not been able to diversify their economies or prepare for a post-oil future either. On the contrary, petroleum has become a magnet for conflict and, in some cases, civil war. African oil-producing countries exhibit all classic oil-related patterns. Initially, oil development seems to work at the beginning, where positive outcomes such increase in per capita income (as seen in Gabon and Equatorial Guinea), but these positive outcomes are undermined by greater rent-seeking. The huge profit margins from the oil rents generally overwhelm all other revenue sources [25].

Growing reliance on oil and gas rent replaces and disrupts healthy pre-existing economic activities as it becomes easier to import food or consumer goods than to produce and to buy technological knowhow than develop it [26]. Thus, the fiscal advantage of petroleum can actually serve as a handicap, hindering the development of other productive activities. The oil windfalls push up the real exchange rate of these countries' currencies and the tendency to render most other exports non-competitive. The decline of the agriculture and manufacturing sectors of oil countries create a vicious cycle where ORSSA countries become more dependent on oil, thereby exacerbating other problems of dependency, leading to a permanent loss of competitiveness [26]. The oil and gas sector being an economic enclave and a highly capital-intensive activity, provides little employment and relatively few linkages with the rest of the economy therefore unable to make up for the shortfall. Oil and gas therefore, continues to be the main source of revenue and foreign exchange, and as a consequence, the economic basis of these countries. This dependence on oil and gas revenues negatively affects the capacity of states and their ability to govern. There is a vicious circle is which the more governments spend, the more they need oil revenues. As a consequence, oil dependence is today overwhelming. Taking Nigeria as example, (with over 200 million inhabitants), oil rent account for more than 50% of federal government revenue and more than 80% of export earnings, although it only accounts for 10% of GDP [27]. Likewise, Angola's oil and gas account for about two-third of government revenue, more than 90% of its export earnings and approximately 30% of its GDP [28]. Although this situation is repeated in a way in many other oil producing countries around the world (including Venezuela, Russia, etc.), it is particularly putrid in SSA. This is as result of the state institutions being weak and unable to tackle the problem in order to broaden its productive base and not fall into the pitfall of the resource curse, as Norway or Dubai managed to do. The challenge of this dependency includes high vulnerability to oil revenues that makes planning and projection of government spending levels difficult. Furthermore, the volatility of oil prices makes planning extremely difficult and undercuts efforts to turn oil wealth into other more permanent forms of sustainable development [29].

5. Discussions and Analysis

The call for acceleration of global energy transition places ORSSA oil and gas endowment at a high risk of stranded asset. The active consideration of a blanket ban on fossil fuel infrastructures by several high-profile financiers would also harm the regions ability to export their endowment. Although this moved is hailed as a good environmental policy as burning natural gas emits carbon dioxide (CO_2), a long-lived greenhouse gas and facilities that produce, transport and consume natural gas sometimes leak methane, a short-lived but even more potent greenhouse gas. However, blocking money for new gas pipelines, gas-fired power plants, or gas-consuming industries in ORSSA would bring hardship and hinder development for the already energy poor regions therefore presents unjust transition. Furthermore, as gas has a pivotal role to play in Africa's transition to clean energy, a ban now could slow the adoption of renewables and reinforce a global energy double standard.

Banning gas in ORSSA does not represent effective way of fighting climate change. This is because the continent is starting from such a low energy use and emissions base that there are few gains from eliminating gas. Currently, Africa's contribution to Green House Emission (GHG) is historically negligible (apart from South Africa). As at 2019, the continent accounted for less than 4 percent of global GHG emissions [30]. While this is expected to increase over time as access improves, it will very likely remain less than Europe, America and China (see Figure 4).

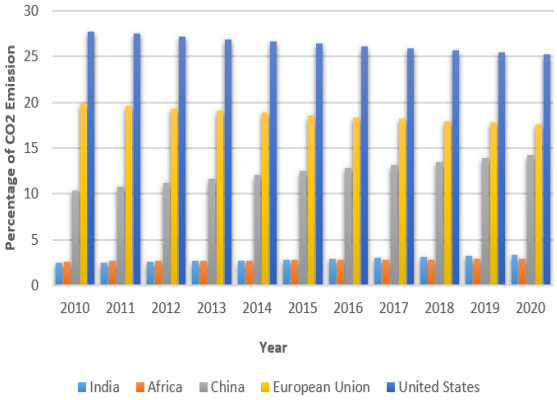

Figure 4. Annual Carbon Dioxide Emission from Fossil Fuel by World Region [30]

Measured by CO2 emissions per capita, the difference between Africa's contribution to climate change and that of other regions and countries is stark (see Figure 5) [31]. If all of Sub-Saharan Africa

tripled its current electricity consumption overnight using only natural gas, the additional CO2 would be equivalent to just 1% of global emissions. While electricity demand may be plateauing in the Global North, in ORSSA, electricity demand is most likely to triple resulting from rising incomes, growing populations and rapid urbanisation. Therefore, barring financing for all fossil fuels would have the very concrete effect of slowing poverty reduction, raising energy costs on the most vulnerable people, and suppressing incomes and job creation.

Ruling out gas would constrain ORSSA countries as they try to adapt to the major impacts of climate change like droughts, floods and soaring temperatures. Gas is particularly well-suited to energy-intensive adaptation technologies, such as steel and concrete for resilient infrastructure, desalination for expanded freshwater supply, and cold storage and air conditioning [30].

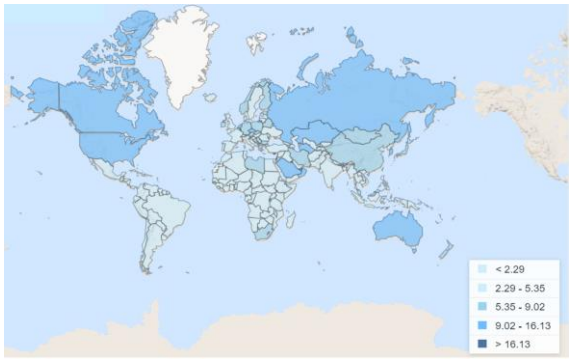

Figure 5 Carbon Dioxide Emissions (Metric Tons per Capita) [31]

Gas-fired power plants are modular and inexpensive compared to coal, geothermal, nuclear and hydro power stations which incur huge upfront capital investments. They are also less polluting than the default modular energy source in emerging markets – the diesel generator. Natural gas is a valuable feedstock for making fertilizer or other petrochemicals and an efficient source of process heat for high-energy industries like cement or steel production. For African countries with industrial ambitions, gas will be an indispensable input.

Given that ORSSA countries have significant natural gas resources that they are already developing, any suggestions to leave this resource in the ground and forego income, or to export all their gas to richer regions, seems indefensible. This is especially given that Global North countries are expanding use of gas as core component of their energy future as seen with the United States, China, and large parts of Asia and Europe. Closing off gas consumption to ORSSA countries just because they are late adopters with more limited financing options for building out domestic gas infrastructure is a politically and ethically fraught stance. Although renewable energy is essential, their intermittency is a major issue. Wind and solar have become much more competitive due to steep price reductions. However, African countries that are rapidly increasing renewable capacity are facing challenges managing intermittency. Kenya, for example, is already suffering from severe voltage instability at only about 15% of installed capacity from wind and solar [30]. With currently available storage technologies, it is impossible for African countries to greatly expand power supply without complementary new investments in gas or other dependable backups. Gas pairs especially well with wind and solar as a technology and a financial model. Gas turbines can start and stop quickly to balance renewable sources affected by local weather variability. Also, the low-fixed-cost/high-variable-cost character of gas-fired power means that – unlike coal, hydro, nuclear or geothermal – it can remain financially viable even when wind and solar are meeting energy demand much of the time.

Furthermore, due to rapid urbanisation in ORSSA, the greatest demand for electricity comes from cities, where space constraints can make it difficult to install new solar and wind turbine facilities. In addition to this, Africa's power system's transmission and distribution grids is developed around central generation nodes. While these might be redeveloped over the course of a century to accommodate more local renewable energy facilities, it would be difficult to implement this as a short- or even medium-term solution.

The most immediately visible environmental and health problem in emerging market cities is outdoor air pollution, which causes around 3 million premature deaths a year. Natural gas unlike coal, burns cleanly and makes a negligible contribution to air pollution. Although gas-fired generation does emit GHGs, burning gas generates fewer local pollutants (SOX, NOX and particulates) than coal and diesel and roughly half as much CO2 per unit of energy (see Figure 6).

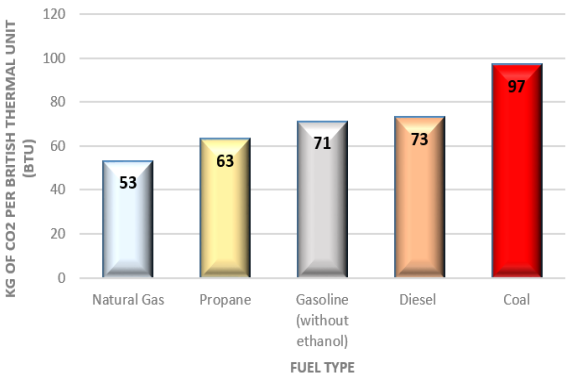

Figure 6. Carbon Dioxide Emission of various Fuel Types

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In ORSSA, piped gas or imported LNG could keep coal out of the future energy supply while displacing existing dirty generators that run on diesel or fuel oil. In countries that produce oil, a functional local gas market would also reduce environmentally harmful gas flaring. Innovation can also position gas to support a future zero-carbon energy system. Monitoring methane leaks by satellite could potentially addressing a serious environmental concern about gas. Emerging technologies for carbon capture and storage (CCS) might also allow gas-fired power plants to operate with a low or zero carbon footprint.

6. Sustainable Framework for Building Just Energy Systems for the Future

The energy transition presents a unique opportunity for redefining Africa's energy systems to deliver on the African Union's Agenda 2063, the Paris Agreement, and the SDGs. This paper agrees with the African common position on energy access and just transition which stipulates that Africa should continue to deploy all forms of its abundant energy resources, including renewable and non-renewable energy, to address energy demand. Natural gas, green and low-carbon hydrogen, will play a crucial role in expanding modern energy access in Africa both in the short to medium term, while enhancing the uptake of renewables in the long term for low carbon and climate-resilient trajectory on the continent.

The energy technological design must be technically adequate, cost optimal, and viable, now and in the future. The energy system must deliver maximum value for sustainable development in ORSSA by strengthening local capacity, resources, and knowledge. Natural gas as a transition fuel will need to be part of Africa's future energy mix, given that ORSSA countries have over 600 trillion cubic feet of proven natural gas reserves, in Nigeria, Algeria, and Mozambique, with new reserves discovered in Senegal, Mauritania, and Tanzania. Furthermore, natural gas power plants will be needed to support the baseload, provide reserves, and balance the grid in ORSSA countries. Additionally, the opportunity exists for ORSSA countries to potentially strengthen the resilience and sustainability of their resource bases and build robust positions in the new energy businesses of the future. The speed and the urgency of the actions required, and what strategies to adopt will depend on the level of reliance that each country has on oil and gas revenues and their position on the global hydrocarbon cost curve. However, it is worth noting that in Sub-Saharan Africa, more than one-third of gas is produced as a by-product of crude oil production (associate gas) and therefore the resilience of gas production in Africa is linked, at least partially, to the resilience of the continent's crude oil production.

Electricity systems and markets must adapt and be re-optimised to incorporate large proportions of variable renewables generation. Identifying an optimal energy mix over the next decades is equally necessary to determine the best contribution of renewables and natural gas in Africa. This focus needs to consider fuel availability, transmission infrastructure for greater country and regional interconnection, fuel cost, technology advancement, and a carbon price subject to change due to policies of non-African and African countries. In fact, new technologies, management systems, and finance will be needed to develop and integrate energy resources, including gas, to drive the industrial transformation.

Renewables are Africa's cheapest generation options. Utility-scale solar photovoltaic (PV) and onshore wind systems are now firmly established as the cheapest sources of electricity generation. According to the latest figures from IRENA and from Lazard, solar PV and onshore wind electricity costs levelized [32] & [33] over their lifetime have fallen to $0.03–$0.06 per kWh.42, 90% fall since 2001). These costs are far below the average fossil fuel levelized cost of electricity of $0.055–$0.145. Solar PV auctions have produced winning bids of $0.025–$0.06 per kWh in some African countries, in a strong falling trend [34]. The first few solar PV and wind projects in a country can commonly be added to the grid without much change in the grid's structure. However, as their share grows, several options for compensating daily and seasonal supply intermittencies of solar and wind power should be included in the system to balance supply and demand, yielding what is sometimes referred to as "clean energy portfolios." Yet, while the potential of such portfolios for Africa is very promising, its feasibility is highly dependent on whether there is enough upfront finance and how quickly renewables and various balancing options can be ramped up, including energy storage and increased interconnection, due to high initial cost. Hence, attaining high shares of solar and wind power requires that African countries strongly commit to such pathways and that they are decisively supported financially by the international community and the private sector. The private sector is becoming increasingly important for closing Africa's energy gaps, but governments will remain vital players. Historically, around 80 percent of Africa's installed capacity has come from state-owned projects, with private IPPs accounting for 13 percent of installed capacity in 2019. However, the number of IPP projects has grown steeply in the last decade. Over 80 percent of financially closed projects since 2010 have been renewable energy–based, although at considerably smaller scale than fossil fuel-based IPPs, which have dominated IPP installations from a capacity perspective since the 1990s and offer promise for large-scale industrial uptake. Generation capacity in Africa, with state ownership has dropped

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to roughly one-third. However, many IPPs, especially public–private partnership plants, have failed in the past, suggesting the need to improve policy and finance support for this category.

Flexible generation on the grid, different storage technologies, interconnectivity, sector integration and demand-side measures, and use of decentralized off-grid energy are needed to balance the supply and demand in integration of renewable energy [35]. Flexible generation on the grid can quickly react to and balance out differences in supply and demand. Certain conventional electricity generation technologies such as open-cycle natural gas turbines can be dispatched flexibly on short timescales to cover electricity shortfalls during prolonged periods of low availability of sunshine and wind. Interconnectivity will increase trade and reliability and decrease end-user costs. The more regionally interconnected an energy system is, the more potential it offers. Africa should continue to seek to make interconnectivity a reality through the Continental Power System Masterplan and the accompanying African Single Electricity Market. Sector integration, which aims to meet energy demand in sectors in which demand is currently not met by electricity (such as transport, cooking, agriculture, and some industries), helps to balance the grid and, perhaps more important, is driving sustainable development and supplying energy services beyond energy as a commodity. Demand-side measures include both improved energy efficiency (reducing demand while keeping service levels constant) and sector integration. This leads to smoother demand profiles because parts of these sectors' energy demand occur at (or can be shifted to) times of the day when renewable energy are abundant. Both measures lower overall unit energy costs.

Diversification strategy is tremendously important for resilience. Given the importance of diversifying ORSSA economies, it is critical to recognise how various dimensions of diversification can have different implications for the different policy options. Economic diversification for ORSSA region should embraces structural transformation from lower to higher productivity sectors that contribute to employment and production (gross domestic product (GDP) diversification), international trade or exports diversification and fiscal diversification. The fiscal element should involve expanding government revenue sources and public expenditure targets and play a central role in helping to catalyse broader economic transformation through the expansion of activity in specific industries and sectors. It is also important to note the role of quality of governance in both economic growth and diversification. Natural gas should be used to develop other sectors of the economy and seen as a bridge fuel rather than a mainstay for economic growth.

The levers to strengthen the cost competitiveness of ORSSA resources, such as addressing sources of cost premium (for example, insecurity), and improving the ease of doing business should also be put in place. This will increase investor confidence and attract foreign investors in the sector. The ORSSA countries could further strengthen the resilience of their resources by considering initiatives to decarbonise their existing oil and gas operations and encouraging investment in lower-carbon energy infrastructure such as gas pipelines. Investment in lower-carbon-energy infrastructure projects, especially gas pipelines, processing infrastructure, and liquefied petroleum gas (LPG), could enable African countries to promote intraregional trade and boost global exports of ORSSA energy products, while also helping to strengthen regional energy access and reduce the risk of stranded gas resources.

Policies to achieve climate resilience and a just energy transition in ORSSA should be inclusive. This transition requires close consideration of the equity implications and challenges associated with prevailing energy poverty, low energy consumption and energy needs for economic growth and transformation.

7. Conclusion

The adoption of energy transition strategies and policies are designed to move the global energy sector away from fossil fuels towards zero-carbon energies by 2050 as determined by the Paris Agreement. There is universal acceptance of the need to transition in order to reduce energy related CO2 emissions and limit climate change. However, there also needs to be recognition that whilst aggressive energy transition programs are being pursued in developed countries and by the international oil companies, many developing countries, and especially those with hydrocarbon-dependent economies such as ORSSA, require a more gradual and flexible approach to energy transition. Therefore a "Ban all fossil fuels, everywhere" (although an intuitively appealing position), will amount to energy injustice when applied to energy-deprived regions like Africa. The ruling out of natural gas will do far more harm than good on environmental, health, and development fronts. This paper therefore concludes that to avoid stranded asset, increase energy access and enable economic diversification, the ORSSA countries must be allowed to use all forms of energy sources and continue using gas as a bridge fuel whilst gradually incorporating renewable energy into the energy profile.

8. References

[1] Mountford, H., Waskow, D., Gonzalez, L., Gajjar, C., Cogswell, N., Holt, M., and Gerholdt, R. (2021). COP26: Key Outcomes from the UN Climate Talks in Glasgow. In COP26, Glasgow.

 | DOI: 10.20533/ijsed.2046.3707.2023.00624

[2] Afreximbank. (2022). Africas just transition demands a just formula guided by african priorities. https://www.afreximbank.com/africas-just-transition-demands-a-just-formula-guided-by-african-priorities (Access Date: 19 October 2022).

[3] Sovacool, B. K., Burke, M., Baker, L., Kotikalapudi C. K., and Wlokas, H. (2017). New frontiers and conceptual frameworks for energy justice. Energy Policy. pp.677-691. Energy Policy, vol. 105.

[4] Williams, S., and Doyon, A. (2019). Justice in energy transitions. Environmental Innovation and Societal Transitions, vol. 31, pp. 144-153.

[5] Jenkins, K. McCauley, D. and Forman, A. (2017). Energy justice: A policy approach. Energy Policy, vol. 105, pp. 631-634.

[6] Sovacool, B. K., and Dworkin, M. H. (2014). Global energy justice, Cambridge: Cambridge University Press, 2014.

[7] Fuller, S., and McCauley, D. (2016). Framing energy justice: perspectives from activism and advocacy. Energy Research and Social Science, vol. 11, pp. 1-8.

[8] Ottinger. G. (2013). The winds of change: environmental justice in energy transitions. Science as Culture, vol. 22.2, pp. 222-229.

[9] Sovacool, B. K., Martiskainen, M. Hook, A. and Baker, L. (2019). Decarbonization and its discontents: a critical energy justice perspective on four low-carbon transitions. Climatic Change, vol. 155, no. 4, pp. 581-619.

[10] Adewuyi, O. B., Kiptoo, M., Afolayan A., Amara, T., Alawode, O., and Senjyu, T. (2020). Challenges and prospects of Nigeria's sustainable energy transition with lessons from other countries' experiences. Energy Reports, vol. 6, pp. 993-1009.

[11] Farret, F., and Marcelo, G. (2013). Integration of alternative sources of energy. Vol. 504, NJ USA: Piscataway.

[12] Schwerhoff, G., and Mouhamadou, S. (2017). Financing renewable energy in Africa–Key challenge of the sustainable development goals. Renewable and Sustainable Energy Reviews, vol. 75, pp. 393-401.

[13] Bell, D. (2004). Environmental justice and Rawls' difference principle," Environmental Ethics, vol. 26, no. 3, pp. 287-306.

[14] Walker, G., and Day, R. (2012). Fuel poverty as injustice: Integrating distribution, recognition, and procedu-re in the struggle for affordable warmth. Energy policy, vol. 49, pp. 69-75.

[15] Steele, W., MacCallum, D., Byrne J., and Houston, D. (2012). Planning the climate-just city. International Planning Studies. Vol. 17, pp. 67-83.

[16] Adger, W., Paavola, J., Huq S., and Mace, M. (2006). Fairness in adaptation to climate change., MIT press.

[17] World Bank. (2021). Universal-access-to-sustainable-energy-will-remain-elusive-without-addressing-inequalities. Worldbank, Online.

[18] The Economist. (2019). More than half of Sub-Saharan Africans lack access to electricity. https://www.economist.com/graphic-detail/2019/11/13/more-than-half-of-sub-saharan-africans-lack-acc ess-to-electricity (Access Date: 22 August 2022).

[19] Climatewatch Data. (2022). GHG Emissions. https://www.climatewatchdata.org/ghg-emissions (Access Date: 12 August 2022).

[20] Mulugetta, Y., P. Carvajal, J. Haselip, and T. Spencer. (2019). Bridging the Gap: Global Transformation of the Energy System. Chapter 6 in The Emissions Gap Report 2019. Nairobi: UNEP (United Nations Environment Programme).

[21] McKinsey and Co. (2015). Brighter Africa: The Growth Potential of Sub-Saharan Electricity Sector Africa. https://www.mckinsey.com/~/media/McKinsey/dotcom/client_service/EPNG/PDFs/Brighter_Africa-The_ growth_potential_of_the_sub-Saharan_electricity_sector.ashx (Access Date: 6 August 2022).

[22] IEA (International Energy Agency). (2019). Africa Energy Outlook 2019. Paris: IEA.

[23] Moner-Girona, M., G. Kakoulaki, G. Falchetta, D. J. Weiss, and N. Taylor. (2021). Achieving Universal Electrification of Rural Healthcare Facilities in Sub-Saharan Africa with Decentralized Renewable Energy Technologies. Joule 5 (10): 2687–2714.

[24] Copinschi, P., and Smedley, M. (2016). Sub-Saharan Africa: A Future Global Gas Player? The Future of Natural Gas.," Markets and Geopolitics, Hof van Twente: Lenthe/Europe an Energy Review, pp. 181-205, 2016.

[25] Ross, M. (2013). The Paradoxical Wealth of Nations. Introductory Chapters.

[26] Ross, M. (2012). The oil curse.The Oil Curse, Princeton: University Press, 2012.

[27] World Bank. (2020). World Development Report, Online: World Bank.

[28] IMF. (2019). Our Connected World, Online: Internation Monetary Funds.

[29] Humphreys, M., Sachs, J., Stiglitz, J., Humpherys M., and Soros, G. (2007). Escaping the resource curse, Columbia: University Press.

[30] United Nations. (2021). Cop26 Climate Top Priorities Africa. United Nations Magazine, https://www.un.org/africarenewal/magazine/july-2021/cop26-climate-top-priorities-africa (Access Date: 12 August 2022).

[31] Global Carbon Project. (2019). Global Carbon Project. Global Carbon Project, https://www.globalcarbonproject.org (Access Date: 12 August 2022).

 | DOI: 10.20533/ijsed.2046.3707.2023.00624

[32] IRENA (International Renewable Energy Agency). (2021). Renewable Power Generation Cost 2021. Abu Dhabi, United Arab Emirates: IRENA. https://www.irena.org/costs/Power-Generation-Costs/Solar-Power (Acc-ess Date: 12 August 2022).

[33] Lazard. (2021). Levelized Cost of Energy, Levelized Cost of Storage, and Levelized Cost of Hydrogen. https://www.lazard.com/perspective/levelized-cost-of-energy -levelized-cost-of-storage-and-levelized-cost-of -hydrogen/ (Access Date: 6 August 2022).

[34] IRENA (International Renewable Energy Agency) and African Development Bank. (2022). Renewable Energy Market Analysis: Africa and Its Regions. Abu Dhabi, United Arab Emirates and Abidjan, Côte d'Ivoire: IRENA and African Development Bank.

[35] Sterl, S. (2021). A Grid for all Seasons: Enhancing the Integration of Variable Solar and Wind Power in Electricity Systems across Africa. Current Sustainable/Renewable Energy Reports 8: 274–281.

 | DOI: 10.20533/ijsed.2046.3707.2023.00624