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How Rapidly Should Africa Go Green?

The tension between natural abundance and economic scarcity

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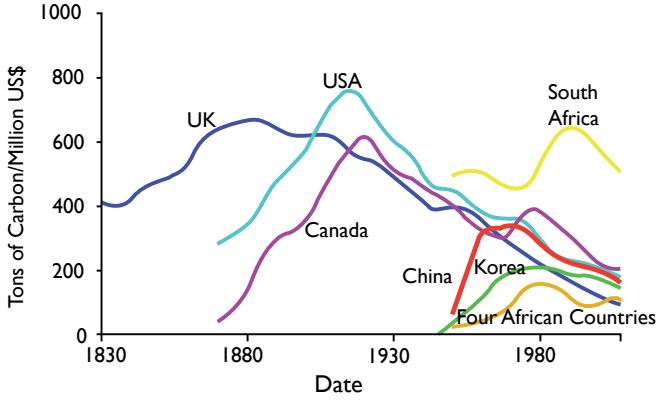
How Rapidly Should Africa Go Green?

The Tension Between Natural Abundance And Economic Scarcity.

By Paul Collier & Anthony J. Venables

Africa is the green continent: its CO2 emissions per person are less than one tonne pa, one-fifteenth of Europeans and one-thirtieth those of a North American.[1] With 12 percent of world population, Africa accounts for just 2.4 percent of world emissions. However, this is a consequence of Africa's poverty, and emissions intensity in Africa (emission per unit GDP at PPP) is at the world average. South Africa has one of the highest emissions intensities in the world; Tanzania, Kenya, Uganda and Nigeria ('Four African countries,' see figure 1) have emissions intensity higher than most European countries. Development typically generates an inverse-U pattern of emissions intensity peaking between $2-$3,000 per capita, implying that Africa's emissions will rise because of rising income and increasing emissions intensity.

Figure 1: Emissions intensity through time



Africa has a particularly strong interest in a robust global system of mitigation since its largely rain-fed agriculture makes it vulnerable to climate change. However, the choices made in Africa in coming decades will be determined largely by the local costs of mitigation. How fast should Africa adopt mitigation measures, given its particular characteristics and the technologies available?

Choices made in Africa will (and should) be shaped by the local costs of alternatives. These differ from those in high income countries because of the distinctive features of Africa, of which four are most relevant. The first is Africa's *natural endowment*. Africa has natural advantage in hydrocarbons (12.2 percent of world oil production and 9.5 percent of proven reserves, plus significant quantities of coal and gas). It has hydro-electric potential, producing 2.7 percent of world hydro-electricity but with an estimated 8 percent of world potential. It has copious sunlight and is well endowed with land.

However, utilization of these natural assets requires other inputs, in which Africa is scarce. One is the *capital endowment*, i.e. the accumulated stocks of physical capital and levels of human capital and skills. Another is *governance endowment*, meaning the institutional and governance capacity required

to implement and regulate economic activity. A critical consequence of these weaknesses is that Africa has not been able to harness its natural endowment: the region is chronically short of energy, with firms and households facing acute shortages of power.

The fourth distinctive feature follows from these; Africa is a *latecomer*. Developed regions have sunk capital in their power supply, transport networks and urban structures. Africa has yet to do so on a large scale. New technologies will be available at the time when Africa is making these investments, offering a potential for more efficient and less polluting investments. However, as a latecomer currently suffering energy shortages, Africa also needs to make these investments soon.

The extent to which Africa adopts green technologies will depend on the interaction between these features of Africa's endowment and the characteristics of the technologies that are available. Some green technologies may be particularly low-cost in Africa, offering choices that are green and economically efficient. However, many green technologies are intensive users of capital, of regulatory and governance capacity, and of highly skilled labour. Since Africa is poorly endowed with these resources, diverting them into climate mitigation rather than other uses has a high opportunity cost.

Capital, Governance, and Energy Supply

Capital and skill scarcity

Africa is capital-scarce and has low savings rates. African governments raise little in tax revenue and are dependent on uncertain aid flows. Their access to international private finance is expensive, and limited following the region's recent history of default and debt forgiveness. Natural resource revenues provide substantial funds for a few countries, but historically these revenues have largely been used for current consumption rather than investment.

Firms in the region face difficulties raising finance. The small enterprises that characterize most of the African private sector have difficulty raising capital and face extremely high interest rates, sometimes in excess of 60 percent. These capital costs result in energy intensive choices. For example, old trucks are highly energy-inefficient, with high fuel costs and high emissions, yet African firms do not replace such vehicles because of the capital constraints they face.

At the household level the most striking example of energy intensive choices is cooking stoves. The cheapest stoves use wood or charcoal; kerosene stoves are more expensive, and LNG stoves are more expensive still, mainly because of the initial cost of purchasing a canister. The consequent prevalence of wood and charcoal-fuelled cooking has substantial consequences for both the local and global environment. A less obvious but pervasive household energy-saving investment choice is that between a bicycle and walking: many millions of Africans walk long distances to work because they cannot afford a bicycle which would substantially reduce their daily energy needs.

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As well as being capital-scarce, Africa is skill-scarce. The region's tertiary education sector is tiny and low-quality, and haemorrhages its limited skilled workforce to other regions which, due to higher private incomes and more abundant public goods, offer skilled immigrants a higher quality of life.

Governance and political economy

African governments typically have limited capacity and operate in a difficult political environment. The consequences are manifest in many areas, power generation amongst them. Since power supply is a classic network industry, involving scale economies and the need for a grid, government involvement is needed either in the form of regulation or public ownership, the system inherited from colonial times. This has proved dysfunctional, resulting in under-investment, lack of maintenance, and severe and persistent power shortages.

African governments are distinctive in that urban electorates hold them responsible for the price of energy, and this has resulted in the systematic under-pricing of energy. The chronic shortage of generating capacity is in part a consequence of this under-pricing. So severe are power outages that almost all citizens would benefit from the switch to higher prices and expanded supply, but such a policy package has to be sequenced: prices must be increased before investment can be committed. Governments have no way of credibly assuring citizens that a price increase will indeed be followed by supply increases. Hence, the equilibrium is a stalemate in which price stays low and supply is rationed.

Government failure suggests that African power generation might be more effectively undertaken by regulated, possibly foreign-owned, private enterprises. However, the same government failure that precludes efficient public provision of power precludes the provision of credible regulation. As a consequence few African countries have significant generation by enterprises with private majority ownership, and two such privatisations have been reversed (in Senegal and Mali); private management contracts are somewhat more common, although some have failed.

Energy usage

These features of Africa's endowment are manifest in the current position. While African firms and households are acutely short of energy, their use is, by international standards, apparently inefficient. This is not because they are failing to optimize, but rather because of the prices which they face for capital, regulation and skill, as in the cases of transport equipment and cooking stoves. An important manifestation

of these problems is users' reliance on off-grid power generation. Because grid-supplied power is highly unreliable, power generation has been turned into a subsistence activity. Private firms of all sizes generate their own electricity using diesel generators, at high cost and absorbing capital that could have been used for other investments: a study of small firms in Nigeria found that three quarters of their entire capital stock was tied up in generators. The resulting inability to exploit scale economies sharply increases unit costs. Typical electricity production costs in Africa are around 12 cents per KWh, about twice that in the developing world and almost as high as in the OECD.

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Africa's difficult governance has increased the emissions intensity of economic activity in other less immediate ways. Rail networks can offer low emission transport but have suffered similar problems as power generation, for similar reasons. High urban density can reduce emissions, but the poor development of land markets and lack of public provision of infrastructure mean that African cities have relatively low population density.

Most conventional mitigation efforts aim to green energy usage by raising the marginal cost of carbon-based power, thereby inducing its consumption to be lower than it otherwise would have been. Given Africa's current position, such a reduction would be particularly damaging. The lack of adequate power has evident consequences: children are not able to do homework due to lack of light: perishable food cannot be refrigerated. Firms resort to high-cost self-generation, and surveys routinely find that the shortage of power is their foremost concern. Indeed, it is a vital matter that Africa substantially reduces its energy costs in order to create badly needed jobs. Africa cannot afford cost-increasing mitigation: any measures that it takes to green its energy must also be cost-reducing.

Natural Abundance and Future Choices

Future choices will be shaped by the factors outlined above. Some implications can be seen from studies of marginal abatement cost curves. A study for Kenya compared options at a 4 percent discount rate and a 30 percent rate. All mitigation options become more expensive at the higher rate. At 4 percent around 4Mt C02e mitigation is negative cost, at total cost saving of $600 million; at 30 percent this falls to 2Mt CO2e at cost saving of $100 million. At 4 percent the most significant gains come from replacing old vehicles and from switching away from charcoal-burning stoves. However, at 30 percent these and other options, such as micro-hydro, go from negative cost to positive cost.

The choice between alternative means of electricity generation is highly sensitive to the discount rate. Gas, hydro, and coal are the least capital intensive and nuclear and solar PV the most. At a 5 percent discount rate, onshore wind and solar are the two most expensive technologies while at 10 percent the cost disadvantage of wind and solar widens further, illustrating the high cost of deploying these technologies in Africa. Africa's power generation choices will be determined by these comparative costs, and by its endowments of alternative fuels.

Hydrocarbon abundance

Africa's abundance of hydrocarbons is such that fuels account for more than half of Africa's exports. During the coming decade this dependence upon carbon-based energy exports is likely to increase substantially. Since 2004 there have been oil and gas discoveries in Chad, Ghana, Guinea, Guinea-Bissau, Kenya, Liberia, Mali, Mauritania, Mozambique, Sao Tome Principe, Senegal, Sierra Leone, Tanzania, Togo and Uganda. There are also substantial coal deposits, principally in South Africa and now also large developments in Mozambique.

While much of these resources are exported, their abundance means that local energy use, for example in power generation, is fossil fuel intensive. If resources were *perfectly* freely traded then their local price would be the same as the international price, but trade frictions reduce the returns to exporting and drive the local price of the resource below the world price. The costs of coal-based electricity generation in coal abundant countries such as Australia and South Africa are about half what they are in coal are in coal importing countries. Costs of international trade are particularly high in Africa; oil found in Northern Uganda is hard to export so might appropriately be used locally to generate electricity. Furthermore, the volatility of commodity prices creates a case for domestic use; exporting the resource exposes the country to economically damaging volatility, while domestic use reduces this exposure, acting as a form of insurance.

These arguments point to the cost advantage of using local fossil fuels intensively. In Southern Africa this means coal, and in other regions more likely oil. Natural gas will also become much more important, both because of possible reductions in flaring, and also because of new gas finds off Mozambique and Tanzania.

Solar abundance

Superficially, the most promising new green energy technology for Africa is solar power. It fits Africa's endowment of sunlight and does not need a grid, so offers the prospect of a leapfrog technology comparable to mobile phones. However, solar power is currently both capital and skill intensive. The enterprises that might be expected to use this technology face very high implicit discount rates and are often unable to collateralize assets such as solar panels due to deficiencies in physical security, the legal environment, and the financial sector.

Shortages of technicians and of managerial capacity to organize service provision reduce the effective life of solar panels and so accentuate their capital intensity.

Hence, despite its advantages, solar power is currently only viable for households and small firms in conditions of extreme energy shortage. It may be a valuable technology for bringing power to outlying villages but not for urbanites who will soon constitute the majority of Africa's population. While the cost of solar panels will continue to fall sharply, the cost of storage of power for night-time use will remain high. Looking at technical change scenarios over coming decades, studies suggest that solar PV will be unlikely to cover more than 10% of households.

Hydropower abundance

Africa has a major natural advantage in hydropower. At present some 38 percent of Africa's electricity is from hydropower (close to 70 percent excluding South Africa). There is unexploited potential on the Congo, Niger Zambezi, the upper Nile (Ethiopia and Uganda), and in numerous smaller schemes. Cost estimates suggest that hydro is the most promising of the renewable energy sources for large-scale development. A considerable expansion of hydro capacity is planned or underway and a trebling of African hydro capacity is forecast by 2035.

However, in this sector also, Africa's lack of governance capacity poses problems. The high ratio of sunk capital costs to recurrent costs exposes hydropower investors to high levels of political risk. The usual tension between the sunk cost of a private investor and the interest of the host government is compounded by the multinational nature of much of the demand for hydropower. Africa is fragmented into 54 countries, and hydro potential is concentrated in a few of them; some 60 percent of Africa's hydropower potential is found in just two countries, the DRC and Ethiopia. Successful development therefore requires export of hydropower to neighbouring countries, but such deals have been hard to implement. The most notable investment blocked by these political obstacles is the Grand Inga hydroelectric project on the River Congo. If fully implemented this would have capacity of 39GWs, double the size of the Three Gorges in China. However, this natural advantage collides with economic and political disadvantage. At the present level of African power usage, Grand Inga would meet a third of the region's electricity consumption and would require transmission lines from the DRC through Zambia, Zimbabwe and Botswana, to the major source of demand in South Africa. Understandably, the considerable potential for hold-up continues to deter private investment.

Land and forest abundance

As with sunlight, Africa's land abundance is a natural advantage with potential for energy production. Africa's population density is low, just one-tenth that of India's, and an estimated 200 million hectares of land in Africa is potentially available for new agricultural use. This creates a potential for biofuels production, although there is an acute trade-off with production of food crops. Africa is a substantial net importer of food and the majority of bio-fuel comes from sugar cane which requires high-quality well-watered land equally suitable for food crops. This suggests that, at least with current technologies, it is inappropriate to substitute bio-fuel production for food.

Africa's enormous rainforests confer another energy-related natural advantage, namely the potential for biological sequestration of carbon. The sequestration generated by the preservation and expansion of these forests could potentially be sold on the incipient global market in carbon credits. However, the region's disadvantages in the economic endowments of capital, skills and governance again offset this natural advantage. The market in carbon credits is intensive in regulatory capacity and regulatory problems are particularly acute in forestry. The core of Africa's rainforest is in the DRC, which is ranked near the bottom of Africa's governance indices, and where forest management will be particularly hard to achieve.

Latecomer advantage

Africa will be the last region in the world to embark on massive expansion of its power capacity. It therefore faces the prospect of avoiding a heritage of old and dirty capital equipment and of moving directly to new technologies that are both greener and more efficient. This is of direct benefit to Africa as well as to the environment although, as we have argued, the uptake of these technologies will depend on complementary inputs and comparative costs.

However, many green technologies will not attain economic viability for several decades, suggesting that there is an advantage in postponing investment until new technologies are available. Africa's circumstances are such that delay is particularly expensive. The social discount rate is high and current energy scarcity means that the marginal social value of energy is far higher than in other regions. As we have seen, this damages households and undermines the competitiveness of firms. Anything that postpones development and causes the quantity of power used to be less than it otherwise would have been is therefore more expensive in Africa than in other parts of the world. The potential green advantage of being a latecomer is therefore stymied by the urgency of installing new capacity.

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Exploiting the Difference Between Local and International Costs

We have suggested that despite the importance for Africa of mitigating global warming, it may well be appropriate for the region to lag rather than lead in adopting green development strategies. However, there are promising sectors, notably hydroelectricity. Furthermore, relative scarcities and prices are not immutable. They can be changed by opening up and improving markets so that relative prices and costs in Africa are brought closer to those in the rest of the world, and by directly supplying scarce factors, either though markets or through development assistance.

Africa has opportunities for emissions reduction which, at international prices of capital, offer far better value than those open to industrial countries. Hence, it would be cheaper for the firms and households of the industrialized world to provide capital to finance African emissions reductions than to achieve the same reductions by domestic actions. One instrument for this is the Clean Development Mechanism, yet its uptake in Africa has been extremely low (it accounts for 2% of registered projects), precisely because it requires other capabilities which are scarce in Africa.

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Another mechanism is official development assistance which could be used to address the divergence between investment choices at domestic and international prices. It is cheaper for the international community to pay for the installation of green technology in Africa's new plants than to retrofit it in existing Northern plants. A second Africa-specific opportunity in generation is for international public finance, perhaps through guarantees, to subsidize the cost of switching from gas flaring to either LNG or gas-fired electricity generation. A third would be to provide international public subsidies or guarantees for hydropower mega-projects.

A different approach is international risk insurance combined with leverage for recovery, as exemplified by the Multilateral Investment Guarantee Agency (MIGA), the political risk insurance arm of the World Bank. MIGA is able to charge low premiums because, with rare exceptions, it has been able to recover from governments those investor claims against them on which it has determined that the evidence warrants payment. There is considerable scope to expand such risk-mitigating uses of international governance.

As well as increasing resources from outside the region, resources within the region need to be better allocated. Within countries, poorly functioning credit markets together with weak corporate governance and legal systems restrict the ability of firms and households to make investments, which could be both privately and socially profitable. This domestic reform offers the prospect of raising both economic and energy efficiency.

Conclusion

Superficially, Africa appears well-suited for green energy. Sunshine, water, land, forests, and being a latecomer all confer significant advantages. However, energy generation, energy saving, and carbon capture are intensive in capital, governance capacity and skills. Unfortunately, all of these factors are scarce in Africa. These factor scarcities offset the advantages conferred by natural endowments and are often decisive. Similarly, the historic advantage of being a latecomer to the installation of generating capacity is offset by the historic disadvantage of the acute energy scarcity inherited from past under-investment: Africa cannot afford to wait for further developments in green technologies. Nevertheless, there is scope for Africa's natural advantages for green energy to be harnessed to a global advantage. But to do so will require international action that brings global factor endowments to bear on Africa's natural opportunities.

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References

1. Sub-Saharan Africa excluding South Africa. For the remainder of the paper Africa will mean the whole of Sub-Saharan Africa.