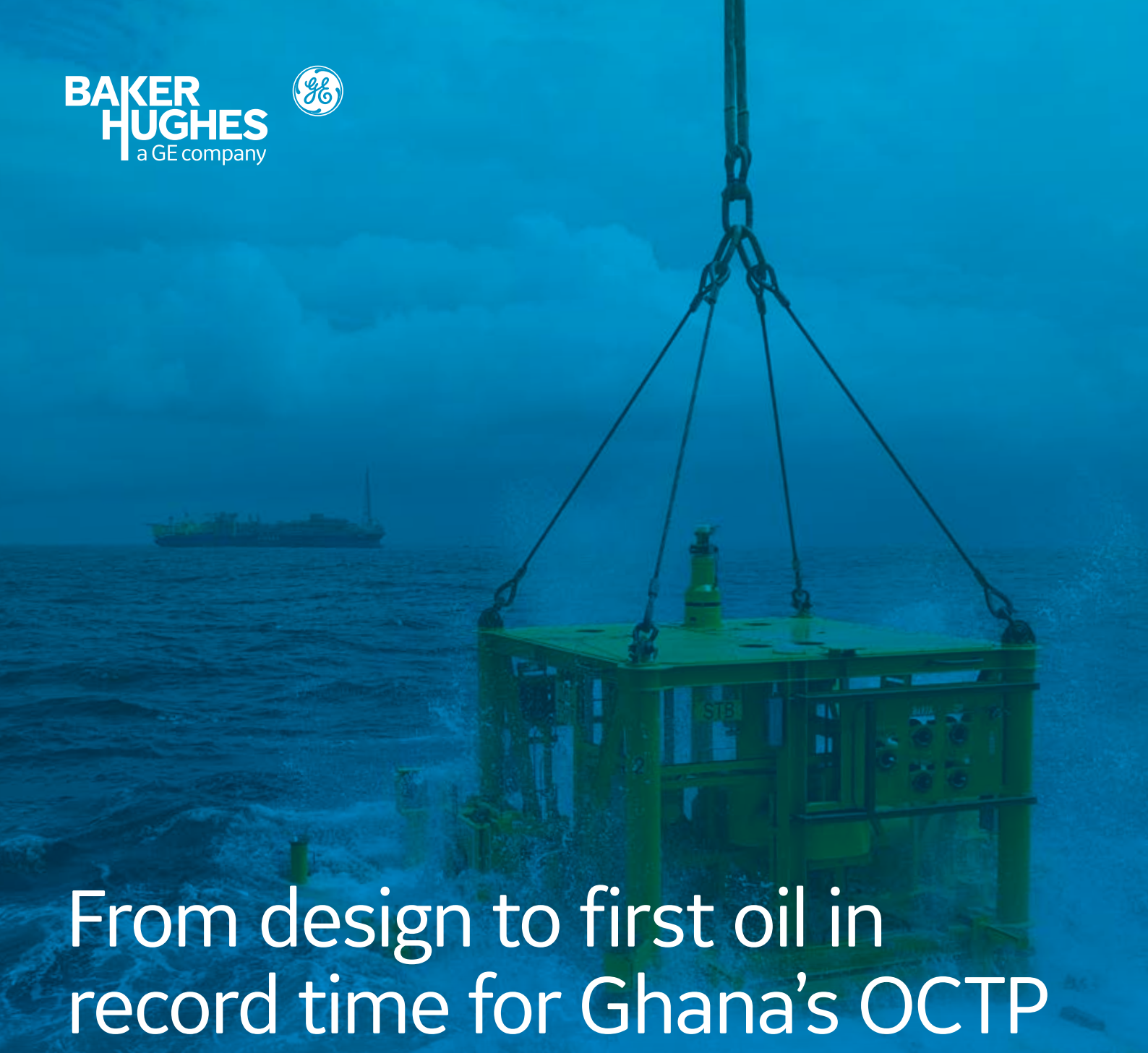

BAKER HUGHES
a GE company

From design to first oil in record time for Ghana's OCTP

For the Offshore Cape Three Points (OCTP) integrated oil and gas development project, we are supplying subsea infrastructure and core rotating machinery for the FPSO.

2017	3	15+
first oil achieved	months ahead of schedule	years of domestic gas supply from OCTP

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Challenge

Offshore Cape Three Points (OCTP) is an integrated oil and gas project located in the Tano Basin, about 60 km off Ghana's Western region coast, in water depths up to 1,000 m. Its three fields (Sankofa Main, Sankofa East, and Gye Nyame) have a combined total of about 40 billion m^3 of non-associated gas, and 500 million barrels of oil.

OCTP's crude oil will be stored in a Floating Production Storage and Offloading (FPSO) vessel to supply tankers for international markets, while its gas will be utilized entirely by Ghana's domestic market — feeding the country's thermal power plants and various industrial customers for more than 15 years.

The challenges here were mostly driven by a compressed timeline. Our customer, Eni Ghana Exploration and Production Limited (Eni), and its partners started developing the fields in January 2015 — targeting first oil by the third quarter of 2017. Subsea components were produced at BHGE facilities in the UK, Norway, Singapore, and Ghana; and turbomachinery equipment manufactured and shipped from our plants in Italy, the US, and France to the FPSO provider in Singapore (with this transfer alone taking one month). Therefore, communication, collaboration, and logistics proved to be just as important as engineering.

Solution

Oilfield equipment

We secured a substantial scope of work for this project, with responsibility for the supply of 21 deepwater, horizontal trees (for oil and gas production, and water and gas injection); 10 subsea wellheads; subsea and topside controls; nine flowline end terminations (FLETs); umbilicals and umbilical termination assemblies (UTAs); an intervention workover control system (IWOCS); and completion workover riser (CWOR).

To support our work, and that of our Ghanaian joint-venture partner, we set up an integrated project-management team in the UK, in strict coordination with the Takoradi site in Ghana, while the client was co-located in our Bristol office. This allowed for excellent collaboration between the various teams to help ensure a smooth execution. As a result, we experienced more productive dialogue and accelerated timelines in response to any deviations, in compliance with the commercial agreement.

We earned Eni's trust by working to a 'Best for Project' philosophy, and maintaining a high say/do ratio — delivering equipment early and ensuring that the client team was fully engaged at every step to minimize changes and keep things moving. Lessons learned and best practices were leveraged from previous projects, helping us to stick to a set rhythm, and control costs.

BHGE's engineering and sourcing teams worked in partnership with our suppliers from the start to identify and eliminate any unnecessary cost drivers, without compromising safety or quality. One example was the use of substitute materials that provided the same functionality while reducing lead times across our different product lines.

With a 'one team' approach, we were able to minimize design changes and freeze engineering early — giving our sourcing team a conceptual design that let them start procurement of 90% of the scope for the subsea equipment. This, coupled with limited delays from our supply chain, meant we were at least 30% ahead of schedule for every component delivered to the customer — with the first two trees delivered to Ghana within 23 months.

In addition to providing technical support during installation, and conducting in-depth operator training, we are providing aftermarket services support for the project, including spare parts management, storage and preservation, and maintenance.

FPSO equipment

While we have undertaken a number of projects in partnership with Eni, this was our first with vessel owner Yinson. More time was therefore required at the outset, as the two teams familiarized themselves with each other's procedures and ways of working.

Converted from Yinson's Ulriken tanker, the renamed John Agyekum Kufuor FPSO is 333 meters long and 58 meters wide, with a double hull to reduce environmental risk. It has a storage capacity of 1.7 million barrels, a treatment capacity of 58,000 oil barrels per day, and a gas injection capacity of 150 mmscfd.

We supplied all equipment for its power generation, flash gas, and reinjection requirements — using a proven modular design approach to ensure the speed and efficiency needed to meet the timeline. Component units were manufactured, tested, and packaged at our various plants in the US, Italy, and France before shipment to Singapore.

The power-generation solution includes three of our revolutionary SeaSmart™ offshore packages. Each contains an LM2500+G4 gas turbine with a dual-fuel, singular-annular combustor (SAC), gear box, and a four-pole, 60-Hz electric generator — with auxiliaries, piping, wiring, and controls fully integrated on the skid. The SeaSmart program is continually pushing boundaries, incorporating advanced materials and more efficient design characteristics to simplify installation, extend maintenance intervals, and increase lifecycle productivity. Each module designed for this FPSO is just 20.7 x 4.4 m, and weighs 200 tons — 5% smaller and lighter than our previous generation of SeaSmart.

A similar approach was taken with our flash gas and reinjection solutions. The flash gas package includes two trains — each is 10.2 x 5 m and 90 tons, and includes an electric motor, gearbox, BCL356 compressor, plus fully integrated auxiliaries. The reinjection

"Starting production only two-and-a-half years after approval of the development plan is an extraordinary result, and a reason for great pride... All of this has only been possible thanks to the unwavering commitment of Ghanaian authorities and of our partners."

Claudio Descalzi, CEO, Eni

package includes two modules — each is 16 x 5 m and 127 tons, and includes an electric motor driving BCL306/B and BCL306/C compressors, and fully integrated auxiliaries.

These extremely compact and lightweight designs are key factors in enabling better space distribution, mass control, and usage of the FPSO.

It would typically take 14 months to build all these packages — but we had less than 11 months to do it on this project. We achieved this timeline through a number of measures. Collaboration between our project management and commercial teams during the project bid phase helped mitigate potential issues during execution, while close contact with Eni enabled the project to proceed smoothly, with few interruptions or scope changes. Our own sub-suppliers, particularly for critical items, were asked to maintain an accelerated lead time with close monitoring to ensure we were able to keep the project on-track. These factors combined for a record-setting completion in just 10 months.

The seven packages arrived at the Singapore yard in January and February 2016, and integration on the FPSO was completed in February 2017 — including partial commissioning with the gas turbine generator (GTG) running on liquid fuel. Final installation activities were conducted in Ghana in July 2017.

Pipeline services

Pipeline pre-commissioning services (PPS) are essential in ensuring trouble-free operations, protecting against erosion, safeguarding efficiency, maximizing throughput, and preventing hydrates from forming. Our PPS responsibility includes a scope of 18 flexible risers, 22 flexible flowlines, 5 dynamic umbilicals, 16 infield umbilicals, and 153 flying leads — with a number of separate operations involved, including flushing, cleaning, and testing operations for the flexible flowlines; high pressure hydraulic and electrical testing of the umbilicals and flying leads; and pressure monitoring during subsea deployment of the umbilicals. Our focus is on ensuring the client is able to achieve production as quickly as possible, while meeting the necessary regulatory parameters.

Building a world-class, local team

Our facility in Takoradi Port was inaugurated in March 2017. Equipped with a 1600 m^2 indoor test area (with capability for simultaneously testing three subsea trees), and 4,000 m^2 of indoor and outdoor storage, this facility is our primary service center for deepwater offshore projects in Ghana. As part of our commitment to building a world-class team at this facility, we plan to deliver more than 45,000 training hours over the next five years, and we've recruited more than 30 Ghanaians, including two fully-trained Field Service Engineers (FSEs), who have been involved in installation activities for OCTP.

In January 2015, we signed a memorandum of understanding with Ghana National Petroleum Corporation (GNPC) and Ashesi University College, for a phased approach to local capacity building. This incorporates education and skills development, curriculum enhancement programs, and improvements to teaching infrastructure at educational institutions, along with supporting the growth of Ghana's oil and gas supply chain, particularly small to medium enterprises.

Benefits

OCTP achieved first oil a full three months ahead of schedule — just 2.5 years from our contract date to production start. This achievement was not just indicative of our client's exploration skills, knowledge and field development vision, but it also illustrates the benefits of their new operational model — where Eni has a central role in project management aimed at improving time-to-market.

Designed for zero flaring and zero discharge, the project will have minimal environmental impact, with the non-associated gas set to expand Ghana's power-generation capacity by feeding its new power plants, and replacing light crude oil at its existing power plants.

Enabling technologies

LM2500+G4

This BHGE industrial aeroderivative gas turbine is based on the high reliability and availability of our LM2500/+ gas turbine heritage, and has the highest efficiency of any engine rated between 20 and 35 MW.

DHXT

Our next-generation deepwater tree is engineered for up to 15,000 psi and 10,000 ft water depths, and incorporates more than 30 years of design heritage. A modular concept is carried through all major components, allowing us to offer more competitive delivery times.

BCL Compressors

Our compressors are customized to cover a wide range of applications and pressures, with the highest efficiency standards in the market, and capability to manage discharge pressures from 70-430 Barg. For OCTP, we supplied three types of compressors: BCL306B, BCL306C, and BCL356.

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