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Power and Roads for Africa

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ABSTRACT

Central to the issue of growth is the development of the private sector. Without the creation of jobs and businesses, there is no real chance for Africans to raise their standard of living. Extensive surveys of private sector businesses carried out over the past decade show that the poor performance of the private sector can be largely attributed to the high costs of the business environment. This essay looks at how the United States can help address two key constraints identified by these surveys: the lack of power and roads. The United States can help solve the infrastructure crisis in Africa by creating a $1 billion Clean Energy Fund for Africa to facilitate the transfer of clean technology, including renewable energy, from the United States to Africa. It should encourage the African Development Bank to focus solely on regional infrastructure projects, in return for which the United States should increase its capital contribution to the organization by 25 percent per year for each of the next four years. And it must ensure that the World Bank increases its allocation toward *regional* infrastructure projects in Africa, with a strong emphasis on clean technology, making this a central mission of its soft loan window.

POWER AND ROADS FOR AFRICA*

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Introduction

The past decade has witnessed a rapid increase in aid to sub-Saharan Africa. In the first four years of the Bush administration, aid levels reached over $4 billion a year, representing almost 20 percent of the total aid budget and a fourfold increase from the year 2000. Two ambitious new initiatives—the President's Emergency Plan for AIDS Relief (PEPFAR) and the Millennium Challenge Corporation (MCC)—were launched to address the continent's health and development needs. In 2001, the Africa Growth and Opportunity Act (AGOA) was implemented to provide African businesses with better access to the U.S. market. Along with other such initiatives, media interest in Africa has also grown, and the public has expressed its support for Africa's economic and social development through consumer campaigns such as Product Red and public events.

Why does economic growth in Africa matter to the United States? For two simple reasons—it's the right thing to do AND the smart thing to do. There is increasing public interest in the U.S. as well as bipartisan support for helping Africa, as recently witnessed by renewed funding for PEPFAR. Furthermore, there are several new opportunities for U.S. firms to compete, particularly in the area of renewable energy.

A perceptible increase in GDP per capita growth in sub-Saharan Africa (hereafter referred to as Africa) since 2003 has relieved some of the Afro-pessimism so prevalent in debates about Africa's prospects. Some countries that are not resource-rich are doing very well: Benin, Burkina Faso, Ethiopia, Ghana, Mali, Mauritania, Mozambique, Rwanda, Senegal, Tanzania, and Uganda are growing at over 5 percent a year (Gelb and Turner 2007). Another group of countries is growing at even higher rates, albeit with the help of oil and other resource commodities. (Figure 1 shows that most of the increase in exports of AGOA-eligible countries comes from oil-related products.) But not all countries have done well, and there is uncertainty about whether even the successful economies will be able to sustain their gains, given their possible dependence on special factors, such as aid or temporary terms-of-trade windfalls. Meanwhile, the larger issue of boosting long-run growth in Africa to levels that would close the income gap with other regions remains a concern.

Central to the issue of growth is the development of the private sector. Without the creation of jobs and businesses, there is no real chance for many Africans to raise their standard of living. Extensive surveys of private sector businesses carried out over the past decade show that the poor performance of the private sector can mostly be attributed to the high costs of the business environment. In this chapter, I look at solutions to the problem of low growth in Africa, focusing on two key constraints identified by these surveys: the lack of power and roads. I argue that there is an urgent need for the United States to support a Clean Infrastructure Initiative to provide modern energy through a variety of renewable energy sources, and facilitate the construction of roads. I also argue that this will be beneficial to both the United States and to Africa. To this end, I propose that the United States take the following three steps:

1. Support a $1 billion Clean Energy Fund for Africa, managed by the Overseas Private Investment Corporation (OPIC), to facilitate the transfer of clean technology, including renewable energy, from the United States to Africa.[1]

2. Encourage the African Development Bank to focus on regional clean infrastructure projects only, in return for which the United States should increase its capital contribution to the organization by 25 percent per year for each of the next four years.

3. Ensure that the World Bank increases its allocation toward *regional* infrastructure projects in Africa, making this a central mission of the International Development Association (IDA), its soft loan window for the poorest countries. At least 50 percent of the IDA allocation for Africa should be spent on regional infrastructure projects, with a strong emphasis on clean technology.

“No Electricity Presently Available”

In the summer of 2007, the government of Kenya made an unusual appeal to the Kenya Association of Manufacturers, urgently requiring them to move their production schedule from their regular hours to a nighttime schedule of 11:00 p.m. to 5:00 a.m. Unable to provide power for more than a few hours a day, the government called for massive load-shedding to protect the power system from being overwhelmed. The manufacturers were in turn faced with the problem of getting workers to and from work in the dark, with vastly increased logistical and security costs than the roughly 4 percent of sales they were already paying to keep their workers and equipment safe (Mbogo 2007). Such infrastructure problems are not uncommon in Africa.

With a sixth of the world’s population, Africa generates only about 4 percent of the world’s electricity, three-quarters of which is used by South Africa and northern Africa. The need for electricity is both enormous and unmet, with many cities and towns experiencing blackouts several times a day (*The Economist* 2007a). Indeed, the *Independent* (Soares 2007) reports that the popularity of the United Nation’s War Crimes Court has more to do with its restoration of power in parts of Freetown, Sierra Leone, than to its justice-related activities. In Conakry, Guinea, young men go to the airport every evening to study because it is one of the only places with reliable lighting. And in almost every major city, the constant roar of backup generators can be heard in the wealthier neighborhoods.

According to World Bank data, about 500 million Africans (75 percent of all households or two-thirds of the total population) are without “modern energy.” The Bank reports that about $17 billion is spent by the “energy-poor” in Africa on fuel-based lighting systems, such as kerosene lamps, that are expensive, provide poor lighting, and create indoor air pollution (World Bank 2007c). Biomass (mostly firewood) constitutes about 56 percent of all energy use in sub-Saharan Africa, which is home to seventeen of the top twenty biomass users in the world (World Bank 2007b). Such fuels also accelerate deforestation; the World Bank estimates that 45,000 square kilometers of forest were lost between 1990 and 2005 across all low-income countries (World Bank 2007a).

Recently, a comprehensive set of Enterprise Surveys conducted by the World Bank has become available to the larger community of policy analysts and researchers. The data are derived from face-to-face interviews with managers and owners of several thousand enterprises of all sizes. This chapter is based on surveys of about 11,000 businesses in twenty-seven African countries.[2] I use only manufacturing sector data in four traditional sub-sectors—food processing, wood products, metal working, and textiles and apparel) to ensure comparability across countries. The data illustrate how seriously the lack of infrastructure is constraining growth in this region.

Perhaps no country in Africa is worse affected than Nigeria. Data from a 2001 survey and from other sources show that almost 40 percent of electricity is privately provided via generators, which costs three times as much as electricity from the public grid (Adenikinju 2005). Almost all businesses own generators of varying quality and vintage to compensate for the extraordinarily unreliable supply provided by the Nigerian Electric Power Authority (NEPA—often referred to by the citizenry as "No Electricity Presently Available"). At the same time, fuel is sometimes hard to find in this oil-exporting country, and maintenance of generator equipment imposes further costs on businesses (World Bank 2002).

Figure 2 shows the number of days that a power outage occurred each year in the countries surveyed. The worst cases are the Democratic Republic of Congo, the Gambia, and Guinea (each with over 170 days of outages), while Uganda, Rwanda, and Tanzania come next with 120 outages. Most of the remaining countries experience outages on more than 50 days in the year. However, six countries—Guinea-Bissau, Lesotho, Mali, Senegal, Swaziland, and Zambia—fare better, reporting outages of between 10 and 50 days. Only a handful of countries—Botswana, Mauritius, Namibia, and South Africa—report outages on less than 10 days in the year. Almost 50 percent of all businesses surveyed cite power as a major or severe constraint; the number rises to 60 percent when middle-income countries are removed from the sample. Comparable data for China show that the burden of power outages is far smaller for businesses in that country. Finally, outages are not just frequent but also unpredictable and long. The average length of a power outage in Africa is five hours; outages can sometimes stretch to more than twelve hours.

How do businesses cope? In Angola, Cameroon, Gambia, Guinea, Guinea-Bissau, Rwanda, and Senegal, over 50 percent of businesses resort to acquiring generators to offset the erratic supply and load-shedding of the public grid. Kenya tops the list with 70 percent of businesses owning generators; electricity is now rated an even greater constraint than corruption, a long-standing complaint of Kenyan businesses. Even in very low-income countries such as Benin, Madagascar, Mauritania, and Niger, 20 to 30 percent of businesses own generators.

The ability to offset power fluctuations varies greatly by enterprise size. Large businesses with 100 or more employees are much more likely to own a generator than a small or medium-sized enterprise—20 times more likely in Zambia, and two to five times more likely in Cape Verde, the Gambia, Mauritania, and Niger, where all large businesses own generators (see Figure 3).

Energy as a share of total cost is as high as 10 percent for African businesses in Benin, Burkina Faso, the Gambia, Kenya, Madagascar, Malawi, Mali, Senegal, and Tanzania (Figure 4). In China, the cost of energy is 3 percent of total cost. Only one country in Africa—South Africa—shows a comparable share, and even that is changing as many cities experience rolling blackouts. Even more troublesome is the fact that this situation will likely deteriorate further before it improves. The *New York Times* (Wines 2007) quotes Lawrence Musaba, manager of the Southern Africa Power Pool, as saying, “We’ve had no significant capital injection into generation and transmission, from either the private or public sectors, for fifteen, maybe twenty, years.”

Roads Are Almost As Bad

In addition to power, the limited availability of physical infrastructure—including roads and railways—also seriously hampers private sector competitiveness. The low-income economies of sub-Saharan Africa lag far behind every other region in the world in terms of paved-road mileage and modern freight- and passenger-transport systems. This lack of adequate transportation impacts the level of business activity by lowering productivity and limiting the entry of new enterprises. Businesses in Africa either supply only to fragmented regional markets, or restrict themselves to market opportunities with profits large enough to cover high transport costs. These effects are difficult to reverse because, unlike the power supply which can improve or deteriorate rapidly, transport bottlenecks are typically long-term—bad roads and limited transnational linkages have kept markets and businesses highly segmented for decades in Africa.

We can see the importance of the transport bottleneck to existing businesses in the data evaluated in the Enterprise Surveys database. Large differences in the performance of firms across countries are clearly correlated with the overall level of economic development and infrastructure facilities. In middle-income countries such as Botswana, Mauritius, Namibia, South Africa, and Swaziland, less that 20 percent of firms complain about transport problems, whereas in Kenya, 53 percent of firms consider transport a major obstacle. In the poorest countries, most businesses sell their goods only in local markets and do not even consider selling anywhere else.

Figure 5 illustrates that transport is a very real constraint for larger businesses. In East and southern Africa, large businesses are much more likely to complain about transport than smaller firms. These businesses account for a large share of manufacturing employment and most of industrial value-added, and they are most likely to expand beyond the local market. Yet in all but the richest countries in our sample, less than half of inputs are delivered by road. Some businesses even rely on costly air shipments to meet their needs; one investor told me of how he had on occasion air-lifted *cement* across countries because the roads are so poor.

Finally, businesses were asked about losses due to transport failures, measured as the percentage of consignment value lost due to theft, spoilage, or breakage in transit. Figure 6 shows that businesses in the low-income economies of sub-Saharan Africa suffer the most, with the larger businesses suffering greater losses than smaller ones. Such losses are much higher than in China, where the average loss is only about 1.25 percent of consignment value.

Overall, business losses due to poor infrastructure are staggering, imposing high cost burdens on African businesses. The result is that, compared with Chinese businesses, the productivity of African businesses is 10 to 20 percent less on average when indirect costs, such as electricity and transportation, are subtracted from value-added (Eifert et al. 2005). It is important to keep in mind that these losses do not include the impact of the various bottlenecks on the *entry* of businesses into the private sector. Finally, the lack of roads and power does not affect just manufacturing but agriculture as well. The lack of infrastructure has meant that farmers are often unable to increase the value-added through processing, or to transport their goods overland to domestic markets or international ports.

What Should the United States Do to Help Africa?

The evidence points overwhelmingly to the need to invest in infrastructure, particularly a sustainable supply of electric power and a good network of roads that will enable businesses to buy inputs and sell their goods. From the data, it is clear that investing in infrastructure will reduce the cost of doing business for *all* businesses, large and small. Small and medium-sized enterprises, which are less able to cope with power shortages, will likely benefit to a greater extent from these investments. Without major new investments in infrastructure, it will be impossible for African businesses to substantially increase their level of efficiency or expand their markets.

There is enormous potential for the United States to contribute solutions to this problem. American businesses have the technology and the know-how and must be given the opportunity to compete on bids to develop Africa's power and roads. The expertise of power companies—both large and small—can be harnessed to address the shortage of electricity in Africa. And construction companies can help to build roads, using the best of American technology and human resources. These efforts will benefit the African people as well as the companies and employees which provide infrastructure services. American investment in African infrastructure can also lead to more business partnerships between the two regions, which can be profitable to both in the long run.

All investments in energy must be in newer, cleaner forms, notably hydroelectric and solar power. Africa has a unique opportunity to lead the way for the rest of the world in becoming a producer (and even an exporter) of energy with zero net emissions of greenhouse gases. It can avoid the predicament that some rapidly growing countries find themselves in, where rising incomes are accompanied by a high incidence of ill health and respiratory disease caused by air and water pollution. It can also avoid the problems that come with dependence on coal, ranging from environmental degradation to high carbon emissions.

Africa has tremendous potential for the production of various kinds of renewable energy (OECD 2003/4), and African reserves of renewable resources are the highest in the world (Buys et al. 2007). According to this latter analysis, African countries have annual solar, wind, hydro, and biofuel generation potential that greatly exceeds annual consumption. Table 1 reproduces their description of the top 33 countries in the world for solar, wind, hydro, and geothermal energy. Overall, 17 countries in sub-Saharan Africa are in the top 33 countries with combined reserves of solar, wind, hydro, and geothermal energy. Among these 33 countries, Africa has 21 countries for solar energy, 6 countries for wind, 11 countries for hydro, and 7 countries for geothermal. Individual country estimates show reserves greatly in excess of annual energy consumption.

Much of sub-Saharan Africa receives solar radiation of the order of 6-8 kWh/m2/day—some of the highest amounts of solar radiation in the world. Figure 7 shows the solar radiation potential of the African continent. For businesses using low-quality, unreliable electricity, the small-scale installation of solar panels would reduce their reliance upon poorly maintained grids, thereby lowering costs and enabling them to compete more effectively in the global market. Solar energy generated via rooftop solar panels is also less likely to run into the regulatory and management problems that have plagued delivery of grid-based energy by public utilities. *The Economist* (2007a) argues that solar energy will become cost effective in Africa if costs are lowered by 30 percent.

There is enormous potential to address the transport bottleneck as well. In 2006, researchers Buys, Deichmann, and Wheeler made a compelling argument for the creation of a major road network in sub-Saharan Africa. They argue that a network of roads connecting all sub-Saharan capitals and other cities with populations over 500,000 would result in an expansion of overland trade of about $250 billion over fifteen years, with both direct and indirect benefits for Africa's rural poor. They estimate an upfront cost of $20 billion, and $1 billion in yearly maintenance to build this network. They point out that overland shipments between South Africa and Nigeria—the two largest economies in Africa—are almost nonexistent because of the poor quality of roads in between. Figure 8 shows the transnational road network proposed by Buys et al., along with the transcontinental corridors proposed by the African Development Bank.

The technology for road construction is fairly mature and U.S. construction companies have considerable expertise in the building of roads in a variety of topographical and climatic conditions. Furthermore, road construction is labor intensive, and would generate much needed jobs across several African countries. Finally, Buys et al. argue that an emphasis on the preservation of biodiversity and wildlife habitat can lead to more environmentally sensitive construction of roads in Africa—there does not have to be as much of a tradeoff as in the past.

What about the maintenance of road and power projects? This is often cited as a bigger challenge than building infrastructure. But there are two reasons to be optimistic: the existence of best-practice models for road construction and maintenance, and the rise of a technocratic class in many African countries. It is beyond the scope of this essay to go into detail on the various ways in which roads can be maintained, but it is worth mentioning that maintenance can be included in construction contracts, outsourced to independent providers, or contracted in other ways based on competitive bidding. User charges can also play a role in funding maintenance costs (Heggie and Fon 1991). Funding for infrastructure projects, no matter what the source, *must* include mechanisms by which maintenance costs can be met, with these costs acknowledged upfront and provided for when the infrastructure contract is signed. Most likely, the best way to ensure competitive bidding is for maintenance projects to be bundled *regionally*, thereby providing enough scale to interest a large number of bidders.

The rising technocratic class in sub-Saharan Africa is well aware of the challenges of infrastructure investments and maintenance. This is not the Africa of the 1970s when many infrastructure projects failed because of poor design and lack of maintenance. Many countries in Africa have undergone macroeconomic reforms and succeeded in checking inflation. As mentioned earlier, several non-resource-rich countries are enjoying high growth rates (Gelb and Turner 2007). Many of Africa's central banks are run by competent, highly trained individuals—some of the best finance minds in the world. In several countries, democratically elected leaders have searched the world to bring the best talent back to their countries to run their ministries. As a middle class emerges across the continent, there will be even greater demand for the maintenance of infrastructure. Designing, constructing, and maintaining infrastructure has a greater promise of success than ever before.

A Clean Infrastructure Initiative for Africa

The next president should announce a Clean Infrastructure Initiative to end Africa's power and transport problems. This initiative should have two main objectives:

- Harnessing innovations in clean energy for Africa
- Financing the construction and maintenance of infrastructure via multilateral institutions.

***Harnessing innovations in clean energy*.** Linkages must be facilitated between American businesses engaged in cost-reducing innovations in renewable energy and African businesses and governments interested in using these technologies. This could include carefully designed financing mechanisms to fund the transfer of clean technology, such as private equity funds that would invest in these technologies in Africa. The United States can also consider advance market commitments, such as those currently being used to develop vaccines and other health products, to spur the development of renewable energy sources that are clean and safe alternatives to biomass fuels.[3]

American businesses, funded by venture capitalists and others, are engaged in the production of an array of new, cleaner power technologies, many of which can be transferred to Africa. The United States can play a role by monitoring new developments in solar, wind, and hydropower, and funding startup or other costs that would bring these technologies to the region. Similarly, exciting new developments are being reported in micro-hydro, wind power, and biofuels, such as oil from the jatropha plant. Micro-hydro projects in Kenya and elsewhere in Africa are now providing electricity for several hundred households each, bringing modern energy to far-flung areas. The community-owned Tungu-Kabiri Micro Hydro project has 200 shareholders, each of whom bought $50 shares in the enterprise.[4] The project supplies 18 kW of mechanical power. On an even smaller scale, pico-hydro schemes, which typically supply power up to 5 kW, are also proving to be good value. In two towns in the Kirinyaga district in Kenya, pico-hydro units are providing power to about sixty households each, while substantially reducing the use of kerosene and biomass fuels (Television Trust 2002). These technological options are extremely relevant for a continent where traditional grid-based electricity will likely never be cheap, reliable, or far-reaching.

Dozens of energy firms in the United States, many funded by venture capital, are engaged in research and development to bring down the cost of renewable energy. Venture capital activity in solar energy has increased almost fourfold from $59 million in 2004 to $308 million in 2006 (*The Economist* 2007b). Rich-country governments' interest in the development of alternative energies, in addition to legislated emissions reductions, are creating demand that investors see as a major incentive for investments in renewable energy sources. Currently, twenty-five states and the District of Columbia have binding clean energy standards, and California's recent greenhouse gas law requires the state to reduce its overall emissions by 25 percent by 2020. Solar efficiency has increased dramatically since the 1970s, accompanied by declines in cost. The U.S. Department of Energy's goal is to make solar power cost-competitive with the grid by 2015, and many in the field think this is a conservative target (ibid.). Some companies are trying to build large-scale plants that will store and supply base-load power on a 24-hour basis at competitive prices.

Most recently, Google, one of the world's most visible technology companies, launched a $500 million effort to develop electricity from renewable energy sources that will be cheaper than electricity generated by burning coal (Google.org 2007). Like some other companies, Google is taking bold steps in this area, focusing on such renewables as solar thermal and high-altitude wind energy. Table 2 lists some of the venture capital-funded efforts in the United States and in other rich countries that are focused on lowering the costs of solar energy.

The United States can use incentives such as tax credits to lower the risks of technological development and speed up the production of clean technologies, and facilitate connections between American businesses and relevant partners in Africa. The Overseas Private Investment Corporation (OPIC), which has a strong tradition of providing support to the private sector, can play a key role. In 2007, OPIC launched a program to reduce emissions from OPIC-supported projects and to support projects that are focused on energy efficiency and clean technology. OPIC has also announced the creation of a Catalyst Private Equity Fund with a target capitalization of $100 million, to invest in water and clean energy projects in the Middle East and North Africa. This type of market-based mechanism could potentially be scaled up to meet the needs of sub-Saharan Africa. OPIC could set up a fund (or funds) similar to the Catalyst Fund that would provide guarantees to investors and facilitate the transfer of clean energy technologies. A $1 billion Clean Energy Fund for Africa would be a great way to get started.

Many of the renewable energies discussed thus far can be provided on a small scale. This is very important for a continent where the population is sparsely distributed. But large-scale power is also necessary, especially for metropolitan areas that will require more electricity as they grow. Of the various types of large-scale projects, hydropower has great potential to meet a significant share of Africa's power needs. Several hydro projects are currently under consideration or at early stages of development in countries like Ethiopia and Uganda. The most ambitious of all is Grand Inga, which seeks to vastly expand Africa's power generation capacity by harnessing the Inga Falls on the Congo River. Inga sends 42.5 million liters of water pouring into the Atlantic Ocean every second—a flow volume second only to the Amazon. Grand Inga is estimated to cost upwards of $40 billion and generate up to 39,000 MW of electric power, supplying the needs of most of the African continent. This project is of enormous scale, and its cost is estimated to be over three times the total amount of investment in infrastructure in Africa since 1985. Several other hydropower projects in various stages of development also have the potential to address Africa's energy crisis.

Hydropower projects continue to generate controversy due to environmental concerns but there are new, best-practice models that can be relied upon to mitigate negative effects. There are also concerns about increasing dependence on hydropower during an era of climate-change induced drought and unreliable rainfall. But it is important to note that water storage capacity is underexploited and is currently at about 5 percent of potential storage levels. If this capacity can be increased, there is considerable potential for hydropower even in areas of variable rainfall. Other concerns—about resettlement of large numbers of people, the destruction of waterfalls, and the loss of habitat for wildlife—are serious, but they can be addressed by consultative processes, involvement of community organizations at every stage of design and construction, and external monitoring by relevant agencies. The Nam Theun 2 hydroelectric project in Lao PDR serves as an excellent example of getting the process right.[5] This 1,070 MW hydropower project has various environmental and social safeguards to protect the people affected by the project and to preserve the biodiversity in the area (Asian Development Bank 2007).[6]

Governance concerns also loom large. Several issues will need to be carefully managed, including the tendering and procurement processes, the collection of tolls, and contracts for the maintenance of roads and power plants. Despite considerable pessimism about the ability of African governments to cope with these issues, governments and investors have new best-practice models to use (including Nam Theun 2), as well as a vast reserve of technical capacity, especially within multilateral institutions such as the World Bank and the AfDB. New arrangements may also be needed to address governance issues in the context of specific regions in Africa, especially if projects are very large.

Regional investment projects with substantial amounts of international funding can lead to perceptions of a loss of sovereignty in decision-making at the national level. But international investors and multilateral funding partners will bring with them layers of safeguards, including requirements around procurement, distribution, and the pricing of services. Policymakers must keep in mind that the end result of major regional investments will be a reliable supply of electricity and transportation services that will drive growth.

One example of excellent cooperation is the West African Power Pool, where collaborating governments have successfully given up some decision-making power in order to maximize the supply of electricity on a regional basis (www.ecowapp.org). Under the umbrella of ECOWAS—an organization of West African States—heads of state meet periodically to set the terms of the regional electricity generation and distribution system. In many ways, this type of large-scale infrastructure investment is more likely to succeed than smaller efforts which come with less money, less international attention, and fewer safeguards. Unfortunately, most investments in infrastructure in Africa have been financed at the national level, resulting in small, poorly functioning projects that have generated more Afro-pessimism than electricity. Big projects at the regional level that visibly improve infrastructure can motivate governments to do more and do better, while providing adequate budgets for supervision and transparent procedures.

Multilateral initiatives for construction and maintenance. To support the development of clean, large-scale power and road projects, the United States must work through the multilateral process, especially by providing support to the African Development Bank (AfDB). Despite the enormous demand, donor financing and the support of infrastructure projects has fallen sharply in recent times (see Figure 9). In 2006, a working group convened by the Center for Global Development made a strong case for the AfDB to focus exclusively on infrastructure over the next three to five years (AfDB Working Group 2006). The authors of the report argue that this focus makes sense for four reasons: the AfDB has substantial experience in infrastructure (which currently represents about 40 percent of its approved projects); infrastructure investment and related expertise is in strong demand among AfDB clients; the AfDB already has a mandate for infrastructure development; and infrastructure is central to growth, and governance of infrastructure is an important part of the wider agenda of governance.

The AfDB should also provide support for tendering, procurement, and ongoing maintenance of infrastructure facilities. Currently, the AfDB portfolio is very fragmented, resulting in a small average project size of $20 million to $40 million, within an overall lending program of between $2 billion and $3 billion. About 40 percent of this amount goes toward infrastructure. This is a tiny share of Africa's infrastructure needs, estimated by various sources (such as the Blair Commission for Africa) to be anywhere from $10 billion to $30 billion per year. The United States, as the second largest non-regional shareholder, should emphasize the need for larger projects focused on clean infrastructure, such as hydropower and other renewable energy. It should also encourage AfDB to build up its professional capacity in the area of infrastructure, particularly in facilitating public-private partnerships for financing, construction, and maintenance. If the AfDB can deliver on this objective, the United States should consider increasing its capital contribution to the organization by up to 25 percent per year for the next four years.

Another key player on the continent, the New Partnership for Africa's Development (NEPAD), has effectively partnered with AfDB in an arrangement where AfDB has the main responsibility for infrastructure investments. In 2006, NEPAD launched its Infrastructure Investment Facility to raise financing for the construction of infrastructure projects. This facility is an outcome of discussions of the African Business Roundtable, a private sector forum that is well aware of the burden of Africa's deteriorating roads and unreliable power supply. The United States can provide support to NEPAD and AfDB on the financing of clean infrastructure projects, as well as technical assistance on the maintenance, regulation, and pricing of services.

The World Bank, with its human resources and accompanying technical capacity, is also well-positioned to play a role in infrastructure provision, both directly and by assisting AfDB in its efforts. The solution to Africa's roads and power crisis is much more regional than national, and the World Bank's soft loan facility—the International Development Association (IDA)—has a regional project component which can address these needs (World Bank 2007). Clean energy and transport projects are ideal candidates for this new funding window, as are road maintenance projects which comprise roads linking several countries.

But none of these multilateral efforts will be easy, and not just because of the scale of the projects. The World Bank Group, the AfDB, and other multilateral institutions are largely geared toward working at the level of individual countries. The World Bank and AfDB are mostly organized by country units, with country directors competing for funds. Getting managers to work across country lines and collaboratively is difficult in this setup. For staff, it means reporting to multiple managers and a greatly increased administrative burden; there are currently few incentives for staff to take on regional projects. Disbursement rates on commitments to regional projects are often low, in part because of these bureaucratic hurdles. Fixing the incentive structure within multilateral institutions is a crucial part of the solution to delivering regional public goods to Africa, and the United States—as a major shareholder of these institutions—is uniquely positioned to get this done.

Conclusion

Africa's road and power crisis can be solved with resources, technological know-how, and support from the U.S. government and from the American private sector. Africa has a unique opportunity to build its infrastructure by using new and clean technology. It has the opportunity to avoid many of the environmental problems that have plagued the rest of the world. Using technology that is low-carbon or carbon-free is not good just for the African people but for the whole world. The United States has an unprecedented opportunity to help Africa in its search for a high and sustainable rate of growth.

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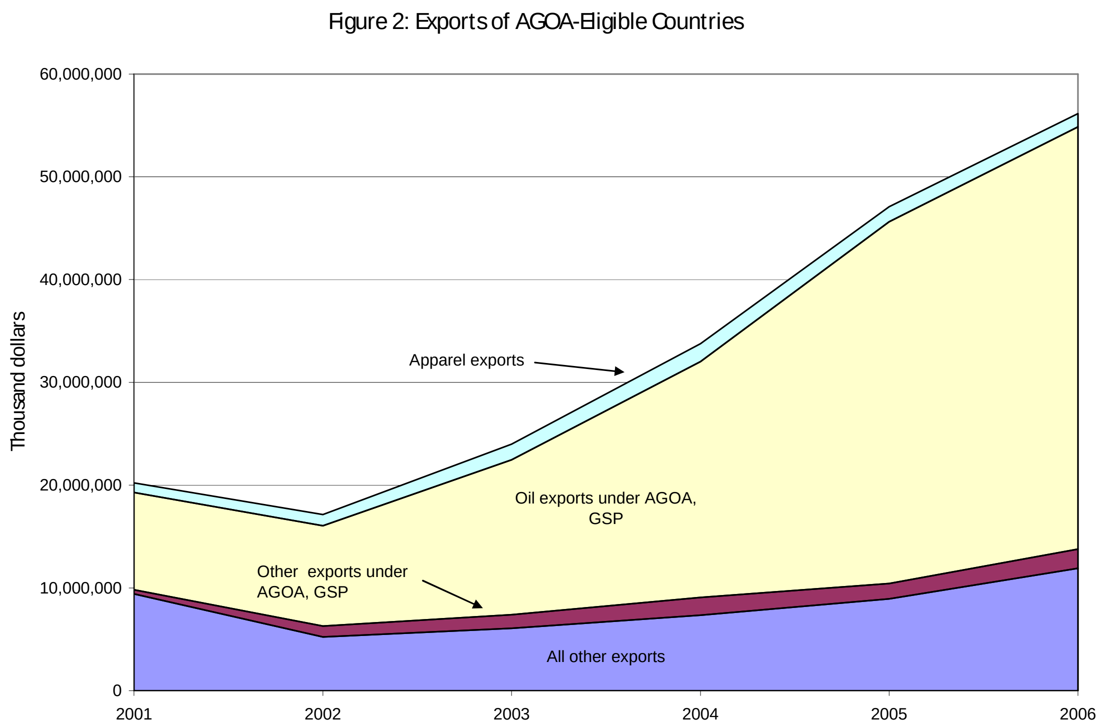
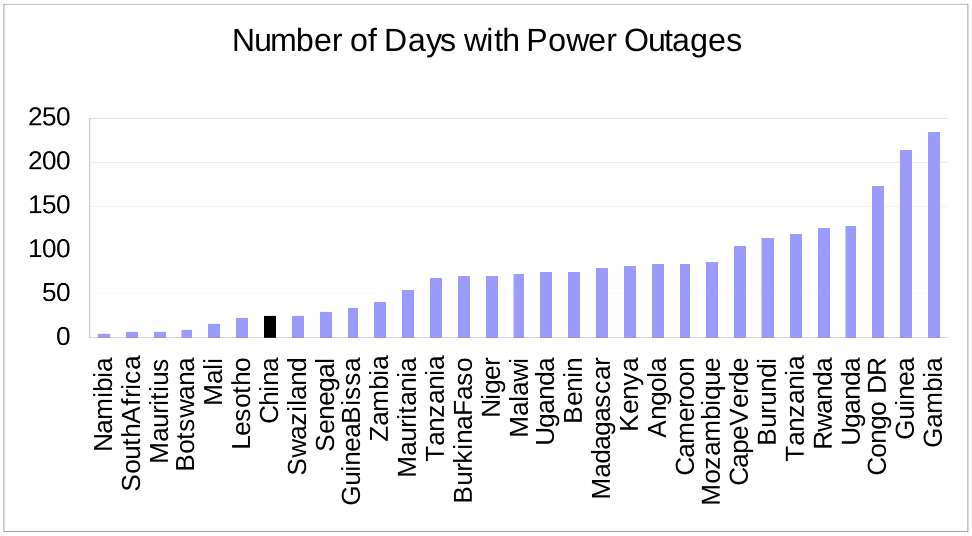
APPENDIX: TABLES AND FIGURES

Figure 1: Exports under the Africa Growth and Opportunity Act (AGOA)



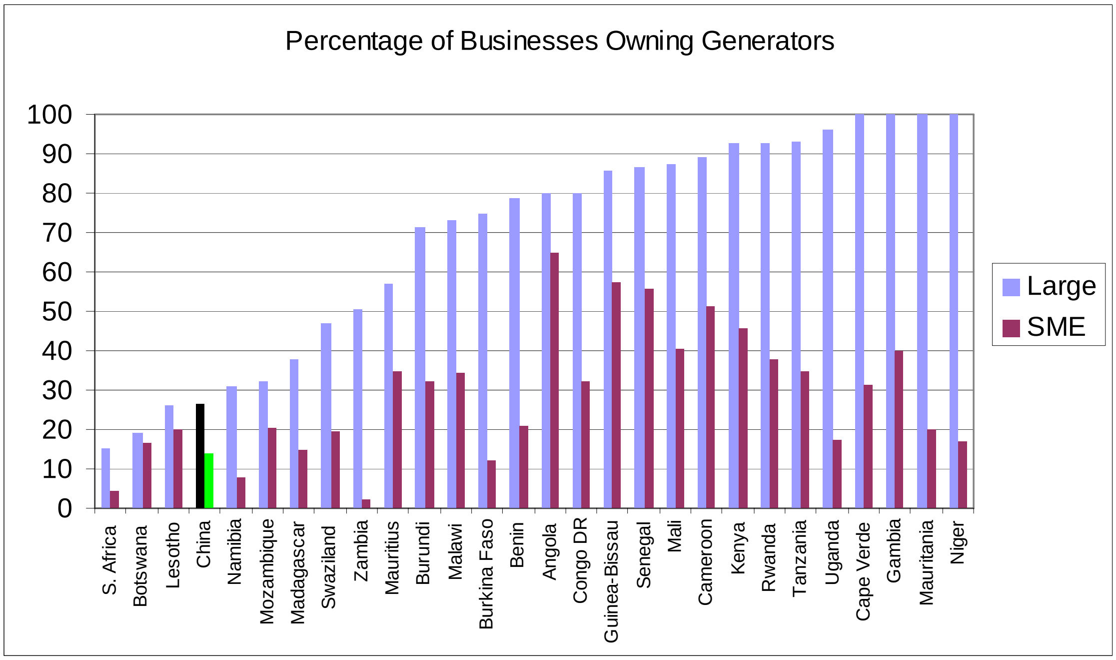
Source: Elliott (2007).

Figure 2: The Magnitude of Power Outages



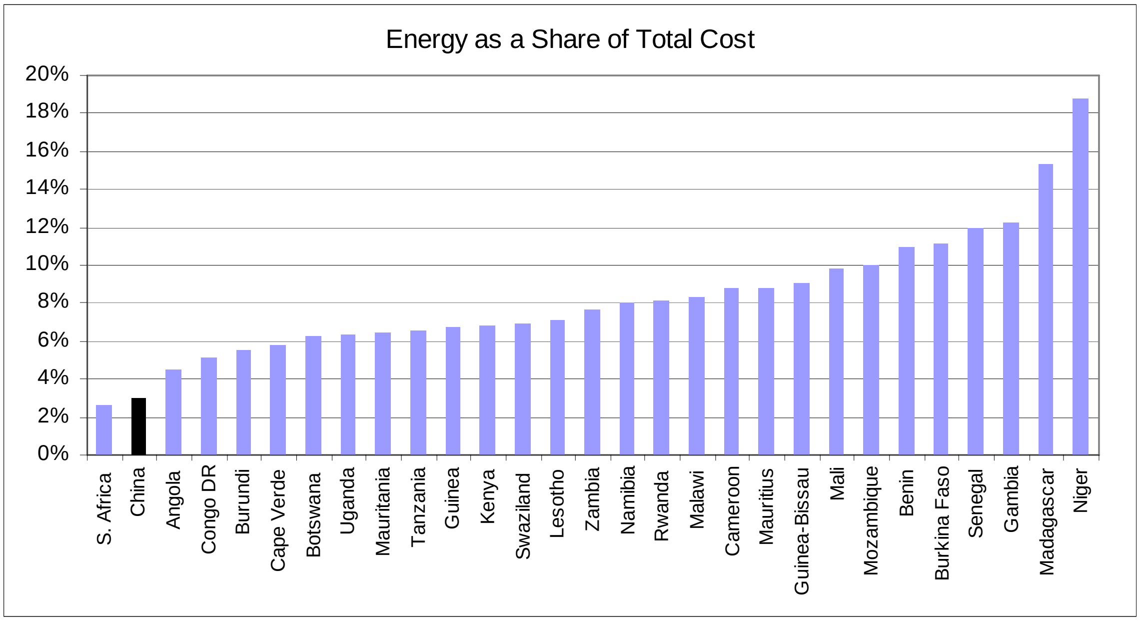
Source: Author calculations from World Bank Enterprise Surveys database

Figure 3: Percentage of Businesses Owning Generators



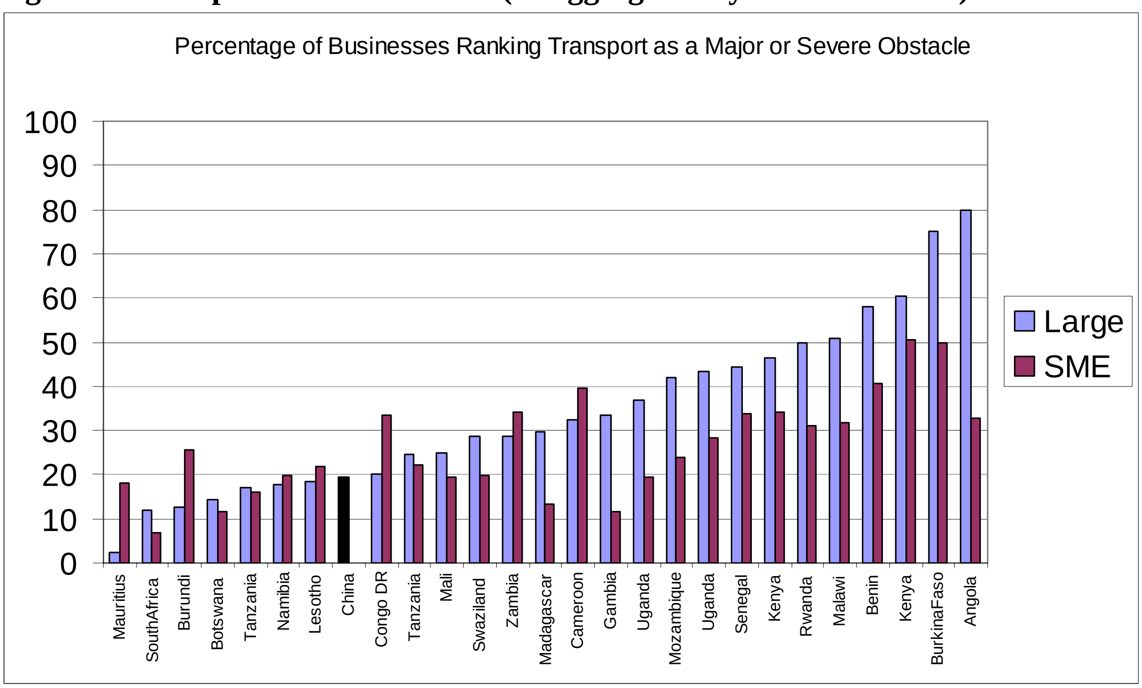
Source: Author calculations from World Bank Enterprise Surveys database.

Figure 4: Energy As a Share of Total Cost



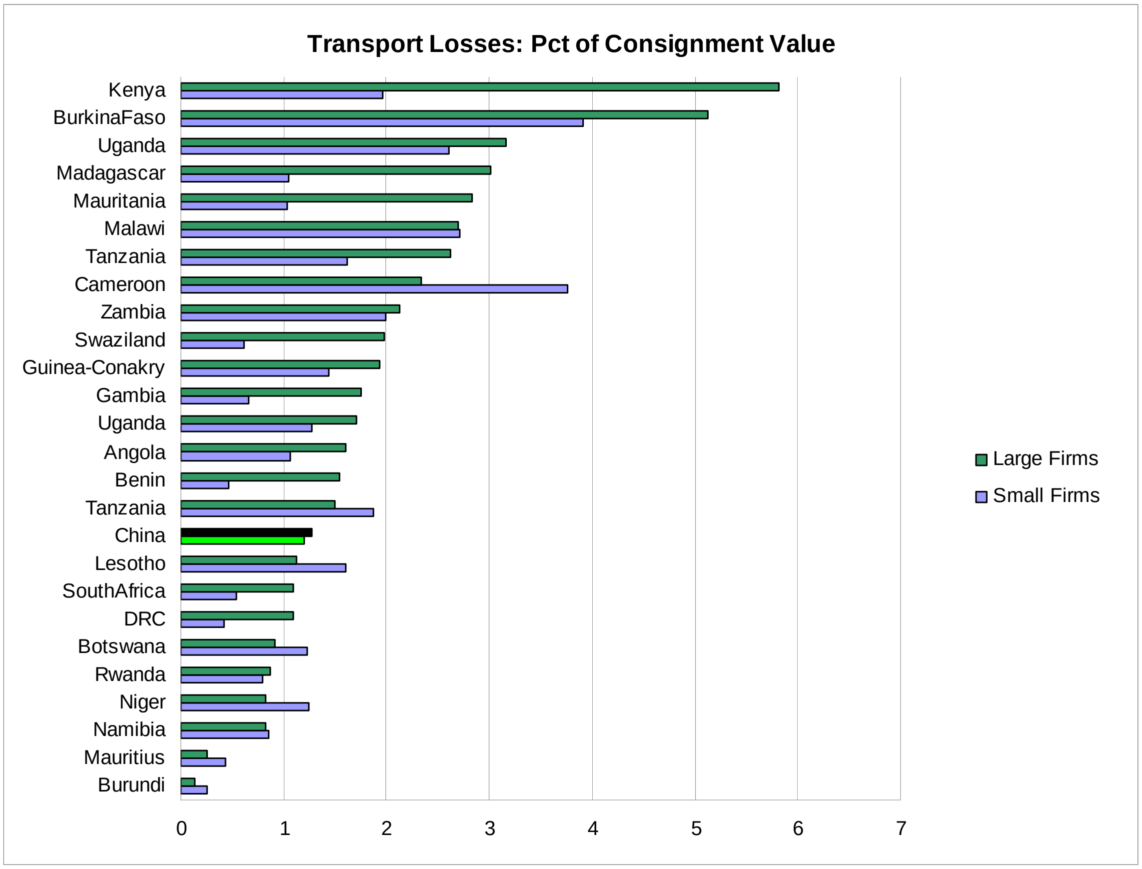
Source: Author calculations from World Bank Enterprise Surveys database

Figure 5: Transport As a Constraint (disaggregated by size of business)



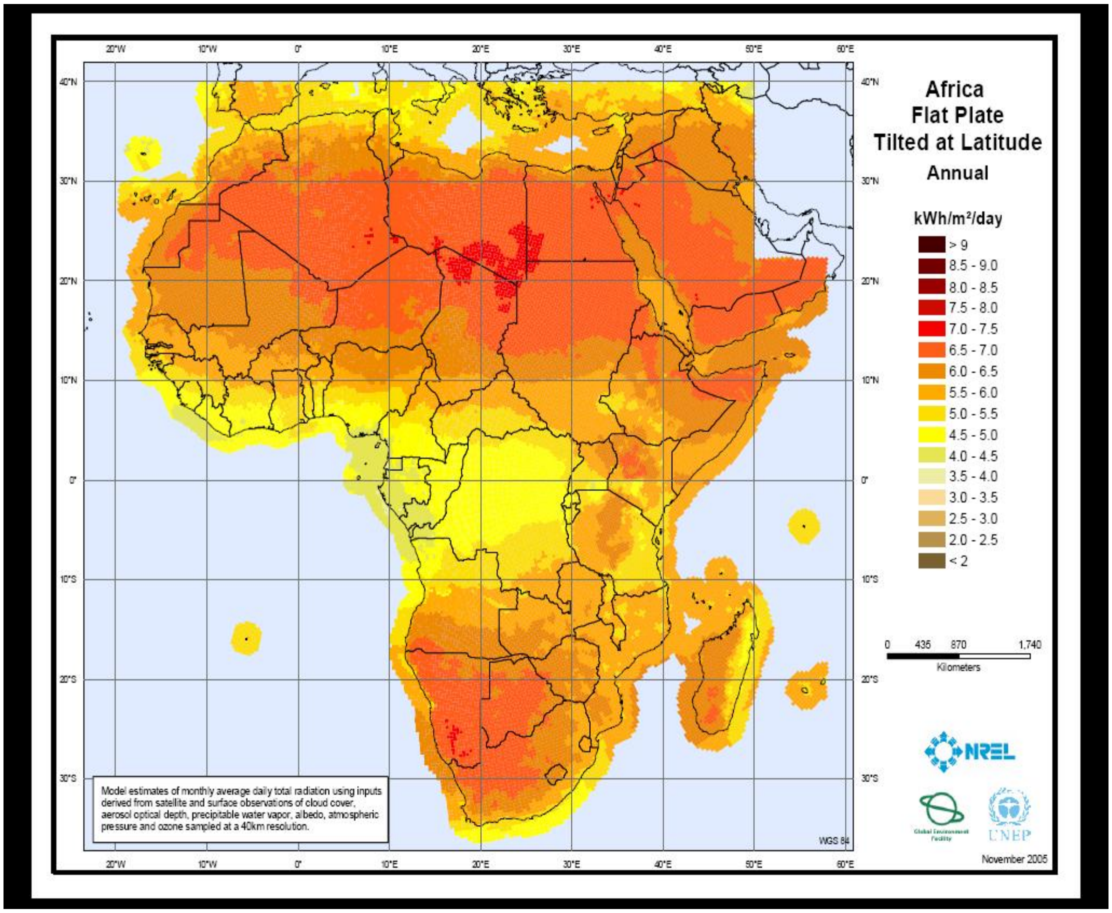
Source: Author calculations from World Bank Enterprise Surveys database

Figure 6: Estimated Losses from Theft and Delays in Transport



Source: Author calculations from World Bank Enterprise Surveys database

Figure 7: Africa Annual Average Solar Radiation Map

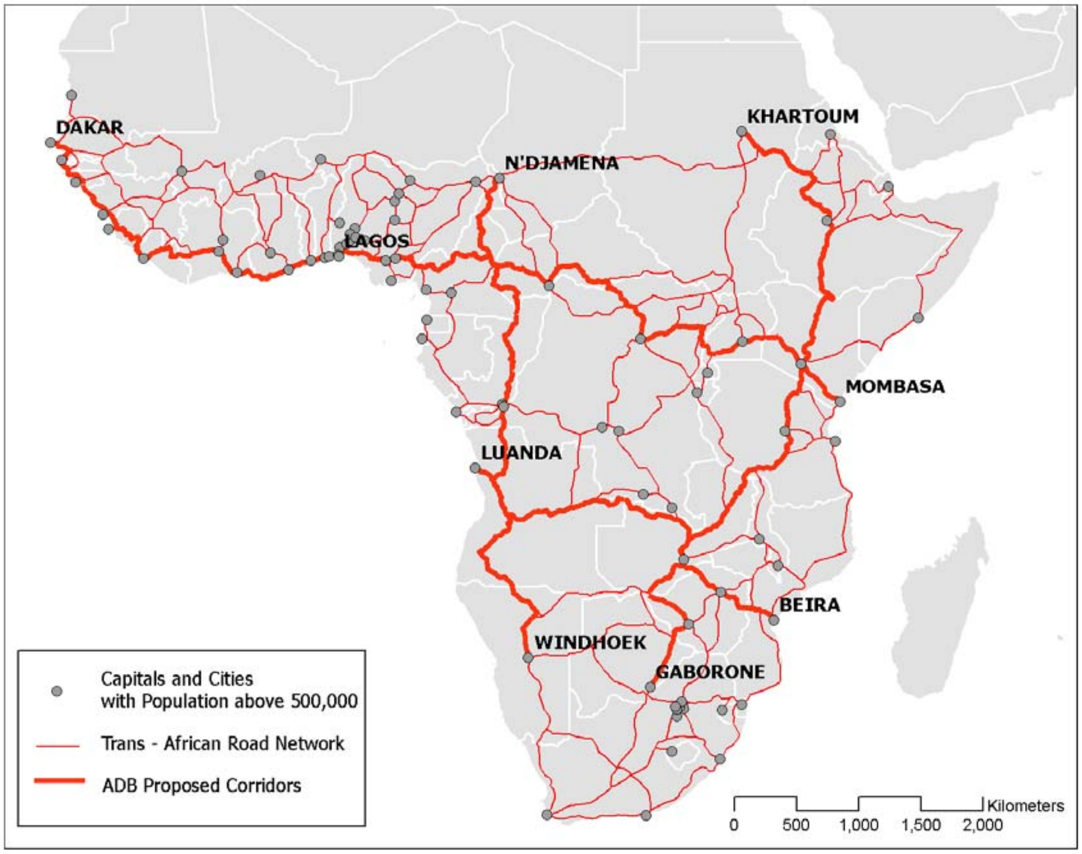


Source: SWERA (2006).

Note on Solar Map:

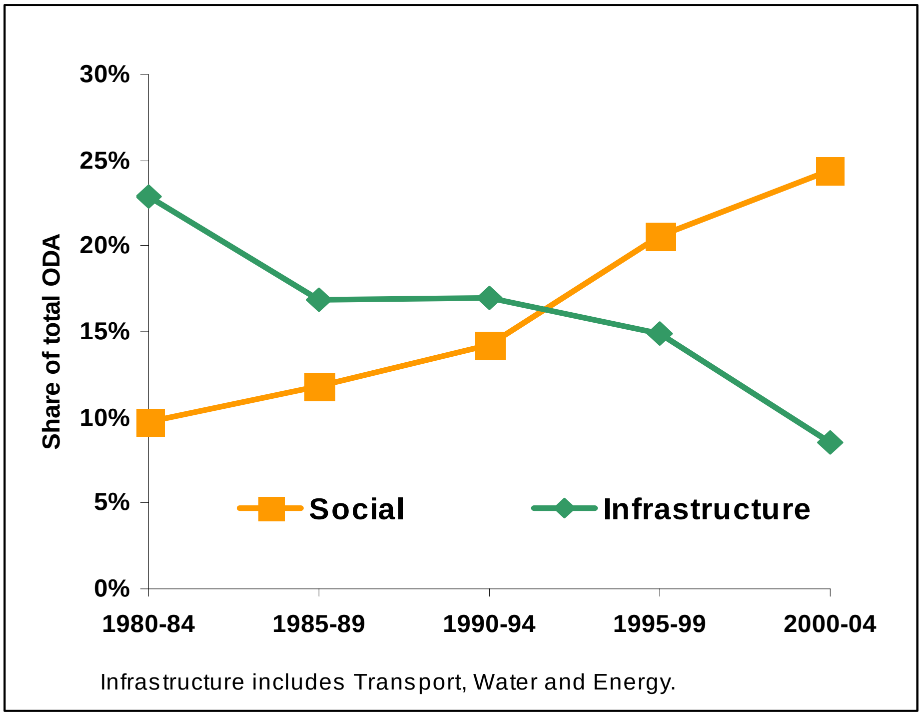
"Latitude Tilt" Measurement of Solar Radiation: This is the total radiation (sun plus sky and clouds) falling on a flat plate that is angled from the ground toward the sun equal to the latitude. In this way, the sun is closer to being perpendicular to the plate during parts of the year, and the overall solar resource is somewhat higher than the "global horizontal" value. This is usually the way in which photovoltaic panels and solar water heating systems are oriented. Since PV and SWH systems are likely to be the dominant solar technologies to be used in Africa in the near future, the "latitude tilt" map is probably the most relevant. I am grateful to Dr. David Renne at the National Renewable Energy Laboratory in Golden, Colorado, who provided this explanation.

Figure 8: Proposed Transnational Road Network



Source: Buys, Deichmann, and Wheeler (2006).

Figure 9: Aid to Sub-Saharan Africa



Source: AfDB Working Group (2006); Data Source: OECD.

Table 1: Top 33 Countries for Solar, Wind, Hydro and Geothermal Energy

Region	**Total**	**Solar**	**Wind**	**Hydro**	**Geothermal**
Sub-Saharan Africa	17	21	6	11	7
East Asia/Pacific	4	5	3	6	4
Europe/Central Asia	3	0	6	5	14
LatinAmerica/Caribbean	7	5	8	9	3
Middle East/N. Africa	2	3	3	0	2
South Asia	0	0	1	1	0

Source: Buys et al. (2007).

Table 2: Development of Solar Energy

Firm	Location US	Contribution to solar market	Investors (or past investors)
Advent Solar	Albuquerque, NM	Thin-film wafers that use less silicon; simplified assembly, higher energy production to drive down costs; locates all electrical content on back of solar cell to free up top surface for more sunlight absorption	ZBI Ventures; Sun Mountain Capital; Globespan Capital Partners; Battery Ventures; EnerTech; Firelank Capital; @Ventures; New Mexico Co-Investment Partners
Akeena Solar	Los Gatos, CA	provider of solar energy systems	Kleiner Perkins Caufield & Byers
BrightSource Energy	Oakland, CA	Utility-scale solar thermal power plant that uses mirrors to focus solar rays on water to convert it to steam and drive turbines	VantagePoint Venture Partners
Energy Innovation	Pasadena, CA	Solar chip manufacturer; Sunflower product tracks sunbeams and produces both PV power and hot water	Mohr, Davidow Ventures; Idealab Holdings LLC
HelioVolt	Austin, TX	Uses CIGS technology; claims it can achieve efficiencies near those of silicon cells but with 1/100th of the material; reusable template capable of mass producing material	Paladin Capital Group; Masdar Clean Tech Fund; New Enterprise Associates; Solucar Energias; Morgan Stanley Principal Investments; Sunton United Energy; Yellowstone Capital
INFINIA Corp	Kennewick, WA	High efficiency heat and power systems; solar generators	Khosla Ventures; Vulcan Capital; EQUUS Total Return, Inc; Idealab; Power Play Energy, LLC
Konarka	Lowell, MA	Leading the arena of organic solar cells; technology relies on a dye to absorb solar energy; could be incorporated into flexible panels or fabrics	Draper Fisher Jurvetson; ChevronTexaco; New Enterprise Associates
Miasole	San Jose, CA	Makes thin-film solar cells with less semiconductor material than traditional silicon-based cells (less than 1% of the silicon of traditional cells); designing a continuous manufacturing process (more automation, faster) that should help reduce cost; pursuing CIGS technology which is higher efficiency	VantagePoint Venture Partners; Kleiner Perkins Caufiled & Byers
Nanosolar	Palo Alto, CA	Thin-film solar panels and continuous manufacturing process to reduce costs; copper thin-film panels will cost 5-10x less than silicon panels; pursuing CIGS technology and is looking at solutions to efficiency-loss of CIGS over large areas; designing cells to be more flexible and attractive than other solar panels, perhaps included in building materials; boss projects company will achieve grid parity this year; building world's largest solar cell fabrication lab near San Francisco; building panel fabrication facility in Berlin	Larry Page & Sergey Brin; Mohr, Davidow Ventures; US Venture Partners; OnPoint Technologies; Benchmark Capital; Capricorn Management LLC; SAC Capital Advisors LLC; GLG Partners LP; Grazia Equity GmbH; Beck Energy GmbH; Klaus Tschira; Dietmar Hopp; Christian Reitberger; Jeff Skoll

Petra Solar	Green Brook, NJ	creating portfolio of semiconductor patents and a variety of products to boost efficiency and power management capabilities of solar power	DFJ Element; Blue Run Ventures; National Technology Enterprises Co
Practical Instruments Inc	Pasadena, CA	uses optical technology to try to reduce the cost of rooftop solar panels; uses less PV material per panel	Nth Power; RockPort Capital Partners; Trinity Ventures; Rincon Venture Partners
Silicon Valley Solar Inc	Santa Clara, CA	acquired NuEdison Inc., a maker of PV modules; designs modules that concentrate energy in flat panels; uses an advanced internal concentrator; sells to large solar integrators	Bessemer Venture Partners
Solaicx	Santa Clara, CA	dedicated to cutting costs of single crystalline wafers for the solar industry; aims to cut 75% of cost of solar cell manufacturing	Applied Materials; DE Shaw Group; Mitsui Ventures; Applied Ventures LLC; Firsthand Capital Management Inc; Big Sky Ventures; Greenhouse Capital Partners
Solaria	Fremont, CA	developing way to make solar panels more efficient and cheaper to manufacture	Sigma Partners; NGEN
SolFocus	Palo Alto, CA	uses lenses and mirrors to concentrate sunlight onto high-efficiency solar cells to reduce cost per watt; increases efficiency of cells	New Enterprise Associates; NGEN
SoloPower Inc	Milpitas, CA	CIGS technology thin-film manufacturer; can be made in large batches which can help reduce costs	Convexa Capital; Scatec AS; Spencer Energy AS; Crosslink Capital; Firsthand Capital Management
Stion Corp (formerly nStructures)	Menlo Park, CA	developing thin-films that lower the cost of manufacturing models; improving efficiency of crystalline silicon materials	Lightspeed Venture Partners; General Catalyst Partners; Khosla Ventures; Braemar Energy Ventures; Moser Baer Photovoltaic
Tioga Energy Inc	San Mateo, CA	provides solar systems to customers; guarantees predictable costs	NGEN; Draper Fisher Jurvetson; RockPort Capital; DFJ Frontier; Kirlan Ventures
	Non-US		
6N Silicon Inc	Mississauga, ON, Canada	produces solar grade silicon tailored specifically for the solar industry	Ventures West; Yaletown Venture Partners
CSG Solar AG	Thalheim, Germany	manufactures thin-film on glass modules which uses less silicon, has fewer production steps	Apax Partners; Good Energies Inc; Renewable Energy Corp; IBG Beteiligungsgesellschaft Sachsen-Anhalt mbH
Day4 Energy	Vancouver, BC, Canada	produces flat panel modules with an electrode that reduces the resistance of a traditional PV cell; produces sun concentrators	Chrysalix Energy; British Columbia Discovery Fund
EnerWorks	London, ON, Canada	manufactures solar thermal products, including solar power water heaters; goal to reduce water heating energy costs	Chrysalix; Investeco Capital

G24 Innovations (G24i)	Cardiff, Wales	non-silicon-based cells; cells based on colored dye and titanium oxide crystals which are used to copy photosynthesis; estimated at 1/5 price of silicon cells; working with mobile phone companies to test whether cells could be used to charge handsets in rural Africa; plan to sell inexpensive devices (for light bulb or cell phone charging) in poor regions of India and Africa to jumpstart sales	Renewable Capital
Hydrogen Solar	UK	uses sunlight to generate hydrogen fuel	E-Synergy
Jiamgsu Shunda Group	China	makes 6" and 8" monocrystalline silicon ingots used in solar power cells	Actis; JOLMO Capital Management; Waichun
Orionsolar	Jerusalem, Israel	uses dye cell nanotechnology which does not use silicon; trying to build a low-cost energy panel	21 Ventures LLC
Solarcentury Holdings Ltd	London, UK	designs and installs solar modules	VantagePoint Venture Partners

Formerly privately held/VC funded companies that have gone public

Firm	Location	Contribution to solar market	Investors (or past investors)	Year of IPO
	US			
Evergreen Solar	Marlboro, MA	rooftop panel manufacturer; uses conventional silicon but in a new, more frugal fashion that uses 30% less	Nth Power; RockPort; Arete Corp; SAM Private Equity; Zero Stage Capital Co; Rockefeller & Co Inc; Perseus LLC; CDP Capital Technology Ventures; Massachusetts Renewable Energy Trust; Impax Asset Management	2000
First Solar	Phoenix, AZ	cadmium telluride-based solar panels (efficiency lower than silicon models, but manufacturing cost is much lower, so price per watt is lower); ground-based, large commercial systems; hopes to be grid competitive by 2010		2006
SunPower Corp	Sunnyvale & San Jose, CA	manufactures silicon solar cells on large scale	Associated Venture Investors; Technology Funding Inc; Nipsco Development Co; Honda Motor Co, Ltd; Cypress Semiconductor Corp bought it in 2002	2005
	Non-US			
PV Crystalix Solar	Oxford, UK; Germany	manufactures silicon components for solar electricity industry	Ventizz	2007

Q-Cells AG	Thalheim, Germany	one of the world's largest solar manufacturers	Apax Partners; Good Energies Inc	2005 (Apax made largest gain by VC group since collapse of dotcom bubble)
SunTech Power	Wuxi, China	large scale solar cell manufacturer	Actis; Goldman Sachs; Dragon Tech Ventures	2005

NOTES

[1] The United States and the United Kingdom currently have clean energy initiatives to help developing countries finance the development and use of renewable energy. The plan outlined in this chapter is specific to Africa, and emphasizes the need to link technology development in the United States with businesses and governments in sub-Saharan Africa.
[2] As surveys vary slightly from country to country, not all twenty-seven countries are represented in every chart. For more information on the Enterprise Surveys, see www. enterprisesurveys.org.
[3] See Barder (2005), and chapter X by David Wheeler in this book.
[4] Intermediate Technology Development Group (ITDG)/Practical Action, www.itdg.org/?id=micro_hydro
[5] For more details, see www.namtheun2.com.
[6] Many of the locations that would be ideal for road or power projects in Africa are also of great importance from a conservation point of view. But we now have detailed information that we can use to substantially mitigate the effects of new construction. A database compiled by the Global Environment Facility, the World Bank's Development Research Group, and the World Conservation Union contains information about habitats and other data relating to 5,329 amphibians, 4,612 mammals and 1,098 endangered birds. These data enable the overlay of biodiversity maps with potential road networks to identify sensitive zones (Buys et al. 2006). More generally, the United States can tap into the considerable expertise on biodiversity that exists within its scientific community to make sure that conservation planning is a *mandatory* component of infrastructure projects in Africa.