

Energy-mix Innovative Solutions; Transition to Gas Value-chain in Nigeria's Oil & Gas Industry

Theme: Breaking Barriers to Innovation, Local Manufacturing and Technology Development in Nigeria

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Abstract:

Energy generation, production and consumption relating to petroleum industry, demand a multidimensional approach that focuses on future cleaner energy for the energy-mix portfolio. This demands prudence to manage operations in sourcing these rich deposits of natural resources (crude oil and gas) in a very effective and efficient manner; for the nation's economic benefits and wellbeing; in growing the economy from the financial gains in the hydrocarbon business. Energy is the ability to do work, and it is also the fuel that drives economy and prosperity. For the extractive operations on this energy resource capital-stock (crude oil and natural gas), the oil deposits and gas reserves have great economic potentials that avail enormous financial opportunities to enrich the economy, if these richly endowed abundant resources are innovatively managed and optimally harnessed locally. The recent hyperinflation and the exorbitant pump price of petrol/gasoline in Nigeria induces the current innovative solutions in energy transition process, necessitating a switch over from consumption of petrol to compressed natural gas (CNG). The three objectives of this product-shift in Nigeria and the sub-Saharan Africa (SSA) primarily include; supporting the global quest for "energy security" in an ever rising world population. To comply with the ongoing United Nations' net-zero carbon emissions target by 2050 through provision of "green fuel" from the proven huge gas reserves (estimated to last 94 years). Most importantly, to alleviate the sufferings of the vulnerable poor masses within the economy by sustainable energy supplies that is economically cheap, reliable and affordable.

Keywords: Energy Consumption, Energy-mix, Innovative solutions, Energy Security, CNG

Introduction:

The energy solutions management occupies the center space that effectively deals with the delivery of the most feasible energy option; which is the choice of product from the available energy-mix products, suitable for specific energy consumption needs or purpose, at any given point in time. This conceptual idea engages all available energy options for management at a given time, as contained in an energy-mix portfolio with the key drivers (Olorunsola, 2021). The ultimate attraction therefore, presents innovative solutions at the end, for that particular value-chain on energy products. In dealing with the energy challenges, and all manners of impediments

that are posing economic bottlenecks and resistance to economic growth and prosperity; energy transition efforts are expected to address the three critical dimensions (economic viability, environmental issues and social factors) that influence the achievable targeted goals. This is pursued through energy innovation (significantly) for manufacturing operations, by exploiting the applicable improved technology. By such methods, innovative technological knowhow is deployed to break barriers that impede rate and speed in manufacturing operations. Its eventual actualization ultimately enhances growth and development within the economy.

From the economic dimension among the three critical factors and pillars of influence that determine the importance of energy to man's life. It is necessary to understand the critical roles of energy, as a factor to human sustainable existence, and also look at its impacts; both beneficial and the unfavorable impact, especially on man's environment. It is based on the outcomes that both its attractive potentials and the challenges alike, are weighed from the empirical results received from different studies and literatures reviewed (Olorunsola, 2021). Without energy, man will definitely not be able to do any work. On that note, "energy scarcity" "energy poverty" and "energy crisis" within the system, should not be entertained, neither be given a chance to occur nor be allowed at any point in the entire energy landscape. This is the essence of the innovative solutions through a transition for an optimally managed energy-mix portfolio that assures a sustainable energy security within the economy.

Expressing energy as a basis for an economy to be sustainable; with the first law of thermodynamics that "energy can neither be created nor destroyed"; as *total energy conservation* (the total energy of an isolated system is constant despite internal changes). Demonstrating the *nature or form of energy formula* in mathematical equation, as a function of work done (within the economy), the following formula applies; $K_i + U_i = K_f + U_f$ **Equation 1** (where U is Potential energy denoted as PE; and K is Kinetic energy denoted as KE; and i denotes initial, while f denotes final). Energy can only be transformed from (either as "heat" or "work") one form to another.

Whereas the formulae to determine both Potential energy (PE) and Kinetic energy (KE) of an object is $PE = mgh$ and $KE = \frac{1}{2}mv^2$ **Equation 2** (where m denotes Mass of the object, g denotes gravitational acceleration, h denotes height; and v denotes Velocity of the object).

Also the equation developed by Albert Einstein is $E = mc^2$ **Equation 3**, shows (the law of relativity of light) that when the energy of a body changes by an amount E (no matter the form the energy takes), the mass (m) of the body will change by an amount equal to E/c^2 ; where c is the speed of light.

The following terms and the relationship between them (where they may apply) are therefore, needed to be noted thus; *Force (F) = *mass x acceleration* (a). SI unit measure of force is in Newton (N). *Weight = mg is *Potential force* or mass x gravitational acceleration (where g has zero horizontal distance but vertical distance h only), or the "*mass at a state of rest horizontally*", or without horizontal velocity/horizontally motionless, or a horizontally static mass with vertical height, h only). SI unit measure of weight is also in Newton (N). *Work done

= *force x distance* moved in direction of force. SI unit measure is in joule (J). *Change in gravitational energy (Potential energy) = mgh . *Power = work done $\div$ time (rate at which energy is used) also called “activity”. SI unit measure of *work* is in watts (W), while *time* (t) is measured in seconds. Also *Power = force x velocity (work done/time) or (energy/time). *Efficiency = total energy transferred in work done x 100%. *Acceleration (a) = net *velocity* $\div$ *net time* squared ($\Delta v/\Delta t^2$) whereas $a = g$ (where “g” is a gravitational acceleration in a vertical direction with horizontal distance (d) = zero; and “a” is acceleration of an object in motion in a horizontal direction). *Velocity (speed) = *distance* $\div$ *time* ($v=d/t$); so a *gravitational velocity has a zero horizontal distance with a constant horizontal velocity* ($k = 9.8 \text{ m/s}^2$) and vertical distance hence, $v = k = g$ for *horizontal velocity without acceleration*, in other words, a motionless object (an object at rest).

The outlined three objectives that border on Social issues, environmental challenges and economic dimensions; clearly summarize the expectations from a gas value chain in Nigeria’s oil and gas industry, through innovative solutions on energy-mix menu. These include supporting the global concerns for “energy security” in an ever rising world population. To actualize the United Nations’ net-zero emissions target by 2050. Produce CNG, the “green fuel” that is economically cheap and readily made available at affordable rates within the economy that shall alleviate the sufferings of the vulnerable poor Nigerians by sustainable energy supplies.

Energy Security:

Energy security as defined by the International Energy Agency (IEA), is “the uninterrupted availability of energy sources at an affordable price”. It focuses on energy demand and supply; to assure non incidences or disallows challenging issues of *energy poverty/energy scarcity*; of which its adverse impact may eventually result to *energy crisis*. The energy consumption issues are carefully discussed, strategically handled and proactively addressed with a long term plan. Such energy supply plan, obviously with its *availability* factor, has in addition; *accessibility*, *acceptability* and *affordability* elements (different possibilities) that are effectively determined/characterized by influential perspectives of the following; economic development, environmental needs and social issues. Invariably, it means, *balancing the increasing need for energy security to meet the continuous growth in energy demand through shortage reduction and increased uptime using optimization as the core of this review paper that provides an insight into recent studies in the field of natural gas supply-chain resilience as a major player in the energy mix* (SN Emenike, G Falcone, 2020).

Focusing on environmental needs from that perspective as an example, with a long-term to diminish carbon emissions; *innovative solutions* are introduced through *energy transition that adds* (Richard York, Shanon Elizabeth Bell, , 2016) *alternative, cleaner energy that is sourced from fossil fuels, on energy-mix portfolio* in Nigeria’s gas value chain by *carbon reduction technology*, with a novel strategic initiative of “maximum energy – minimum emissions” (Jaber, 2022). This concept improves on a similar older study inter alia; “Overall, our results imply that

renewable energy consumption is crucial for achieving sustainable environmental goals and discourages fossil fuel use in the energy mix. We recommend that China consider empirical evidence and initiate long-term strategies to diminish carbon emissions for a sustainable environment". (Kashif Raza Abbasi et al, 2022).

The competing essence for energy security and energy sustainability therefore, is borne out of necessity; the need to diversify the energy-mix is based on the pressures of global energy demand that is backed up with energy security plan. It still maintains the first law of thermodynamics/total energy conservation, tied to increasingly global population rise; and the pressures of net-zero targets ($K_i + U_i = K_f + U_f$). Energy security ultimately would be meaningfully applied on energy production and consumption by efficient management of energy solutions on energy-mix menu, at any given period.

Energy-Mix Portfolio:

The energy transition program majorly focuses on introduction and development of renewable energy sources (wind, sun, geothermal and hydro). This is in line with the UNs' climate action agenda to mitigate global warming impact by net zero emissions target by 2050; for low carbon energy efficiency, and the carbon footprints neutrality. However, observation has indicated that the pool of currently available renewable energy sources remains insufficient, to adequately and satisfactorily satisfy the global energy demand, based on the mounting pressure from continued rise in global population. This points to a fact that energy-mix module from the perspective of global solutions management, is always expected to be strategically engaged, to constantly and sufficiently deliver efficient energy supply services that align with the concept of sustainable energy security. These observed insufficient sources still require addition of more energy products to augment and meet the future global energy demands in many economies. Nigeria for instance, as an oil rich nation, is presently faced with acute *energy crisis*; electricity power supplies and energy for transportation/mobility are insufficiently supplied at even a very exorbitant pricing tariff. Based on the manifestation of energy poverty (as presented) in the economy, energy-mix portfolio is therefore, indicated to attract more, newer and cleaner energy products, through further research efforts (Jaber, 2022).

Nigeria's oil and gas industry, over the years is observed to be grossly underutilized in terms of local manufacturing of refined products; whereas the economy swims on ocean of abundant natural resources. This however, indicates a significantly huge *gap in the nation's unemployed oil and gas resources/capital stock* (Nwaozuzu) for local refining. Available records from the Organization of Petroleum Exporting Countries (OPEC) on proven quantity of crude oil reserves is put at thirty seven billion (37,000,000,000 barrels); along with the proven huge gas reserves that is estimated to last 94 years (Nnodim, 2023). The energy crisis consequently shall manifest if a continued resistance on consumption of energy sourced from fossil fuels; both in Africa and some parts of Europe is enforced. Contrary to that position because of energy shortage, for instance, *Algeria, Nigeria, Morocco, Egypt and South Africa (the big five) are still heavily dependent on fossil fuels* (G. Mutezo, J. Mulopo, 2021).

With the concept of energy additions that will assure a sustainable energy security in an ever rising world population; energy-mix portfolio can be improved in Nigeria (particularly) with the maximum energy-minimum emissions strategy that generates environmental friendly, alternative cleaner energy, the CNG that is in the gas value chain, among fossil fuels. It becomes imperative that energy supply from the fuel components in the diversified energy-mix portfolio, expresses innovative solutions management action (Olorunsola, 2021); which innovatively bridges any gap in local manufacturing and technology development in Nigeria.

Net-Zero Emissions:

In a world that is faced with energy and climate issues, needs to tackle this dual challenge by meeting global energy demand, and at the same time reduce carbon emissions. This dual global challenge has an urgent task to accomplish by strategically applying innovative solutions that could be accessed through technological advancements in realizing the targets; to sustainably conserve the earth that will support man's future existence (to escape the looming climate Armageddon). Net-zero carbon emissions target in 2050 target therefore, is essential and it is the global process action (among other climate mitigation methods) required to advance decarbonization goals to shape a more secured, sustainable and livable environmental future. Carbon balancing or carbon neutrality is a way of absorbing equal amounts of carbon that is emitted into the atmosphere. It is an environmental decarbonization strategy that sustains energy consumption process within a temperature limit of $+1.5^{\circ}\text{C}$ to suppress further escalation of global warming, as the temperature limit is the suggested safe threshold by the Intergovernmental Panel for Climate Change, IPCC; while economic and commercial activities go on, driven by fossil fuel energy usage that keeps emitting carbon dioxide.

This situation makes it inevitable for introduction of cleaner energy of the future that is innovatively sourced from fossil fuel gas value chain. It then becomes imperative to add the green fuel (CNG) into the energy-mix portfolio. Nigeria, at this stage of the global challenge on energy demand and supply value chain within the entire energy ecosystem needs to properly key in and align fully through energy transition planning and implementation. In addition, the climate change issue that is already affecting the entire world, with the global environmental challenges of extreme weather conditions, worst of all being the flooding of cities and communities with frequent landslides and heavy rains; and in some other occasions, it is either drought or heat waves that ravage some parts of the planet earth. Through technological development, the nation could innovatively adapt (with the best available scientific method), and establish private sector-driven local manufacturing of the cleaner energy of the future, to actualize energy sustainability. The economy by so doing, will comply with the ongoing United Nations' net-zero carbon emissions target in 2050 through massive provision of CNG/green fuel from utilizing the huge gas reserves (estimated to last 94 years). *Natural gas, as the cleanest fossil fuel, serves as a transition fuel for medium-term emission mitigations in various sectors, such as power, heating, transportation, and industry* (Y Yin, JSL Lam, 2022).

Discussions:

Breaking barriers to innovation, local manufacturing and technology development in Nigeria; as treated under the study topic, “energy-mix innovative solutions; transition to gas value-chain in Nigeria’s oil & gas industry”, offers the readership an opportunity to further discover novel concepts for innovative energy products that are added from the gas value chain into the energy-mix menu. This is for a specific purpose of exploiting the gas value-chain of hydrocarbon background (fossil fuel sourced) for a purpose, realize sustainable energy security provisions in a changing world that is progressively laden with an ever-mounting global energy demands and consumption due to the rising global population. This global energy consumption is innovatively pursued alongside the UNs’ climate action resolutions for energy efficiency (where Efficiency = total energy transferred in work done $\times 100\%$) by provision of cleaner/green energy, sourced from gas value-chain of fossil fuels origin in the oil & gas, which is exploited for ultimate final gains to the economy, in the twenty first century strategic energy needs by man. The heavy carbon emitters during industrial production are innovatively managed with energy solutions that optimally balance out carbon emissions by carbon neutrality through technology developed for decarbonization acceleration (where Acceleration (a) = net velocity $\div$ net time squared ($\Delta v/\Delta t^2$) whereas $a = g$ (where “ g ” is a gravitational acceleration in a vertical direction with horizontal distance (d) = zero; and “ a ” is acceleration of an object in motion in a horizontal direction). This concept is implemented by carbon capture and storage method (Tabbi Wilberforce et al, 2021).

The fascinating aspect of the study is underpinned in the fact that reduced carbon emissions from the strategic energy transition by addition of sustainable and affordable cleaner energy is innovatively sourced from the gas value-chain to continually enrich the energy-mix portfolio into the future energy security. In Nigeria therefore, the green energy utility of CNG product, is an environmentally, very efficient emission compliant energy that is equally affordable in the energy market. This contributes to the social needs of the people in terms of sustainability and availability. It also complies with the climate net-zero emissions target by 2050; and finally it supports national economic growth through backward integration policy (from its local manufacturing strategy) for self sufficiency in the consumption of domestic energy, and the overall actualization of national productivity or gross domestic product (GDP).

Conclusion:

Breaking the barrier to innovation is going to be achieved in the country’s energy industry with application of technology to local manufacturing of CNG as a cleaner energy of the future from the abundant gas reserves available in the Nigeria’s gas value-chain. Decarbonizing the energy system by accelerating the production and consumption of CNG in Nigeria’s gas value-chain requires transformation that will help shape the future of the energy sector. This involves technological approach in the way industries consume, transport, and provide this fossil fuel sourced clean energy of the future.

The CNG’s popular focus, with great economic potentials that avail enormous financial opportunities to enrich the economy if optimally harnessed locally, is presently borne out of necessity in the Nigeria’s energy sector, due to the sudden emergence of hyperinflation caused

by the removal of fuel subsidy policy in the economy; where the generality of Nigerians contend with the challenges of tumbling disposable incomes and weaker purchasing power, among other energy products in the energy-mix menu. This all important product would raise the hope in growing the economy, from its financial gains in the hydrocarbon business.

As an acknowledged clean energy for the future, it remains the fuel that shall drive economy and prosperity in a very effective and efficient manner; for the nation's economic benefits and wellbeing; if optimally harnessed locally, which of course, will support the global quest for "energy security" in an ever rising world population. Its other benefits include the compliance to the ongoing United Nations' net-zero carbon emissions target in 2050 through provision of this "green fuel". It is also not without the alleviation of the sufferings of the vulnerable poor masses within the economy by sustainable energy supplies that is economically cheap, reliable and affordable. Further work on the gas value-chain is recommended towards more efficient approach to low carbon energy products from hydrocarbon based raw materials.

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