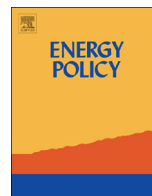




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Powering Africa's sustainable development: The potential role of nuclear energy

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HIGHLIGHTS

- We examine the potential role of nuclear power in Africa.
- There is growing African interest in nuclear power.
- Nuclear power in Africa will require grid strengthening.
- Small modular reactors could enhance Africa's energy security.
- There are concerns about Africa's safety culture for nuclear power.

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ABSTRACT

The electricity deficit is one of the most serious contemporary issues facing sub-Saharan Africa. Many countries in the region have insufficient generation capacity to meet rapidly rising demand. Electricity shortages have become a binding and powerful constraint on the continent's sustainable development. Their resolution will require coordinated effort to improve the effectiveness and governance of the region's utilities and to significantly scale-up generation capacity. A broad portfolio of low carbon (low-C) technologies needs to be deployed in order to address the electricity deficit in a cost-effective way and not be disruptive to economic growth. Since nuclear power can deliver low-C electricity in bulk, reliably and without intermittency, it could make a significant contribution towards resolving Africa's power crisis. However, the post-Fukushima safety concerns related to large nuclear plants with substantial radioactive inventories will be especially pronounced in Africa. Moreover, large scale reactors with huge upfront investment requirements are likely to be unsuitable for capital-constrained African countries with small electricity grids. One promising direction for nuclear development in Africa might be to downsize reactors from the gigawatt scale to less-complex smaller units (with substantially smaller radioactive inventory) that are more affordable.

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1. Introduction—Africa's power crisis short-circuits sustainable development

Today, while the world is experiencing the most accelerated technological revolution in its history, most of the African continent is still unplugged and in the dark after nightfall (Fig. 1). Only about one-fifth of the sub-Saharan population has access to electricity. School children often cannot read after dusk, clinics cannot refrigerate medicines and vaccines, and businesses cannot operate without expensive backup generators. Long before night falls, women have to spend hours and frequently walk to far places

to collect wood or dung as fuel for cooking, damaging their health and the environment. Indeed, most Africans are forced to rely on wood, coal and paraffin for heat and light. Burning those fuels indoors produces harmful indoor air pollution whose devastating impacts include respiratory and cardiovascular diseases, especially among young children. They can also lead to deadly fires and loss of life.

Today, 25 of 48 countries in sub-Saharan Africa are facing an unprecedented power crisis evidenced by crippling electricity shortages and extensive load shedding. For the ordinary citizens, extensive blackouts are causing significant disruption of their civic and economic life. For the industrial, commercial, and agricultural users, the costs of power shortages can be enormous. The normal rhythm of production cycles has been especially disrupted in electricity-intensive sectors like textiles, basic metals, rubber and plastic, paper, and leather products. The costs of load shedding are

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Fig. 1. Electrical illumination on Earth as seen from space. Source: Osaisai (2011).

two-fold: (i) direct costs, which include the net value of production permanently lost, spoilage costs, process restart costs, damage to machinery, etc.; and (ii) indirect costs, arising from the adjustments made by firms in their operations to recover at least part of the output lost during and immediately after outages. Thus, these chronic power problems are taking a heavy toll on the continent's economic growth, hampering job creation, livelihoods and ultimately sustainable development.

There has been no significant capital investment, from either the private or public sectors, into Africa's power sector for the past 15 or 20 years. External finance during the same period has averaged only around US\$600 million per year of official development assistance plus a similar volume of private finance. The consequences of underinvestment were predictable and profound. Sub-Saharan Africa is one of only two regions in the world where the majority of the population remains unelectrified. In fact, sub-Saharan Africa accounts for 48 percent of the unelectrified rural population in the world. Between 1990 and 2010, while globally access to electricity outpaced population growth by about 128 million people, during the same period growth in the electrified population of sub-Saharan Africa fell behind that of total population. In a business-as-usual scenario, the region's average electrification rate will barely rise between now and 2020. Around 585 million people in sub-Saharan Africa had no access to electricity in 2009—that figure is expected to increase to over 650 million by 2030. It is estimated that doubling of the region's abysmally low current rates of electricity access by the year 2020 will require sustained investment at much higher levels (SE4ALL, 2013; Welsch et al., 2013).

The causes of the power crisis in sub-Saharan Africa are manifold. In addition to insufficient investment, supply has been hampered by droughts that reduced hydropower output in East Africa, oil price hikes that elevated the generation costs in West Africa, conflict that destroyed power infrastructure in fragile states, and lack of proper maintenance (Eberhard et al., 2008).² Key issues include:

- *Low access and insufficient capacity*—Only about 24 percent of sub-Saharan's population has access to electricity versus over 40 percent in other poor countries and 83 percent globally. Nineteen of the top 20 countries with the lowest electrification rates are in sub-Saharan Africa. The total installed capacity of the region, 48 countries, is 68 gigawatts (GW), no more than Spain's.³ In fact, excluding South Africa, the entire generating capacity of sub-Saharan Africa is only around 28 GW, equal to that of Argentina. As much as 25 percent of these 28 GW of installed capacity are mostly unavailable for generation due to a variety of causes, including aging plants and lack of proper maintenance. Even if we include the countries of North Africa, the continent's total installed capacity is still only 147 GW (comparable to the capacity China installs in just one or two years), and its electricity consumption accounted for only 3 percent of the world total although the region has 15 percent of the world's population (Fig. 2; Eberhard et al., 2008; SE4ALL, 2013).
- *Poor reliability*—African manufacturing enterprises experience power outages on average 56 days per year, and 30 out of 48 countries of the region experience daily power interruption. In many countries of the region, virtually all businesses and many residential households have installed backup (typically diesel) generators to supplement the frequently interrupted grid supply, saddling economies with extra energy costs and polluting the environment. The total costs of load shedding amount to more than 5 percent of GDP in Malawi, Uganda and South Africa, 1–5 percent in Senegal, Kenya and Tanzania, and 2.1 of the region's GDP on average (Foster and Briceno-Garmendia, 2010).
- *High costs*—In 2010, the average retail electricity price in Africa was US\$0.14 per kilowatt-hour (kW h) against an average of US \$0.18/kW h in production costs. These tariffs are much higher than in other developing regions. For instance, in 2010, the

(footnote continued)

on the heels of a global economic recovery, the prospect of continuing high commodity prices, and investment in productive capacity (Devarajan and Fengler, 2013). Population growth and rising incomes are likely to stimulate substantial electricity demand.

³ The units megawatts (MW)/gigawatts (GW) used throughout the paper measure electrical output.

² Africa's population is projected to grow from 1 billion in 2010 to 3 billion by 2050. Moreover, even with the shortages of power, during the past decade Africa has been experiencing an economic resurgence. Despite the global economic crisis, Africa's GDP has been growing rapidly, on average almost five percent a year since 2000-s only to developing Asia. Medium-term growth is expected to remain robust,

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