Is Enhanced Oil Recovery the Future of Angola's Oil Production?

Interview of Geraldo Ramos, *Senior Production Engineer,* Sonangol EP

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Production decline in mature fields is a common challenge to offshore operators throughout the globe. And in West Africa especially, where developing new fields often requires delving into unexplored deepwater and ultra-deepwater territories, many have decided to take advantage of innovative technical developments in enhanced oil recovery technologies to recover the maximum from their existing oil reserves.

Sonangol EP is one of those companies who, despite recent positive discoveries in its offshore pre-salt acreage which should comfortably allow Angola to maintain its status as Africa's second largest oil producer, sees the need to ensure additional reserves are extracted from existing wells. Today, we speak with Geraldo Ramos, Senior Production Engineer at Sonangol EP who is currently undertaking a PhD at the University of Aberdeen focusing on Advanced Enhanced Oil Recovery techniques with specific focus on Angolan onshore/offshore fields. We discuss his results so far, his vision for Angola's 2018 production landscape and the experience he gained from the North Sea.

Geraldo Ramos, Senior Production Engineer, Sonangol EP

Offshore Network: What do you forecast for Angola's offshore production outlook for 2018?

Geraldo Ramos: I want to emphasise that oil production in Angola come from both onshore and offshore fields with a majority of the daily production coming from offshore assets. The average daily production is approximately 1,600,000 barrels with 14 blocks (assets) in production of which 3 are onshore and 11 offshore.
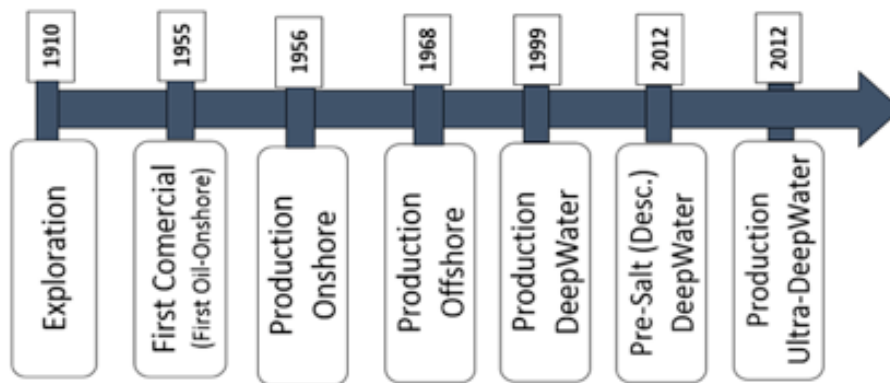
Angola's offshore production outlook for 2018 is dependent on several independent variables. These include the oil price, the president of Angola's recent decree to revitalise the oil and gas industry, the cost of operations, the dynamic attitude of Sonangol's new Board of Administration as well as the interaction between the new board and operators and service companies within the PSA (Production Sharing Agreement) contract or joint venture contract. Because the success of production activities in 2018 is not in the hands of Sonangol EP alone, but in those of all the key players of the oil and gas industry as well as other parts of Angolan society and government.

On October 6, 2017, the new Angolan President met operating companies (BP Angola, Cabinda Gulf Oil Company, Eni, Esso, Statoil and Total) and National Oil Company (Sonangol EP). He issued a presidential decree awarding the group's leadership to the Minister of Mineral Resources and Oil, Diamantino Azevedo. The group is tasked with delivering results that will improve investment conditions in the oil and gas industry. The development of an "effective institutional collaboration framework" with oil companies was identified as "important", allowing the assessment of the current opportunities and threats to the domestic market and industry. The challenges include optimizing the process of approving investments, budgets and other contractual documents; assessing tax issues applicable to oil and gas research and production; and proposing a framework of collaboration between the Government and oil companies.

The oil price is another important variable. Many projects suffered from the dwindling oil price in this market. As a result, Sonangol is working to reduce the cost of crude oil production. All these dependable variables and others will play a key part in defining the success of Angola's production in 2018.

ON: Enhanced Oil Recovery is the main subject of your research – why did you focus on this topic?

GR: EOR projects will form an important part of Angola's future production. My point of view is that it can boost the oil production in Angola and contribute to the economic development of the country. If we can recover at least 1% or 2% oil daily that could not have otherwise been recovered beyond secondary recovery, then more oil can be recovered thus creating more opportunities for small, medium and big (major) companies. However, this requires involvement from all the key players in the oil industry and other parts of Angolan society and government.

1910	1955	1956	1968	1999	2012	2012
Exploration	First Comercial (First Oil-Onshore)	Production Onshore	Production Offshore	Production DeepWater	Pre-Salt (Desc.) DeepWater	Production Ultra-DeepWater

**ON: Can you tell us a bit more about your current research project?**

GR: My current research is on enhanced oil recovery with a specific focus on Angola oilfields. Angola's exploration and production commenced in 1910 with first oil achieved in 1955. Since then, the majority of actual production has come from offshore oilfields varying from shallow to ultra-deep operations while the type of oil has ranged from light to heavy oil.

Angola's production to date is characterized by primary and secondary recovery where most of the oil production rates have reached a plateau and some have declined. To reverse this trend, enhanced oil recovery (EOR) methods are the best way to boost the production from current oilfields, instead of moving to remote areas where exploration, drilling & completion is very costly and carries a high degree of uncertainty. And we know worldwide oil recovery from secondary recovery is about 1/3 of OOIP. This implies that approximately 60 to 70% of the oil still remains in place. Using EOR, Angola can recover more than 50% of the OOIP. Therefore, I decided to work in this project which I think can benefit the country.

" Enhanced oil recovery (EOR) methods are the best way to boost the production from current oilfields "

The project has several steps as illustrated in the figure below, but all are interrelated. The first step is laboratory work: data of implemented EOR projects and data from several blocks in Angola were collected, processed and analysed. Then an Artificial Intelligence (AI) model was used to select the candidate wells and identify the correct technique. Finally, intensive experimental work is performed on a specifically designed multipurpose EOR rig, which was built within the scope of the project.

" 60 to 70% of the oil still remains in place"
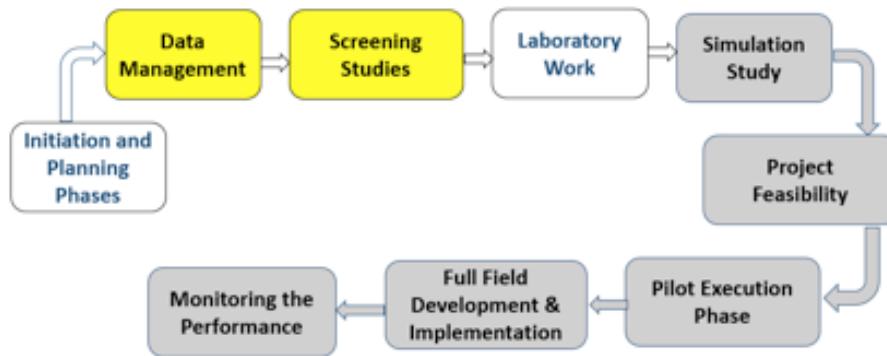
Other steps include reservoir simulation, project feasibility, pilot execution phase, full field development & implementation and finally, monitoring of the performance. From initiation until monitoring the performance, without stopping, it may take at least 10 years to get feedback on oil production through this process.

ON: How are candidate wells selected for this process?

GR: It has been said that "computers have become exponentially better in understanding the world. Recently, a computer beat the best Go player in the world, 10 years earlier than expected."

As such, we believe that employing robust AI models for selecting the reservoir candidates is a significant contribution to EOR projects.

Hence, the candidate wells are selected by employing the artificial intelligence model developed within the scope of the project. The reservoir rock-fluid data of the implemented EOR projects are collected using a training and validation process and the investigated data from the Angolan oilfield is used as testing data. The set of options which generates the least root mean square error (RMSE) and non-dimensional error index (NDEI) 80% (4/5) of the data-set were selected at random for the training and the remaining 20% as the validation or prediction set. This set of data 20% (1/5); which generates the least root mean square (RMSE) and non-dimensional error index (NDEI) is used as prediction or validation data-set for the testing process. The set of data which gives the least NDEI (non-dimensional index error) define the technique suitable for a defined well.

ON: Do you think the future of Angolan production will rely on EOR or are there also opportunities in the deep and ultra-deep waters?

GR: Yes, I think the future of Angolan production must rely on EOR because it will allow for the recovery of oil that is still in place. In addition, these fields provide less risk and the uncertainty is reduced compared to the green or new fields. It appears a safer options than moving into green fields or into remote areas such as deep-water and ultra-deep-water, where it becomes more difficult to discover and develop new oil fields.

That being said, there are also some opportunities in the deep and ultra-deep waters including pre-salt; but as I said, these green areas present some risks and a degree of uncertainty compared to exiting oilfields (both onshore and offshore). Also, the current oil price is another constraint to developing green oilfields in deep and ultra-deep water. But there are a lot of opportunities in Angola for both EOR, and deep and ultra-deep water development.

ON: You're a keynote speaker at the Offshore Well Intervention Workshop West Coast of Africa in Accra on March 7-8. What do you hope to get out of the networking and knowledge sharing at this event? Have you had much opportunity to exchange ideas during your time in Aberdeen in similar settings?

GR: Yes, I had the opportunity to attend Dave Puckett's talk (Senior Reservoir Engineer - Enhanced Oil Recovery, Hunting Energy Services) in May 2017 which was very important to learn more about the UK EOR's strategy and the opportunities for operators and service companies. There are also some periodic post-graduate seminars within the University such as the 38th IER-EOR Workshop and Symposium in Riviera Maya, Mexico (26th – 30th September 2017). There, I had a chance to meet some speakers from the North Sea and absorb knowledge from their own EOR projects.

At OWI WCA, I'm hoping to exchange ideas with different experts from different fields, with a specific focus on EOR and IOR. I'd like to learn from their experience in the oil and gas industry including the challenges and opportunities in their own countries.

ANGOLA'S RESERVES AND PRODUCTION

Proven Oil Reserves in Thousand million barrels
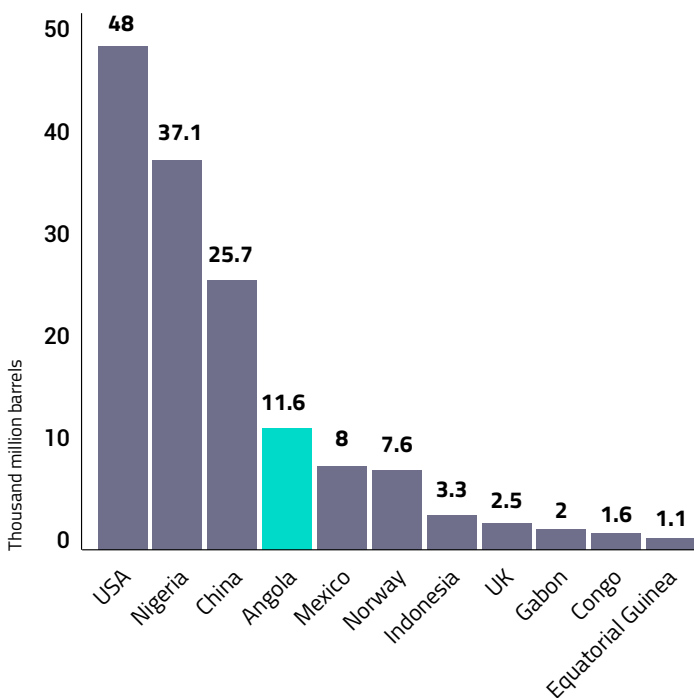
Production in thousands of barrels per day
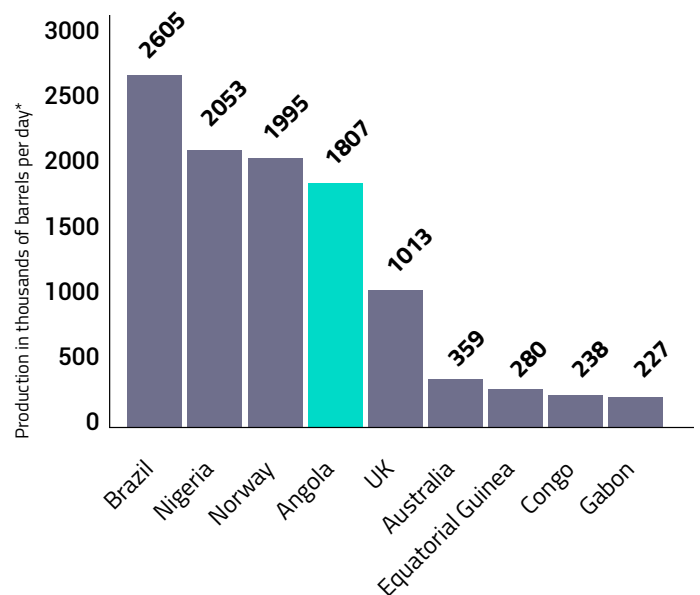
Source: BP Statistical Review of World Energy - June 2017

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