Exploring utilisation options of local energy resources in Nigeria in compliance with the Paris Climate Agreement

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Introduction

The objectives of this paper are to review briefly the main clauses of the Paris Agreement and to explore investment and utilisations options of the natural energy resources in Nigeria in compliance with the agreement. Accordingly, the paper comprises the following sections:

1. Stipulations of Paris Agreement and some of its economic implications
2. Current status of investments and utilisation of energy resources in Nigeria
3. Renewable sources and uses in some developed nations
4. Analysis of resources and alternative options
5. Recommendations

1. Stipulations of Paris Agreement

The Paris Agreement is designed to enable the international community to respond more effectively to the threat of climate change in order to enhance sustainable development and efforts to eradicate poverty. The Agreement was reached at the 2015 United Nations Climate Change Conference, COP 21 held in Paris from 30th November to 12th December 2015. It was the 21st yearly session of the Conference of the Parties (COP) to the 1992 United Nations Framework Convention on Climate Change (UNFCCC). It is relevant to note that the COP is the supreme decision-making body of the Convention. All countries that are Parties to the Convention are represented at the COP.

The conference negotiated the Paris Agreement, its text is a consensus of views of the representatives of the 196 parties in attendance. The agreement will become legally binding when it will be joined by at least 55 countries which together represent at least 55 percent of global greenhouse emissions. Such parties will need to sign the agreement in New York between 22 April 2016 and 21 April 2017, and also adopt it within their own legal systems through ratification, acceptance, and approval by their relevant bodies. They will deposit their instruments of ratification with the UN

The national governments agreed to the following [1]:

- A long-term goal of keeping the increase in global average temperature to **well below 2°C** above pre-industrial levels and to aim to limit the increase to **1.5°C**, since this would significantly reduce risks and the impacts of climate change;

- Increasing the ability to adapt to the adverse impacts of climate change and foster climate resilience and low greenhouse gas emissions development, in a manner that does not threaten food production;

- Making finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development.

It may be helpful to explain what is meant by the statement "to keep the increase in global average temperature to below 2 degrees Celsius above pre-industrial levels". The average temperature recorded between the pre-industrial years, 1850 – 1900, is considered the reference temperature. In effect, one of the objectives of the Agreement is to maintain the global average temperature to be lower than 2 degrees Celsius above this reference temperature. By November 2015, it was noted that the Global annual average surface temperature in 2015 was getting to 1°C above the pre-industrial average (as represented by the 1850-1900 reference period).

As stated in the third statement of the Agreement, the final text also pledges financial support from rich, developed nations to developing countries as they adopt changes needed to meet the temperature targets.

Some Economic Implications

Use of fossil fuels, such as oil and coal, is the major cause of greenhouse gases. These fossil fuels also are resources that constitute the main source of revenue for developing economies. Eliminating their use and switching to renewable energy sources, such as wind and solar power, could be very costly for developing countries. For example, Nigeria's national budget is almost completely based on oil revenue. The 2016 budget is proposed to be funded on oil price of $38 per barrel. After reviewing the trends in the global oil industry, the government set a benchmark price of $38 per barrel and a production estimate of 2.2 million barrels per day for 2016. The budget presented by President Buhari amounted to N6.08trillion (US$ 0.03 trillion, that is US$30billion) on December 22, 2015. It is therefore difficult to contemplate the survival of the country if revenue from oil is completely removed.

Prior to the oil boom and the wealth, it has created in Nigeria, this was before 1970, coal was a major source of income. It was in much demand because it was used to power the electricity generating stations, factories, ships, locomotive trains, etc. When it was replaced by oil, much income was lost by the country and by the major cities built on its wealth. In Nigeria, there is an important state capital in the present South East, Enugu, it used to be referred to as the "coal city"; its commercial importance was greatly diminished when coal lost its income earning power. [2]

2. Current status of investments and utilisation of energy natural resources

Natural resources relevant to this discussion include natural gas, oil, and renewable resources. Some of their uses are here reviewed.

Natural gas

Nigeria had an estimated 180 trillion cubic feet (Tcf) of the reserves as of January 2015, according to the Oil and Gas Journal (OGJ), making it the ninth-largest natural gas reserve holder in the world and the largest in Africa. It produced 1.35 Tcf of dry natural gas in 2013, ranking among the world's top 30 largest natural gas producers. Natural gas production is

constrained by the lack of infrastructure to monetize natural gas that is currently being flared. Most natural gas reserves are located in the Niger Delta.

Natural gas flaring

A significant amount of Nigeria's natural gas is flared (burned off) because some of its oil fields lack the infrastructure needed to capture the natural gas produced with oil, known as associated gas. In 2013, Nigeria flared 428 Bcf of its associated gas production, or 15% of its gross production. According to the U.S. National Oceanic and Atmospheric Administration (NOAA), natural gas flared in Nigeria accounted for 10% of the total amount flared globally in 2011. The government has been trying to end gas flaring for several years without success. In 2008, it developed a Gas Master Plan that promoted investment in pipeline infrastructure and new gas-fired power plants to help reduce gas flaring and provide more gas to fuel much-needed electricity generation. However, progress is still limited because security risks in the Niger Delta have made it difficult for the Independent Oil Companies (IOCs) to construct the infrastructure that should support gas monetization. [3]

Gas-to-liquids (TL)

Chevron-operated Escravos GTL project is still active although about nine years behind schedule. Chevron (75%) and Nigerian National Petroleum Company (NNPC) (25%) are jointly developing the $10 billion facility. Sasol Chevron, a joint venture between South Africa's Sasol and Chevron, provided technical expertise to design and develop the GTL plant. It finally achieved first production in mid-2014. The project is challenging due to its location in a swamp, requiring large quantities of sand landfill to support heavy reactors and other equipment at the site. It will convert 325 MMcf/d of natural gas into 33,200 bbl/d of liquids, principally synthetic diesel for cars and trucks. This will provide significant environmental benefits by converting natural gas to produce ultraclean GTL diesel.

LNG and pipeline exports

Nigeria exports the vast majority of its natural gas in the form of liquefied natural gas (LNG), and a small amount is exported via the West African Gas Pipeline (WAGP) to nearby countries. Nigeria exported about 800 Bcf of LNG in 2013, ranking it among the world's top five LNG exporters, along with Qatar, Malaysia, Australia, and Indonesia. Nigeria's LNG exports accounted for about 7% of globally traded LNG. Japan is the largest importer of Nigerian LNG and imported 23% of the total in 2013, followed by South Korea (17%) and Spain (14%).

Bonny LNG facility

The Nigeria's LNG (NLNG) facility on Bonny Island is the country’s only operating LNG plant. Its partners include NNPC (49%), Shell (25.6%), Total (15%), and Eni (10.4%). NLNG currently has six liquefaction trains with a production capacity of 22 million tons per year (1,056 Bcf/y) of LNG and 4 million tons per year (80,000 bbl/d) of liquefied petroleum gas. A seventh train is planned to increase the facility's LNG capacity to more than 30 million tons per year (1,440 Bcf/y).

Brass LNG Limited

There is also an LNG plant in Brass which is being developed since 2006. It is being built by a consortium made up of NNPC, Total, and Eni. ConocoPhillips was a partner in the consortium but pulled out of the project in mid-2014 and transferred its shareholder interest to the other members.

West African Gas Pipeline

Nigeria exports a small amount of its natural gas via the West African Gas Pipeline (WAGP), which began commercial operations in 2011. The pipeline is operated by the West African Gas Pipeline Company Limited (WAPCo), which is owned by Chevron West African Gas Pipeline Limited (36.9%), NNPC (24.9%), Shell Overseas Holdings Limited (17.9%), Takoradi Power Company Limited (16.3%), Societe Togolaise de Gaz (2%), and Societe BenGaz S.A. (2%). It carries natural gas from Nigeria's Escravos region to Togo, Benin, and Ghana, where it is mostly used for power generation.

Proposed Trans-Saharan Gas Pipeline

Nigeria and Algeria proposed to construct the Trans-Saharan Gas Pipeline (TSGP). It should carry natural gas from oil fields in Nigeria's Delta region to Algeria's Beni Saf export terminal on the Mediterranean Sea and to supply gas to Europe. In 2009, NNPC signed a memorandum of understanding (MoU) with Sonatrach, the Algerian national oil company, to proceed with plans to develop the pipeline. Several national and international companies have shown interest in the project, including Total and Gazprom. However, security concerns along the entire pipeline route, increasing costs, and ongoing regulatory and political uncertainty in Nigeria have delayed the project. [3]

Electricity generation, the main use of the natural gas

In Nigeria, for power generation, the country uses mostly natural gas. In 2014, for example, **t**here were 23 grid-connected generating plants in operation in the Nigerian Electricity Supply Industry (NESI). They constituted a total installed capacity of 10,396.0 MW and available capacity of 6,056 MW. The thermal generation had an installed capacity of 8,457.6 MW (81% of the total) and an available capacity of 4,996 MW (83% of the total). Hydropower, from three major plants, accounts for 1,938.4 MW of total installed capacity and an available capacity of 1,060 MW. [4] From the foregoing, power generation should not be affected much by the Paris Agreement since its main fuel is gas and not oil. However, the use of natural gas has many problems which include the vandalisation of the pipelines, and poor infrastructure which contributes to the flaring of excess natural gas. Natural gas flaring, the burning of associated natural gas that is produced with oil, has contributed to environmental pollution.

Nigeria has one of the lowest rates of net electricity generation per capita in the world. Electricity generation falls short of demand, resulting in load shedding, blackouts, and a reliance on private generators. Nigeria's power sector suffers from poor maintenance of electricity facilities, natural gas supply shortages, and an inadequate transmission and distribution network. Only 41% of Nigerians have access to electricity and actual electricity demand in Nigeria is estimated at 10,000 MW. According to a 2010 Harvard paper, more than 30% of electricity is produced by inefficient private generators. Businesses often purchase costly generators to use as

back-up power supply during outages. Most Nigerians use off-grid traditional biomass and waste, such as wood, charcoal, and animal dung, to fulfil household energy needs, such as cooking and heating. [3]

Privatisation: On November 1, 2013, the Federal Government of Nigeria officially privatised the electricity generation companies (GenCos) and distribution companies (DisCos). The privatisation was part of a power sector reform initiated by the 2005 Electric Power Sector Reform Act, which called for the privatisation of the state-owned Power Holding Company of Nigeria (PHCN), and the creation of the GenCos and DisCos.

Current developments: The development of the electricity industry continues. For example, on December 17, 2015, the Nigerian Electricity Regulatory Commission, NERC, issued licence to eight companies with a combined capacity to generate 1,648.25 megawatts of electricity. The Commission also licenced a distribution company during the event that took place at its headquarter in Abuja.

The licences according to a statement issued by the Commission, were a mixture of on-grid, off-grid, embedded generation and distribution of electricity. They were issued to the following organisations:

- Ossiomo Offistes and Utilities/ Ossiomo Power &Infrastructure, based in Edo state will engage in electricity distribution and in embedded generation of 55 Megawatts gas power electricity.

- Anambra state Independent Power Generation Company Limited, located in Onitsha, has an on-grid gas-fired plant with the capacity for 528mw.

- Cummins Power Generation, Nigeria Limited (NBC) Ikeja with a capacity for a 3.5mw capacity, off- grid. The company also has licence for a 1.7mw to serve A&P Foods, in Agege, Lagos.

- Sinosun Investment Limited, based in Jibiya, Kastina state is for an on-grid, solar power generation of 100mw capacity.

- LR-Aaron Power Limited, located in Gwagalada has a licence for 100mw solar powered electricity generation. [5]

The last two licences in the list are very welcome developments because they are for solar power generation which are the preferred energy natural resources.

Power generation outlook and gas supply.

Nigeria has continued to enjoy significant increase in power generation and supply in later part of 2015. For instance, the country's power generation, which was below 2,000MW between January and May 2015, recorded peak generation of about 4,057.20MW in July, according to a power generation report by the Presidential Taskforce on Power. This is still below the peak

demand forecast of 12,800MW. The highest peak energy generated was 4,517.6MW recorded in 2012.

Chairman of Nigerian Electricity Regulatory Commission (NERC), Dr. Sam Amadi said that power generation might peak above 5,500MW after July 2015 if on-going repairs on gas supply pipelines were completed. Amadi, said a lot work had been done to contain the frequent vandalism of gas pipelines. He added: "much of the vandalisms are in the gas side. The gas problem is getting better. We had meeting with the Group Executive Director of gas at NNPC and he told us of improvements coming up. We hope that by the end of July, with the repair work going on, we might be able to do maybe above 5,500mw.

"The assurance we have is the East-West Gas Pipeline is projected for completion sometime towards the end of 2016. The idea is that we should be able to do slightly above 6000mw. The problem is that it depends also on increase in capacity. If we get the NIPP plants in, we are looking that 4,700mw. If we add this to the distribution companies, we can go above 9,000mw. Right now, we do not have enough gas to do above that.

"They are looking at 2016-2017. With the gas that will come from the new and existing pipelines, the operators think that we can get enough to get us the available capacity that we have, and the recoverable capacity that the generators would have".

He expressed the hope that the new government would do more to curb vandalism, adding that the "reports we have from them is that there is containment and vandalism has dropped as well". Meanwhile, the core investor of Ughelli Power Plc, Transcorp Ughelli Power Limited, has unfolded plans to ramp up the generation capacity of the plant from the current installed capacity of 972megawatt (mw) to 2200mw in the next three years.

Briefing the post privatisation monitoring team from the Bureau of Public Enterprises (BPE), last week, the Chief Executive Officer (CEO) of Transcorp Ughelli Power Limited, Adeoye Fadeyibi explained among other things that in the company's generation forecast, by December 2015, the generation capacity would be raised to about 850mw and in December 2017 to about 1650mw and 2200mw in 2018. He however lamented that due to the quality and quantity of gas available to the plant, only about 350mw could be made available to the grid. He pointed out that another major challenge facing the company was the wheeling capacity of the Transmission Company of Nigeria (TCN) and tasked the Federal Government on investment in the transmission segment of the value chain of the power infrastructure to strengthen the wheeling capacity of TCN. [5]

Gas - power plant generation bottleneck

Nigeria's energy crisis deteriorated Monday, May 25, 2015 as the Nigerian Electricity Regulatory Commission (NERC), the government agency responsible for regulating operations in the electricity sector, reported that only five of the country's 23 power plants were functional because of lack of gas. By implication, Nigerians would have to contend with a biting fuel supply crisis, which almost grounded the economy for months, and lack of electricity to power.
On Friday, May 22, the Permanent Secretary, Federal Ministry of Power, Godknows Igali, had during a meeting with the outgoing Vice-President, Namadi Sambo, in Abuja raised the alarm over the epileptic supply of electricity across the country. He attributed the situation to the epileptic performance of most key power plants in the country, including those located in at

Utorogu, Chevron Oredo, Oben gas-fired power plants, as well as Ughelli and Chevron Escravos power plant, which have all been shut down. Mr. Igali also spoke of the closure of the National Integrated Power Plants (NIPPs), including Nigeria's largest power plant at Egbin, Olorunshogo 1 & 11, Omotosho 1& 11, Geregu I & 11, Ihonvor and Sapele on the western axis and Alaoji on the eastern end.

Late on Monday, May 25, the Chairman of NERC, Sam Amadi, said: "At present, 18 out of the 23 power plants in the country are unable to generate electricity due to shortage of gas supply to the thermal plants, with one of the hydro stations faced with water management issue. This has led to loss of over 2,000 megawatts in the national grid". He said the situation was further compounded by the strike action by the Nigerian National Petroleum Corporation (NNPC) chapter of the Petroleum and Natural Gas Senior Staff Association of Nigeria (PENGASSAN). The strike, he explained, had seriously affected all other sectors in the energy supply chain of the economy, particularly gas supply to the thermal power plants. Although the Chairman said the Commission had recently engaged the gas supply companies and its licensees on strategies to boost gas supply to power plants, he expressed regrets that not much progress was made. He blamed the poor outcome on the inability of the NNPC and its subsidiary, the Nigeria Gas Company (NGC) to maintain regular supply, due to the high incidence of vandalism on the Trans-Forcados pipeline in the western axis and Escravos-Lagos gas pipeline in the eastern axis. [6]

Oil

Nigeria is the largest oil producer in Africa. Despite the relatively large volumes of oil it produces, Nigeria's oil production is hampered by instability and supply disruptions.

Local groups seeking a share of the oil wealth often attack oil infrastructure and disrupt oil shipments. In addition, oil thefts lead to severe pipeline damages, causing loss of production, pollution, and forcing production companies to shut down.

Ageing infrastructure and poor maintenance also result in oil spills. Protest from local groups over environmental damages from oil spills and natural gas flaring have increased tensions between some local communities and International Oil Companies (IOCs). The industry has been blamed for pollution that has damaged air, soil, and water, leading to losses in arable land and decreases in fish stocks.

NNPC has Joint Venture arrangements with Shell, ExxonMobil, Chevron, Total, and Eni, these are some of the International Oil Companies (IOCs). Other companies active in Nigeria's oil and natural gas industry are Addax Petroleum, Statoil, and several Nigerian companies. IOCs participating in onshore and shallow water oil projects in the Niger Delta region have been affected by the instability in the region. As a result, there has been a general trend for IOCs, particularly Shell, Total, Eni, Chevron, and ConocoPhillips, to sell their interests in marginal onshore and shallow water oil fields, mostly to Nigerian companies and smaller IOCs, and to focus their investments on deep water projects and onshore natural gas projects. According to the Oil & Gas Journal (OGJ), Nigeria had an estimated 37 billion barrels of proved crude oil reserves as of January 2015—the second-largest amount in Africa after Libya. The majority of reserves are found along the country's Niger River Delta and offshore in the Bight of Benin, the Gulf of Guinea, and the Bight of Bonny. Current exploration activities are mostly focused in the deep and ultra-deep offshore. NNPC had undertaken onshore exploration activities in northeast

Nigeria, within the Chad basin, but the lack of discoveries and the presence of the militant group Boko Haram put exploration at a standstill. Exploration activities in the onshore Niger Delta have decreased because of the rising security problems related to oil theft and pipeline sabotage. [3]

Air pollution from cars and privately owned electricity generators

There is generally traffic gridlocks on roads in major cities such as Lagos both mornings and evenings during peak periods of traffic. Poor roads, under-utilised waterways as well as the lack of a metro system ensure that many of the city's estimated 2 million vehicles get stuck around the same spot for hours, their occupants trapped inhaling polluted air.

Unregulated emissions from biomass burning, vehicles, diesel generators and factories in the industrial areas of the city pose serious problems for the health of its inhabitants, admits an official in the Lagos State Environmental Protection Agency (LASEPA), who asked not to be named. "There are high levels of volatile organic compounds (VOCs) - harmful organic emissions that easily vaporise at room temperature - in the air and that is what government is trying to reduce," he says. "We have closed down some schools and factories as part of our campaign, so we are working." In March 2014, LASEPA shut down a school after 13 students fainted from inhaling carbide. They were rushed them to hospital for treatment. In August 2015, it temporarily sealed off a number of hotels for directing the exhaust pipes of its industrial generators towards the road. Carbon monoxide poisoning is another danger associated with generators. In July, a family of three died from inhaling toxic fumes from their indoor generator. [7]

"No matter how much you legislate, there will still be some level of pollution, so it is up to government to enforce that and carry out remediation," says Gabriel Babawale, a senior lecturer in environmental sciences at the University of Lagos. "I'm not sure that government is doing much of this at the moment."

In February 2007, the Lagos Metropolitan Area Transport Authority initiated a 14-month Lagos air quality monitoring study as a result of a smog - Nigeria's first ever - on 12 October 2005. The results confirmed what many already knew; that motor transport is the major cause of pollution in the city.

In November 2015, the Nigerian government banned the import of miniature generators because of their contribution to air pollution. Diesel generators are undoubtedly part of the problem, but they will continue to be used until the electricity supply improves. Nigeria's power plants have been privatised along with the distribution systems, but the government still operates the largely inefficient transmission lines. For industries and citizens looking to power their businesses and light up their homes, use of private generators is the solution.

The World Health Organisation estimates the annual number of deaths from outdoor air pollution in Africa as 176,000. Additionally, the UN Economic Commission of Africa has put that the cost of air pollution in select African cities including Lagos, to be as high as 2.7% of the continent's GDP. Opeoluwa Abimbola, a consultant with the city's ministry of environment, says: "When Lagos fixes its transport system in the coming years that will spur on development in the city and improve the living conditions of the people. Only then can it truly claim to be a megacity."[7]

Oil consumption and refining

Nigeria has a crude oil distillation capacity of 445,000 bbl/d. It consumed 305,000 bbl/d of petroleum in 2014. The country has four oil refineries (Port Harcourt I and II, Warri, and Kaduna) with a combined crude oil distillation capacity of 445,000 bbl/d, according to OGJ. The refineries chronically operate below full capacity because of operational failures, fires, and sabotage mainly on the crude pipelines feeding the refineries. The combined refinery utilization rate was 22% in 2013. As a result, the country imports petroleum, it imported 164,000 bbl/d of petroleum products in 2013.

For several years, the Nigerian government has planned the construction of new refineries, but the lack of financing and government policies on fuel subsidies have caused delays. A Nigerian company, the Dangote Group, plans to construct a $11 billion, 500,000 bbl/d refinery near Lagos. The refinery is expected to come online by mid-2018. The Senior General Manager, Civil and Structural, Dangote Refinery, Madhar Kelkar, said:

"With this project, Nigeria will reach self-sufficiency in little or no time and the vision is not just to supply the domestic market but to export to neighbouring countries to be able to generate some foreign exchange (Forex) for the economy.

"Besides, we will be generating and saving a significant amount of forex, so it is a massive investment for Nigeria," he added. [3]

3. Renewable sources and their uses in some developed countries

Coal, oil and natural gas are all non-renewable, and when continually used will eventually dwindle and disappear. By contrast, a number of renewable energy resources, such as wind and solar energy, are constantly replenished and will not run out. The sun is the major source of most renewable energy because it produces solar energy and also helps to drive the wind. Not only can solar energy, through the use of solar panels, be used directly for heating and lighting as well as for generating electricity, the sun's heat also drives the winds, whose energy is captured with wind turbines. There are other sources of renewable energy such as hydrogen, geothermal energy, and ocean energy. The renewable sources are clean sources of energy, such that they have a much lower environmental impact than conventional energy technologies.

Global wind power

Wind power now generates 706TWh of electricity, 3% of total world electricity generation. That is almost equivalent to the total power generation of Germany and the Netherlands combined. Note that one terawatt-hour is one million megawatt hour (MW), it is also the same as one thousand gigawatt-hour (GW). China leads the world in installed wind capacity (115GW), and in 2014 China recorded the largest addition of new wind capacity (23GW), followed by Germany (6GW) and the US (5GW). In 2014 Asia Pacific overtook Europe and Eurasia to become the largest regional market in terms of total installed wind power capacity, with 147GW (39% of the world total) versus Europe's 135GW.

Wind has become an important contributor to European electricity generation. In Denmark wind power provided 41.4% of power generation in 2014. Wind power now provides 15% or more of

power generated in Spain, Portugal, Ireland, in Lithuania. Germany, which overtook Spain as the largest wind power producer in Europe in 2014, obtained 9.1% of its power from wind last year. Wind has a much smaller share in the US, the largest wind power producer in the world, where it contributes 4.3% of power generation.

Government support remains the single most important factor behind the fast growth of wind generation. Future growth is also dependent on further technological advances in offshore wind. This segment of the wind market is led by the UK, where offshore wind capacity reached 4.5 GW by the end of 2014.

The growing share of wind power in the electricity mix also reportedly presents unique operational challenges to grid operators. Because of the unreliability of wind power (reflected in a low utilization factor of around 25%), adding more wind generation capacity to the grid increases the need to boost the percentage of overall plant capacity set aside to provide ancillary services. [8]

Solar power

By 2050, the International Energy Agency forecasts that solar photovoltaic technology could generate up to 16% of the world's electricity. It also predicts that solar thermal electricity could provide another 11% on top of that. So, photovoltaic energy remains a promising emerging technology.

Over the past six years, solar modules have reduced in cost by some 80%. However, these technologies remain very capital intensive, with the majority of expenditure required upfront. Statistics from BP's Technology Outlook show that in 2012, utility-scale solar photovoltaic technology was the most expensive way of generating electricity in North America, compared to seven other sources, including onshore wind, nuclear and coal. Current solar cells are mainly made of silicon-based materials. Breakthrough technologies such as perovskite (a compound containing earth-abundant minerals) solar cells are evolving. Along with improved designs that convert a higher percentage of light than today's solar cells, these technologies promise higher efficiencies, lower cost and flexibility in application. In addition, improvements in biotechnology are likely to improve agricultural performance, enhancing the efficiency and scale of solar conversion to biomass. Overall advances in this area may affect natural gas usage for electricity generation, as well as accelerate electrification in the transport sector. [9]

Denmark and Solar Energy

In October 2012, Ministry of Foreign Affairs, Denmark announced that the country had already achieved its 2020 goal for solar energy production. The country previously publicized its national goal to produce 200 megawatts of energy from solar power by the end of this decade. Now, it seems that rapidly growing demand for clean energy and a solar-friendly government have allowed it to exceed that goal eight years before the target. Danish experts now predict that if this growth continues, 2020 levels of solar energy production will be 100 times what was first expected. According to Project Manager Kim Schultz from Invest in Denmark:

"The demand for solar cells has increased dramatically since net metering was implemented in 2010. Net metering gives private households and public institutions the possibility of 'storing'

surplus production in the public grid, which makes solar panels considerably more attractive. This means that solar solutions are more likely to meet consumers' demands." [10]

Solar Power and the Greek Economy

Greece needed to boost its economy. In October 2012, Greek Prime Minister Lucas Papademos spoke about the Greek government's plans to produce 100 percent green electricity by 2050. Papademos said green energy investment is a "national priority" to boost the economy. Greece wanted to become the EU's largest green energy exporter through Project Helios. The plans included increasing Greek solar power production from 206 megawatts (MW) in 2010 to 2.2 gigawatts (GW) by 2020, and up to 10 GW by 2050. The government hoped the plans would attract up to 20 billion euros ($27 billion) of investment. Although Project Helios would be expensive to implement, it would reduce Greece's carbon emissions by 80 percent by 2050 and would create jobs.

Günther Oettinger, EU Commissioner for Energy, praised Project Helios. "The proposal of Greece to develop the Helios project together with other member states and the European Commission has the potential to be truly groundbreaking," he said.

"Greece now has to demonstrate that it is possible to exploit the many hours of sunshine that it enjoys and to translate that into an economic benefit for Greece and those European regions that are not quite as sunny," he added. "Helios is also a unique opportunity to demonstrate that renewable energy technologies like photovoltaics are becoming competitive in the near future through European cooperation. It could be the showcase project on the way to a truly integrated European market for electricity from renewable sources, while simultaneously helping the Greek economy to recover."

Greece becoming a major exporter of solar power would definitely be a boost for the global renewable energy sector and would prove that the green economy is truly the way forward. Fingers crossed that Greece could actually make good on its plans. [11]

However, the Helios project has collapsed as at now. It is a complete shutdown of the solar energy project in Greece. In 2012, Greece added 890 MW. In 2013, 1047 MW. And then the numbers completely collapsed to only 13 MW in 2014. In 2015, it was 7 MW from January to April, with zero in March and April. So the 2014 record is only about one percent of the 2013 record.

In general, it is probably easier to pull off large scale solar projects in Greece than in Northern Africa, for various reasons. However, the project failed because of the insecurity and turmoil over the failure of the financial bailout by IMF and EU. Since Greece just went into default, people were unable to get their own money out of the banks, and it certainly did not help with pulling off something like the Helios project, or even just a normal development of these excellent solar resources. [12]

4. Analysis of resources and alternative options

One of the conclusions that could be arrived at from the foregoing study is that in order to comply with the Paris Climate Agreement, Nigeria may have to invest more on renewable energy. This is further buttressed by the following brief analysis of the researched alternative

options of the natural resources that could be harnessed to meet our energy requirements, for example in electricity generation.

Vulnerability of the natural gas supply: It is certainly evident that there is abundant supply of natural gas in the country. Theoretically, it should be possible to provide fuel for many thermal generating power plants in the country. However, operational experience has shown that it is vulnerable to pipeline vandalisms and other actions that disrupt the flow of gas and stop power generation. Two examples cited in this report are as follows:

- On Monday, May 25, 2015, only 5 out of 23 available gas thermal generators were in operation. The others could not be used because of shortage of gas caused by damages to pipelines supplying gas to the generators.

- Still linked to the scarcity was the fact that the union of gas workers had taken their members out on strike in spite of the disruption of gas supply to the country's major generators.

The above examples are recurrent events and pointers to the fact that for sustainable and stable power supply the country should not depend majorly, as it does now, on gas fired thermal electricity generators. Whilst it is necessary to work amicably with the workers' union all the time, their strike does not guarantee the continuity of gas supply. The pipelines spread across for miles on end to different power thermal plants. It is therefore impossible to police and watch over every inch of each important pipeline. It is inevitably vulnerable to attack and sabotage by any person such as an aggrieved worker or even a member of the public.

Inadequacy and unreliability of hydropower stations: Hydro power stations do not pollute the environment as fossil fuel fired generators, such as oil-fired do. However, often they cannot be used at full capacity because of low water level. A number of times, even at crisis times when the thermal power plants are not operational because of disruption of gas supply, the hydro power generators are found unavailable as a result of low water level. It therefore stands to reason that they are not reliable enough to be used as the basis for long-term sustainable power supply for the country.

The use of renewable energy sources: Renewable energy resources, such as wind and solar energy, are constantly replenished and will not run out. The potential to harness both wind power and solar power is quite great. In our hot and equatorial climatic conditions, solar power should be available all year round apart from few months when it rains heavily. In many rural and urban areas, there should be almost limitless scope for exploiting solar power. The intensity of the sun is very high and continuously available for hours, indeed, as high as some 10 hours and more every day. Wind power is also so powerful and very much available in many areas of the vast country.

5. Recommendations

1. From this analysis, it is clear that the use of fossil fuels, of which the most popular and probably most acceptable, is gas, has its vulnerabilities which make its unsuitable.

2. The limitations of hydroelectric generation have been highlighted such that it is not as reliable as solar and wind power.

3. In view of the foregoing, it is recommended that future investments on power generation should be on solar and wind power. Other reasons for this suggestion include the following:

   - They make for clean power generation in compliance with the Paris Climate Agreement.

   - If properly planned and implemented, solar power could be used not only to provide the power requirements for the country but also could be exported internationally. If the Greeks could plan Helio project to power much of Europe, Nigeria should be able to generate much power to sell to neighbouring countries. The geographical conditions for developing the power scheme could be the same in other countries but our neigbouring nations may not have the resources required to embark on such projects.

   - If we would invest on such a project, it should not only be in compliance with the Paris Climate Agreement but also in promotion of the objectives.

   - It is highly probable that it could attract funding from developed nations as stated in the Paris Agreement. They may be interested to support it as partners.

4. A think-tank comprising relevant experts and professionals could be established and charged with advising the country on its medium to long term power investments. It should include representatives from Federal Ministries of Science and Technology, Power, Industry, and Planning, etc.

5. While security has been a major requirement to keep the gas pipelines free from vandalisation, it is still likely that such a problem may be encountered in whatever infrastructure that is built to meet our power requirements.

6. It might be wise to consider the production of solar panels in Nigeria so that the problem of maintenance and replacement could be adequately addressed within the country instead of depending on importation. Inability of replacement parts has been a major reason for the past failures of many well commissioned industrial and power generating facilities. We need to learn from that experience as we embark on future projects.

7. Air pollution from gridlock, use of diesel generators, and other inefficient power sources is also a problem that requires attention by the government especially the Ministries of Health, Science and Technology. Such pollutants and their destructive emissions aggravate climate warming and therefore should not and cannot be overlooked.

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