POLICY BRIEF

Smart mixes of solar, wind and hydropower in West Africa

A new study shows the high potential of a regionally integrated power system in West Africa to increase solar and wind power penetration and avoid hydropower overexploitation.

WASCAL
West African Science Service Centre on Climate Change and Adapted Land Use

Combating Climate Change. Improving Livelihoods

CIREG
Climate Information for Integrated Renewable Electricity Generation

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West Africa's electricity sector is at a crossroads. Population and industrial growth put strong pressures on planners to ensure power system adequacy in the years to come. Electricity in West Africa has historically been generated from thermal fuels (natural gas or diesel) and hydropower. Yet, as everywhere in the world, solar and wind power are emerging thanks to their ever-dropping costs.

Plans to integrate national electricity grids into a unified regional electricity market, the West African Power Pool (WAPP), have been high on the political agenda recently. A power pool could serve to lower the overall cost of electricity, helping countries to share their power-generating potential with their neighbours.

However, until today, the master plans of the power sector, of most West African countries, still envisage a strong expansion of natural gas and hydropower capacities, with less importance accorded to solar and wind power. Many grid operators are wary of the technical risks that solar and wind power may pose for grid stability, due to their variable and intermittent nature.

In the fight against climate change, however, it is important that countries become less dependent on gas infrastructure (since fossil fuel use will worsen climate impacts) and hydropower (since climate impacts may increase pressures on water resources). Instead, they could choose a path that leads to high and diverse penetration of renewable energy sources, thereby aligning policies with the Paris Agreement.

This requires power systems to be highly flexible to compensate for the hourly, seasonal, and multi-year variability of solar and wind power. A new study conducted by the CIREG project in which WASCAL is a scientific partner (Sterl et al. 2020), has looked at the synergies between

the WAPP initiative, the operating rules of hydropower plants, and the emergence of solar and wind power. Using high-resolution hydrometeorological data to assess hydro, solar, and wind power potential across West Africa, the team of scientists investigated the mutual synergies between these three resources.

This study concludes that the WAPP can be an extremely important lever to support renewable power generation in West Africa. This is because a power pool would connect regions with highly divergent hydro, solar, and wind power potentials, allowing three synergies to be exploited: spatial, diurnal and seasonal.

SPATIAL

Solar power potential is omnipresent throughout West Africa. Hydropower potential can be found mostly in southern West Africa (e.g. Ghana, Nigeria, Côte d'Ivoire, Guinea), and wind power potential in northern West Africa (e.g. Senegal, Mali, Niger). These resources can only be shared with better interconnected grids.

DIURNAL

Solar power can only be generated during daytime when the sun shines, whereas hydropower can be operated to peak in the evenings and nights, and this is also when the wind blows hardest in the northern West African countries during the Harmattan (see Sterl et al. 2018). The three resources thus support each other in delivering reliable electricity day and night.

SEASONAL

Solar and wind power potential are both at their highest during the dry season. In a hydro-solar-wind mix, hydropower plant dispatch will therefore be reduced during the dry season and increased during the wet season, when reservoirs receive most inflow anyway. This means hydropower reserves can be more easily safeguarded throughout the dry months.

Without a regional power pool, these synergies cannot be fully valorized as individual countries lack the natural resources to exploit them simultaneously. With a power pool in place, this could be solved. Each country could then contribute to the power pool to the best of its capabilities.

We estimate that around 60% of West Africa's current electricity demand could be met with existing and planned hydro, solar, and wind power plants if they were efficiently combined in a regionally integrated grid. This is illustrated in Figure 1.

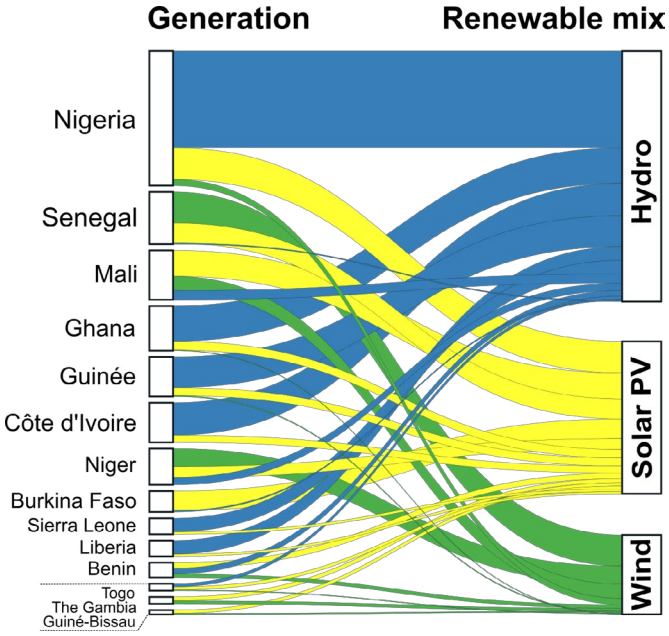
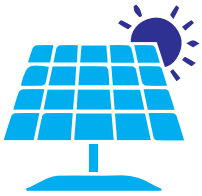
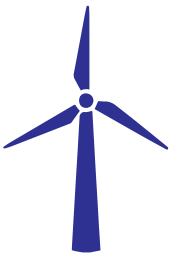


Figure 1: A regional power pool in West Africa could help all countries benefit from the renewable resource potential, which is spatially very unevenly distributed.

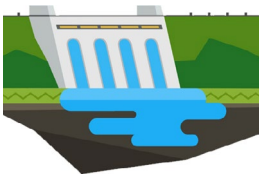
Each West African country could then center its renewable electricity policy plans around the needs that would best serve the regional power pool. This means, very concretely, that countries could emphasize the rollout of renewable resources in policy planning as follows:



Solar PV power in all West African countries, irrespective of climate regime and monsoon intensity, as the resource is strong and omnipresent in the region.



Wind power mostly in the dry Sahelian regions of Mali and Niger and along Senegal's Atlantic coastline, with additional possibilities in northern Nigeria.



New hydropower mostly in the wet, highland regions of Nigeria, Guinea and Sierra Leone, with additional possibilities notably in Ghana, Côte d'Ivoire and Liberia.

This implies a shift away from today's renewable energy policy, often dominated by plans for hydropower expansion. The difference between resource prioritization in current policy and the proposed "power pool scenario" is shown in Figure 2.

In addition to these national efforts, expanded cross-border transmission infrastructure to connect high-potential areas with high-consumption centers will be of high importance. Existing and planned hydropower plants would also have to be operated with the highest possible flexibility to enable effective grid integration of solar PV and wind power. This will help countries to avoid the use of fossil fuels and diversifying the renewable power portfolio, which reduces hydro-dependency. West African countries will thus benefit threefold:

- Reducing countries' dependencies on extractive resources, such as natural gas and diesel, and avoiding fuel costs.

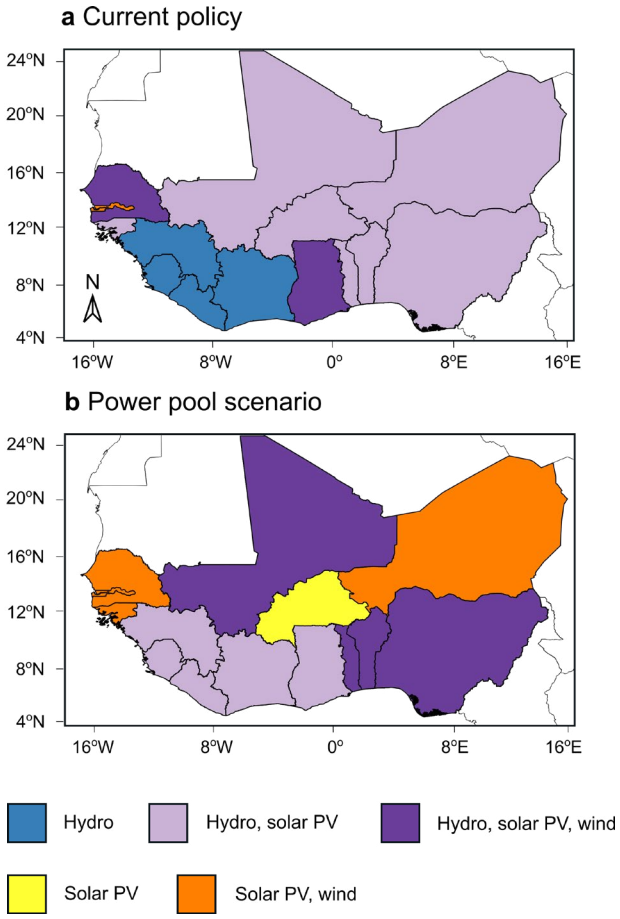


Figure 2: In order to best contribute to the West African Power Pool while supporting renewable electricity generation, West African countries could revise their resource priorities according to regional hydro-solar-wind synergies.

- Setting countries on a path towards dominance of modern renewable technologies, which are getting cheaper and cheaper, while increasing energy security.

- Avoiding future ecologically damaging river-damming interventions by implementing only those hydropower projects that are best suited to support solar and wind power.

In the future, modern storage technologies are expected to become affordable as well, which will further benefit solar PV and wind power integration. The proposed development of solar PV across West Africa, and of wind power in selected countries, is thus fully in line with preparing for such developments in the longer term.

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