From an Exploration Prospect to A Developable Opportunity, with no New Well: A Contingent Resource Story

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ABSTRACT

The strong push of the Nigerian petroleum industry towards the decade of gas, quick exploration, and development of fields, within the context of the global drive to reduced greenhouse gas emissions and environmentally friendly operations, requires quick and early wins and minimal environmental footprint. This opportunity was one of several exploration prospects outlined for concurrent maturation, within a cluster area. This area was targeted in an on share exploration campaign, with one primary objective - to rapidly identify and supply meaningful gas volumes, and hence enhance NLNG supply security. The exploration strategy was a two-phase evaluation approach, which focused on near-field,amplitude-supported prospects within the hydrostatic-mild pressure regime. The first phase of the work adopted an integrated, multi-field exploratory process to create a consistent foundation for understanding all opportunities in the area. This included the development of sub-regional structural and statigraphic frameworks, depositional environment models, quantitative interpretation [Q.I] forward-prediction and sub-regional depth conversion models based on seismic velocities. As this prospect crystallized, the second phase adopted a scaled, prospect-specific maturation method - this incorporated an advanced workflow, detailed Q.I amplitude and seismic gathers analysis, a prospect-peculiar depth conversion based on nearby well velocities, and the prediction of reservoir properties. The evaluation evolved the view of the opportunity from a prospective resource to a gas-bearing contingent resource opportunity, based on the techniques described above. This has added significant contingent gas resource volumes, with no additional operational expenses. Hence, improving the overall profitability of the portfolio and eliminating any attendant operational or environmental impacts of exploratory activities.

Keywords: Green-hous, Gas emission, Maturation, Subsurface uncertainty, Mapping, Quantitative

INTRODUCTION

The Niger Delta basin has experienced significant oil and gas exploration and development since the discovery of hydrocarbon in the 1950s. following over 70 years of significant activity in this mature basin, a viable strategy for hydrocarbon growth shifts focus to the identification of hydrocarbon on near-field opportunities, through exploration oil and gas resource growth is linked to exploration, which is typically initiated through prospecting efforts, where basins are assessed for pools of undiscovered hydrocarbons i.e.,Prespective Resource (PR) as highlighted in Table 1.Extensive research exists on the topic of exploration well is drilled, and a commercial discovery is made, there is only a probability of a successful outcome of prospecting, and this carries the inherent risk of loss of capital.

In addition to the cost risk, exploration and appraisal efforts historically require the execution of activities which result in the emissions of amounts of greenhouse gases [GHG] into the atmosphere, which impact the ecosystem. There has been a global call for environmentally sustainable energy operations, underpinned by COP 21 [Paris Agreement].The Nigerian petroleum industry, through relevant policies, regulations, and an enabling environment, is also driving an focus on gas production and utilization, towards economic prosperity and lowered GHG emissions. The "Decade of

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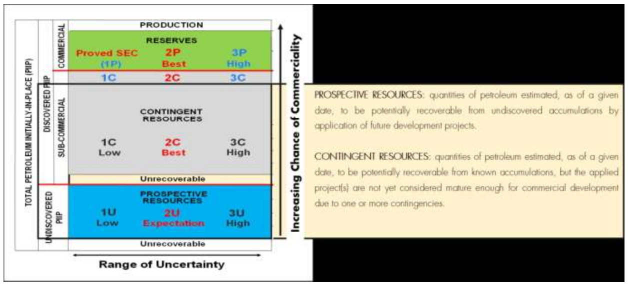
Table 1: Classification of Resource categories based on range of uncertainty and chance of commerciality based on the 2018 petroleum resources management system (PRMS).



Gas"initative [Brevityanderson.com, 2021] is an example of this effort.

An avenue foe hydrocarbon growth without further exploration and appraisal drilling (with attendant risks and environmental footprint),is in the identification and development of Contingent Resource [CR] fields. A mature basin like the Niger Delta is favored by this approach, given the strong understanding of the basin character and the abundance of near-field exploration and development opportunities.

The Adi field was identified amongst a cluster of multiple exploration opportunities in a variably mature onshore acreage [Figure 2]f or concurrent gas maturation. The acreage, which has an area of ~580 km2, has a mix of discovered, non-producing fields primarily in the northern area [Adi opportunity is in the north-east of the acreage], and a producing field in the southern part of the acreage.

Adi field was discovered in the 1960's by the Adi-001

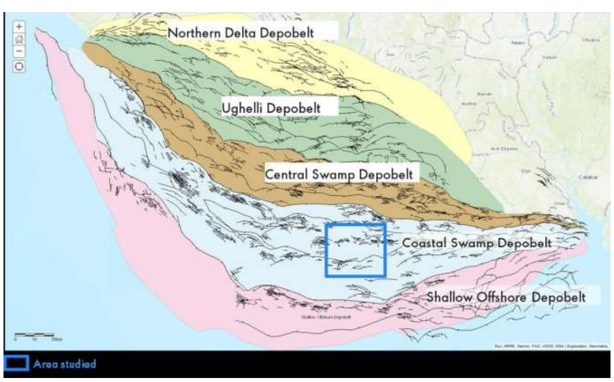


Figure 1: Map showing the location of the opportunity.

well, which logged gas bearing reservoirs [U1100, U1200, U1300]. it is a non-producing field with only two wells drilled currently. The second well, Adi-002 encountered the same reservoirs as in Adi-001, but only logged water.

The legacy structural understanding of Adi field had been based on 2D seismic data,which had subdivided the field into Adi South blocks from the shallow to the deep intervals. As an outcome of this analysis, the Adi South block was assumed as untested and potentially a PR interest at all levels [Figure 2].

INTENT & BUSINESS DRIVERS

Adi is strategically poised among other fields, to quickly unlock near-field gas volumes and delivers gas to bridge supply shortfall and enhance Nigeria Liquefield Natural Gas [NLNG] supply security.

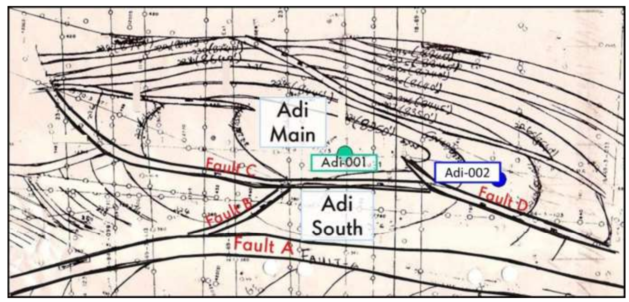


Figure 2: Legacy map of Adi field, showing the prior structural understanding. Hydrocarbon discovery was limited to the Adi North block.

The intent of this technical work was to address the above mentioned by carrying out the following:

- * A concurrent assessment of the framework and play potential of the cluster of prospective opportunities in the acreage.
- * The re-evaluation of the hydrocarbon potential of Adi field, using more recently acquired data and applying modern techniques.

DATA AND APPORACH/METHODOLOGY

Proper data mining, review, quality assurance and control was critical to this integrated study.

Some relevant data utilized for work included the following:

a. Well data from relevant wells across the acreage, which included:

i. Taps - Maximum flooding Surface [MFS] picks based on biostratigraphic data [Tortonian. 1(Tor. 1))/10.4 Ma], seravallian 3 [Ser 3]/11.5 Ma and serravallian 2 [Ser.2]/12.8 Ma] and several reservoir tops.

ii. Petrophysical well logs

iii. Well velocities

b. Pre-Stack Depth Migration [PSDM] seismic volume covering the acreage

c. Pre-stackgathers, Near: A0015, Mid: A1530, far: A3045

To address the intent, a two-phased evaluation approach was adopted [figure 3],which aimed at first identifying near-field,amplitude-supported prospects within the hydrostatic-mild pressure regime for exploration maturation through a cluster-based approach, followed by detailed opportunity-focused analysis for Adi field.

Cluster -Based Approach

1. Play-Based Explanation (PBE) assessment. The first scope for evaluation was done through a PBE assessment of the entire acreage. PBE is a scalable approach for evaluating exploration opportunities in a holistic manner at basin, play or prospect scale.

In this evaluation, it was geared at establishing a common and consistent framework for analysis and categorization of opportunities, uncertainties, and risks for all prospects in the acreage. The plays were defined on chrono-stratigraphic distinctions, based on identified regional flooding surfaces (3rd order events).

ii. Sub-regional depth conversion: To convert the northern and southern areas of the acreage from time to depth, a sub-regional time-depth conversion approach was adopted based on scaled seismic velocities. This integrated the regional MFS maps for Tor.1, Ser.2 and Ser.3, the equivalent MFS well tops, well logs and the seismic velocity model.

Opportunity- focused Approach

I. Structural Framework Definition & Event Mapping: Following the sub-regional/cluster-based approach, the evaluation was concentrated on Adi field, for detailed fault and horizon mapping of prospective reservoir levels. Seismic soft loops with bright amplitudes were identified for mapping, as potential reservoirs.

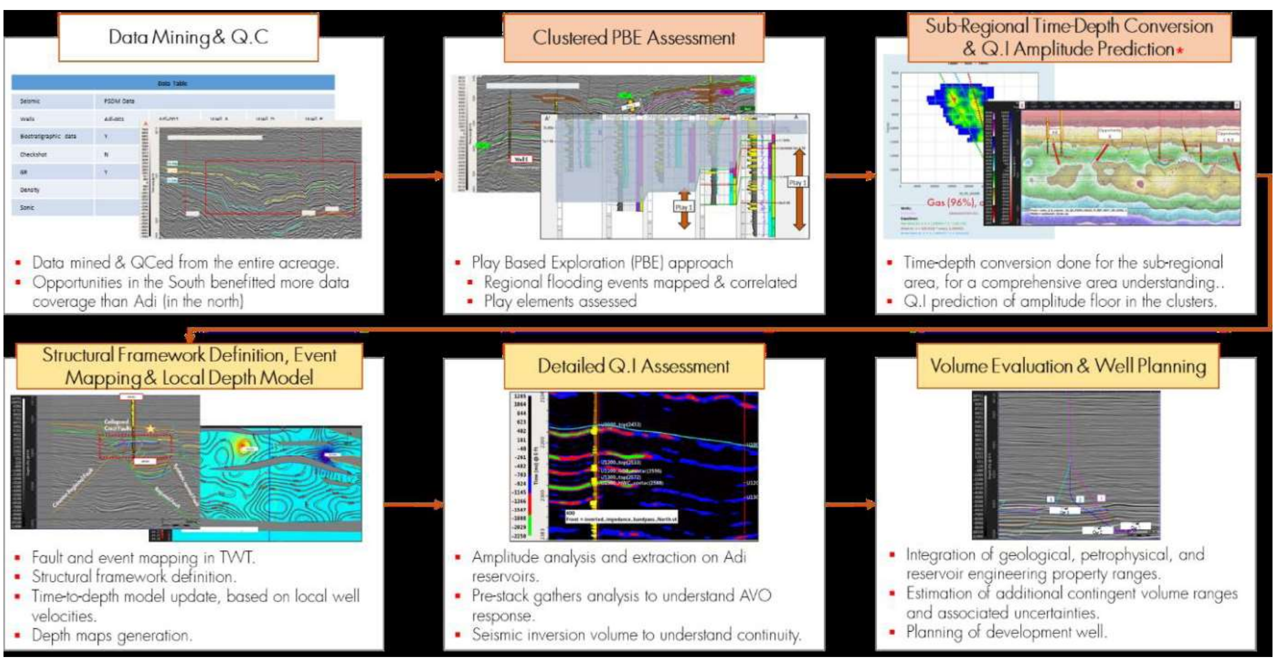


Figure 3 A schematic showing the methodology and workflow adapted.

ii. Local Depth Model: To mitigate the larger depth uncertainty ranges which were observed in the sub-regional model, based depth conversion, a local depth model (specifically suited to the Adi prospect) was created, based on well velocities acquired in Adi-001.

iii. **Detailed Quantitative Interpretation (Q.I) Assessment:** Amplitude analysis of the potential gas-bearing reservoir levels were done integrating interpretation from the full stack, near, mid, and far sub-stacks of the seismic volume. A seismic inversion volume was also generated to evaluate reservoir and fluid quality and continuity.

iv. **Volume Evaluation:** Ranges of probabilistic in-place and recoverable volumes were estimated for each reservoir, based on the GIP formula, and applying a recovery factor. The ranges of recoverable volumes and associated uncertainties, overall project economics and the fit of the project to business goals, formed the basis of well planning.

RESULTS AND DISCUSSION

PBE Interpretation

Based on the clustered PBE analyses, the acreage is understood to be predominantly of Miocene age, with structural styles typical of the extensional setting of the Niger Delta i.e., gravity dominated, syn-sedimentary structures.

The gross depositional environment analysis places it in a shelf to slope palaeo-environment. Hence, shelf deposits are expected to have (in a broad sense), good lateral continuity and similarity of depositional facies, which is advantageous to reservoir properties and the quantity ot hydrocarbon accumulation which can be trapped. A summary of the PBE assessment is as follows:

* Trap: These included structural traps typical to the extensional setting of the Niger Delta with gravity-dominated structures, such as deep rollovers, collapsed crests, faulted anticlines; and stratigraphic traps due to facies changes.
* Seal: Competent sealing shales were logged in all wells and fault sal was proven by tested hydrocarbon accumulations.
* Reservoir: Good reservoir sands were identified in the wells drilled in the area and these reservoirs could be correlated on seismic.
* Charge: Charge was proven by logged hydrocarbon in wells within the plays.

Three working stratigraphic plays were proven to exist in the middle to late Miocene, with plays 1 & 2 proven in northern area (which includes the Adi opportunity) and Play 3 proven in the southern area (Figure 4 and Figure 5).

Adi Interpretation

The field is structurally bounded by normal, synthetic growth faults, which created a deep roll-over structure with a collapsed Crest in the shallow section. This forms

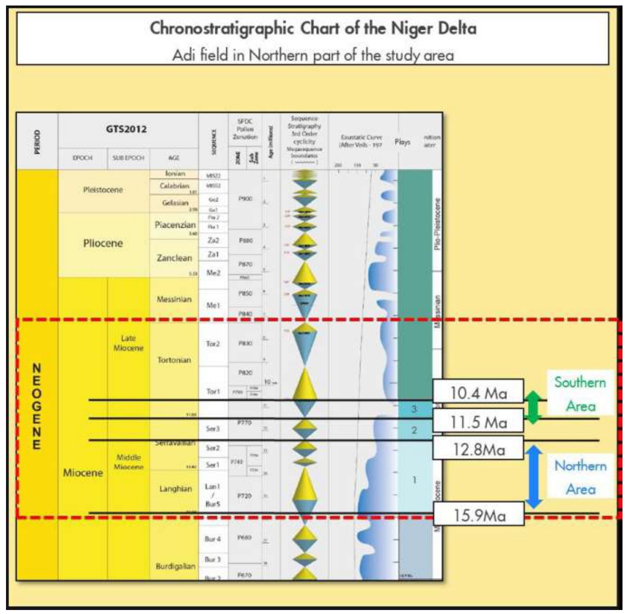


Figure 4: Chronostratigraphic chart of the Niger Delta.

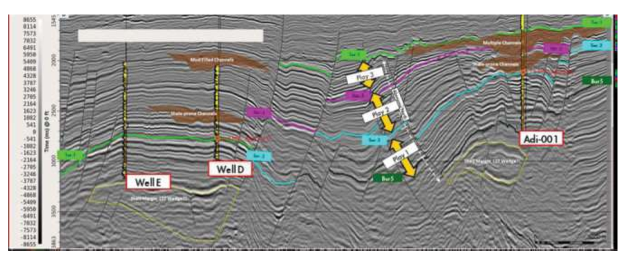


Figure 5: Seismic Section showing plays and play elements.

the structural trapping mechanism for the Adi field. From reservoir and top structure mapping in time and depth, the crest of the structure in Adi is in the southwest of the field as shown in the Figure 6.

Previous evaluation of the Adi field had assumed a full separation of the Adi area into the Adi main block and the Adi South block at all levels, hence constraining the hydrocarbon discoveries to Adi Main block only. This view has been conclusively changed based on good imaging and interpretation of the area on the 3D seismic volume.

At the shallow reservoirs down to U1200, the 3D seismic

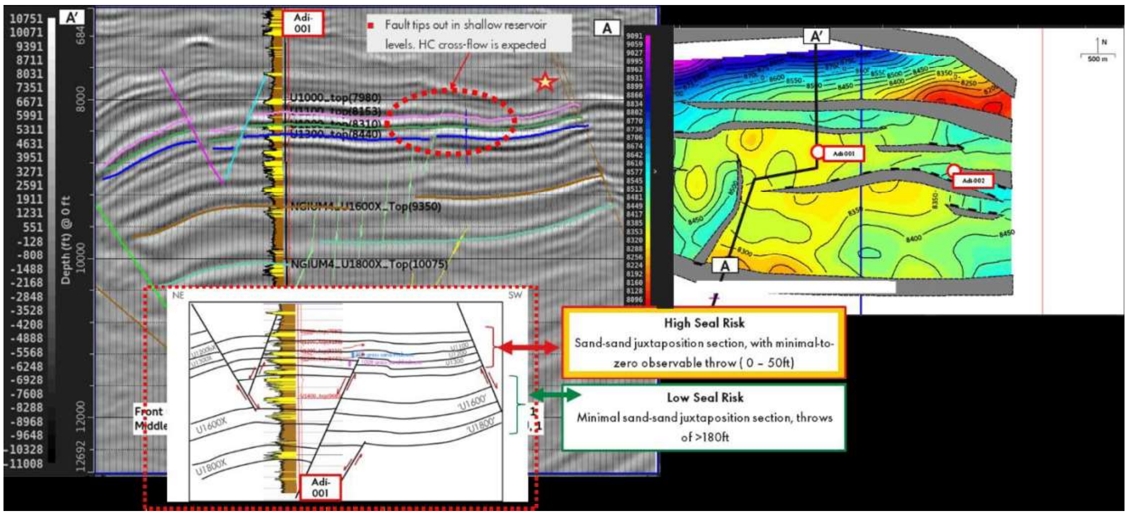


Figure 6: Current understanding of the Adi structure, enabled by well-imaged seismic data.

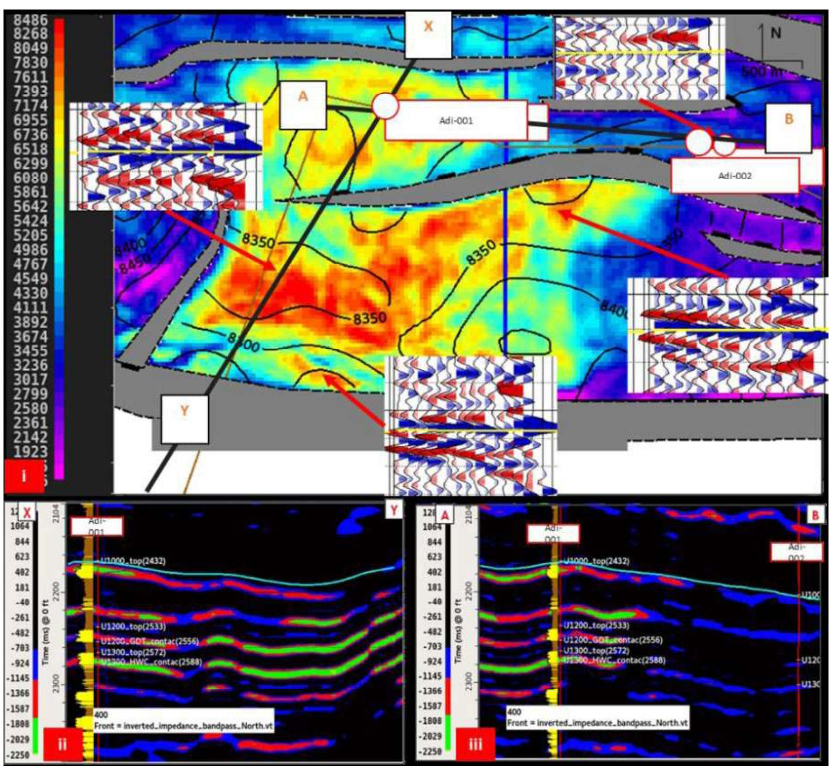


Figure 7: Q. I analysis of Adi field. i. Shows amplitude response in U1200 reservoir, with gathers analysis which corroborates gas presence in southern section. Ii. A line from inversion volume, showing reservoir and hydrocarbon presence from Adi-001 to the south. Iii, A line from inversion volume, showing reservoir and hydrocarbon presence from Adi-001 to Adi-002 (wet).

data reveals that there is structural connectivity across Adi North and Adi South blocks. However, the eastwest trending antithetic fault sub-divides the Adi area into the Adi main block and the Adi South block in deeper sections, starting from Ul300 reservoir as shown in the Fiqure 6.

Five interpreted reservoir levels (U1100, U1200, U1300, Ul600 & UI800) showed strong amplitude anomalies at structural highs. These were interpreted and confirmed

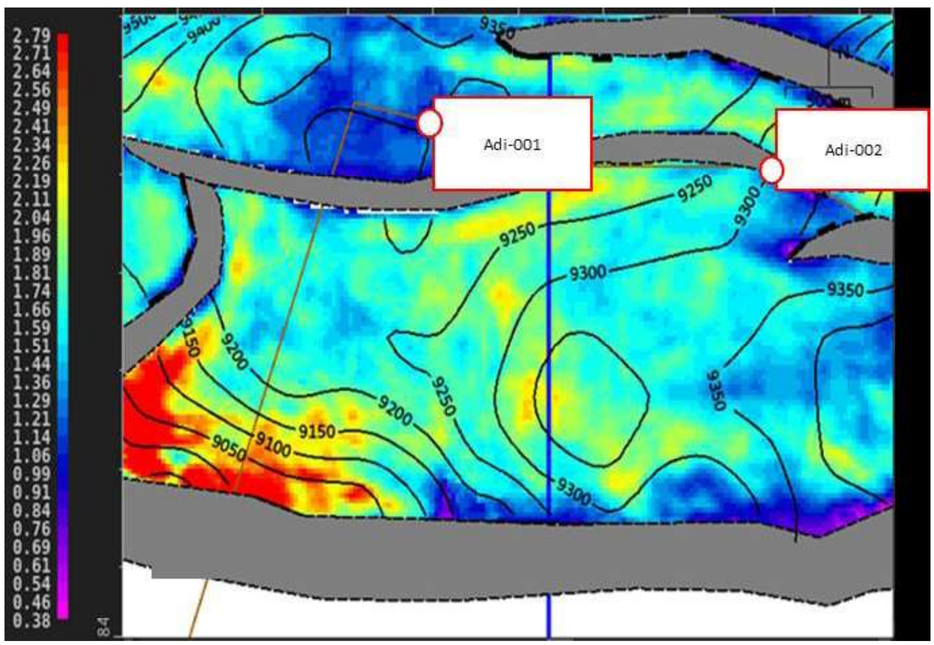


Figure 8: Structure of U1800 reservoir, with amplitude extraction overlay. Fault completely separates both blocks and the bright amplitudes while largely conformable, are restricted to the south of Adi field.

through Q.1 analysis (which was calibrated with responses in Adi001, Adi-002 wells and AVO predictions of gas response) as hydrocarbon-bearing reservoirs.

U1100 and U1200 reservoirs both logged gas in the Adi-001 well, which is downship. Therefore, it is expected that given the observed connectivity in the structure at U1100 and U1200 reservoir levels, and the reservoirs' amplitude anomalies which fit to structure, the entire reservoir area shallower than the Adi-001 well is also gas-bearing. Other reservoirs deeper than U1200 are separated by the antithetic fault in Adi (Figure 8). In view of these, there was a clear case for the U1100 and U1200 reservoirs to be reclassified as CR targets, while deeper reservoirs remained PR opportunities.

The legacy volumes associated with the U1100 and U1200 levels has only been estimated in the "Adi Main" area of the structure. Hence this necessitated an updated estimation of the volumes, to capture the incremental volumes from "Adi South" section of these CR reservoirs. Revised volume evaluation indicates an addition of 115% P50 ultimate recoverable volumes to the company's reserves, which had initially been booked, from only the 2

Table 2: An approximate range of UR volumes (bscf.) estimated in Adi CR based on comparison between past understanding and current work.

	P90	P50	P10
Incremental UR volume based on current evaluation	+20%	+115%	+260%

CR levels.

The deeper reservoirs U1300, U1600 and U1800, although amplitude-bearing, are not economically viable at this time, but could remain in-scope for exploration in the future. They are not discussed in detail this paper.

Initial field development efforts have identified this as a potential single-well, development opportunity and further work is necessary to carry out field development planning.

BUSINESS IMPACT AND CONCLUSIONS

This evaluation of the Adi area has identified additional 115% of P50 gas volumes from the two CR reservoirs only.

Some subsurface enablers to the project are the maturity of the basin which accelerates opportunities to drill readiness, objective of near-field, normally pressured targets with direct information on reservoir and fluid properties from Adi-001 and -002 wells, Q.I uplift, data richness and quality (seismic imaging).

Significant outcomes of this project include:

- **a. Cost reduction:** Elimination of further exploration activities i.e., exploratory well and related activities are not required for the assessed Adi area.
- **b. Project Acceleration:** Shortened time to field development which is advantageous to meeting PIA regulations for retention of fields/concessions.
- **c. HSSE exposure:** Limited exposure due to reduction and elimination of some activity scopes.
- d. **GHG emissions reduction:** Scope 1 and 2 emissions related to further exploration and appraisal well drilling is eliminated.
- **e. Economic Advantage:** Gas development to strengthen the local economy and further cements the Nigerian intent towards the "*decades of gas*".

Due to this revised view of Adi field, the attractiveness of the portfolio is inceased and the timeline for development of the Adi field is significantly accelerated, taking Adi from being an exploration prospect to a short-term, developable opportunity.

In conclusion, the Adi CR reservoirs will deliver gas to meet the project objective of bridging supply shortfall and enhancing NLNG supply security.

REFERENCES CITED

Brevityanderson.com. (2021). The Decade of Gas. Retrieved from Brevity Anderson Website: https://brevityandderson.com/decade-of-gas/

Figueiroa, S.F., Peyerl, D., & Good, G.A. (Eds.). (2019). History, Exploration & Exploitation of Oil and Gas. Germany: Springer International Publishing.

Hachay, O., & Gaci, S. (Eds.) (2017). Oil and Gas Exploration. Methods and Applications. United Kingdom: Wiley.

Onuoha, K.M. (2004). Oil and Gas Exploration and Production in Nigeria. Recent Developments and Challenges Ahead. Ibadan: Postgraduate School, University of Ibadan.

Tissot, B., & Welte, D. (2014). Petroleum Formation and Occurrence. Berlin: Springer.

United Nations Website. The Paris Agreement. Retrieved from Climate Action: https://www.un.org/en/climatechange/paris-agreement.