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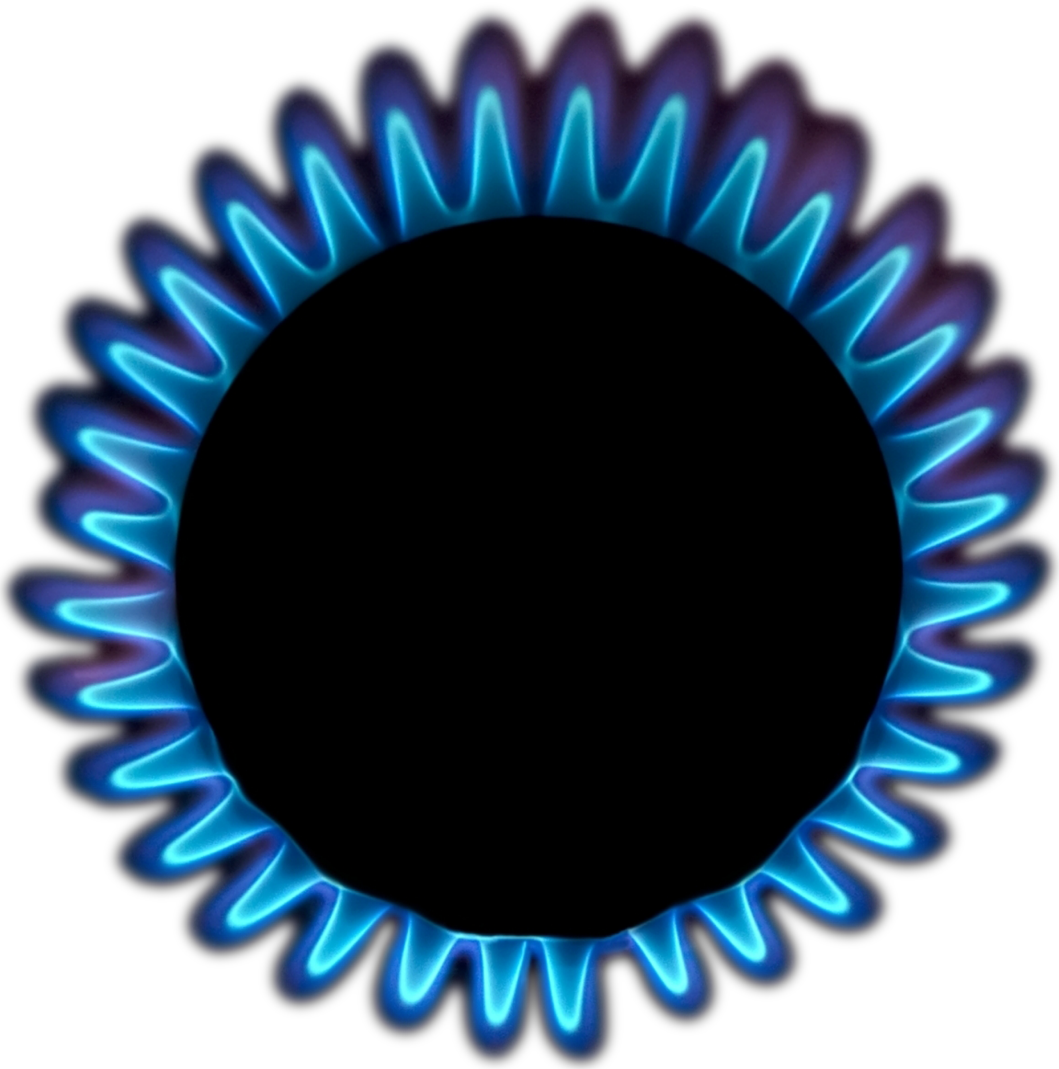
Natural gas as a bridge to a low-carbon future in Africa



Accelerating Africa's low-carbon future

September 2022

A key theme of COP27 will be the "just and sustainable energy future for all" and the unique challenges faced by African nations. Dr. Mahmoud Mohieldin, UN Climate Change High-Level Champion for Egypt, said that "Africa must balance the need to combat climate change with the urgency to economically prosper, to alleviate food insecurity and poverty, and achieve the UN Sustainable Development Goals."[1] Climate change disproportionately affects Africa, and addressing this issue is key to building resilience in the region.

Natural gas as a bridge fuel to a low-carbon future has drawn considerable debate from governments and companies, in their commitments to achieve net zero global carbon dioxide (CO_2) emissions by 2050, under the Paris Agreement.[2] Countries like Nigeria have called for a "Just Energy Transition"[3] to use natural gas as a bridge to achieve net zero emissions. Natural gas will be a key part of the energy transition in Africa; it has already contributed substantially to decarbonization of some of the most polluting power systems in the world and can continue to support long-term decarbonization efforts.[4] Given the importance of natural gas in increasing grid reliability and electricity access in many developing nations, a nuanced approach to its use and development may help accelerate the deployment of renewable energy (RE) to promote economic growth and reduce emissions. For example, a switch from coal-fired generation to a combination of RE, battery storage, and gas-fired generation can reduce greenhouse gas (GHG) emissions by 68 - 80 percent.[5]

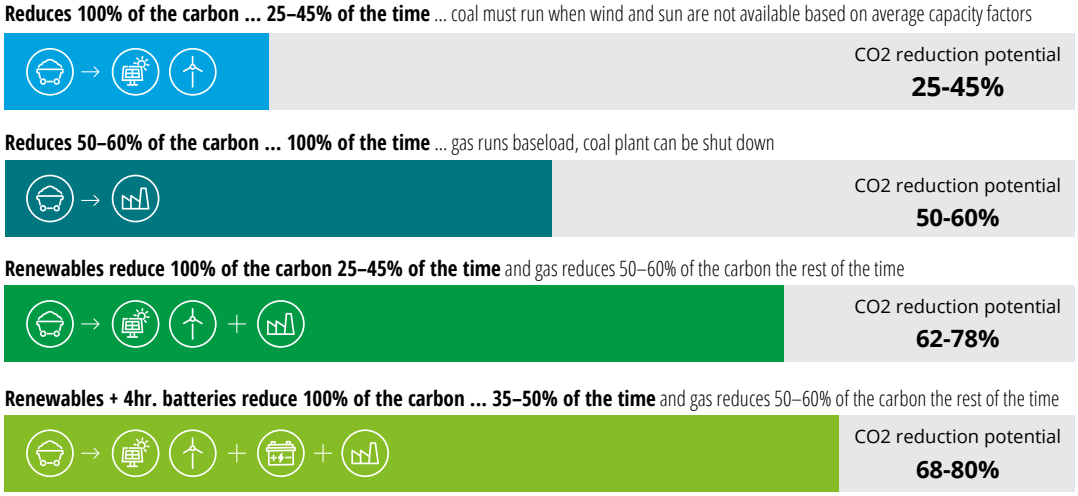
Deloitte believes that the selective use of natural gas can help to accelerate RE penetration, reduce CO_2, and enable expanded climate change goals via: 1) Fossil-fuel subsidy elimination; 2) Gas flare reduction; 3) Using natural gas to support RE penetration and RE integration; 4) Simple-cycle to combined-cycle gas plant conversion; 5) Using Integrated Resource Planning (IRP)[6]; and 6) Implementing fuel switching.

Issues

RE has a lower levelized cost of electricity (LCOE) than coal and natural gas fired power plants[7]. However, intermittency places additional stress on power grids. Battery storage technology can help improve intermittent power challenges, but it can

Renewables + gas has greater carbon reduction together vs. alone

Potential for reducing coal emissions by using renewables + gas power



Source: GE gas power marketing analysis.
Note that CAPEX and required land are not addressed in the above analysis.

"Given the time it takes to deploy new renewables and to implement energy efficiency improvements, coal-to-gas switching represents a potential quick win for emissions reductions."

-International Energy Agency, 2019 World Energy Outlook

1. COP27 Will Be a Global Conference With an African Focus – Dr Mahmoud Mohieldin
2. The Paris Agreement is a legally binding international treaty on climate change. Its goal is to limit global warming to well below 2, preferably to 1.5 degrees Celsius, compared to pre-industrial levels.
3. The Just Energy Transition Partnership (JETP) was agreed with South Africa at the COP26 climate summit.
4. African Development Bank, "Responsible and Sustainable Natural Gas: Challenges and Opportunities in Africa," September 14, 2021.
5. GE Gas Power Marketing Analysis.
6. IRP is an approach to electricity system development planning that utilizes an assessment of available energy resources to derive a least-cost supply to meet long term requirements for electricity services and can be configured to incorporate objectives such as climate change considerations to design a decarbonization pathway
7. Why did renewables become so cheap so fast? - Our World in Data

be an expensive and nascent technology, and its use changes the LCOE economics of RE. Grid stability in many cases, will be impaired as more utility-scale RE projects are introduced to the grid.

Broad-based economic growth will require centralized power solutions to satisfy larger loads. Countries that can source domestic or imported natural gas inexpensively will likely choose gas-to-power options for baseload electricity. According to the International Energy Agency (IEA), Africa is the fastest growing natural gas producer globally, with output increasing at an average of five to six percent per year.[8] In 2025, Africa's supply of natural gas will increase 15 percent to an estimated 295 billion cubic meters (bcm) of natural gas a year. While much of this supply will be allocated to export markets, a sizeable amount will be used for domestic power generation, fueling Africa's energy transition.

New gas-to-power plants without conversion elements can also reduce reliance on older, heavy fuel oil and coal-fired plants by expanding and diversifying a nation's energy mix. Côte d'Ivoire, Mauritania, Mozambique, Nigeria, and Senegal are developing large-scale gas-to-power projects, from which they will realize these benefits. In 2014, Ghana began a transition from liquid fuels-based power generation to gas-powered generation and has now essentially eliminated use of liquid fuels in favor of natural gas for power, substantially reducing its GHG footprint.

The siting of centralized power generation must consider the environmental and economic burdens borne by nearby communities. In addition to the technical and financial feasibility considerations, the just and equitable distribution of environmental and economic benefits to the local community must be prioritized early and often in the decision-making process, including environmental impacts, public health, safety, and high-quality jobs.

Africa's climate position

Africa is home to the world's youngest and fastest growing population, and with 16 percent of the world's population, the region consumes about 3.3 percent of global primary energy.[9] It contributed 3.9 percent of global fossil fuel emissions through 2020.[10] Indeed, more than two-thirds of people without access to electricity in the world today live in Sub-Saharan Africa.[11] Many of these countries advocate that efforts aimed at advancing climate goals must create "carbon space" for growing economies. For countries with significant oil and natural gas wealth, encouraging government action to reduce oil and natural gas utilization is more difficult because of government subsidies. For example, petroleum subsidies in Nigeria account for over $9 billion in 2022, or almost two percent of the country's GDP.[12]

For nearly 10 years, Sub-Saharan Africa has been the site of world-scale (Mauritania, Mozambique, Namibia, Senegal, South Africa, Tanzania) or significant (Côte d'Ivoire, the Democratic Republic of Congo, Equatorial Guinea, Gabon, Ghana) natural gas discoveries. Numerous natural gas export projects are under development and should bring significant sources of income for the countries while improving the security of supply to Europe and Asia, particularly given Russia's invasion of Ukraine, and the resultant embargoes on Russian natural gas. In most of these countries, natural gas is set to become the catalyst for economic development because of increased investment and lower energy costs.

Opportunities to reduce carbon emissions

Deloitte identified six opportunities that can ultimately lead to an absolute reduction of CO_2 emissions.

1. Fossil-fuel subsidy elimination

Support for policies that aim to eliminate petroleum subsidies can have a positive impact on federal fiscal positions,[13] the functioning of electricity markets, and a nation's carbon budget. In countries where a lack of reliable electricity supply exists because of limited generation capacity and insufficient national and regional transmission capacity, customers rely on distributed gasoline/diesel generation units. In Nigeria, the available on-grid capacity is 5.4 gigawatts (GW), which is insufficient to meet current demand.[14] To fill the gap, an estimated 14 GW (2013 estimate)[15] of decentralized gasoline/diesel generation was installed. While an accurate current inventory of decentralized gasoline/

8. International Energy Agency "Gas 2020 Report"
9. Atlas of Africa Energy Resources, 2017.
10. BP Statistical Review of Energy 2021
11. World Energy Outlook 2019
12. The World Bank Group. "Nigeria Development Update – The Continuing Urgency of Business Unusual." June 2022. World Bank Document
13. In Nigeria in 2022, the FGN allocated US$9.6 billion (e.g. 2% of the federal budget) for petroleum subsidies, which has substantially impacted Nigeria's overall fiscal position despite high world petroleum prices.
14. Nigeria - Electricity and Power Systems (trade.gov)
15. The Nigerian Energy Sector (2015), Deutsche Gesellschaft fur Internationale Zusammenarbeit (GIZ)

diesel generation is not available, Deloitte estimates that at least 24 GW[16] of gasoline/diesel generation currently exists, which emits between 31 - 44 $MTCO_2$/year out of Nigeria's 347 $MTCO_2$/year (2018).[17] GE estimates that Nigeria contributes 39 percent of CO_2 emissions in Sub-Saharan Africa if domestic use of diesel generators and industrial flare gas pollution are considered. Gasoline and diesel subsidies encourage the use of petroleum products in distributed electricity generation units and discourage the migration from captive generation to on-grid or off-grid electricity markets. Eliminating gasoline generators by eliminating subsidies could make a substantial contribution to Nigeria's commitment to reduce CO_2 emissions.

2. Gas flare reduction

Natural gas flaring is a significant contributor to carbon emissions. The top 10 producers of flared gas account for approximately 100 million cubic meters of flared gas annually.[18] Nigeria has dramatically decreased flaring by 70 percent since 2000, but it remains the seventh largest country in natural gas flaring, as measured by 2020 gas flare volume. Angola, Gabon, and the Republic of Congo are in the top 20.

Deloitte identifies an opportunity to provide technical support for the incorporation of productive use of associated gas,[19] including opportunities such as gas flare commercialization. Liquified petroleum gas extraction and marketing can also help purify natural gas and combat deforestation by displacing charcoal and liquids. By diverting natural gas that would otherwise be flared to a productive use, an alternative source of energy, which is often diesel or gasoline, could be reduced. For example, Deloitte estimates that associated gas flaring in Nigeria contributes 14 million tons of CO_2 annually, at an estimated loss of $1 billion/year. Utilizing natural gas that would otherwise be flared as a feedstock to replace electricity generation from inefficient, off-grid diesel generators leads to reduced GHG emissions.

3. Natural gas used to support RE penetration and RE integration

A Just Energy Transition means that local communities should benefit from the economic development of new power generation resources while minimizing the environmental and health burdens that have often disproportionately affected marginalized populations. Engagement with these stakeholders in the co-creation of their community's clean energy future is key to building successful development plans. As gas projects advance and are fully commissioned, track where and to whom environmental and economic benefits and burdens are accruing over time to stay on track.

Identifying the most efficient use of natural gas can support increased levels of RE penetration in electricity systems. Electricity systems rely on a "spinning reserve," often provided by fast-start gas-fired or hydropower generation, to be available on an almost instantaneous basis to balance supply and demand, when either supply diminishes or demand increases. The integration of RE generation at scale can cause challenges in load balancing for a grid without reliable baseload generation and advanced forecasting capacity.[20] There are benefits to using natural gas to enable integration of utility-scale solar into flexible grids, as demonstrated in Thailand, Brunei, and Singapore, where natural gas for electricity generation has enabled investments in solar and offshore wind generation.[21]

Further, utility-scale RE resources are often distant from electricity loads and use long, radial transmission systems. These characteristics make grids vulnerable to real-time changes. Connecting intermittent RE resources to weak grids can make the transmission system unstable and can introduce operating characteristics that can damage other synchronous, grid-connected generation capacity. The deployment of centralized, on-grid firm dispatchable generation units is vital to increasing intermittent RE at levels required to substantially reduce carbon emissions.

The supply of reliable electricity on a delivered basis encourages the migration of users from decentralized gasoline/diesel generation units since the lack of reliability from the electricity grid is a primary driver for the use of decentralized gasoline electricity generation. The provision of reliable electricity supply is increasingly being linked to full-cost recovery.[22] Full recovery of costs, along the electricity sector value chain, is fundamental to provide for a self-funding electricity sector.

16. Based upon extrapolation of 2013 inventory figures at a 6% growth rate.
17. Nigeria's Nationally Determined Contributions, 2021 update report.
18. Global Gas Flaring Tracker Report (worldbank.org)
19. Associated gas is produced as a necessary by-product of the production of petroleum, where petroleum is the primary commodity sought
20. African Development Bank, "Responsible and Sustainable Natural Gas: Challenges and Opportunities in Africa," Sept. 2021.
21. Natural Gas as a Key Alternative Energy Source in Sustainable Renewable Energy Transition: A Mini Review, " May 2021.
22. In Nigeria, the National Electricity Regulatory Commission (NERC) has established 'service-reflective' tariffs whereby the recovery of all costs by the distribution company supplying electricity service depends upon the level of service provided, as measured in hours of reliable electricity provided per day.

While battery applications provide limited solutions, battery storage can still be prohibitively expensive in many developing economies. However, an Australian study found that battery storage can be 30 percent cheaper than new gas plants for peak demand.[23] Simple and combined-cycle gas-fired generation stations acting as spinning reserve in combination with hydropower generation and the economic use of battery storage. When coupled with efficient transmission and systems operation, they provide support for the maximum level of RE penetration.

4. Simple-cycle to combined-cycle gas plant conversion

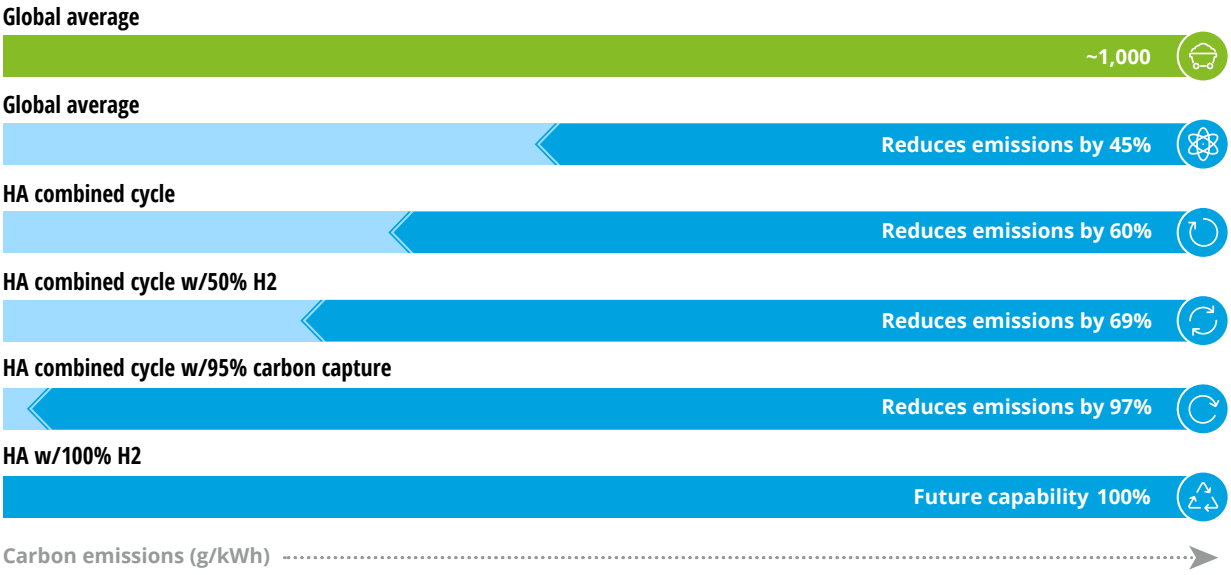
Conversion to combined-cycle plants (thermal efficiency of ~60 percent) results in significant increases in efficiency and output (MW) compared to simple-cycle gas turbines (thermal efficiency of ~35 percent).[24] These conversions, when using a heat recovery steam generator, provide substantial increases in generation capacity (MW) with no additional increase in natural gas use. This supports reliable electricity service and enhances electricity sector cash flows from service-based tariffs. In Nigeria, only four[25] electricity generation stations run in combined-cycle mode; the remaining 19 plants (which total 7,260 MW of installed capacity) run in simple-cycle. Deloitte estimates that if the remaining 19 plants were converted to combined-cycle operation, the carbon savings would be approximately 5.5 million tons of CO_2 per year, which is approximately five percent of Nigeria's current CO_2 emissions.[26]

5. Use of integrated resource planning (IRP)

Aligning supply and transmission expansion plans with projected demand growth provides an integrated approach to electricity sector expansion planning and offers a roadmap for the sequential procurement of generation and network resources to avoid stranded capacity. It enables countries to identify the minimum amount of gas-fired generation necessary for an efficient, reliable electricity system. Where electricity sector generation assets have been developed without consideration for the need to evacuate power, it can result in assets that operate sub-optimally.[27] An electricity transmission system that efficiently evacuates power, limits transmission constraints, and reduces localized generation requirements and associated spinning reserve is optimal, as fewer generation resources are required to support system operation. The African Development Bank identifies that "gas-based projects should be supported where it is demonstrable that they will lead to

A decade of action | pathway to low or near-zero carbon power

Coal-to-gas switching, hydrogen, carbon capture and sequestration are viable pathways to low or zero carbon power



Source: GE future of energy white paper Dec 2020

23. Battery storage 30% cheaper than new gas peaker plants, Australian study finds - Energy Storage News (energy-storage.news)
24. Combined Cycle Plant for Power Generation- Introduction (wartsila.com)
25. Egbin (1,320MW), Afam VI (650MW), Okpai (480MW) and Sapele (120MW).
26. Nigeria: CO2 Country Profile - Our World in Data
27. In Nigeria the Niger Delta Power Holding Company (NDPHC) was established to develop gas-to-power generation assets; however, as network expansion plans were not linked to the development of assets, insufficient transmission evacuation capacity exists, and assets run at lower capacity factors than required given electricity demand.

improved energy access, improved energy security, have positive economic impacts while promoting appropriate technologies/ business models and maximizing local content."[28] In July 2022, the European Union passed a law designating natural gas as a green and renewable energy source.

6. Fuel switching

Where natural gas is available domestically or imported via liquified natural gas (LNG), substantial GHG emissions reductions can be achieved with a relatively low investment in fuel switching. In Africa, oil-fired capacity totals just over 40 GW, and coal-fired capacity totals almost 50 GW.[29] Combustion of natural gas emits about half as much CO_2 as coal and 30 percent less than oil, as well as far fewer pollutants per unit of energy delivered.[30] In many African countries, liquid fuels and coal are the primary source of electricity production. This has an impact both on the cost of electricity production and on GHG emissions. For example, in Senegal, about 75 percent of the electricity produced comes from liquid fuels or coal, and the cost of generation and CO_2 emissions per kilowatt hour (kWh) are high. Replacing heavy fuel oil, diesel, and coal, which account for nearly 55 percent of the cost of electricity, with natural gas, would reduce the cost of electricity production by 40 percent, and CO_2 emissions by almost 30 percent.[31] In Mauritania, the displacement of heavy fuel oil at the Nouakchott power plant with domestic natural gas could reduce the cost per kWh and the CO_2 emissions by similar percentages.[32] In Burkina Faso, small-scale LNG could facilitate the conversion of up to 232 MW of heavy fuel oil plants managed by Sonabel and up to 140 MW of heavy fuel oil plants for mines that are not connected to the grid; these conversions would decrease the cost of generation and CO_2 emissions by up to 25 percent.[33] In Ghana, recent fuel switching interventions in the natural gas sector led to a combined cost savings of nearly $300 million annually to the government's treasury, while also delivering 1 $MtCO_2$ emissions savings annually, which is equivalent to taking a quarter of Ghana's cars off the road, and reducing national GHG emissions by two percent.

Bottom line

There is an immediate need to increase access to reliable power in Africa. The region could become the leading global natural gas supplier by 2040, and this increased production can be used to accelerate decarbonization. If implemented, the opportunities discussed in this white paper will not only improve electricity reliability, but also accelerate the reduction of carbon emissions.

28. African Development Bank, "Responsible and Sustainable Natural Gas: Challenges and Opportunities in Africa," Sept. 2021
29. World Energy Outlook 2019
30. Natural Gas - Center for Climate and Energy SolutionsCenter for Climate and Energy Solutions (c2es.org)
31. Technical assistance delivered by the WAEP to the Ministry of Energy in Senegal, 2021
32. Technical assistance delivered by the WAEP to Kosmos Energy, 2022
33. Technical assistance delivered by the WAEP to Sonabel, 2021

Let's talk

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