Competitive Wholesale Electricity Market, Transactions, Pricing and LMP Decomposition

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Ghana Grid Company Limited (GRIDCo)
Presentation Outline

• Brief overview of the Ghana Grid Company
• Ghana wholesale electricity market (GWEM)
• Vertically integrated versus deregulated electricity market
• Benefits of electricity market
• Market products, services and transactions
• Day-ahead market, real-time market and settlements
• Energy bid, market clearing and locational marginal pricing (LMP)
• Conclusions
Ghana Grid Company (GRIDCo) - Overview

• Ghana Grid Company is wholly owned by the Government of Ghana
• GRIDCo began operation in 2008 in accordance with the
  – Ghana Energy Commission Act, 1997 (Act 541)
  – Volta River Development (Amendment) Act, 2005 (Act 692)
• Governed by a government appointed Seven Member Board
• GRIDCo is the independent system and market operator of the Ghana National Interconnected Transmission System (NITS)
GRIDCo Overview – Core Functions

- Acquire, own and manage transmission assets
- Develop, promote and **facilitate fair and competitive wholesale electricity market**
- Provide transparent and open access for all market participants
- Serve as the main artery between bulk electric system customers and generation companies
- Facilitate the development and **connection of new assets to the NITS** including renewable energy
- GRIDCo is a **major power utility industry player** within the West Africa Power Pool (**WAPP**)
GRIDCo Overview – Ghana NITS

- **2,361 MW** record system peak demand (Feb. 2016)
- **4,300 MW** load forecast (2020)
- **28** Bulk electric customers
- **7** Generation companies (incl. IPPS)
- Volta River Authority is the national power generation company
- **3,739 MW** installed generation capacity (**3 hydros & 11 thermals**)
- **4,100 MVA** transformer capacity across **65** Substations
- **5,500** circuit-km of transmission lines (69 kV – 330 kV) with about **50%** fiber-optically equipped

Control area inter-ties and service areas
- West – Cote D’Ivoire
- North - Burkina Faso (service area)
- East - Togo and Benin (service area)
Ghana Wholesale Electricity Market

Market Regulators
• Public Utilities Regulatory Commission
• Energy Commission

Market Participants (MP) and Markets Coordinators (MC)
• 7 - Generation companies (3 hydro and 11 thermal plants)
• 3 – Distribution companies
• 28 – Bulk customers including
  CIE of Cote D’Ivoire
  CEB of Togo-Benin
  SONABEL of Burkina Faso
GWEM – Market Design and Status

• The GWEM design comprises of bilateral and spot markets
• Phase 1 implementation (Operational) – Submission of only MW quantities to serve as market familiarization for MPs
• Phase II Design - Market participant (MP) submits pairs of MW quantity-price bids and offers to GRIDCo via its Market Coordinator

Phase II design status and key milestones
• **July 2016** (Expected) - Selection of market rules design consultant
• **2017 Quarter 1** (Expected) – Market rules design completion
• Conclude service agreements with MPs
• RFP for market rules implementation and vendor selection
• Market rules implementation, testing and Go-Live
Vertically Integrated vs. Deregulated Electricity Market

**Vertically Integrated**
- Utility Owned Generation
- Utility
- Customer

**Deregulated**
- Independent Generators
- Power Marketers
- Market/Scheduling Coordinators
- Market Operator
- Customer

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Benefits of Deregulated Electricity Market

- Provides a "one-stop shop" for trading bids, transmission capacity and operating reserves
- Consumers make greater effort to use existing capacity more efficiently
- Electricity market introduces competition and provides transparent signals for investments in transmission and generation as well as demand response
- Locational marginal pricing creates a highly transparent system and prices electricity based on the cost for generating and delivering it.
- Access to larger pool of available energy which allows for increased competitive pricing
- Enhances system reliability even during planned maintenance, unplanned equipment failures and system congestion
Bilateral Market Arrangements

• Buyers seek out supply to meet their base load
  – Establish contracts for either long-term or short-term supply

• May procure contracts with:
  – Energy traders/marketers
  – Merchant generators
  – Importers

• Buyers procure additional energy in the day-ahead market timeframe, based on their load forecast

• Any demand consumed in real-time is supplied with supplemental offers of generation (Spot Market)
Network model shows where energy is injected into the grid or taken off the grid (source and sink) and is key to pricing.
Market Transactions

• Bids or schedules for energy
  – Physical supply from generation or imports
  – Physical demand from load and exports
• Bids or self provision for ancillary services capacity
• Bids for Residual Unit Commitment (RUC) capacity – additional capacity based on forecast
Day-ahead Market Input/Output Data

Bids, Outage Information, LF, A/S and RUC requirements

- Categories of Data
  - System parameters
  - Resource parameters
  - Outage information
  - Bid information

- Requirements
  - Ancillary services
  - Residual unit commitment
  - Demand forecast
  - RMR determinations
  - Transmission interface limits

DAM Market Results
Day-ahead Market Processes

- **Begin DAM process**
  - Pull data from external sources

- **Run MPM**
  - Evaluate bids for market power

- **Run DAM**
  - Will clear bid-in supply with bid-in demand plus procure 100% of the ancillary service requirement

- **Run RUC**
  - Will procure additional capacity to meet locational requirement

- **Publish results**
  - DAM results are published
Real-time Market Input/Output Data

- From the Day-ahead
  - System information
  - Energy schedules
  - AS and RUC awards
  - Master file information
  (via Automated Dispatch System - ADS)

- From Real-time
  - Real-time system information-State Estimator
  - Supplemental energy and AS bids
  - Outage information
  - Transmission interface limits

RT Market Results
Energy Bid (MW-$/MWh Pairs)

Provides the Market Operator an economic signal about what you’re willing to accept or pay for energy

SUPPLY
Monotonically INCREASING and segmented

DEMAND
Monotonically DECREASING and segmented

Supply Resource (Generators and Imports)

Demand Resource (Demand and Export)

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Day-ahead Market Clearing

Bid-in Supply with Bid-in Demand PLUS 100% of A/S Requirement and additional demand based on LF

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Locational Marginal Pricing and its Components

The marginal cost of serving the next increment of demand at a given pricing node subject to existing transmission constraints and the performance characteristics of resources.

- System Marginal Energy Cost is the same at all locations.
- Marginal Cost of Congestion reflects the cost to move energy across transmission lines due to the physical limits and demand on the line.
- Marginal Cost of Losses is the cost associated with losses as energy moves across the system.

Energy + Congestion + Losses = Locational Marginal Price
Settlement System Input/Output Information

- Energy Schedules and Awards
- AS Awards
- RUC Capacity

- RT dispatches
- AS Awards
- Start-up/Shut down via ADS

Settlement and Market Clearing System

- Deviations from the day-ahead schedule are assessed in the real-time market settlement
- Day ahead settlements remain same in real-time if the resource followed instruction
Conclusions

• Market price is competitive and reflects actual cost of generating and delivering energy

• Using the Bid pool, the market will clear Bid-in Supply against Bid-in Demand, and procure any additional demand
  – Procure 100% of the ancillary service requirements
  – Respect resource constraints
  – Honor transmission limitations
  – Produces financially binding energy schedules
  – Produces ancillary service awards

• Schedules and awards are settled at hourly LMP and ASMP as produced by the DAM and dedicated RTM time intervals

• GRIDCo is committed to the implementation of the Ghana Wholesale EM and the WAPP’s regional electricity market

Benefits from deregulation must come from a change in market participants’ behavior
What to take away