PUTTRU

Discussion Paper

AFRICA'S SUSTAINABLE ENERGY TRANSITION:

Assessing the true costs

Reflections for COP26

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Foreword

The paper is comprehensive and well written. It captures elements of the tangible and intangible costs to Africa in joining the net zero emissions targets proposed mainly by the G20 and other wealthy countries. To be sure, those who have been responsible for pollution must clean up, especially given the fact that the developed world has burned vast amounts of fossils fuels since the last one hundred years as it powered the industrial revolution that has led to its socioeconomic development. With Africa having largely been left out of this industrialisation process, the continent must insist on Climate Justice.

Therefore, I agree as the paper suggests, that Africa must have an intentional strategy of utilizing the continent's energy resources, both renewable and non-renewable. Given its current low level of economic and technological development, Africa must insist on a strategy that does not leave it behind. As things stand, the net zero 2050 carbon neutrality targets will not work for Africa. On their part, the Chinese and the Saudis have proposed and adopted a 2060 target, which I think looks more like a target Africa should adopt.

Already handicapped, African countries should not be punished by setting targets which are beyond their means. They should be allowed to determine the least-cost options for a sustainable energy transition. The costs should include those of education and capacity building to equip African countries with the skills to cope with new technologies in wind and solar, which are required in order to sustain the application of renewables in electricity generation. Furthermore, Africa should aggressively replant its forests and set targets for intensive additional tree planting. Climate financing provision should support this with incentives to meet targets and reward those who do. Bearing this in mind, COP26 should be ensuring that in determining Africa's pathway African countries should not be denied funding from traditional financing sources. Of note is the fact that the current climate finance goals have not been met, many years after. As such, it is imperative for Africa to demand and obtain a fair share of climate financing, since the stronger economies are able to finance investments in climate-resilient infrastructure which Africa cannot afford. A strong electric grid system that is able to connect electricity to renewable sources of power generation would be a challenge, as it requires considerable human and financial resources.

It is true that the long-term cost of nuclear energy (costs of handling nuclear waste) remains unknown. Given these facts, Africa should not be stampeded into developing nuclear technologies for electricity generation. For example, pressure is being put on South Africa by the United States to increase its investment in nuclear energy and to reduce its high reliance on coal for electricity generation. Meanwhile, Greenpeace is campaigning against nuclear energy for South Africa. The implication of this is that South Africa might be left with the choice of focusing on renewables, which are often intermittent and variable as well as not being entirely reliable or sustainable. No doubt, therefore, only practical solutions that work for Africa should be considered.

It is worth reiterating that cutting emissions cannot be sudden, and Africa should not even be considering the United States' zero emission target of 2035 for its power sector. Africa must be allowed to generate its own electricity with fossil fuels, hence the embargo on funding new fossil fuel development should apply to only the wealthy, developed countries. It should be noted, however, that certain Western countries have been discouraging foreign investors from investing in oil and gas assets in Africa, claiming that they might end up with stranded assets in the future. This mindset must be addressed robustly by African countries.

While I agree that Africa should not ignore renewables, the continent must not pursue development of alternative energy sources to the detriment of its fossil fuel assets. In any case, immediate cessation of fossil fuel usage is not possible for Africa at this point, as countries' needs differ in many ways. Even the so-called targets are a fudge and educated guesses, at best. Therefore, adaptation and mitigation must be a continuous process, especially for Africa's vulnerable economies.

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1 Introduction

Western countries are pressuring African countries to abandon their oil and gas assets for an immediate switch to renewables.[1] Moreover, the representatives of Western countries are advising foreign investors to avoid oil and gas assets in Africa if they do not want to end up with stranded assets in the future (Reuters, 2021a).

It is important to note that Africa has had a similar trend of increasing renewables in its energy mix as advanced economies. In Africa, 20% of electricity generation sources are from renewables (IEA, 2021a). Moreover, Africa's energy mix, in line with the experience of advanced economies, has been changing for the past 20 years, with coal and oil sources declining while cleaner energy sources are growing (IEA, 2021a)

In addition, Africa is among those regions which contribute the least to carbon dioxide emissions. The continent was responsible for only 3.9% of the total carbon dioxide emissions in 2020, second only to Southern and Central America at 3.6% (BP, 2021, p.15). However, while carbon dioxide emissions are now declining, showing negative growth rates in advanced economies, Africa's carbon dioxide emissions have had a positive growth rate over the same 10-year period (BP, 2021).

Regarding the suggestion that Africa urgently needs to turn away from its oil and gas assets, it seems that the real issue is the positive growth rates of Africa's carbon dioxide emissions. This is seen as a problem for climate change by those who argue that the different regions of the world need to be on a declining pathway for carbon dioxide emissions. However, are these demands well informed?

[1] *"The African Energy Chamber has called for the region's countries to boycott companies shunning the continent's fossil fuels sector as part of net-zero ambitions, highlighting the growing concern of energy-hungry African nations over the shift to clean energy by most Western producers"* ***- S&P Global (2021). African Energy Chamber calls for boycott of firms shunning Africa's oil sector. Press Release. 13 July 2021.***

Exploring the imbrications of energy, environment and the economy, this paper argues that Africa has to follow a pragmatic pathway to a decarbonized energy system. The pragmatics of the situation is based on how other economies are prioritizing their energy system planning, centring it on **economics** and the **economy**. Furthermore, the continent could follow an energy transition pathway that chooses green, not just clean, energy sources, thus catering to an African society that is growing in environmental activism—the case in point being Greenpeace's activism against South Africa's nuclear energy agenda (Greenpeace, 2011).

We recommend that African policymakers adopt a continental long-term energy mix strategy with 2030, 2040 and 2050 as the respective targets for utilization of the continent's renewable and non-renewable energy resources. We further note that it is only by accounting for and internalizing the true costs of an evolving energy mix that African countries can appropriately determine the least-cost options for a sustainable energy transition. We conclude by noting that financing Africa's sustainable energy transition will require innovative financing instruments that allow Africans to invest in their own sustainable future, especially now that western development financial institutions are backing away from financing fossil fuel projects.

The paper is divided into four sections. Section One is the Introduction and presents the objectives of the paper. Section Two defines and discusses what the paper considers as inherent constraints of energy systems, namely technical feasibility and stability of the grid, environmental concerns, security of energy supply, and energy costs. Section Three presents the implications of these inherent constraints on Africa's evolving energy system. The paper concludes in Section Four with recommendations and conditions for a decarbonized energy system pathway for Africa.

1.1. Aim and Objectives of the Paper

The primary aim of this paper is to deepen the climate discourse. Our goal is to highlight the inherent constraints which energy systems face globally and, by examining the factors that influence energy systems for both advanced and African economies, separate such systemic constraints from barriers that are addressable.

In terms of its objectives, the paper seeks to stimulate discussions and debates that will contribute to arriving at workable solutions to the issue of energy transition in Africa. Moreover, by placing global energy system constraints at the forefront, the paper aims to step out from abstract ideas pertaining to an instantaneous replacement of fossils by renewables towards a concrete pathway for decarbonizing Africa’s energy system. The authors believe that this is a more rational strategy for a global net zero emission planet.

2 ENERGY SYSTEMS AND TRANSITIONS

Energy transition is a process of moving from fuels considered less ideal to what a society considers as more ideal. A number of factors drive the desire for such a transition, including changes in consumer preferences (i.e., demand for environmentally friendly energy sources or widespread concern for probable disasters, e.g., in the case of nuclear accidents), technological advances, availability of energy supply, issues surrounding energy costs, environmental concerns and need for energy security. These factors together interact to determine the energy mix an economy may pursue.

With a strong focus on Africa, there has recently been a push for an immediate cut-off from fossil fuel energy sources, one of the widely used reference documents being the IEA report on Net Zero by 2050. Regarding what to do to avert critical levels of global warming, the report recommends thus: “From 2021: No new oil and gas fields approved for development; no new coal mines or mine extensions” (IEA, 2021b, pp. 102 - 103).

Moreover, the COP26 Explained report by the United Kingdom, shows how the United Kingdom has reduced its carbon footprint while still maintaining economic growth – noting that this is proof that a low carbon economy is possible (COP26, 2021).

While the United Kingdom’s energy system might appear cleaner today, it may be argued that this sustained positive productivity path is made possible by her legacy energy system which produced current technological advancements, infrastructure, and deepened capital markets as well as an educated and highly skilled populace.

In contrast, China has chosen a different energy system pathway to becoming a global economic powerhouse.[2] It is important to note that Africa is choosing to develop using cleaner fuels. For instance, natural gas is the primary fuel used in electricity generation. Variable renewables, although still a smaller share at 3% as at 2019, are progressively growing (IEA, 2021a). For example, from 2000 to 2019, electricity generation from solar photovoltaic grew at an average rate of 49% per annum and wind at 26% per annum (IEA, 2021a).

Nonetheless, a marked difference in Africa's energy mix in the coming years will depend on how inherent constraints to energy systems evolve, as discussed below. Furthermore, investment and financing will be a significant catalyst in ensuring that the pathway to a carbon-neutral energy system is fast-tracked.

2.1. Inherent Constraints of Energy Systems

While emissions may be one of the factors considered in energy system planning, advanced economies are also balancing this factor with technical feasibility and stability of the grid[3] as well as security of energy supply and energy costs. These are described, in this paper, as inherent constraints of energy systems.

With regard to a functional energy system that drives growth and meets socioeconomic needs, advanced and African economies are choosing the best technologies in the frame of the inherent constraints faced by their energy systems. For some advanced economies natural gas is leading as the dominant fuel, with the same being true for the African continent.

[2] *As of 2020, China's electricity sector was heavily dependent on coal, which was the source of 67% of total electricity generated. Moreover, between 1990 and 2020, coal consumption increased by close to 1000%, i.e., from 469,762 GWh to 5,014, 841 GWh, according to IEA 2021 data. China is the single largest country contributor of carbon dioxide globally, followed by the United States (BP, 2021).*

[3] *Grid stability requires that electricity produced and transported through the transmission network can be consumed, as electricity cannot be stored on the transmission network. When produced electricity and consumed electricity do not match this affects the grid frequency (Hz), as countries and regions have a standard grid frequency. Very low (electricity consumption is more than electricity produced) or very high frequencies (electricity produced is more than electricity consumed) lead to damage of the network's infrastructure.*

A review of the energy mix of selected economies on the database of the IEA (2021a) reveals that both advanced and African economies are increasing their shares of green energy sources while retiring dirtier fuels.

Increasing the shares of variable renewables, as will be demonstrated in this paper, is more likely to occur as constraints evolve and open up new opportunities. An indication that constraints are relaxing is that, through market structures such as the European Electricity Market, Europe is now better positioned to increase renewable penetration in the years to come without a commensurate increase in fossils for baseload energy. It is argued that Europe is able to do this because of the strength of its economy. To be sure, considerable investment is required for the coordination of intermittent renewable sources over vast geographical areas as well as for the transmission and ancillary infrastructure needed to make this happen.

In the African region, however, transmission infrastructure coverage is lower. Comparing Africa with other economies, Streatfeild (2018) reports that Africa has a coverage of 247 km of transmission lines per million people, whereas in Peru, Brazil, and the United States this is 339 km, 610 km, and 807 km of transmission lines per million people respectively. If Africa is to catch up with Europe’s electricity market, specifically in terms of the market’s capacity to increase intermittent renewable energy, power infrastructure at the national level will need to increase significantly. Moreover, adequate investment for power infrastructure development at the national level will be a precondition for Africa’s regional power pools to be effective and to be able to decarbonize Africa’s energy system in the long run.

2.1.1. Technical Feasibility and Grid Stability

Power systems have certain constraints. For example, an efficient power system requires a baseload generating source. Baseload power is the minimum amount of power that must be available to serve consumers. Baseload generating units operate daily throughout the year to avoid grid failure, i.e., power outage. During fluctuations in energy demand variable energy is introduced to cover the difference. Baseload energy technologies include coal, natural gas, nuclear, and some renewables such as hydroelectricity, geothermal and biomass.

Power system planners are well aware that switching completely to renewables such as solar and wind has its technical complexities. The intermittent nature of renewables such as wind and solar means that to increase the capacity of these intermittent energy sources in the grid, a corresponding increase in a baseload energy will be required (Matek and Gawell, 2015).

While proponents of intermittent renewables such as solar and wind have argued for energy storage technologies (IRENA, 2017), including air and battery storage technologies and pump storage hydro as well as cross-border electricity networks as remedies, if technically feasible, this comes at much higher investment costs. Moreover, in the absence of cross-border electricity networks, the choice of hydroelectricity, geothermal energy and biomass as baseload energy will depend on whether the country in question has these natural resources (or, for biomass, whether it can guarantee security of supply). In Kenya, for example, the main source of electricity generation is geothermal (46%) and hydroelectricity (30%), these two being baseload renewable energy sources (IEA, 2021a). Baseload and variable renewables account for 89% of electricity generation sources in the country (IEA, 2021a), making the country’s power sector a good example of a decarbonized energy system.

For the United Kingdom, the United States and Europe4 the primary fuel for electricity generation is natural gas, based on IEA 2020 data, representing 36%, 39% and 21% respectively for those countries (IEA, 2021a). For Europe, natural gas, and nuclear energy, which are baseload energy technologies, are almost on a par. For Germany, the largest economy in Europe, coal is the most significant fuel used — at 25% (IEA, 2021a). Nuclear energy is also significant in the United Kingdom (16% in 2020) and for the United States nuclear energy and coal are almost on a par at 20% and 19% respectively in 2020 (IEA, 2021a).

As noted above, baseload energy — not variable energy such as solar or wind — tends to represent the principal share of the energy mix in any given economy. Furthermore, availability of the energy resource (or security of energy supply, which will be discussed below) influences the choice of baseload energy. What this implies for Africa's energy system is that, while there will be examples such as Kenya with significant geothermal and hydropower resources, many African countries will have no other choice but an energy mix with a baseload that is based on fossil fuel. The goal for a least-costs decarbonized energy system will therefore be to displace more carbon-intensive baseload fuels with cleaner fuels such as natural gas, while investing in power infrastructure to support grid stability and integration of variable renewables. Moreover, in the long run, as interconnection capacity and cross-border electricity trading increases through Africa's regional power pools, African economies without these baseload renewable resources will be better positioned to increase the share of renewables in their energy mix.

[4] *Note that the United Kingdom is still part of the European Electricity Market, as of the latest European Electricity Market Report.*

2.1.2. Environmental Concerns

Environmental sustainability is another key constraint in energy system planning. Considering the relationship between energy consumption and economic development, even environmentally conscious policymakers have to grapple with the issue of **the cost of not polluting.** In other words, at what level can we pollute, while avoiding intolerable[5] damage to the economy, human health and natural resources as well as the environment?

In weighing these different options, trade-offs occur. For example, policymakers may choose an expansive pollution envelope with intentions to develop economically and, having attained higher human and economic development, they may now be able to afford to clean up. This assumes, of course, that the threshold of irreversible damage has not been exceeded.

In June 2020, the World Bank lauded China's government for its remarkable investments towards cleaning up the environment, noting that "China <u>was</u> home to many of the world's most polluted cities and is the world's largest emitter of greenhouse gases (GHGs)" (World Bank, 2020). Considering the approximately 1000% increase in coal power generation, from 1990 to 2020[6] and the congratulatory messages China now receives for cleaning up at home and abroad[7], it may possibly be claimed that the trade-offs paid off.

The United States' example of the 1990 Clean Air Act Amendments (CAAA), however, could be brought up as a counterargument to the cited China example. As LaCount et al. (2020) show, environmental protection can be achieved in conjunction with economic growth – and not one or the other. LaCount et al. (2020) report how the introduction of the allowance trading program, which put a ceiling on emissions from electric power plants, led to a significant decline of air pollutants (sulphur dioxide and nitrogen oxide), as well as to improved human health without reduction of electricity generation in the United States.

[5] *The word 'intolerable' is subjective, as will be seen from the examples in this paper.*
[6] *Calculated from IEA (2021a) data.*
[7] *In September 2021, during the United Nations General Assembly Annual Summit, President Xi Jinping announced via a video recording that China would not be building new coal-fired power projects abroad.*

However, such a counterargument may not appear strong given that LaCount et al. (2020) also discuss how, in addition to switching to natural gas for instance, the CAAA pushed power plant operators to introduce sophisticated technologies such as flue gas desulfurization (FGD) technology, selective catalytic reduction (SCR) and non-catalytic reduction (SNCR) technologies, among others. Indeed, it may be argued that rapid technological innovations and adoption of sophisticated technologies are more likely to occur in economies which are able to easily deploy capital, thereby lending even more credence to the policy trade-offs made by China.

Thus, what seems important is that an emissions target should be set and an acceptable energy mix that achieves the set target regardless of approach should be encouraged. This will allow African countries and other less developed countries to create an affordable path for achieving the overall objective without withholding developmental capital from them, as doing could be counterproductive and destructive to their economies.

2.1.3. Security of Energy Supply and Energy Costs

Scarcity drives costs upward. Those who live in economies where dependence on electricity for normal life functions is incredibly pervasive may find the idea of living without constant electricity unimaginable. In fact, according to Pollitt (2019), Europeans are willing to pay about 100 times more than the retail price of electricity to avoid power outages, and this reflects the higher income status of Europeans. It is interesting to note that the middle- and upper-class residents of African countries are also quite dependent on constant supply of electricity, which is the main reason why they have made huge investments in generator sets and lately solar panels.

However, it is not in the best interest of economies for electricity prices to be exorbitant given its negative effect on economic activities and economic growth. For instance, reporting on the United Kingdom, Reuters (2021b) noted that “A jump in gas prices has forced several domestic energy suppliers out of business and has shut fertiliser plants that also make CO_2 as a by-product of their production process." According to the European Commission's quarterly report on European electricity markets, the spike in natural gas prices is as a result of high global demand for natural gas in Asia (China in particular); the report also noted that "High prices in Asia increase prices in Europe as LNG cargoes are redirected to these markets, leaving less supply for Europe" (EC, 2021a, p.27). It is important to note here that higher natural gas prices led to a preference for coal to generate electricity in the region's electricity market. The European market for wholesale electricity operates on a merit-order dynamics whereby power plants having the lowest short-run marginal costs are given priority before more costly options (EC, 2021a). In describing the effect of higher gas prices on fuel choice, the report notes that "coal and lignite generation returned to the profitability zone, leading to more coal-fired running time (EC, 2021a, p.32). Clearly, this option was preferred to power outage, and it is significant that the countries involved are some of the wealthiest in the world.

Juxtaposing this situation with that of Africa, where customers currently pay more for electricity compared to the global average, may help one appreciate the impact which high energy prices is having on Africa's economic development. For a start, African economies are developing their energy infrastructure at higher financing costs. IEA (2021c) notes that the cost of capital for investment in energy infrastructure in developing and emerging economies is seven times more than that for advanced economies. McKinsey (2015) notes that Africa's dependence on more costly energy generation options translates to Africans paying three to six times more for electricity, thus making the continent's industries globally less competitive. Moreover, power outages occur frequently, especially in West and Central Africa where the outage is approximately half of the entire year (AUC, 2021).

While Europeans may have a willingness to pay for electricity that is higher than the retail price to avoid power outages, Africans, on the other hand, must pay more than the current rate if they are to have any electricity in the first place. Streatfeild (2018) notes that while Africans may be paying higher tariffs for electricity, what is being paid is still too low to cover the production costs of electricity, leading to the inhibition of additional investments.

Thus, a policy strategy whereby natural gas-rich African countries decide to abandon the development of their assets could place these countries in a more disadvantageous position than they are already. Firstly, it will not be in the best interest of these African countries to compete in a global market for natural gas since they have failed to develop their assets.

On a price basis, Africa will not be able to compete with wealthier economies such as Asia (China) and Europe. Secondly, for a region where energy prices are already significantly higher than in wealthier economies, deciding to generate electricity using sources that are not least-cost options does will not make any economic sense. As demonstrated by the European electricity market example, advanced economies are making decisions that reward least-cost options over more costly ones. Certainly, for the continent to create an energy system that achieves the desired climate outcomes, the factors leading to high energy costs and energy prices should be regarded as critical barriers.

3 Implications for Africa's Energy Transition

Sustainable development demands that development decisions made today take into consideration how these decisions will affect the well-being of generations in years to come. The goal is to avoid (or mitigate to the extent feasible) the negative impact of such decisions on the lives of future generations.

Access to modern energy services has eluded many generations in Africa. This situation, driven by factors hindering investment decisions in Africa's energy sector, clearly goes against everything sustainable development. Africa has the lowest energy consumption per capita, in addition to being the only non-advanced economy where annual growth rate of energy consumption per capita was negative from 2009 to 2019 (BP, 2021). Energy poverty and its negative impact on human development stretches over millions of African lives today and will continue if nothing is done to change the situation.

Given the very high rates of energy poverty in African countries, development indices there have lagged behind the rest of the world for several years. According to the World Bank (2021), out of the thirty-nine (39) heavily indebted poor countries (HIPCs) globally, thirty-three (33) are African states. While there is no question that Africa must make development choices that align with environmental sustainability, the other two arms of sustainable development (i.e., social and economic development) cannot be ignored. In fact, there is no evidence that social and economic development is being jeopardized (or that there are plans to this effect) by countries that are already well advanced on these indicators as discussed above.

Moreover, according to the Intergovernmental Panel on Climate Change (IPCC) the magnitude by which climate-related risks will impact human lives and the natural environment will depend on “levels of development” and other factors (IPCC, 2018, p.5).

It is well known that poorer communities are more vulnerable to climate change. Furthermore, the extent of this vulnerability due to poverty is already being experienced in Africa, a region where majority of households depend on traditional biomass for cooking. Consequently, Africa’s economic development should be seen as a matter of survival, a necessity for posterity and resilience to the impact of climate change.

No doubt, these issues involve significant costs for the African society, a fact which must be accounted for in Africa’s energy decisions. African policymakers will need to make certain trade-offs in the short run in order to ensure that carbon neutrality can be achieved in the long run. By aligning strategic long-term planning with investments, inherent constraints to energy system planning can indeed be managed to produce the desired net zero emission results.

3.1. Africa's Pathway to Carbon Neutrality: Lessons from other Economies

Stronger economies mean a stronger ability to do the following: to deploy capital to innovate and install advanced technologies which reduce emissions from power generation; to invest in infrastructure that supports security of supply and grid stability while increasing the penetration of variable renewable power in the grid; and in situations where pollutions are unavoidable, the ability to invest significantly towards environmental amelioration. Moreover, stronger economies are better equipped to invest in climate-resilient infrastructure and, hence, are better positioned to withstand the impact of climate change. Thus, in order to support a carbon neutrality ambition, Africa's energy systems need to be able to support economic development.

Using the inherent constraints of energy systems as the framework, below are considerations for Africa's sustainable energy transition. Also, due to the interlinkage between these constraints, 'security of energy supply and energy costs' will be mainstreamed in the other two:

	Inherent constraints of energy systems	Considerations	Addressable challenges
1	**Technical feasibility and grid stability** **/** **Security of energy supply and energy costs**	A well-functioning grid network makes integration of variable renewables possible, hence supports a decarbonized energy system. Moreover, increasing cross-border electricity networks strengthens the ability to have a cleaner and reliable energy system. Europe does enjoy the benefits of a regional electricity market that allows the region take advantage of differences in the intermittencies of renewable energy production and different periods in peak demand, thus creating the semblance of a baseload power system for this common market.	Grid instability and power outages cause African economies significant costs, considering the impact this has on industries and commercial activities as well as the quality of life in general. Moreover, grid instability damages electric infrastructure equipment. For many African utilities, unavailability of capital is already constraining investment towards expanding energy access. Furthermore, for the African Single Electricity Market (AfSEM) to achieve its objectives of electrification and decarbonization, national electricity markets need to have the necessary functional infrastructure and equipment in place. Grid stability and investment towards the least-cost baseload energy for a country should not be compromised in order to build an energy system on its way to carbon neutrality in the long term.
2	**Environmental concerns** **/** **Security of energy supply and energy costs**	Matek and Gawell (2015, p. 102) note that in addressing the current energy-environment issues, system planners need to make decisions on the technology choices that will meet climate goals using scarce capital. 'Climate goals' should rather be called 'sustainability goals' in order to be more inclusive of the three arms of sustainable development – economic, social and environment. Moreover, focusing on 'climate' makes it easy for some to limit measurement of sustainability to carbon dioxide emissions, whereas there are other concerns to ensure that development is just.	African countries may struggle to fit into the perfect mould of 'sustainability' because this does not seem to be set in stone. For instance, while nuclear energy is sustainability for France, this is clearly not the case for the European countries of Germany, Switzerland and Italy. This therefore means that the external costs of using nuclear energy, specifically on the future generations of these European countries, have changed and are assessed differently from France. To ensure a sustainable and just transition, African policymakers need to internalize the external costs relevant to Africa. Such costs have so far been largely silent, shrinking and oversimplifying sustainability to carbon dioxide emissions.

	Inherent constraints of energy systems	Considerations	Addressable challenges
2	**Environmental concerns** **/** **Security of energy supply and energy costs**	For instance, following the 2011 Fukushima nuclear accident, Germany decided to terminate the use of nuclear power by 2022 (IAEA, 2021). This implies that the external costs of a probable nuclear accident are intolerable for German society. Italy and Switzerland took the same positions following Fukushima (IAEA, 2021). It is important to note that nuclear power is not considered a green energy source, although it is considered clean since the technology produces no greenhouse gases during the plant's operation. The environment-related issue with nuclear power concerns waste disposal after the power plant is decommissioned. According to Greenpeace (2011) "High level waste (from nuclear power plants) is a particular concern. To reach the end of its radioactivity it must be insulated from the environment for 244,000 years. By comparison, the human race is only 200,000 years old" (Greenpeace, 2011). The European Union, for example, is still considering "whether or not to include nuclear energy in the EU taxonomy of environmentally sustainable activities" (EC, 2021b). Obviously, even without knowing what the true costs of using nuclear energy in the distant future will be, the immediate costs of lack of security of energy supply and high energy prices to France's society today reflects the preference for nuclear energy.	For example: ✓ What is the cost of 600 million Africans still lacking access to modern energy services by 2030 and beyond? ✓ What is the cost of a heightened vulnerability to climate-related risks on African lives as a result of the low-income status of African states? ✓ What is the cost of increasing dependency on foreign aid, irregular migration, insecurity, unsustainable dependence on forests, etc., if African economies fail to develop? Internalization of these external costs should be integrated in informing Africa's energy policymakers on the least-cost energy supply options that enable the continent to meet the sustainable development goals and carbon neutrality ambitions.

4 Conclusion

One of the biggest challenges that investment towards Africa's sustainable energy transition may face from foreign financiers and investors is inappropriate accounting and internalization of external costs – the true costs of Africa's energy choices. Without accounting for Africa's level of socioeconomic development and how this reinforces Africa's unique experience with the inherent constraints of energy systems, foreign financiers and investors may wrongly write off investment projects that would have put Africa's energy system on a path to carbon neutrality in the long run. For instance, it will be necessary, at some point, for the vintage capital stock in Africa from transportation to industry, housing and power infrastructure to be replaced with efficient stocks, if the continent is to be in tune with the global energy transition. The possibility of this being actualized without investment that supports a strong economic growth is indeed limited.

Certain sections of the international system seem to be advocating strong-arm tactics requiring Africa to abandon the use of its natural gas resources–a situation which does not seem to reflect Africa's external costs in the short or long term. Moreover, these demands do not seem to reflect appreciation of the complexities involved in navigating the inherent constraints of energy system planning. It is not clear, however, if such demands are drawn from real-life examples from other continents. As discussed above, these complexities and how countries/regions choose to navigate them demonstrate lack of a perfect model, except one that underlies economics and the economy. For instance, China has been recognized as a leader in the acceleration of renewable energy installations globally (IEA, 2021 c, p.45), against the backdrop of a significantly high consumption of coal for baseload energy.

Thus, to answer the question posed in the Introduction, there is no convincing argument to suggest that the demands for the abrupt abandonment of Africa's oil and gas resources are well informed. In fact, denying Africa the funds to develop its natural resources, which have been the mainstay of power generation across the globe for generations, is likely to be misconstrued by critics as another form of neocolonialism.

However, one thing remains true: Africa is more vulnerable to climate change. Therefore, while other economies may have the luxury of oversimplifying sustainability and reducing this to carbon dioxide emissions, Africa does not have this luxury if Africans are to survive the already-present impact of climate change.

Furthermore, the continent needs to channel investment towards an energy transition that is sustainable by increasing the capacity of African economies to address barriers to resource efficiency (e.g., land use as well as land-use change and forestry, taking into consideration the lifecycle of energy choices), the circular economy (such as increasing manufacturing and recycling capacity), lack of infrastructure to support sustainable mobility and sustainable behavioural practices, among others. Industrial and infrastructure development is necessary to actualize these.

4.1. Transforming in the Next 10 Years

African policymakers need a continental long-term strategy of how Africa's energy mix will evolve by 2030, 2040 and 2050, based on an appropriate accounting and internalization of the external costs relevant to Africa.

For the first decade, Africa's economic situation can significantly transform in ten (10) years if there are concerted efforts to channel investment into achieving the three outcomes listed below:

i. Industrial development, specifically investment in large-scale industries that support regional market development and integration efforts and maximize the continent's manufacturing capacity in a way that allows African countries to produce what is needed to accelerate installation of wind, solar and other clean energy technologies. This creates a market where the continent's demand for clean energy can be met. Moreover, such large-scale industries make it cost-effective to install Carbon Capture, Utilization and Storage (CCUS) and green hydrogen technologies.

ii. Investing in infrastructure development such as interconnections for electricity and gas transmission infrastructure, transportation, housing, telecommunication, etc., will enable the continent to attract additional investment, thereby creating the environment which global businesses need in order to establish a long presence in African markets.

iii. Producing a critical mass of well-educated and highly skilled African workforces will be pivotal in driving Africa's sustainable energy transition. From skills in construction and manufacturing to analytical and critical thinking, Africa's sustainable energy future will require women and men with strong problem-solving capacities.

It is important to stress that, without an intentional strategy of utilizing within Africa the continent's renewable and non-renewable energy resources in the next decades, Africa may remain at a level where the continent is rich enough to be a market for international commodities but not rich enough to be on a sustainable economic, social and environmental development pathway. African economies must therefore strike a balance between, on the one hand, exporting energy (or being a site for energy production for export) in order to increase government revenue and, on the other hand, using its resources for its own economic development.

In order to actualize the continent's sustainable development goals, it will be important to identify foreign partners and financiers who are keen on accounting for and internalizing Africa's true energy costs, using these as the bases for investment decisions.

Finally, financing Africa's sustainable energy transition will require innovative financing instruments that allow Africans to invest in their own sustainable future.

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