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Prospects of Tar Sand in Nigeria Energy Mix

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ABSTRACT
In ancient times, the Elamites, Chaldeans, Akkadians, and Sumerians mined shallow deposits of asphalt, or bitumen occurring in tar sand for their own use. Mesopotamian bitumen was exported to Egypt where it was employed for various purposes, including the preservation of mummies.
Tar sand had many other uses in the ancient world. It was mixed with sand and fibrous materials for use in the construction of watercourses and levees and as mortar for bricks.
In Nigeria, development of heavy oil and bitumen in Tar sand reserves is increasing around the western part of the country. The increasing volume of cheaper heavy oil in the supply mix has provided an incentive for refiners to upgrade their equipment to process the poorer-quality heavier crude occurring in tar sand. The upgrading investments have helped to maintain a demand for heavy oil in spite of the declining price of conventional crude since the early 1980s. As the demand for heavy oil and synthetic crude from tar sands remains strong, heavy-hydrocarbon development projects are being initiated in western part of Nigeria. In addition, unsuccessful attempts to find new giant conventional oil fields in recent years have caused some producers to turn to the marginally economic heavy hydrocarbons to replace depleted petroleum reservoirs. Bitumen development in Nigeria is also poised to become Nigerian major foreign exchange earner, second to conventional oil in the coming years.

Keywords: *Tar-sand, Oil sands, Bitumen, Heavy hydrocarbon, Steam Assisted Gravity Drainage (SAGD), Western Part of Nigeria.*

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I. INTRODUCTION

Oil sands (called tar sands) are sands or carbonates containing bitumen or other hydrocarbons of such high viscosity to be immobile under normal reservoir temperatures. In order to be utilized, the hydrocarbons must be mined or extracted in site from the rock by the use of heat or solvents.
The largest single hydrocarbon deposit in the world is the Athabasca oil sands of northeastern Alberta, which contains over one trillion barrels of bitumen in place. About ten percent of the deposit is shallow enough to be surface mined. Two open pit mines together produce over 350,000 barrels of synthetic crude per day, equal to about 12 percent of Canadian needs. In situ extraction of bitumen produces about another 150,000 barrels per day from deposits, which are too deep for mining, including much of the Athabasca deposit, and the smaller and deeper Cold Lake, and Peace River deposits.
The process of choice for in situ extraction is Steam Assisted Gravity Drainage (SAGD), in which pairs of horizontal wells are drilled near the base of the bitumen deposit. Steam is injected into the injector well, which is placed about 5 meters above the producer well. The steam rises and heats the bitumen, which flows down under the force of gravity to the lower producer well from which it is pumped to the surface. The bitumen is either upgraded at site, or at a regional upgrade, or mixed with diluents and shipped to a refinery. Several pilot projects have tested the SAGD process, and several commercial scale projects are currently in the construction, engineering design and regulatory approval stages.
Tar sands are found in several countries around the world, including the former Soviet Union, Venezuela, Cuba, Indonesia, Brazil, Jordan, Madagascar, Trinidad, Colombia, Albania, Rumania, Spain, Portugal, Argentina, and Nigeria. The United States contains scattered deposits of oil sands, mainly in Utah, Kentucky, Kansas, Missouri, California, and New Mexico.
On the basis of the progress made in developing improved technology for recovery of bitumen from tar sands, it is logical to assume that as the world's supply of light and heavy oil is depleted, production of synthetic oil from the bitumen resources in tar sands will accelerate. As most of the known deposits of tar sands were discovered by accident, there is reason to believe that a worldwide exploration program based on sound geological principles will discover much more of this material. The long lead times required to mine this massive resource into acceptable alternative refinery feedstock at a reasonable price make it imperative that we vigorously pursue

the development of recovery technology at this time if we are to avoid shimmies of liquid fuel early in the next century. There is no question that the Light-crude-oil substitute developed from this resource will be more expensive than the Conventional light and heavy crude are being used today. However, there is reason to believe that the differential in costs will narrow as the search for new sources of light oil swings to deeper targets in more remote and hostile environments, such as the southern part of Nigeria.

And arctic islands, and more expensive enhance recovery techniques are used to recover the oil now left behind in deep depleted light- and heavy-oil reservoirs. The Petroleum engineers have defined tar sands pragmatically as oil too viscous to flow into a well in sufficient quantities to be produced economically.

This definition, if universally applied, causes problems because oils of Different gravities are included, depending on their depth of burial and the reservoir temperature. Others have defined tar sands as reservoirs containing bitumen i.e., oils heavier than water or with gravity of less than 10"API. A compromise definition proposed by UNFTAR [states that tar sands contain crude bitumen with a gravity of less than 10"API at 60"F or have a viscosity greater than 10,000 mpa. s at original reservoir temperature.

No definition of tar sands enunciated to elate is universally acceptable to geologists, petroleum engineer, and refiners. If one were to classify a reservoir as a tar sand only if it contains a semi liquid hydrocarbon that is heavier than water (less than 10"API gravity), has a viscosity of more than 10,000 cp at reservoir temperature, and cannot be produced in significant quantities through a well by prima~ production, some large deposits widely accepted as tar sands, such as the Orinoco belt reservoirs in Venezuela, the Cold Lake deposit in Alabama, the Asphalt Ridge deposit in Utah and Bitumen deposits in western Nigeria would be excluded for failing to meet one or more of the three criteria. Defining crude bitumen as oil with gravity Iess than 10"API at 60"F puts these ultra-heavy oils in a group consistent with their commercial value, regardless of their depth of burial, once they have been produced. It also is a good indication of the amount of "upgrading" necessary to make them into refinery feed stock. Crude oil heavier than water commonly contains significant quantities of asphaltene and usually is contaminated with impurities such as oxygen, nitrogen, sulfur, vanadium, nickel, and iron.

Note that bitumen is found in the same variety of rocks as light oil and includes sandstones, carbonates, and volcanic rocks. Because bitumen is so widely dispersed, it is not surprising that the world's largest petroleum accumulations and bituminous in nature and the question of its origin has attracted considerable attention since biblical times.

The recent realization that the world's supply of conventional oil is limited, the question of how much bitumen can be extracted economically and converted to a light synthetic crude has assumed new importance. The amount of bitumen in the world has been estimated conservatively at 4.07 trillion bbl. However, remain speculative, as there is no reliable published quantitative information on the resource outside Canada, the U. S., and Venezuela. This gap in our knowledge is, not surprising since, until recently, Little commercial value was assigned to the material and thus there was almost no incentive to embark on a costly drilling and coring program to prove up reserves. This situation should change now that the technology for extracting and upgrading the low-quality hydrocarbon to

Marketable refinery feedstock is ready economical. Observations on the geologic setting of giant tar sand deposits have led to the formulation of generalizations about their occurrence but the most striking feature is the sheer size of the bitumen accumulations. For example, the amount of bitumen in Alberta, Canada, and the Orinoco belt in Venezuela each exceeds 1 trillion bbl in the ground.

II. PROSPECTS AND NIGERIAN ENERGY MIX

The country's bitumen deposit which belt covered the four states of Edo, Ondo, Ogun and Lagos, according to geo-physical surveys carried out since 1901 when it was first discovered by the Germans, have not less than 42 billion barrels of extrapolated reserve, out of which 43 industrial chemicals, including heavy petroleum crude, could be obtained.

A giant step towards the realization of the century-old dream of economic exploitation of Nigeria's massive deposits of bituminous tar sand, reputed to be second only to that of Venezuela.

The exploitation of the bitumen in Tar sand deposit according to experts would open a new source of foreign exchange earnings for the nation's oil-dependent economy.

Consider how hard it is to squeeze oil from rock. Only 8-16% of the material takes the form of bitumen, the desirable, energy-rich bit. The rest is clay, sand and other unwanted stuff. Also, a lot of the bitumen lies too far underground to be mined, and has therefore to be pushed to the surface by injecting steam into the ground through many costly wells.

Engineers and miners have come up with two techniques that have greatly reduced costs here. For projects aimed at tapping the deeper reserves, they are able to use the fancy multi-directional wells now commonly employed in deep-seal oil drilling. Two of these (one for injecting the steam, one for extracting the bitumen) will do a job that once required many individuals, vertical wells. Innovative technology is helping with surface-mining operations, too.

The federal government has awarded two blocks within the bitumen belt in the western region to two successful bodies, Nissands Limited and Bitumen Exploration and Exploitation Company Nigeria Limited (BEECON).

Bitumen which can be defined as any of a group of solid and semi-solid hydrocarbons that can be converted into liquid form by heating and can be refined to produce such commercial products as gasoline, fuel oil and asphalt is expected to play its part in the country's search for alternative sources of income and catalyst to private sector driven mineral exploitation.

Some accounts have it that it had been exploited and used by man as far back as 5000 years ago when the ancient Egyptians mummified their dead with bandages wrapped in natural pitch.

Tar sands are grains of sand or, in some cases, porous carbonate rocks that are intimately mixed with a very heavy, asphalt-like crude oil called bitumen. The bitumen is much tool viscous to be recovered by traditional petroleum recovery techniques. Tar sand contains about 10-15% bitumen, the remainder being sand or other inorganic materials.

The estimated worldwide resources of tar sands are about three times the known petroleum reserves. The world's largest deposit of tar sands is near Athabasca, in Alberta, Canada. Other large deposits exist in the former Soviet Union, Venezuela and in Nigeria. In the United States, small deposits of tar sands are found in Utah.

If tar sand is heated to about 80oC, by injecting steam into the deposit in a manner analogous to that of enhanced oil recovery, the elevated temperature causes a decrease in the viscosity of the bitumen just enough to allow its pumping to the surface. Alternatively, it is sometimes easier to mine the tar sand as a solid material. When the mined tar sand is mixed with steam and hot water, the bitumen will float on the water while the sand sinks to the bottom of the container, allowing for easy separation. Heating the bitumen above 500oC converts about 70% of it to a synthetic crude oil.

Distilling this oil gives good yields of kerosene and other liquid products in the middle distillate range. The remainder of the bitumen either thermally cracks to form gaseous products or reacts to form petroleum coke.

A bitumen project implementation committee [BPIC] was set up by the Obasanjo administration in 2000 and headed by Professor Julius Ihonvbere. This committee played a seminal role in achieving this exploitation milestone. Professor Ihonvbere envisioned long term economic returns from bitumen in Tar sand exploitation including capital gains and contribution to road maintenance.

Presently, Nigeria, which boasts of 59,892 km of paved roads with an additional 1,194km of dual carriageway, the longest in Africa, spends an estimated N2billion annually on importation of asphalt, a bitumen derivative. It is projected that domestic demand could guzzle total production for the next five to ten years.

The potential for meeting domestic consumption and launching into export of the mineral exits when potential demands from Nigeria west African neighbors-Ghana, sierra Leone, guinea and Liberia - are factored in. these are heavy importers of asphalt who could exploit their geographical proximity and growing integrative economies to Nigeria's to ease the logistics of sourcing from outside the region.

III. UNIQUE FEATURES OF THE NIGERIAN TAR SAND GRADE THAT GIVES IT A CUTTING-EDGE MARKET VALUE ARE:

- Higher bitumen content
- Lower impurities like heavy metals, clays etc
- Absence of gas and water saturation
- Medium to good sorting in the sands grains
- Absence of Tar sand stress due to incumbent loads
- Smaller volume of basal gas that dissipates through bore holes, and
- Manageable basal aquifer devoid of the need for depressurization.

If the Nigeria's tar sands are ever to yield our bounty to the world's consumers, producers must overcome technical obstacles in three areas: complexity, cleanliness and cost.

Nigeria's bitumen holds great attraction for the foreign investor because it offers high returns on investment given that Tar sand are more amenable to open mining and gravity drainage, have a potential for steam assistance (SAG-D), while its Sulphur content is adjudged to be very low - between 0.98 and 1.2%.

Within three years of its establishment, the BPIC achieved what could not be achieved since political independence in 1960 and since 1900 when bitumen was first discovered in Nigeria. The BPIC renewed contact with the African Development Bank (ADB) in connection with an outstanding technical aid grant to the project; met with a high-powered team from PDVSA of Venezuela to discuss practical ways of implementing the project;

establishment of a technical committee to review bids for the environmental baseline study of the entire bitumen belt and the subsequent award of a contract to the baseline study of the bitumen belt; contacted embassies and missions of countries with relevant technology that could be of use to Nigeria; established a website and an e-mail service as these are critical in these days of globalization and growing information network. The BPIC also comprehensively reviewed and restructured financial procedures and administrative structures in order to improve transparency and accountability; took full inventory of project facilities/ properties including efforts to retrieve public/project properties such as cars and satellite phones that had been deployed to the use of non-project persons; renovated and relocated to the office building in Alagbaka Quarters, Akure thus saving government millions of naira in rent; and renovated and rehabilitated all project buildings in Akure and Ore including the Guest House.

Furthermore, the BPIC remarkably digitalized block demarcation and other technical data to support the bidding and block allocation processes; initiated processes, following Presidential approval, to conduct a seismic survey of a portion of the bitumen belt; initiated additional core drilling activities in the bitumen belt; carried out a major media program to increase the generation, processing, packaging and dissemination of accurate information on the bitumen project; contacted bitumen-bearing states and communities in order to bring them on board and earn their confidence and cooperation; initiated contacts, research and negotiations the establishment of a Bitumen Training Institute to produce local manpower for the eventual takeoff of the bitumen project; reviewed the proposed legal instrument for the project and made recommendations to incorporate therein environmental and community relations concerns; commenced a comprehensive community relations program designed to mobilize and educate bitumen bearing communities on all aspects of the project and on what to expect when investors begin operations; verified all contracts and claims of debts and in the process saved the project millions of naira; and grandly accessed the bids for bitumen block allocation and successfully allocated the bids to winners in September 2002.

IV. ENVIRONMENTAL BASELINE STUDIES

The Environmental Baseline Studies shall form the basis for detailed Environmental Impact Assessment (EIA) that must be carried out by the operators in line with the laws of the land. The ministry will ensure that all operations are carried out according to international practices.

This should also involve all stakeholders in the development of the Bitumen from tar sand producing communities, viz; providing jobs and self-employment schemes for the youths, thereby providing security and a conducive environment for more foreign investment into the area.

To this effect the ministry of solid minerals in Nigeria has carried out a detailed Environment Baseline Studies (EBS) that involved the study of the Flora, Fauna, socio economic, air quality, water quality, aesthetic and all other baseline data to ensure that operators restore the environment to its original status after exploitation.

This study was carried out to assess the environmental impact of bitumen exploitation on wildlife resources in Ode-Irele forest area of Ondo state, Nigeria. The result of the study showed that there are 9 orders and 40 species of mammals in the study area. Primates recorded the highest species number and rodentia as the highest percentage distribution (74%). Predictably every 10% reduction in tree cover will make the expected number of animals alive to decline from 1524.12 m to 240.70 until the value will become negative
(-217.59). Also, the rate of mortality will increase from 0.17 to 1.00, and the percentage interval of tree destruction will increase from 173.77 to 252.03.

V. TECHNOLOGY IN TAR SAND EXPLOITATION AND PRODUCTION

New clean coal technologies can substantially improve efficiency and reduce emission from power plants. Until they are proven at commercial scale, however, their use entails more risk for utilities than conventional technologies. This additional risk could make it difficult for these new technologies to enter the marketplace quickly, especially given the tight deadlines of the Clean Air Act Amendments of 1990. The Clean Coal Technology Program, the single largest technology development program in the Department of Energy, is designed to help overcome this risk by offering the Federal Government as a financial partner in demonstrating worthy projects.

The long-term risk of investing in new technologies that have not been demonstrated in multiple commercial applications inhibits the new technology market to such an extent that Federal resources have been needed to help fund commercial demonstration efforts. The Department of Energy's cost-shared Clean Coal Technology Demonstration Program, to which industry has contributed \$2 for every \$1 of Federal money invested, as evolved from an early focus on emission control systems to an emphasis in its later rounds on highly efficient, environmentally superior advanced power systems.

Coal, petroleum and natural gas are the traditional fossil fuels whose direct use today accounts for most of the world's energy consumption. Equally Oil recovered from tar sands, commonly referred to as synthetic crude, and is a potentially significant form of fossil fuel. These fuels are rich in carbon and hydrogen. A relatively large amount of energy is stored in them and they have a high calorific value.

However, these are not the only fossil fuels found on our planet. As they are depleted, or as their price increases, other fossil fuels can become more attractive for commercial exploitation. Furthermore, the abundant Tar sand in Nigeria can be converted into cleaner and more convenient gaseous and liquid fuels, similar to petroleum and natural gas. These non-traditional, or unconventional, fossil fuels are discussed in this paper.

Worldwide at least 62 experimental thermal in-situ pilot tests have been conducted in tar-sand reservoirs. Two-thirds of these tests have been in Albetia, where more than 42 in-situ thermal experimental field pilots have been run in tar sands with vital degrees of success. Field pilots have ranged in size from single-well injectivity tests of steam and air to hilly sophisticated multi-pattern semi commercial demonstration plants. The technology has been perhaps slower developing than some expected but still satisfying in that a great many of the technological barriers have been overcome and a better understanding of the relationship between reservoir performances has been achieved.

The highlights of 1983 are the results from the multipatten steam Shell/AOSTRA pilot in the Peace River deposit, which produced its millionth barrel of bitumen; the announcement of a semi commercial cyclic steam 1100-m3 project by BP and Petro- Canada in the Cold Lake deposit; and the announcement by Esso Resources that it will expand its successful steam soak operation at Cold Lake from 2880 m3/d to 5890 m3/d. Considerable evidence supports the thesis that the success of in-situ thermal recovery pilots results more from choice of reservoir than from the engineering effort that goes into hardware and operating strategy.

Probably the most significant single lesson that has been learned from the many field tests in tar sands is that unpredictable variability in the reservoir is the most important Factor militating against the success of field experiments. For example, communication between vertical wells less than 50 ft apart has been dictated to establish with certainty in some pilots. There is little support for the hope that processes can be transformed from one reservoir to another without the need for expensive field pilots.

Another technical snag looks likely to be the environmental impact of producing oil from tar sands. For a start, the process uses enormous amounts of water. Some companies insist that they recycle much of it, but even they accept that water scarcity will become an issue if many tar-sands operations take off in future. Indeed, local people are grumbling already.

One problem with these bitumen deposits is that about 15% (at present) of the gross energy available in the bitumen must be consumed directly to extract and process the materials to oil. A much higher capital investment is needed than for conventional oil wells, and this plant requires additional energy for its construction. Therefore, the "net energy" available from "tar sands" deposits are less.

This problem of declining net energy also appears in drilling deeper wells on land and in accessing oil and gas deposits under the sea. Some fossil fuel deposits will be left in the earth, because getting them out would devour so much energy that the efforts would be profitless in energy terms alone. Probably the net energy yield of tar sands will decline in future.

As the tar sands deposits are landlocked, transport from them is expensive and the bitumen is mixed with sand and other material processing must take place near the deposits.

This means that the air pollution from burning very large amounts of fossil fuels will be concentrated in western Nigeria, which will be especially serious in dry season.

It is estimated that the extraction of the roughly 300 billion barrels (oil equivalent) which appears to be accessible with current or foreseeable technology will result in the creation of a lake of oily water and sludge the size of rivers around the existing location. Thus the exploitation of the tar sands on a very large scale would involve the relegation of much of western Nigerian areas, to be destroyed for the benefit of the urban lifestyles, and the "car culture" of the more densely inhabited areas of the continent.

Due to the high capital investment needed, labour requirements and environmental factors, industry opinion seems to be that the tar sands will be exploited in a different pattern that conventional oil much more steadily over a period of 100 years or more.

However, social and political pressures as other sources of fossil fuel decline may clash with economics and the environment. The energy economics will likely win, but there may be some "collateral damage" in battle.

If the process by which future Nigerian leaders learn from reality follows the same pattern as for the current administration, which is to say they learn through high impact collisions, the outlook for Nigerian is not good.

I would like to put in perspective what the petroleum engineer is being asked to do in thermal in-situ recovered in tar sands. It is analogous to ask a chemical engineer to make a high-pressure, high-temperature process work in a leaky vessel of unknown dimensions, tilled with that, buried 1,000 ft below the surface. It should not be surprising, therefore, to find that results of thermal in-situ pilots are somehow erratic and unpredictable.

VI. CONCLUSION

Nigeria has the second-largest tar sand and bitumen deposit reserves in the world, after Venezuela.
Nigeria's dependence on aid as main revenue earner may be broken as exploitation of bitumen promises billions of naira in annual revenue. The Federal Government's new national policy on solid minerals is to provide adequate infrastructure, human development, and preservation of the environment, establish health and safety measures.
As Nigeria is basking in the euphoria of having this new foreign exchange earner, there is an urgent need for Nigerians to pause and reflect on the negative implications of the exploitation of tar sand on the environment and the communities concerned, because there is no doubt that the commercial exploitation of this important mineral will be a plus in the economic growth of our great nation through enhanced foreign exchange earning.

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BIOGRAPHY

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