

Technical & organizational challenges to achieve interconnection in West Africa

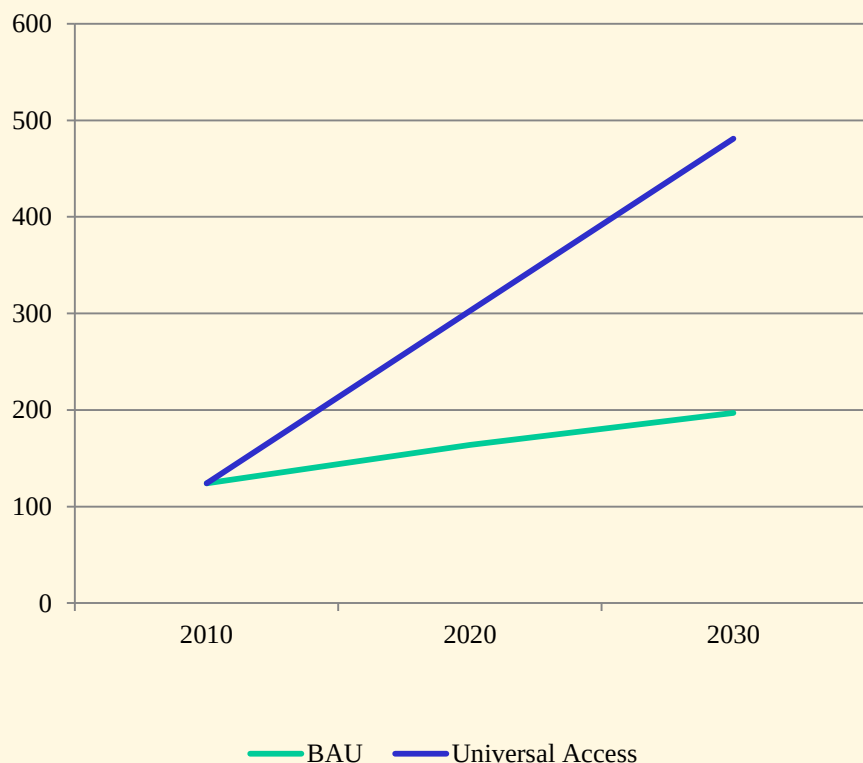
The West Africa Power Pool

Franklin K. Gbedey
Energy Specialist
Africa Energy Group Unit
The World Bank
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The WAPP profile

- **The power pool includes: 15 countries; 300M population (36% of SSA' population); 28% of SSA's GDP; 41% access in the WAPP region**
- **The WAPP grid covers two geographical zones A and B:**
 - **The countries of zone A : Already connected by interconnections (Nigeria, Niger, Benin, Togo, Burkina Faso, Ghana, and Ivory Coast)**
 - **The countries of zone B (Mali, Liberia, Guinea, Sierra Leone, Guinea Bissau, Senegal and Gambia). Only Senegal and Mali are already interconnected.**
 - **The peak load of the region has exceeded 6500MW for a total consumption of almost 40000GWh.**

WAPP Population with access to electricity (million)

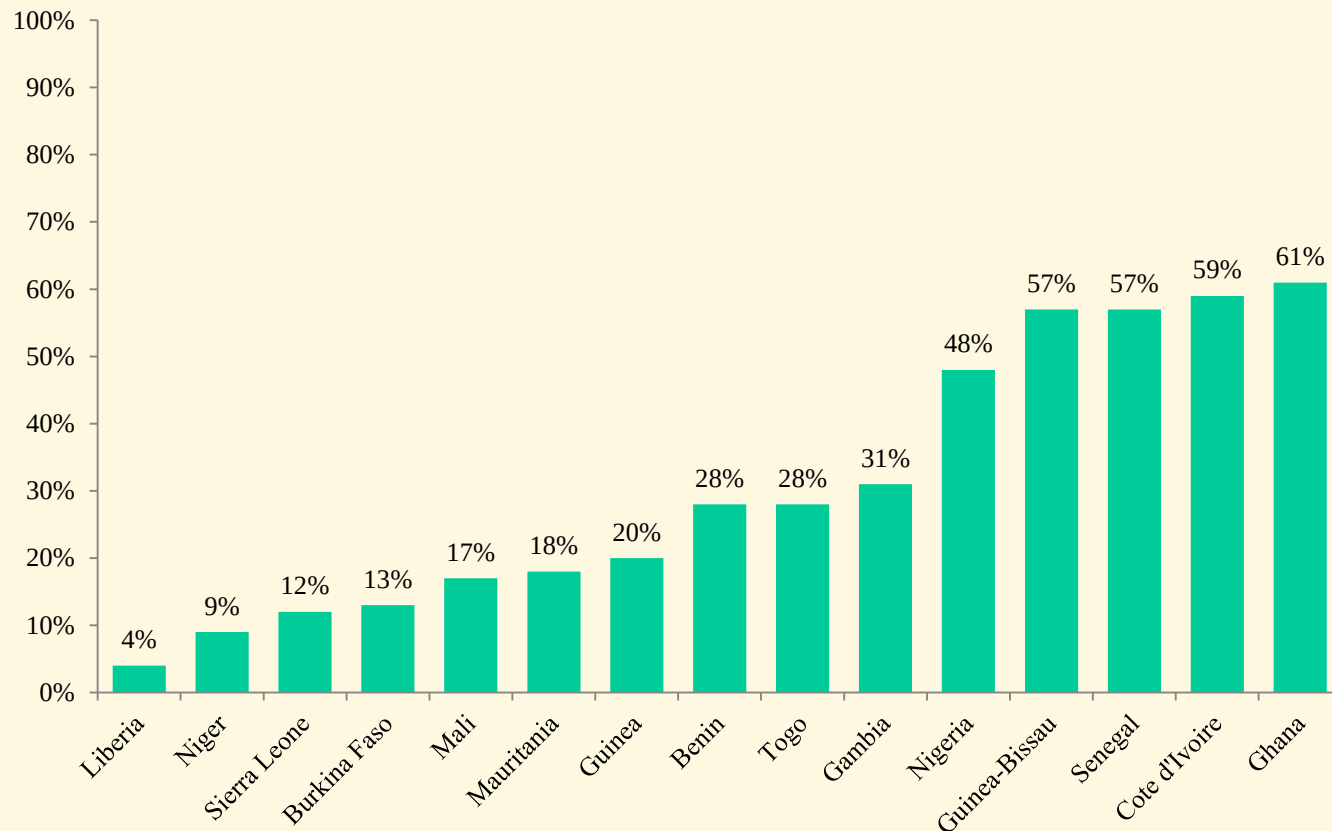


Currently 41% access in the WAPP region, or 124 million people. Achieving universal access by 2030 would require connecting an additional 360 million people, or 18 million people per year

Access to electricity in WAPP countries

Access to electricity (2010)

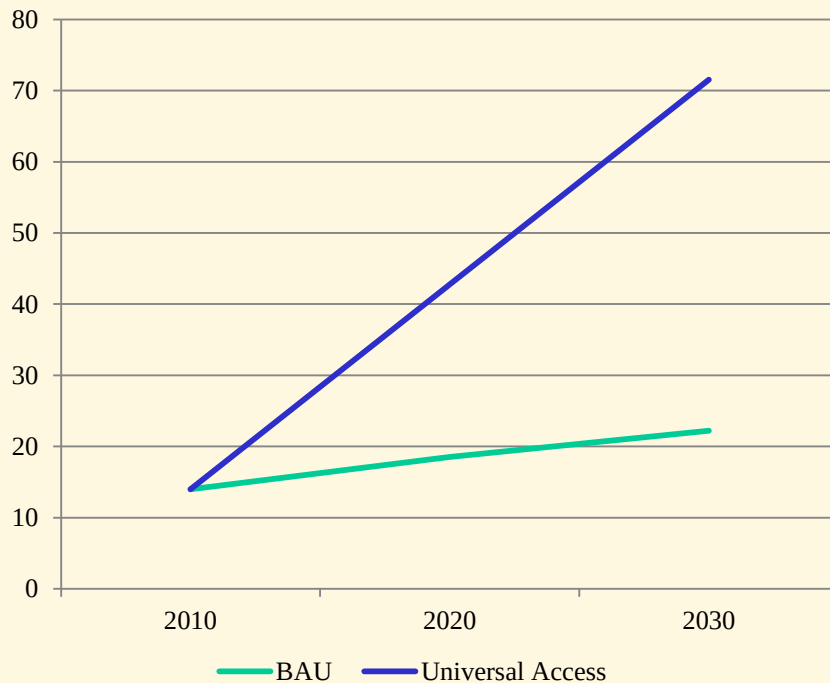
Source: SE4ALL Global Tracking Framework (2013)



The Generation shortfall Challenge

- Despite the huge potential resources reserves, there is a supply shortfall in every WAPP countries due to inadequate generation capacity and/or dependence on hydro for many years
- For example in Guinea, 6 GW (20-25 TWh/year in energy terms) of economically feasible hydropower potential is still untapped
- The Nigerian enormous natural gas reserves not yet unlocked: Gas reserve figures : Associated Gas, 93 Trillion SCF, Non Associated Gas, 95 Trillion SCF. Gas flaring : 1.2 BCF/day

Generation Capacity in the WAPP (MW)

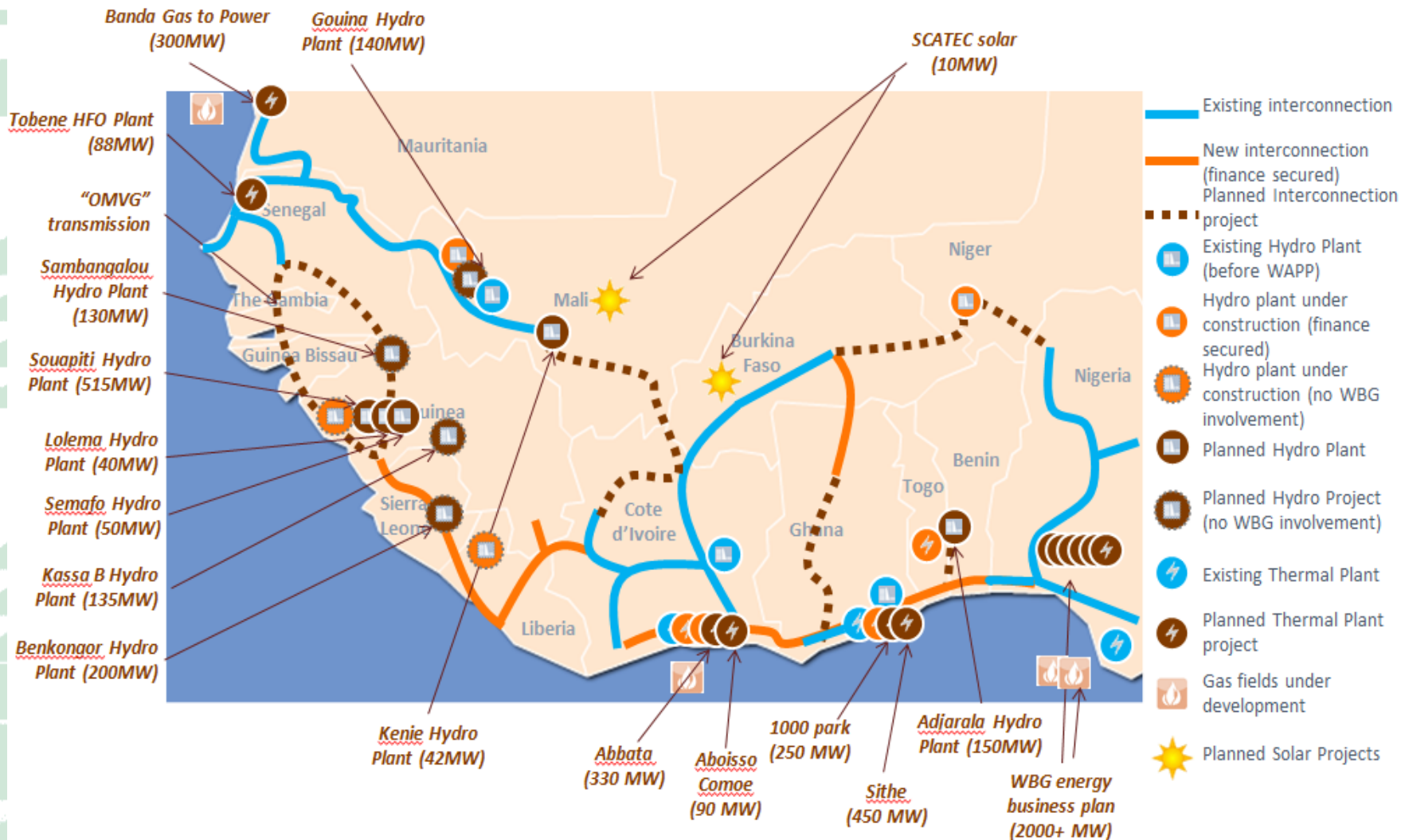


Maintaining current levels of access would require alone would require an additional 7GW in generation capacity. Achieving universal access would require an additional 60GW, or 3 GW per year

The Actual WAPP Network



The WAPP network in 2020



The Principles of the WAPP Network Operation

- **8 policies in the WAPP operation manual**
 - **Load Frequency Control**
 - **Interchange scheduling and Accounting between Control Areas**
 - **Operational Security**
 - **Operational Planning**
 - **Emergencies Procedures**
 - **Communication Infrastructure**
 - **Information Exchange Between Systems**
 - **Operator Personnel and Training**

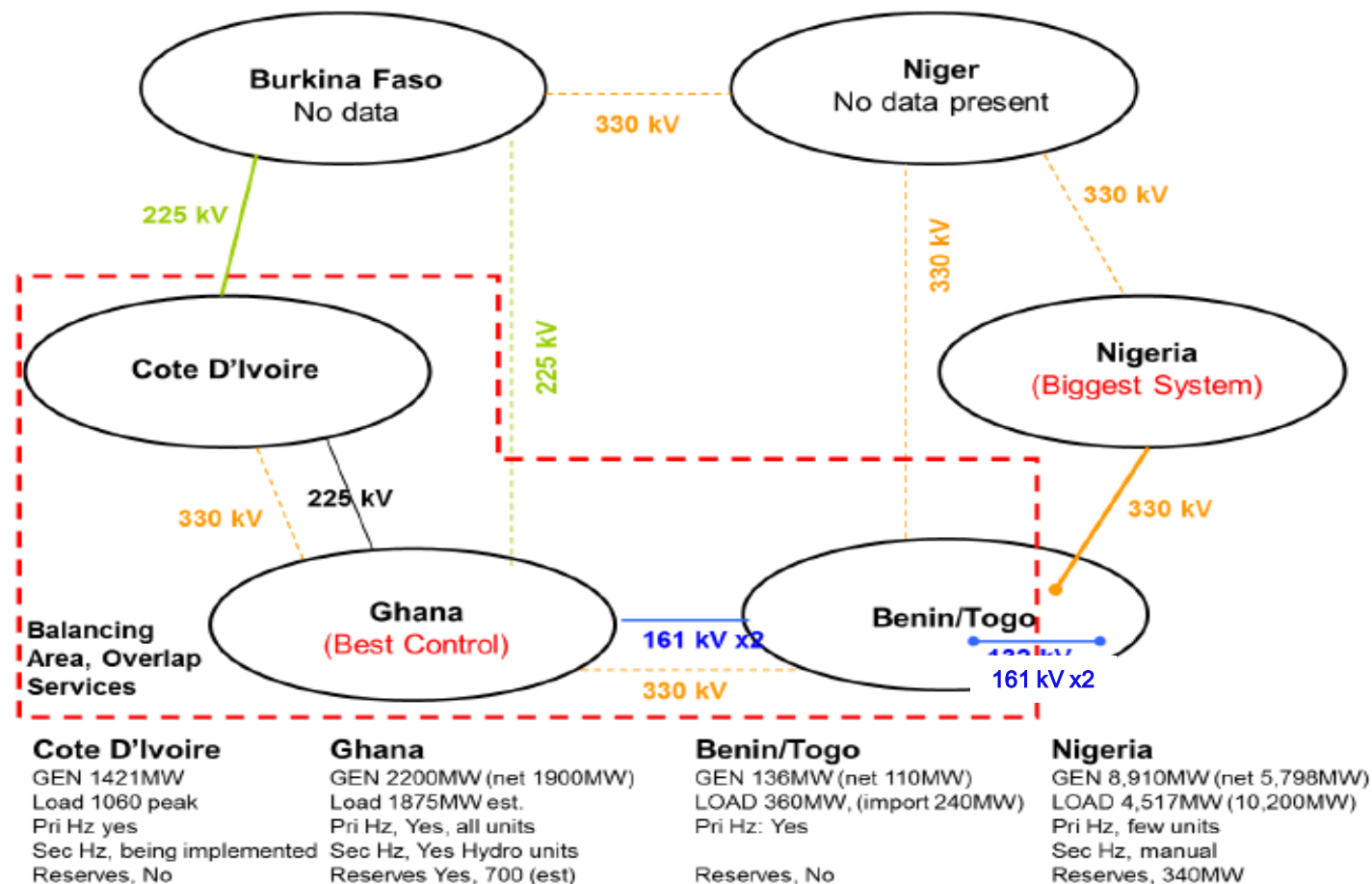
The WAPP Control Areas

- The WAPP interconnected power system is composed of 5 Control Areas coordinated by Control Area Operators (Control Center Operator of the Control Area):
 - Côte d'Ivoire - Burkina-Faso, the operator is **Côte d'Ivoire**,
 - Ghana - Togo - Benin, the operator is **Ghana**,
 - Nigeria – Niger, the operator is **Nigeria**,
 - Guinea – Liberia – Sierra Leone, the operator is **Guinea** ,
 - Senegal – Mali – Gambie – Guinée Bissau, the operator is **Senegal**

The System Synchronization Challenge

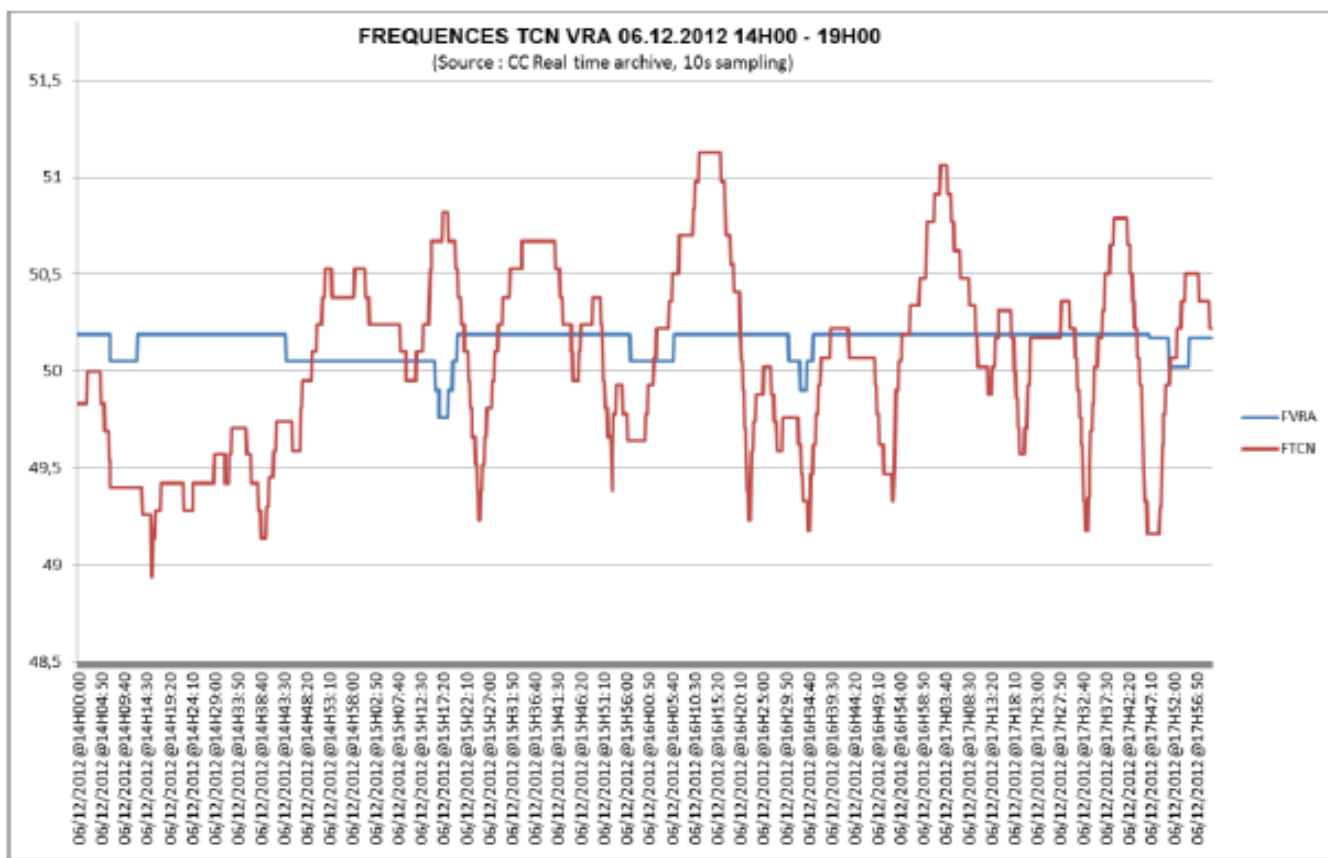
- In WAPP Zone A region, the power systems of Cote d'Ivoire, Ghana, Burkina Faso and Togo/Benin are interconnected and have been successfully operating in a synchronous mode for several years.
- However, attempts made to synchronize the Nigerian power system with these five interconnected power systems have been unsuccessful.
- The causes of unsuccessful synchronization are identified as lack of adequate frequency control and voltage support in the Nigerian system and poorly damped inter-area oscillations.

Interconnection system in WAPP Zone A



Frequency Stability

- Measurements (10 seconds mean values) from December 2012 reveal that the frequency in Nigeria is very unstable. The blue line is the frequency in the western grid (including Côte d'Ivoire, Ghana, Togo, Benin) and the red line is the frequency in Nigeria.



Source : Synchronisation Study Phase 1 report: GRIDCo & WAPP

How to Address the Synchronization Problem

The following studies, tests and measurements will be carried :

- Stability studies with 2012 system conditions to identify the limitations of the existing systems

- Comprehensive system studies based on the planned system conditions, including planned upgrades, particularly on the Nigerian system. These include: **small-signal stability studies; voltage stability and control studies; frequency stability and control studies; and transient stability studies.**

- On-site tests and measurements on individual power plants to: identify and validate generator data; identify and tune AVR and PSS settings; and identify and optimize frequency control capability.

- Development of a Restoration Plan to ensure that the interconnected system can be energized safely and quickly following a blackout.

- Implementation of a well-designed wide-area monitoring system using phasor measurements to generate real-time data to assist in the secure and efficient operation of the interconnected system.

The Back-to-Back HVDC Link Alternative

- In the unlikely situation when deficiencies in the Nigerian power system cannot be successfully eliminated, a back-to-back HVDC link with the converter station located at Sakete substation (Benin) may be the best way to ensure stable and reliable interconnected system operation.
- To assess the full impact of this option, detailed studies will be carried out and cost evaluations should be made.
- The assessment should be based on a power transfer capacity of 600 MW, with possible increase in capacity to 1000 MW in the longer term.
- Both VSC-based converters and line commutated converter technologies should be considered as possible alternatives in assessing the costs and overall power system performance

Formation of Technical Committees and Task Forces

To address various technical issues related to the planning and operation of the interconnected system that arise periodically, technical committees and task forces should be established, with membership from utilities throughout the interconnected system. **These could be patterned after the CIGRE Technical Committees and Task Forces.** Their establishment helps address specific problems, share information and develop solutions based on industry-wide experience.

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