

A Comprehensive Overview of Ancillary Services in the Ghanaian Power Market

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Abstract- This paper deals with support and ancillary services which are provided by the Ghanaian power market operator. The System operator services ensure a balance between production and consumption of electricity and the quality and control of the entire electricity system. Frequency, Voltage and Grid Integrity, are the critical criterion of efficient network management. Formally, this has been the job of the vertically integrated utility (VIU). Hence earlier, during the time of system planning for network expansion adequate resources were mobilized for the ancillary requirements also. To develop competition amongst the various generation and distribution utilities, the VIU has been unbundled, and the wire business has been kept as a natural monopoly for Ghana Grid Company (GRIDCo), the system operator in the Ghanaian power market. Parameters such as frequency, voltage and grid Integrity, known as Ancillary Services, are entrusted to (GRIDCo), for keeping them within limits by procuring these services from various Generating and Transmitting Agencies under the regulatory supervision and guidance of Energy Commission. The primary ancillary services in the Ghanaian power markets are; reactive power, frequency regulation, black start, and spinning reserve.

Index Terms- Ancillary Services, Frequency, Power Market, Reactive Power, Spinning Reserve, System Operator,

I. INTRODUCTION

Since electricity cannot be stored in large quantities at reasonable cost, part of the job of the power grid operator is to make sure that supply and demand balance at every moment. Because supply must meet demand continuously, a supply and demand constraint on average power production over an interval or on forecast conditions at the end of a dispatch interval do not adequately ensure that supply and demand balance is satisfied continuously. Besides, because markets dynamics cannot respond to equipment failure such as loss of a generator, transmission line, etc. an alternative means of support to the power system is the way out. The additional services to continuously satisfy supply and demand balance and sustain other constraints are called ancillary services [1].

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This means that the power grid is making adjustments every single second as demand changes (actually, much more quickly than one second). Many of these adjustments are automated responses. Ancillary Services Markets allow the ISO to maintain a portfolio of backup generation in case of unexpectedly high demand or if contingencies, such as generator outages, arise on the system. These are value-added services geared towards supporting and improving power system security, quality, and reliability.

II. THE GHANAIAN POWER SYSTEM

Ghana presently operate the unbundled power system. In this unbundled system, the Volta River Authority (VRA) as a Genco, owns generation assets and combines hydro, thermal and solar for power generation. The Bui Power Authority (BPA), another state-owned authority, is charged with the responsibility of the operation of the Bui Hydroelectric Power Plant. In addition to the foregoing, various IPPs have been licensed to build, own and operate and transfer (BOOT) power plants to help augment the power supply and address the deficiencies in the country. Transmission of electrical power has always been the sole responsibility of GRIDCo after the deregulation of the Ghanaian power sector. According to the model, to have a perfect competition in the wholesale market, an independent system operator (ISO) should exist, however, this function is currently carried out by GRIDCo. Again, the retailing aspect of the distribution is carried out by distribution companies like ECG and NEDCo. The structure also emphasizes decentralization at the distribution level, with plans for eventually adding more distributors, each operating in a defined geographic service area. The Electricity Company of Ghana is the primary distribution company with over 70% market share. It is responsible for distribution of power in six administrative regions in Ghana namely: Western, Central, Greater Accra, Ashanti, Volta and Eastern regions. The Northern Electricity Department Company (NEDCo) was established under the Volta River Authority (VRA), to take the responsibility of electric power distribution in the Northern part of Ghana. There is a third distribution company, Enclave Power Company, the only privately owned distribution company which is mainly responsible for the industries in the Free Zone Enclave of Ghana in Tema. The leading companies in the electricity market in Ghana are VRA, GRIDCo, ECG, IPPs, Mines, VALCO, NEDCo., and Enclave Power.

III. ANCILLARY SERVICES

Ancillary services" - those tools that grid operators have to handle fluctuations in supply and demand in between those discrete moments when the real-time market clears. There are four primary types of ancillary services [2]. These are:

- Reactive Power
- Frequency regulation
- Spinning and Non-Spinning Reserves
- Black Start

In Ghana, GRIDCo. procures ancillary services for ensuring security, reliability, and quality of the power supply to the consumers. Also, Ancillary services can be provided by generators, Load Serving Entities (LSEs) and transmission operators. Ancillary services are classified, procured and remunerated depending upon the operational practices of the Electricity Supply Industry (ESI). Energy is sold in forward (e.g., day-ahead markets) and real-time markets and is usually settled at locational marginal prices. To support the scheduling of energy on power systems, operators require ancillary services. Ancillary services may include some different operations which include frequency support, voltage support, and system restoration [3]. These services can be economically contracted from a range of different IPPs. Such system offers competition and diversity in the provision of ancillary services and ensures Independent System Operator (ISO) with contracts for all the services which are needed [4] [5].

IV. CLASSIFICATION OF ANCILLARY SERVICES

There are many different types of ancillary services, corresponding to the speed with which the backup generation needs to be dispatched.

- *Reserves* represent capacity that can be synchronized with the grid and brought to some operating level within 60, 30 or 15 minutes.
- *Regulation* represents capacity that can change its level of output within a few seconds in response to fluctuations in the system frequency.

For this study, the classification of ancillary services will fall under Fig. 1

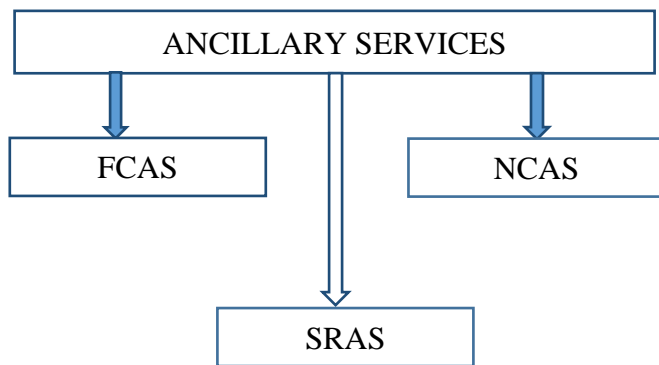


Figure 1. Ancillary Services

FCAS: Frequency Control Ancillary Services
 NCAS: Network Control Ancillary Services
 SRAS: System Restart Ancillary Services

A. Frequency Control Ancillary Services

A certain amount of active power, called frequency control reserve, is kept available to perform this task. Three levels of control are generally used to achieve FCAS: (i) Primary frequency control, (ii) Secondary frequency control and (iii) Tertiary frequency control. Primary frequency control requires a response period of 5 to 10sec; secondary frequency control requires a response period of 10s to 15min, and tertiary frequency control requires a response period of 10 to 30min. Frequency control reserves required to perform above control tasks can be of (i) positive frequency control reserve and (ii) negative frequency control reserve.

B. Network Control Ancillary Services

These are the services required to maintain the network parameters within the permissible range. VCAS are needed for supporting the voltage to be kept within the allowable limit. Three levels of control are generally used to achieve VCAS: (i) Primary voltage control, (ii) Secondary voltage control and (iii) Tertiary voltage control. PFCAS are needed to improve Available Transfer Capability (ATC) and the performance of real-time operation considering network constraints.

C. System Restart Ancillary Services

Frequency control reserves required to perform above control tasks can be of (i) positive frequency control reserve and (ii) negative frequency control reserve.

V. ANCILLARY SERVICES IN THE GHANAIAN POWER MARKET

Table 1. depicts ancillary services in the Ghanaian power market compared to what is in literature.

TABLE I
 Ancillary Services

Ghanaian Power Market Context	Literature (FERC / CIGRE / Other Authors)
Economic Dispatch	Black Start
Inter-area power flow control	Energy Imbalance
Black Start	Economic dispatch
Reactive Power - Voltage Control	Real Power Balancing
Real Power Balancing	Transmission Security
Transmission Security	System Protection
Reactive Power - Voltage Control	Scheduling and Dispatch
Frequency Control	Losses
	Financial Trade Enforcement
	Reserve
	Inter-area power flow control
	Frequency Control
	Voltage Control
	Reactive Power

VI. FOUR PRIMARY TYPES OF ANCILLARY SERVICES

Reactive Power: This service is also referred to as Voltage control. Its purpose is controlling reactive power flows which are essential for a power system to operate within acceptable voltage limits. Reactive power flows can give rise to substantial voltage changes across the system, which means that it is necessary to maintain responsive power balances between sources of generation and points of demand on an area basis. At low loadings, capacitive effects dominate and voltages tend to increase (the Ferranti effect). At high loadings, inductive impact dominates and voltages tend to become depressed. The Surge Impedance Loading point is a point at which both effects cancel each other [6].

Frequency regulation: In general, frequency control action can be provided anywhere in the system, but the transmission capabilities and limits must be taken into account to prevent congestions or overloading of transmission elements [7]. The benefits of frequency control include avoided costs of loss of industrial production, community disruption, and inconvenience, equipment damage, and market distortion. Many of these benefits are very difficult to assess because of a large number of people involved. Above all, frequency control is necessary to maintain power system security and, therefore, it has a commercial value. It is the result of a demand from customers to keep electric energy security at an acceptable level.

Black Start: Despite the best efforts of the system operator, a disturbance occasionally spirals out of control and the entire power system collapses. Black Start is the procedure to recover from a total or partial shutdown of the transmission system which has caused an extensive loss of supplies.

Spinning Reserves: This is the capability of a generator to respond to frequency change due to supply and demand imbalance after for example, a generator outage and then to a further respond to ISO signals change. Spinning reserves are expected to be able to produce power within a specified time (10 minute, 30 minute and 60 minutes) of being called on. *Non-spinning Reserves* represent capacity that has not started up but could start up and be ready to produce power within a specified time of being called on.

VII. PROVISION OF ANCILLARY SERVICES IN THE GHANAIAN POWER MARKET

Table 2. depicts the various ancillary services in the Ghanaian power market.

TABLE II
Provision of Ancillary Services

Ancillary Service	Provides by	Paid for by
Voltage Support	Generators	Load in areas
Black Start	Generators	GRIDCo.
Frequency Maintenance	Generators	Generators
Instantaneous reserves	Generators and load	Generators and GRIDCo.
Over frequency reserve	Generators	GRIDCo.

Frequency maintenance and instantaneous reserves are managed as part of economic dispatch every market trading period. Over frequency reserves and voltage support are

dispatched at GRIDCo.'s discretion when certain conditions are met.

VIII. PROCUREMENT OF ANCILLARY SERVICES

Two primary methods are adopted in handling this. Namely, (i) Compulsory Provision and (ii) Market Based Provision. The choice of a technique depends on several factors such as; type of service, nature of the power system, history of the power system, etc.

A. Compulsory Provision

As part of connecting conditions, a fixed amount of ancillary services is provided. Consequences: (i) volume of the service supplied may exceed what is needed, (ii) potentially low-cost providers are treated on the same basis as more expensive one.

B. Market-Based Provision

Bilateral contracts: (i) this form of procurement lacks transparency, (ii) this type of negotiation can be long-term, complicated and costly, (iii) because of high transaction cost of contracts, price and volume often remain fixed for a long time. Tendering process and creation of a spot market to enhance transparency and foster competition are sometimes used.

IX. SELLING ANCILLARY SERVICES

Ancillary services are another business opportunity for generators in Ghana (VRA, TICO, CENIT, AMERI, AKOSOMBO, BUI, etc.). However, technical characteristics of the generating units (maximum ramp rate, reactive capability curve, etc.) make it difficult for some generators to trade in this business. Also, the Opportunity cost (need to optimize the sale of energy and reserve jointly) is a limiting factor. With proper design and regulatory framework, this services can be of a source revenue to the market participants.

X. CONCLUSION

With increasing demand for power, the capacity addition has seen a significant boost, especially in the renewable space. This has made the grid much more difficult to control, and peak demands can make grid parameters go haywire. Ancillary services will further help in improving the reliability of the network and also further help phase-out the Unscheduled Interchange (UI) mechanism as well as act as a deterrent to market participants that are a threat to the grid security. The ancillary services markets are no exception. Potential changes to the existing ancillary services markets are likely to occur due to the changing requirements of those ancillary services. The market design rules guiding the ancillary services markets should not preclude technologies that can provide the desired need. This may soon include ancillary services being supplied by variable renewable resources. Lastly, careful consideration should evaluate system needs that may currently be provided without market incentives to understand if new ancillary services markets are needed to provide the required services at lowest cost. Development of a market mechanism for ancillary

services shall take the country towards the next level of reforms. The present paper has identified the primary Ancillary Services for remuneration purposes and also pointed out the responsible agencies for providing these services, as per the present day regulations and provisions of the energy commission. The paper has also identified the process and mechanism for procurement of these services.

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