

A power crunch in sub-Saharan Africa (draft)  
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For small loads such as cell phone charging and LED lighting there is solar PV. Solar PV is also adequate for vaccine refrigerators in health clinics and light up low power computers as well. But it is inadequate for the kind of motor loads that can propel agro-processing, small industry and allow sub-district hospitals and secondary schools to effectively function. For this Africa needs low-cost and reliable grid power. For these applications and to allow them to grow seamlessly one needs grid power, at least until solar photovoltaic power sees a five fold reduction in prices. In the meantime the vast majority of communities in sub-Saharan Africa that are not connected to the electric grid must wait.

But in the last couple of years, those few that are connected to the grid are experiencing what have become routine black-outs and brown-outs as the utilities are unable to provide adequate power. East, West and Central Africa (the article is about this region of Africa comprising of a population of about half a billion) is experiencing a particularly unique energy squeeze this year. These regions generally relied on hydropower and oil/diesel fired thermal power to feed their electric power grids. Those countries that did not have access to hydropower within their borders or were not connected by a grid to their neighbor relied exclusively on expensive oil/diesel fired thermal, e.g. Chad with only a 10 MW capacity until recently.

For those relying on hydropower for bulk of their grid supply, the generation capacity even with good rainfall was becoming inadequate. Hence with water levels in lakes/storage structures running at historic lows in the last two years, generating stations were forced to curtail the hydroelectric supply being dispatched. At the same time, lively economic growth and increasing urban/peri-urban electricity use continue to push demand levels higher. Businesses and even government have had to increasingly rely on expensive small-scale captive power using diesel/petrol generators.

The countries that exclusively relied on oil/diesel saw an already precarious situation get worse. For these countries a near doubling of fuel prices led to a near doubling of the fuel component of power from 15 cents to 30 cents per unit. Those that had hydropower, generally relied on diesel generation for peak-load demand management in the absence of the gas infrastructure that fuels gas turbines in most developed countries for such peak-loads. For these countries the percent increase in electricity generation costs have been even higher as the climate-driven interruption in hydropower supply, forced them to lease high cost diesel capital equipment at short notice and provide a higher fraction of their

electricity mix from diesel generation. The cost of leasing emergency diesel generation capacity can be as high as \$400 per kW per year. At 50% capacity factor this adds nearly 10 cents/kWh to fuel costs that are nearly 20 cents/kWh at current high prices of diesel in interior SSA. A simple illustrative calculation describes the quandary this can lead to. A bus-bar power mix of 80% hydro at 3 cents/kWh and 20% at 15 cents/kWh (say with older HFO fired generators) averages out to 5.4 cents/kWh. A power mix of 50% hydro at the same 3 cent/kWh and 50% diesel at 30 cent/kWh now averages out at bus-bar costs of nearly 16.5 cents/kWh. Considering that technical T&D losses can be 20% what this means is that the cost of electricity to the utility just went up from 7 cents to 20 cents per kWh, a nearly three-fold increase. (This illustrative calculation considerably simplifies the situation: e.g. Kenya has some geothermal baseload; Nigeria has captive gas power).

It is considered political suicide to pass through these increases in the cost of generation to utility customers through tariff increases. Cross-subsidization of public services and lifeline rates for the poor are also severely jeopardized. We are beginning to see stories in the media of fuel-supplies being held up as suppliers are not getting paid in time. Under these circumstances utilities are unlikely to have any incentive whatsoever to increase access to electricity to the rural poor who are likely to be paying lifeline rates while the marginal cost of new supply is dramatically higher. Other than the immediate fallout of this crisis, there is the longer term damage to the economy and industrial investment due to expensive inadequate and (and hence generally unreliable) power. It is critical that just as economic growth rates pick up in Africa, energy access and supply does not become one of the bottlenecks. The eventual demand for electricity in Africa will be multiple times what it is today, as the average per capita consumption of the population living in the three regions (west/central/east) of Africa would have to grow nearly hundredfold to match the consumption of those living in the United States. However the more immediate and urgent question is how to just double the dispatchable energy supply of this region within the next three to four years. Such increases might be necessary if one has to meet the current shortfalls, meet the growing energy needs of the economy and at the same time accelerate the rate at which energy access is provided to communities where there is none.

Some observations about the current energy supply scene. While one would normally expect a low-cost base load supply (as is provided by coal, hydro and/or nuclear in other parts of the world) that has predictable outages. This is not the case when the only base-load source is hydropower and yet the maximum hydropower capacity is close to or less than the baseload demand. In most countries this baseload supply comes from a combination of coal, nuclear and hydropower. There are no significant coal reserves in these three regions of Africa, with the exception of limited coal deposits in Tanzania. East Africa however does have significant geothermal potential in the Rift valley. While the potential in the entire East Africa Rift valley is perhaps no more than a few GW, this potential is enough to easily double the entire grid capacity of the East Africa region quickly. Geothermal energy is perhaps the only clean energy source that can provide 24-7 reliable base-load power and hence could become the buffer to high oil/diesel prices.

With the exception of the Sahel, there is also considerable potential in the form of micro and mini hydro power and in central Africa there is the possibility of the rehabilitating capacity at Inga Falls and developing the larger Grand Inga project whose technical potential is in the tens of Gigawatts. Why develop hydropower even further when it is prone to such climate variations as now, when dams with large storage reservoirs have been responsible for multiple negative ecological and health impacts. I am not suggesting that any and all hydropower capacity be developed. A nuanced and careful examination of each site will be needed to determine if indeed it is ecologically viable. Most run of the river hydro plants have minimal impacts but in turn they do not provide storage capacity and hence are even more vulnerable to supply variations. The steady flows of the Congo with a large drop in head would make even the Grand Inga closer to a run of the river power plant not requiring large submerged land areas. But run of the river plants are inherently more expensive per kWh delivered since they frequently operate at part load. However the central argument I wish to make here is that in the absence of coal, nuclear and captive gas based thermal power plants, higher cost hydropower is still the next best option to geothermal and it is by far more economical than diesel power even when it is subject to the high variability. One would need to address the problem of dispatch and the location-specific nature of hydropower through additional transmission line capacity.

West Africa and Central Africa have significant oil and gas reserve. Nigeria's resources are the most significant other countries in West Africa are also beginning to invest and find hydrocarbons offshore. Tanzania has natural gas as well. Increasing capture of flared gas would allow Nigeria to export gas to its neighbors through pipelines as is planned in the West Africa Gas Pipeline project. However more such projects are needed. Chad is now in its third year of oil production. Pretty much all production is however exported through the Chad-Cameroon pipeline and the plans to build a small refinery in Chad have not materialized. Otherwise this could made it possible to provide motor fuels, heavy fuel oil for electricity generation and other products such as tar for the much needed roads. Even the associated gas that was unexpectedly found in the Chad oilfields has allowed the operating consortium to generate their captive power from gas. There is considerable natural gas production and potential in Nigeria and. Gas capture distribution infrastructure is however still inadequate. There is a particular advantage to gas pipelines since they can efficiently transport not just gas for electric power but also for multiple other industrial/domestic and transport uses. While gas prices have seen sharp increases recently, they still remain competitive when compared to liquid fuels. An investment in gas infrastructure is particularly attractive since even if gas loses out as a fuel of choice for power generation, it would be only because the industrial/transport demand for gas would be high.

It is not obvious what to make of the nuclear power option that is being considered by Egypt and Nigeria. The absence of nuclear power and coal power plants in Africa, in my view had to do with underlying fact that cheaper hydropower was available; nuclear plants had to be large in size and required a deeper human capital in science/technology; coal would have had to be imported via sea routes thus requiring dedicated port infrastructure which only becomes viable at larger generation capacities. Individual countries and their demands were historically much smaller.

Part of the intransigence in making progress comes from the fact that most sources of new hydro or geothermal, or gas fired power in Africa are not likely to be as low in cost as would traditionally expect them to be, especially from a western perspective. And they make sense for the African situation. Gas pipelines are likely to have lower capacity with lower price-guaranteed demand and with LNG technology on the scene, suppliers do not need to enter into longer term supply contracts which otherwise made point to point gas pipelines feasible. New hydro would have to adhere to stricter standards now that we know more about dams, and the capacity factors are likely to be lower. New geothermal in the African Rift valley may have higher initial costs as the probability of finding a productive well there might be a lot lower than in Iceland, say. Run of the river hydro may be more expensive than the costs of large hydro power we are used to. And yet the gains to be made compared to the next best options such as diesel fired power or solar power (being fed into the grid) are so large, that even higher cost geothermal or hydro can still provide cost-effective electricity. Thus generation costs even if they are as high as 5 to 10 cents/kWh (nearly twice of what the developed world is used to) will actually be attractive options especially in the interior land-locked countries of Africa.

East, West and Central Africa is not short on primary energy sources and in fact exports far more hydrocarbons to the developed world than uses on its own. There are multiple ways these and other resources described above could be utilized to address the energy needs of Africa. While the exact mix of sources is not obvious, it is clear that regional networks with perhaps continent wide interconnections will be needed. Such an approach would then have multiple countries as potential beneficiaries with high voltage transmission lines (or gas pipelines) crossing national boundaries. Much progress aided by a renewed commitment to infrastructure by the AfDB and the World Bank has already taken place on this front. NEPAD through AFREC is supporting the process and so are groups such as FEMA meeting regularly. So this is a very opportune time to build consensus around the issues of energy in the region. This consensus must come with a set of *quick-wins* that can bring new generation and transmission capacity online. This would be the first step towards a longer term process which is geared towards creating vision for energy delivery in SSA. It is of course critical that all the energy ministers of Africa, AfDB, NEPAD, WB, IAEA, UNDP, UNIDO, the bilaterals, EAC, and ECOWAS participate in this dialogue and create such a vision.

There many obvious complexities to this venture and the only hope of resolving such issues are through high-level summits/dialogues among heads of states, perhaps starting with a single region. The proposed meeting in Djibouti is exactly one such effort. The approach can create a stalemate as well if the process is not sensitive to the internal energy needs of each of the countries, or if parties involved have other prior disputes. So if the stakeholders recognize the importance of building in-country electricity distribution infrastructure particularly addressing the energy needs of the poorest, it would be easier to generate political support for exporting some or bulk of the energy to another country. Moreover the chicken-and-egg problem of creating base-load demand first before someone commits to financing supply remains. This problem could be brought to the table, with possible commitments from the private sector to provide and

guarantee a base-load demand. Many private companies are looking for “clean power” as their corporate social responsibility commitment of simply as a way to project a strong environmentally friendly image for their brand.

Base-load demand would also grow with rapid expansion of the distribution grid to provide access to a dramatically higher population. Such infrastructure would allow one to meet the energy targets as articulated recently by both West and East African energy ministers. These targets were designed so that maximum impact on the Millennium Development Goals since many countries will end up limiting new access as well. Energy ministers are trying to put out day to day “fires” in this crisis mode, unable to think about the high capital investments that in my view are needed urgently to address the problems within the next two or three years.

The longer term process would engage the expertise of the regional bodies such as ECOWAS and EAC to examine SSA-wide options and linkages to North and South Africa. Such analyses would look at all the technical options, demand projections, the technical implications of a large interconnected network or multiple smaller networks; the issues of grid stability; how can one ensure access right down to the household level. Household level demands, when they are for lighting and communications can at least be met with stand-alone PV; such needs to at least have some sense of the fraction of the overall demand such an approach represents; are there locally appropriate solutions such as wind power or solar thermal power or power from biomass gasification or industrial cogeneration plants that would benefit from having the ability to be feed power into grid. Such a study would have a very specific goal. It would assist in the long range technical planning of energy for sub-Saharan Africa as a whole.

This exercise can take time and time is of the essence right now so some quick wins that are proposed that can build momentum immediately. These quick-wins are:

1. Begin an intensive effort to enhance geothermal capacity in East Africa.
2. Begin an intensive effort to identify every possible run of the river hydro potential
3. Fast-track implementation of grid interconnects.
4. Complete the West Africa Gas Pipeline as soon as possible.
5. Add additional natural gas fired capacity in Nigeria and ensure that this capacity is connected to the rest of West Africa.
6. Expeditiously complete the repair of all existing power infrastructure at the Inga Falls power plant.
7. Complete the following strategic transmission network links.
8. Negotiate concessionary pricing and dedicate some photovoltaic cell production capacity for community institutions such as health clinics and schools in Africa.

While these efforts are underway one also needs to carry out regional energy planning on a war footing.