EU Global Technical Assistance Facility (TAF)
for the Sustainable Energy

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2020 – 2040 Regional and Continental Planning Scenario and Sensitivity Analysis Results

The Continental Power System Masterplan (CMP) was initiated in 2019, following a decision of the African Energy Ministers to serve as a blueprint for the African Single Electricity Market (AfSEM).

The integrated planning scenarios, developed with support from the European Union - Global Technical Assistance Facility (EU-GTAF), provide an outline of credible pathways of how the electricity sector in Africa will evolve in the next 20 years, considering the unique challenges and aspirations of each of Africa's five regions and guided by the continental aspirations espoused in the AU Agenda 2063 Goals.

The synergy and complementarity of the AfSEM and CMP assignments will ensure that efficient generation facilities and resilient electricity interconnections will support adequate and efficient market-based mechanisms for trading.

OBJECTIVE

This deliverable aims to follow up from the analysis carried out in three prior deliverables:

- Del. 2 Part 2 (Integrated Continental Demand Forecasts - Scenario Analysis),
- Del. 4 (Integrated Continental Planning Scenarios), and
- Del. 7 (2020 – 2040 Baseline and Reference Case Planning Scenario Results).

The focus of this deliverable is on aspects related to the analysis performed on additional regional and continental CMP scenarios.

METHODOLOGY

This deliverable:

- Considers the regional and continental scenarios that are more in line with the goal of AfSEM to link all the regions of Africa. The regional and continental scenarios allow greater intra- and inter- regional connections, as opposed to the baseline and reference scenarios which were limited to planned transmission interconnections.
- Determines the incremental generation and transmission investments needed to achieve universal access by 2035 under the medium growth scenario at regional and continental level. Through this examination, it identifies the primary cross-border transmission corridors for inter-regional trade.
- Carries out a comparison between the regional and continental scenarios versus the baseline and reference scenarios in order to highlight the benefits of more intra- and inter- regional connections.
- Conducts sensitivity analysis to test the robustness of the assumptions used in the SPLAT-Africa model.

Scenario's description

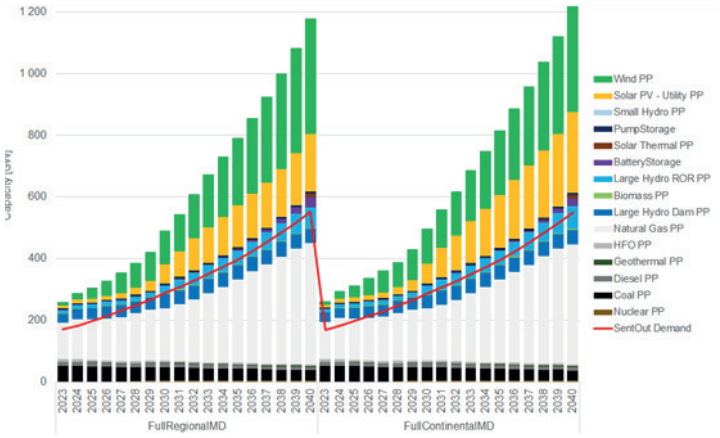
The additional CMP scenarios are determined by the degree of regional integration and more ambitious demand forecasting cases. This deliverable focuses on scenarios that result from a combination of medium growth in demand and either full regional or full continental interconnection levels.

Sensitivity analysis was further conducted to test the robustness of some of the assumptions used in the SPLAT-Africa model, primarily the impact of variations in the discount rate, delays on key candidate generation projects dominating power flows on the continent, as well as adverse weather conditions on hydro projects. The sensitivity analysis was conducted on the continental scenario, because this is most aligned with the goal of the AfSEM to increase inter-regional trade.

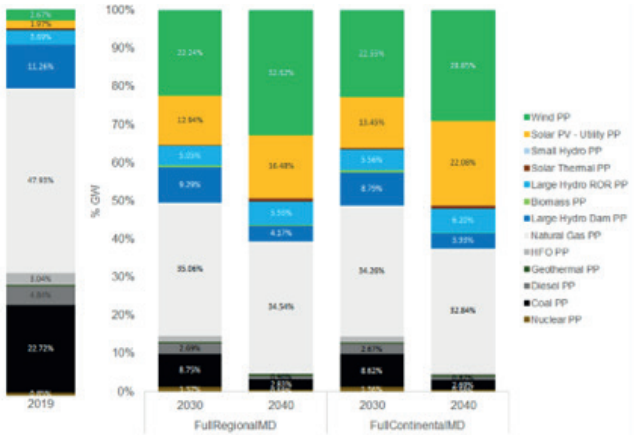
Overview of results

The total installed capacity in Africa is projected to increase from 266 GW in 2023 to 1,176 GW and 1,218 GW in 2040 for the regional and continental scenarios respectively.

Total installed generation capacity in Africa



Evolution of technology shares in Africa's generation capacity mix



New investments in hydro, solar PV, wind, natural gas and battery storage will mainly drive the increase in installed capacity in Africa. Variations in capacity for the regional power pools are observed, depending on the regional resources.

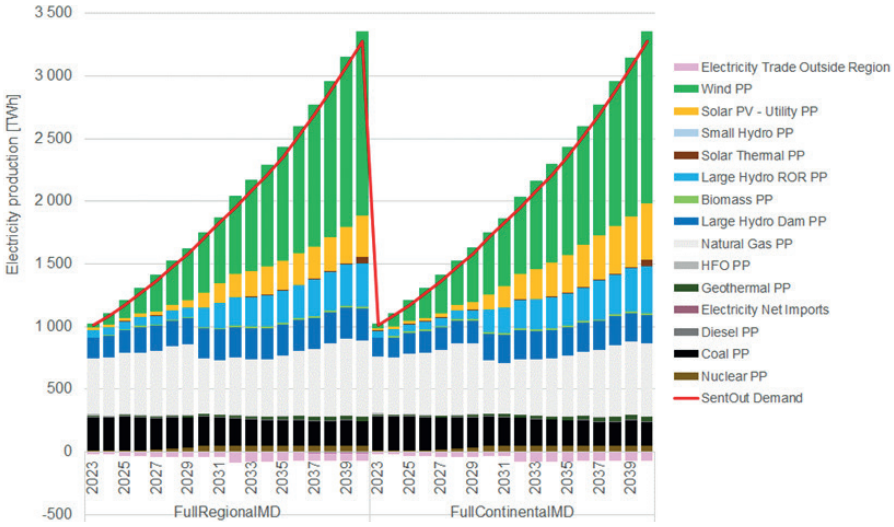
In particular:

- The installed solar capacity is projected to increase by about 178 GW and 252 GW by 2040, from about 10 GW installed in 2023, in the regional and continental scenarios respectively. The corresponding wind capacity increase is projected to be 363 GW and 334 GW by 2040, in the regional and continental scenarios respectively. Although the projected increase in solar and wind capacity is significant compared to the current capacity, it still represents less than 25% of the exploitable potential of these resources identified in the CMP studies.
- In both scenarios, the capacity from natural gas is projected to increase by about 270 GW and coal capacity to decrease by 20 GW, mainly attributed to the planned decommissioning of ageing coal plants in South Africa.
- Battery energy storage is projected to increase from about 125 MW in 2023 to about 32 GW and 25 GW by 2040 in the regional and continental scenarios respectively.
- The installed capacities from diesel and HFO are projected to reduce, solar CSP to increase tenfold, and pumped storage capacity to double
- Geothermal and biomass capacities are projected to increase by a factor of five and three respectively from 2023 to 2040.
- Nuclear capacity is projected to be added to the 1,860 MW currently installed in South Africa, from the committed 4,800 MW capacity in Egypt.

The evolution of technology shares in Africa's generation capacity mix indicates a reduction in fossil fuels, apart from natural gas where this is less significant. The share of variable renewable energy (solar and wind) becomes more prominent.

The annual electricity production from these technologies within Africa's interconnected power system is projected to increase from 1,022 TWh in 2023 to around 3,355 TWh in both scenarios by 2040. Electricity production from hydro, solar and wind is projected to increase, while the output from coal is projected to decline.

Electricity production from the regional and continental scenarios in Africa



The table and figure below outline the key cross-border transmission investments optimally required to link Africa's five regions over the study horizon.

Interconnector Name	Status	Investment Date	
		Regional	Continental
Angola (Cabinda) – Congo (Point Noire)	Committed	2027	
DRC (Inga) – Angola (Cabinda)	Committed	2027	
DRC – Angola	Generic	-	2030
Kolwezi (DRC) - Solwezi (Zambia)	Candidate	-	2030
DRC – Zambia	Generic		2030
Mozambique – Tanzania	Candidate	2027	
Malawi - Tanzania	Generic	-	2030
Tanzania - Zambia	Generic	-	2030
Tanzania (Mbeya) – Zambia (Nakonde) - ZTK	Committed	2025	
Burundi - Tanzania	Candidate	2023	
Rwanda - Tanzania	Candidate	2023	
Rwanda - Uganda	Candidate / Generic	2030	2038
DRC - Uganda	Candidate / Generic	2030	2037
DRC (Inga) – South Africa (Merensky) HVDC	Candidate	2030	
Cameroun – Nigeria (Calabar)	Candidate	2033	-
Cameroun - Nigeria	Generic	2030	
Sénégal - Mauritania	Generic	2030	
Egypt - Libya	Existing		
Egypt - Greece	Candidate	2032	
Egypt – South Arabia	Committed	2025	
Morocco - Spain	Candidate	2026	
Morocco - Italy	Candidate	2030	
Tunisia - Italy	Candidate	2028	
Mauritania - Morocco	Candidate	-	2039

The total CO2 emissions and CO2 emissions per sent out demand can be compared across all scenarios (baseline, reference, regional and continental).

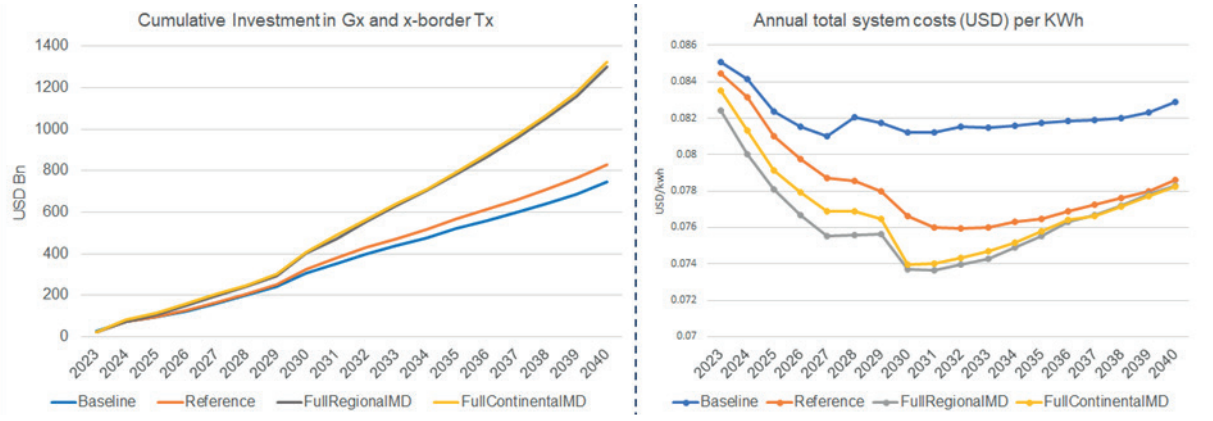
In all the scenarios, the decline in CO2 emissions is mainly attributed to the planned shutdown of existing coal-fired plants, reducing the pace of electricity production from natural gas and the in-troduction of renewable energy sources. However, CO2 emissions intensity reduction is accelerated in the regional and continental scenarios due to the increase in cross-border interconnections which facilitate the increased penetration of variable renewable energy technologies.

By 2040, the cumulative investment costs for the regional scenario are projected to grow to about USD 1.27 trillion and for the continental scenario to USD 1.29 trillion.

Selected inter-regional candidate and generic interconnectors

CO2 emissions and emissions intensity in Africa

Cumulative investment cost and annual total system costs in Africa



Key insights

- The primary sources of new power generation capacity additions are natural gas, wind and solar PV technologies. Additionally, large hydro run-of-river plants play a significant role in regions like CAPP, EAPP and SAPP. In the continental scenario, solar PV installations are preferred compared to the regional scenario, because they have a greater ability to harness variable solar generation in a more interconnected Africa.
- SAPP and WAPP are projected to be the net importers in both scenarios, while CAPP, COMELEC and EAPP are projected to be net exporters. CAPP is projected to export to SAPP, EAPP and WAPP, highlighting the importance of the region as the hub for power exports in Africa. However, CAPP has the lowest intra- power pool trade volumes.
- In absolute values, the largest intra- power pool trade volumes are projected within the SAPP, WAPP and EAPP power pools, with SAPP being the dominant. In both scenarios, intra- power pool trade within SAPP will double from 2030.
- Inter-regional trade will be significantly facilitated by inter-regional interconnectors between:
    - Cameroun – Nigeria
    - Namibia - Angola - DRC
    - DRC – Zambia
    - Tanzania – Zambia
    - Morocco – Mauritania – Senegal
    - Egypt – Sudan – Libya
- Although the absolute level of required investments in the continental scenario is higher than the baseline scenario, the actual cost per MWh produced is 2 USD/MWh lower. This means that the goal of universal access can be achieved and the actual cost per unit of electricity produced will be lower through a more interconnected Africa.
- The discount rate sensitivity reveals that investments in hydro, solar PV and natural gas plants remain robust across a range of discount rates. Wind power is influenced to a lesser extent, while solar thermal, coal and battery storage technologies are more sensitive to the level of discount rate.
- The impact of delaying the increased capacity from the key Grand Inga hydroelectric potential highlights the significant effect on DRC's power system through the increased installation of solar PV and wind capacity. At the regional and continent levels, additional thermal generation capacity is required in this sensitivity analysis.
- The extreme dry hydro sensitivity case leads to the optimal installation of more coal, solar and wind capacities in Africa.