Navigating the African-Atlantic Gas Pipeline project

Andreas Hausmann, ILF Consulting Engineers, outlines the details of the African-Atlantic Gas Pipeline project, one of the most ambitious and transformative infrastructure projects in Africa.

By completing the FEED Phase II in May 2024, the project sponsors, Nigerian National Petroleum Company Ltd (NNPC) of Nigeria and Office National des Hydrocarbures et des Mines (ONHYM) of Morocco, as well as other stakeholders, including the Economic Community of West African States (ECOWAS), National Oil Companies (NOCs) of

ECOWAS member countries, and SMH (Société Mauritanienne des Hydrocarbures) of Mauritania, made a tremendous step forward in the development of this strategic mega-project, the African-Atlantic Gas Pipeline (AAGP), also known as the Nigeria-Morocco Gas Pipeline (NMGP).

This project is one of the most ambitious and transformative infrastructure projects in Africa, with the potential to reshape the continent's energy landscape.

It falls in line with the "Decade of Gas Master Plan" that the former Nigeria's President Muhammadu Buhari launched in 2020. On the Moroccan side, this landmark project is part of the South-South cooperation upheld by King Mohammed VI. In 2024, His Royal Majesty King Mohammed VI of Morocco and His Excellency, Nigeria's President Bola Ahmed Tinubu reiterated their commitment for the actualisation of the project, with the support of ECOWAS, its member countries and Mauritania.

The AAGP project, an onshore/offshore gas pipeline crossing the land/waters of 16 countries, shall bring Nigerian, Mauritanian, and Senegalese gas to the West and North African markets and also extend to the European market via Spain.

By traversing 16 countries, the pipeline shall not only supply the local markets with a sustainable and reliable source of energy, it will also support industrial and economic development and create a competitive regional power market.

This is particularly important in a region where energy access remains a significant challenge, hindering growth and development.

The pipeline will provide a new avenue for the countries along the route to export/import gas to/from their neighbouring countries and Europe.

The objectives in detail:

- Electrification and energy self-sufficiency in the region.
- Improved living conditions of neighbouring populations.
- Boost regional economy, develop industry, and create jobs and wealth.
- Economic integration of countries crossed.
- Unlock Africa's vast untapped natural resources.
- Reduction of gas-flaring and use of reliable and sustainable energy.
- Energy security and autonomy for underserved West African nations.

Potential gains from the project

Significant new hydrocarbon accumulations of natural gas were discovered offshore Mauritania and Senegal in 2015. Nigeria, an OPEC member, has the largest gas reserves in Africa and the seventh-largest in the world.

Morocco stands to gain immensely from the pipeline. By securing a steady supply of natural gas, Morocco can reduce its energy imports, lower costs, and support its ambitious renewable energy goals. Moreover, the pipeline will position Morocco as a key energy hub between Africa and Europe, enhancing its strategic importance on the global stage.

The project also enhances Africa's role in the global energy market. By connecting African gas resources directly to Europe, the AAGP offers an alternative to Russian gas, which has dominated the European market for decades. This diversification of supply is particularly relevant in the context of the ongoing energy transition and the European Union's efforts to reduce its reliance on fossil fuels from politically unstable regions.

This pipeline will become a symbol of pan-African cooperation, economic development, and geopolitical strategy.

Seen from today's perspective, this more than 6000 km long gas pipeline, when completed, will be the longest offshore pipeline in the world and the second longest pipeline over all.

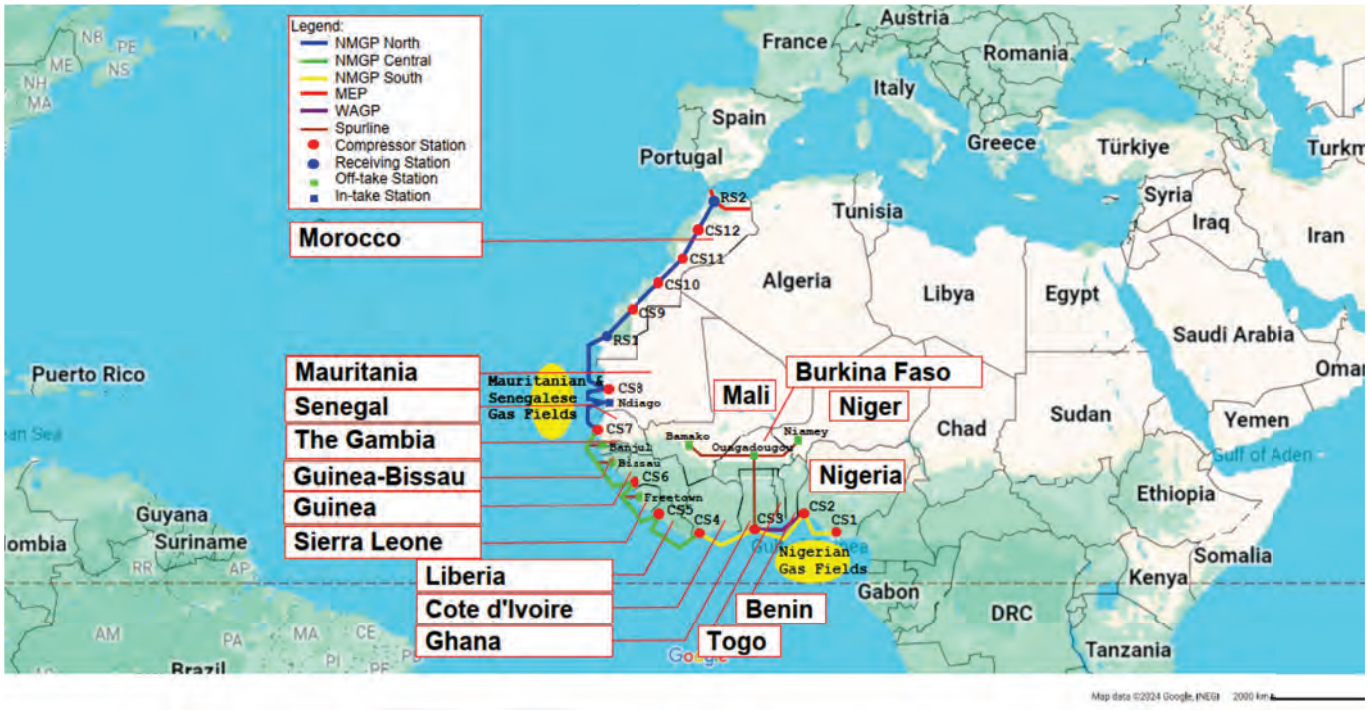

Figure 1. Project map.

Project specifics

The pipeline starts at Brass Island in Nigeria, goes offshore from Nigeria to Southern Morocco with intermittent onshore returns for compression and offtake in Ghana, Cote d'Ivoire, Liberia, Guinea, Senegal and Mauritania. It proceeds to onshore Morocco with several compressor stations and offtake points and finally connects to the existing Maghreb-Europe Pipeline, also known as Gazoduc Maghreb Europe (GME), close to the Strait of Gibraltar, where it extends to its end point in Spain.

Landfalls in Ghana and Nigeria have been located to best synergise with the existing West African Gas Pipeline (WAGP) for gas injection so that AAGP gas can be accessed by WAGP offtakers in Ghana, Togo and Benin.

Land-locked ECOWAS countries of Burkina Faso, Mali and Niger will be fed from the AAGP by onshore spur lines. Coastal ECOWAS countries without compressor stations, like Sierra-Leone, the Gambia and Guinea-Bissau will be connected to the AAGP by offshore spur lines and stand-alone offtake facilities.

Intakes to the AAGP may be provided in Nigeria, Mauritania and Senegal for gas coming from the following sources: Brass Island (including Escravos/Badagry), Nigeria; Yakaar-Teranga, Senegal; Greater Tortue Ahmeyim, Senegal/ Mauritania; and Bir Allah, Mauritania.

The technical details of the AAGP project are as follows:

- Pipeline length: 5110 km offshore, 1830 km onshore.
- Diameter: 32 - 46 in. offshore; 48 in. onshore.
- Pressure class: 1500 lb offshore, 600 lb onshore.
- Throughput (Design): 15 billion m^3/y (initial), 30 billion m^3/y (final).
- Number of compressor stations: 12 (+5).
- Number of receiving stations: 2.
- Number of (standalone) offtake stations: 6.
- Number of (standalone) intake stations: 1.
- Number of block valve stations: 61.

The locations of the above ground installations (AGIs) have prudently been chosen not only out of flow assurance reasons but also by considering potential gas intakes and offtakes and the vicinity to large cities.

The design of the AGIs has consistently been following the approach 'design one – build many'. For that a standardised, repeatable concept broke the design down into standard blocks, like: pigging, compression, metering, gas offtake, gas intake, and utilities.

These blocks allowed for addition/deletion from the particular stations as required. Design capacities of the AGIs are as follows:

- Design life: 40 years.
- 1500 lb rated compressor station.
- Compressor station design capacity: 30 billion m^3/y.
- 48 in. inlet and 48 in. outlet.
- Gas intake area design capacity: 10 billion m^3/y.
- Gas offtake area design capacity: 5 billion m^3/y.
- Standalone gas intake station design capacity: 10 billion m^3/y.
- Typical block valve station rated at 600 lb with design capacity of 30 billion m^3/y.

Offshore pipeline design

The following parameters were used for the offshore pipeline design:

- Standard: DNV-ST-F101.
- Design life: 40 years.
- Design pressure: 220 bara.
- Design flowrate: max. 30 billion m^3/y, varying per section.
- Material specification grade: DNVGL 450.
- External coating: 3LPE.
- Internal coating: high solid liquid epoxy coating (solvent-free).
- Thickness of concrete weight coating: 50 - 95 mm.
- Cathodic protection: sacrificial anodes (offshore), impressed current (shore/onshore).

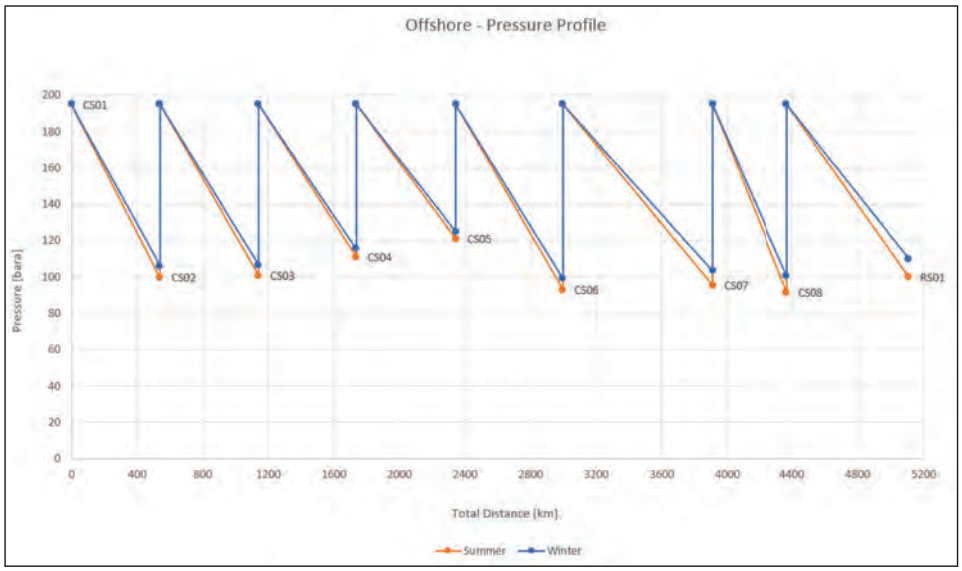

Figure 2. Simplified offshore pressure profile phase 4.

Preliminary flow assurance calculations determined the approximate distance between offshore compressor stations and the design pressure.

The offshore routing sections were developed by considering constraints such as environmentally protected areas, existing infrastructure (pipelines, cables, platforms, etc), fishing areas, ammunition dumping grounds, exploration areas, local bathymetry (e.g. canyons), etc.

Onshore pipeline design

The following parameters were used for the onshore pipeline design:

- Design life: 40 years.
- OD - nominal pipe size: 48 in. (1219 mm).

- Maximum design temperature (°C): 75.
- Minimum design temperature (°C): -10.
- Design pressure (barg): 103.
- Maximum allowable operating pressure (barg): 93.
- Material specification grade: API 5L X70 PSL 2.
- Specified minimum yield Strength (MPa): 485.
- Cathodic protection: impressed current.

The onshore pipeline sizing has been based on a preliminary steady state flow assurance calculation.

The onshore routing sections were developed by considering existing infrastructure corridors, use of relatively flat terrain/avoidance of steps, optimum number of crossings, avoidance of populated areas, avoidance of environmentally sensitive areas, consideration of other projects/developments in the area. The onshore route is crossing the Atlas mountains, and the route selection was challenging in that region.

Construction phases

The project construction has been segregated into the following phases:

- Phase 1A: Installation of AAGP Takoradi to San Pedro segment; with the main objective to bring gas from the WAGP to Côte d'Ivoire.
- Phase 1B: Installation of AAGP Dakar to GME (North of Morocco) segment; the main objective is to connect sources of gas in Mauritania and Senegal to Morocco/ Spain.
- Phase 2: Installation of AAGP Brass Island to Takoradi segment; the main objective is to increase the gas supply from Nigeria to Ghana and Côte d'Ivoire.
- Phase 3: Installation of AAGP San Pedro to Dakar segment; main objective is to complete the AAGP, deliver gas to all intermediate consumers, increase the export to Morocco and Spain/Europe with gas from Nigeria.
- Phase 4: Upgrade of the capacity in case of business needs (adding compressors and intermediate compressor stations).

Contracts

For the contracting strategy, multiple drivers have been taken into account, including: project structure, CAPEX distribution, project schedule, main project risks/ opportunities, market environment/feedback, contractors core competence, logistics and financial considerations, and potential commercial opportunities.

Focus has finally been laid on traditional lump sum turnkey EPC contracts. The chosen contracting strategy has been based on: regional PMCs, line pipe supply, marshalling yard/concrete weight coating, EPC for offshore and/or onshore pipeline, and EPC for AGIs.

The project implementation will require several Financial Investment Decisions (FIDs) for a first gas of the first phases by 2029. Total estimated CAPEX of this project are in the range around US$25 billion.

Conclusion

The African-Atlantic Gas Pipeline is a landmark project with the potential to transform Africa's energy sector and enhance the continent's role in the global energy market. By fostering economic growth, promoting regional integration, and providing an alternative energy supply to Europe, the AAGP will have far-reaching impacts that extend well beyond the immediate regions it serves.

ILF Consulting Engineers (ILF) with its office in Munich, Germany, together with its Joint Venture partner DORIS Engineering (DORIS) located in Paris, France, were commissioned to carry out the Project Management Consultancy (PMC) services for the FEED Phase II of this project, including the quality management, project control, design vetting and CAPEX/OPEX review, which will support ONHYM & NNPC in the delivery of this strategically important project.

The overall project services managed by ILF and DORIS comprise the onshore and offshore pipeline and above ground installations (AGIs), the engineering surveys, the environmental and social impact assessment (ESIA), the land acquisition studies (LAS), and the project implementation framework.

The Joint Venture excelled in supporting ONHYM & NNPC in the delivery of this strategically important project by combining the expertise of ILF and DORIS in their special fields of competence.

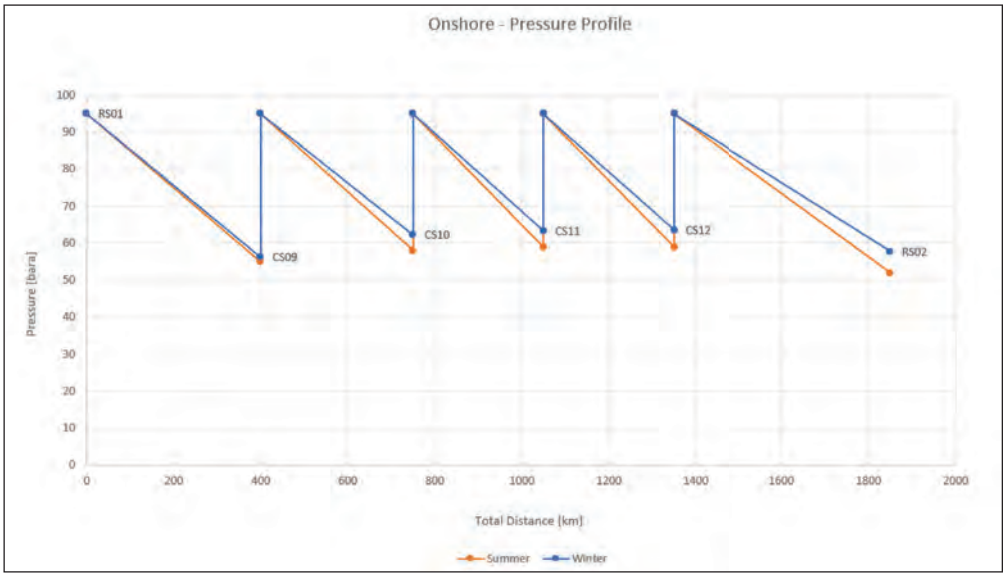

Figure 3. Simplified onshore pressure profile phase 3.