Global Scientific JOURNALS

GSJ: Volume 9, Issue 10, October 2021, Online: ISSN 2320-9186

www.globalscientificjournal.com

ANALYSIS OF DEREGULATED ELECTRIC POWER SECTOR AND EMERGING ANCILLARY SERVICES IN NIGERIA

BY

T.D. BESTMANN, A.O. ODUKWE and J. C. AGWUNWAMBA

Maintenance Department, Nigerian Agip Oil Company Limited, Kwale, Delta State, Nigeria.

Faculty of Engineering, University of Nigeria, Nsukka

Abstract:

Ancillary services on the interconnected grid are necessary support for power transmission while maintaining reliable operation and to ensure exact level of quality and safety. So many activities of the operator are classified under the preview of ancillary services and the correct meaning and explanation of some of these services and distinctions are given enough clarity. The basic three ancillary services with importance that are provided by the independent power producers in a deregulated power set up are; (i) system voltage profile maintenance in an adequate range, (ii) keeping system frequency within economically related value and (iii) maintaining the system security with required spinning reserve. An overview of how reactive power, spinning reserves and frequency regulation services are managed by the system operator in a deregulated electricity markets in Nigeria is presented. Economic models are proposed for participants in reactive power, spinning reserve and frequency regulation service markets. With the optimal procurement of the ancillary services by the independent power producers in consideration, this work attempt to obtain a beneficial plan for the power system, from both technical and economic views and prospects.

Keywords: deregulation, electricity market, ancillary services, reactive power, frequency regulation, reforms

1.0 Introduction

The electric power industry has over the years been dominated by large utilities that had an overall authority over all activities in generation, transmission and distribution of power within its domain of operation. Such utilities have been referred to as vertically integrated utilities, and these served as the only electricity provider and were obliged to provide electricity to everyone. Since the past decade, power utilities in Nigeria have been going through a process of reforms in order to introduce commercial incentives in generation, transmission and distribution. The main objectives of the reforms are achieved through a clear separation between production and sale of electricity, and network operations. The vertically integrated generation, transmission and distribution system operations have been separated into independent activities. The generation companies and power stations sell energy through competitive long-term contracts with customers or by bidding for short-term energy supply at the spot market [7], [8].

Transmission is still a monopoly since the economics of scale are very high. Transmission open access has proved to be an important requirement in deregulated systems. To guarantee a level playing field for the generators and customers to access the transmission network, the transmission system operator is required to be independent from other market participants. The Independent System Operator (ISO) has acquired a central coordination role and carries out the important responsibility of providing for system reliability and security. It manages system operations, such as scheduling and operating the transmission related services. The ISO also has to ensure a required degree of quality and safety, provide corrective measures when faced with incidents, and several other functions. [7] In addition, the ISO could also manage market administration, energy auction and unit commitment functions in the pool market structure. To this effect, certain services, such as, scheduling and dispatch, frequency regulation, voltage control, generation reserves are required by the power system, apart from the basic energy and power delivery services. Such services, which are now commonly referred to as ancillary services, had all along been part of the normal electricity supply and were not separated in the traditional vertically integrated power systems. Ancillary services are also referred to as Interconnected Operation Services by the Nigerian Electricity Regulatory Council (NERC). However, in a deregulated power systems, transmission networks are available for third-party access to allow power wheeling, thereby giving rise to spot markets for electricity. In such a deregulated environment, the ancillary services are no longer treated as integral to the electricity supply, they are unbundled and priced separately, and system operators purchase ancillary services from the providers. Issues pertaining to costing of ancillary services and hence appropriate pricing mechanisms for all market participants to recover the costs become an important case for proper functioning of the system, [4].

1.1 Problem statement

Regulated vertically integrated utilities have provided the main bulk of electricity service to consumers in Nigeria for the past decades. The traditional regulatory compact for electricity service grants a utility the exclusive right to supply electricity to customers in a specified geographical area. The compact also maintains the utility's financial integrity by allowing it to recover reasonably incurred expenses and to earn a fair return on its capital investment. Government regulate these utilities to ensure that they provide safe, reliable and reasonably priced service to all consumers within the franchise area, subject to the condition that they do not unduly discriminate against any consumer, However, there is a growing consensus that this regulatory compact has failed to provide low cost electricity. Policy makers have arrived at the conclusion that cost-of-service regulation has been a major cause of high electricity costs. It is also understood that this regulatory frame work is fundamentally at odds with and ill-suited to bring about a reduction of these costs. The deregulation of utilities and the introduction of competition to the electricity service market are seen as an alternate market framework to exert downward pressure on the prices of residential, industrial and commercial consumers,. During the period of reviewing the system and timing of electric markets deregulation and the introduction of competition, various market models have emerged; the manner in which these competitive models are implemented affects how electricity products are priced. The electric power sector will be in a disorderly and confused price tracks in the short run with introduction of competition and change adjustments. These prices will begin to stabilize in the medium run as independent partners enter and exit the market, moving towards competitive equilibrium positions. In theory, over time all remnants of the regulatory body composition will be taken off, and the electric market will function in a perfectly competitive pattern.

As new capacity is required due to plant retirements and new electricity demand growth, electricity prices will move towards a long run prices based on the cost of service set by new electricity generating plants. Due to homogeneous characteristics of electricity, it has been seen as a product that will be transacted with a single price attached to it. The implication is that the long run price of electric service rests on a single value and that all consumers will receive same types of power product service. However, this view does not take cognizance of the electricity market place fragmentation as soon as individual customers gain the ability to choose providers, and providers gain the ability to offer consumer tailored services. Given the large diversity of consumption patterns and requirements by the array of residential, industrial and commercial establishments; the perception that electric services can only involve a uniform level service is not true and can mislead reform efforts. Individual consumers in a deregulated market place will have the freedom to create their own custom bundle of electricity that will invariably reflect the current traditional full service provided. Competitors will find and deliver to customers more efficient ways to provide service needs but also possibly find new different services to meet consumer needs. [4] [8].

2.0 Concepts of ancillary services

The customers see ancillary services as integrated to its electricity supply and are not separately analyzable. Any customer connected to the network is indirectly a consumer of ancillary services through continuity of the supply and its quality received. For power producers, whether they are vertically integrated utilities or independent power producers, ancillary services are mainly defined by the basic contributions being made to fulfill the system functions. The power producers supply active power, absorb reactive power, control the grid voltage and equally maintains the system frequency and in addition, will carry out improvement services on the system operation, such as following up daily load, supplying reliable forecast information with regards to availability, and restoring voltage when failure occurs, hence their capacity to create load trip. Finally, the power system operator brings both power producers and customers together. The power operator collects the basic contributions of power producers, incorporates them into the economic management of the system while adding its own contribution and provides carefully worked out services to assure continuous supply to customers. By implication, this calls for resources and costs padding; it therefore raises the problem of evaluating the cost for the system, compensation of service suppliers and the allocation of costs to service customers.

2.1 Definition of Ancillary services

Ancillary services are those services provided by the machines in the system and generators that generate, control, and transmit electricity in support of the basic services of generating capacity, energy supply, and power delivery. These services are necessary to support the transmission of power while maintaining system reliability and also ensure the required level of quality and safety.

2.1.1. Services for routine operation

- System Control: the control area operator functions are that of schedule generation, transactions and control generation in real-time to maintain load balance;
- Voltage Control: the injection or absorption of reactive power from generators to maintain system voltages within required limits;
- Regulation: the use of generation to maintain minute-to-minute generation/load balance within the control area; and
- Load following: the use of generation to meet the hour-to-hour and daily variations in load.

2.1.2. Services to prevent an outage leading to catastrophe

- Spinning Reserves: The provision of unloaded generating capacity that is synchronized to the grid and can immediately respond to correct load imbalances, caused by generation and/or transmission outages, and that is fully available within several minutes;
- Supplemental Reserves: The provision of generating capacity and reduce load to correct load imbalances, caused by generation or transmission outages, and that is fully available within several minutes; and
- Network Stability Services: Maintenance and use of special equipment (power-system stabilizers and dynamic-braking resistors) to maintain a secure transmission system.

In addition to these three services, voltage control service falling in item (1) can also act like item (2) services and prevent voltages from decaying provided voltage drop occurs, and system control is required to manage these services.

2.1.3. Services to restore a system after blackout

- System Blackstart Capability: The ability of a generating unit to proceed from a shutdown condition to an operating condition without assistance from the electrical grid and then to energize the grid to help other units start after a blackout occurs. System Black start, along with several of the services discussed previously (system control, voltage control, network stability, contingency reserves, regulation, and load following) is required to rebuild the electrical grid after system blackouts.

3.0 Reactive power management as ancillary service

Power system is characterized by bulk flows, where a major share of generation is located near most of the load centers over long distance transmission lines. As reactive power cannot be transmitted over such distances, power providers within the locality should take over supply responsibility. The transmission system in Nigeria comprises 330KV and 132 KV circuits and substations. Reactive power services are provided on a basis required by law although various schemes for financial compensation to the providers of this service are being considered. Reactive power exchange on the national grid is controlled by instructions from Transmission Company of Nigeria (TCN). It is recommended that reactive power flow between different parts of the grid be kept 'near zero'. The Independent System Operator (ISO) has the right to the supply of reactive power from spinning generators directly connected to the national grid. The various network companies are responsible for voltage control in their respective areas. Under normal conditions the independent network operators use as much static reactive power production as possible. Large generators are rarely used for secondary voltage control and are reserved for serious situations. Such units operate at a constant reactive power output, with a stable operating point considering vibration and losses.

3.1 Arrangement for Reactive power transfer over the Grid

For power transactions over the network, Nigeria Electricity Regulatory Council (NERC) enters into formal agreements for reactive power exchange with independent generators. Agreement for feeding power into the national grid is mostly with producers but in certain cases, can also be with other networks. The standard set of agreements is discussed below:

- A hydro unit connected directly to the national grid is required to be able to inject as well as absorb reactive power as per the following limits.

  $$Reactive\ injection = \frac{1}{3} P\ \mathrm{max}$$

  $$Reactive\ Absorption = \frac{1}{6} P\ max$$

- A thermal unit connected directly to the national grid is required to maintain capability of reactive power injection as per the limits, given below. However, it has no requirement on absorption of reactive power.

  $$Reactive\ injection = \frac{1}{3} P\ \mathrm{max}$$

- A regional network with agreement to inject real power into the national grid is required to maintain a capability to inject reactive power, depending on the instantaneous real power injection, as given below:

  $$Reactive\ injection = \frac{1}{3} P\ \mathrm{instantaneous}$$

The system has no requirement on absorption of reactive power from the national grid, and no specific requirement from a generator connected to the regional grid.

- A regional network with agreement for drawing real power from the national grid, has no requirement for injection or absorption of reactive power to/from the national grid.

The power transmission capability available from a transmission line design is limited by technological and economic constraints. Therefore, in order to maximize the amount of real power that can be transferred over a network, reactive-power flows must be minimized. Consequently, sufficient reactive power should be provided in the system to keep the bus voltages within nominal ranges in order to satisfy customers' equipment voltage ratings.

The reactive devices have different characteristics in terms of dynamics and speed of response, ability of voltage changes, capital costs, operating costs, and opportunity costs. For example, synchronous generators are very fast reactive support devices, but have high opportunity costs if real-power output has to be reduced to produce more reactive power. Opportunity cost of reactive power is the profit that could otherwise be harnessed, but is given up by the power supplier in order to generate reactive power. On the other hand, capacitors are slow and have poor performance but are cheap to install and operate. The characteristics of different types of voltage-control equipment are given in Table 1, [3].

Table 1: Characteristics of different types of voltage control equipment

S/N	Equipment type	Speed of Response	Ability to support voltage	Capital cost per (kVAr)	Operating Cost	Opportunity Cost
1.	Synchronous Generator	Fast	Excellent, additional short-term capacity	Difficult to separate	High	Yes
2.	Synchronous Condenser	Fast	Excellent, additional short-term capacity	$30-35	High	No
3.	Capacitor	Slow	Poor, drops with V2	$8-10	Very low	No
4.	Static VAR Compensator	Fast	Poor, drop with V2	$45-50	Moderate	No

Source: [4]

In a vertically integrated power system, reactive power support was part of the system operator's activities and the expenses incurred in providing for such services were included within the electricity tariff charged to customers.

In a deregulated electricity market, provision for reactive power support needs to be made by the Independent System Operator (ISO) in order to meet the contracted transactions in a secure manner. Since it is not desirable to transport reactive power over the network, procurement of reactive power services should be done taking cognizance of the perceived demand conditions, mix of the load and availability of reactive power resources. Often times, the independent generators own the resources for reactive support such as synchronous generators, synchronous condensers, capacitor banks, reactors, static Var compensators and Flexible Alternating Current Transmission System (FACTS) devices, and the Independent System Operator (ISO) needs to obtain contractual agreement for such provision.

Reactive power management and payment mechanisms vary for each deregulated electricity market, usually the Independent System Operator (ISO) enters into contracts with reactive power providers for their service provisions. In the Nigerian context, as per Operating Policy, only that reactive power provided by synchronous generators are considered ancillary services and can receive financial compensation for their services, [3] [11]. This is also true for the UK and Australian markets. The Australian market additionally considers reactive power from synchronous condensers as an ancillary service; and in a similar manner network companies in Netherlands, have to take care of their reactive power requirement individually. These companies however purchase reactive power locally through bilateral contracts with generators or through exchanges with other network companies. Those generators that have been contracted for the reactive power service are paid for their reactive power capacity only.

Presently, there is a move towards creating payment mechanisms for reactive power services in many systems. However, a fully competitive reactive power market is not available; albeit, several issues are making operating reactive power services within a competitive market framework very difficult. Some of these are listed out as follows:

• Reactive power services are required to be provided locally, and hence the 'worth' of one Mega Volt Ampere Reactive (MVAr) of reactive power is not the same everywhere in the system. Consequently, if a reactive power market is settled like a real power market, the Independent System Operator (ISO) can end up contracting a set of low-priced offers, from such locations that are undesirable from system considerations. Therefore, reactive power markets need a new approach that takes into account both offer prices and location of the resource.

• None of the deregulated electricity networks yet recognize reactive power from sources other than generators or synchronous condensers as "ancillary services." Changes at the policy level are necessary to include other reactive power sources such as capacitors, reactors, Static Var Compensator(SVCs), i.e. (for utility power grid to improve Power Transmission and Distribution performance) and Flexible Alternating Current Trans mission System (FACTS) devices etc., as ancillary services. This would enlarge the market and increase the competition, and inevitably increase the market efficiency and fairness. However, in this frame work, only generators and synchronous condensers are considered as reactive power ancillary service provider.

• A long-term contract based reactive power market could prevent providers from exercising their market power and offering their reactive energy at higher prices than the cost of alternative reactive power generation [10] [14]. It can be invariably summarized that reactive power needs to be introduced in the ancillary service markets in a fair and equitable manner. Providers of reactive power support should be compensated for their services. However, there are several complex issues involved in handling a reactive power service and in creating an efficient market for reactive power.

4.0 Deregulation concept and impact on power sector in Nigeria

Deregulation is best described as the process by which government show blanket intention to leave market economy to dominating forces in the market place and pull out its control and authority through laws and regulations imposition. [9] [12] stated that the famous quality of deregulation is the need to liberalize the economy to enable market forces produce effectiveness and reduce system inefficiencies, and restructure the rules and economic incentives as a plan to control and drive the power industry deliberately to success. It has been argued that deregulation has becomes a necessary policy by the government when it becomes important for certain utilities handled by government to be transferred to private investment such as the electric power industry. The purpose of the deregulation policies highlights the advantages in a capitalist economy like Nigeria; however, this impressive economic concept is not without its negative or undue adverse effects.

[5] [6], stated that deregulation of the economy in Nigeria was the main basis for introduction of Structural Adjustment Programme (SAP) in 1986 by the ruling government at then. Largely, the Nigerian economy had been under the singular control of the government that destroyed the entire economic system, because the business of leadership and economic success that would create stability in the social life of people are quite two different things altogether. The government of Nigeria at the introduction of the policy was thought to be the final solution to the economic crisis faced by the country prior to 1986, but how fair has the journey taken until now?

The Nigerian power sector before 1999 was to say the least, in a deplorable condition. Only 15 out of 79 generating units installed were available for service as at 1999, with generation capacity of only I, 520 MW, hence severe outages crippled the economy, because no new power plants were built over the years and no major overhaul of the existing power infrastructure took place, [10]. With the last transmission line built in 1987, the power transmission infrastructure was weak while the epileptic distribution network was incapable of providing a satisfactory level of service to consumers.

While the government clearly understood that massive investment in all the three tiers of the electricity industry was necessary, a holistic approach was essential in tackling the problem. The first few years were therefore utilized in system studies, planning and preliminary engineering designs, rehabilitation of existing facilities as a transitional initiative to raise generation capacity to about 3,000 MW by the year 2003, [5] [9]. This was intended to provide relief to consumers, because new power plants will require several years to build and put into use.

This unprecedented growth in power infrastructure evolved to National Integrated Power Projects (NIPP), under which a large sum of $2.5 billion was expended. National Integrated Power Project (NIPP) is a catalyst for sustainable power supply through the policy of 2001 and the Electric Power System Research (EPSR) Act 2005, initiated by the government, was committed to a comprehensive power reform program to restructure, privatize and liberalize the power sector. This blueprint was aimed at ultimately bridging the huge gap that existed between demand and supply, and intended to foster in the short run reliance on public sector generation projects with only a few private sector initiatives, but in the medium and long terms, the entire sector would be privatized under the new Public Private Partnerships (PPP) model.

The 2001 Power Policy and EPSR Act 2005 reform blue print set the stage for the unbundling of NEPA into 18 semi-autonomous (11 distribution, I transmission and 6 generation companies) controlled by the Power Holding Company of Nigeria (PHCN), [12]. Eventually, NEPA's successor company (PHCN) as a transitional enterprise is expected to be privatized into private ventures. To demonstrate its commitment in providing a road map for the power sector, the Federal Government set a generation target of 10,000 MW capacities and in marching its ambitious reform with action, the government introduced a comprehensive plan to increase power generation and overhaul the entire power system with focus on delivery. No sooner than expected, two new power plants Afam V and Delta II providing 426MW were commissioned and the 300 MW IPP AES Barge came on stream; alongside, the Agip IPP 480MW. Under the arrangement with Chinese partnership, the government funded new electricity generation stations in Omotosho (315MW), Geregu (414MW), Papalanto (335MW), Alaoji (346MW) and Delta III (150MW).

4.1 Electricity pricing in a deregulated market in Nigeria

Deregulation of the electricity industry in the industrialized and developing countries encourage new independent power producers (IPPs) to enter into the market. In 1996, IPP accounted for 3% of the market for new power plant, compared with less than 5%s some ten years ago when IPP were first established in the United States and the United Kingdom's following deregulation. Presently, the model has spread to other countries that require private finance to fund their growing request for electricity. In this line, the pricing process has to be looked into, to ensure that the poor are not left out of the scheme. In Nigeria before the transition to deregulation, electricity price per kilowatt hour was between N4 and N6 for single phase resident and N6 and N8 for industrial users; while maximum demand users pay N8 and N12 per kilowatt hour. But with total deregulation the price of electricity may be reduced [2] [3].

The Nigerian Electricity Regulatory Commission (NERC) has adopted a Multi- Year Tariff Order (MYTO) as against a single year Order (SYTO), giving the MYTO system to provide a price path into the future. It allows for limited adjustments each year according to cost of inflation and changes in fuel costs and for major reviews each five years to allow a fundamental review of the inputs into the tariff calculations, hence it is believed that the MYTO would reduce some of electricity producers and other investor's costs. This regime of tariff is expected to encourage investment in Nigeria's electricity market, thus expressing the tariff model as shown below:

$$P = \sum_{n}^{N} \left(C_c + C_m + C_{O+m} + C_f + C_{mc} + \infty \right)$$

Where N is number of years:
C, m, o+m, f, mc + co are Capacity, Maintenance, Operation and Management, fuel and metering and Connection Charges respectively. To maximize profit, then the tariff should be the unit production of electricity which will be adjusted in such a way that marginal revenue will be equal to the marginal cost.

Table 2: Electricity Pricing in Regulated Market in Nigeria

S/N	User	Date	Regulated Market Per Kilowatt hr. (N)
1.	Single Phase Resident	22/07/017	N4- N6
2.	Industrial	22/07/017	N6 – N8
3.	Maximum Demand	22/07/017	N8 – N12

Source: [3]

Table 3: Electricity Pricing in Regulated Market in Nigeria

S/N	User	Date	Deregulated Market Per Kilowatt hr. (N)
1.	Single Phase Resident	22/07/019	N4- N6
2.	Industrial	22/07/019	N6 – N8
3.	Maximum Demand	22/07/019	N8 – N12

Source: [3]

With the result shown on table 2 and 3 above, electricity deregulation is recommended to developing the economy, hence it creates job, wealth and improves performance, [13] [15].

5.0 Conclusion

This analysis is to examine the various issues involved in electric power ancillary services in the context of power sector deregulation. Particular emphasis is on reactive power service, spinning reserve service and frequency regulation service, and how they are managed by the system operator in deregulated markets. To this, an overview of ancillary service management in Nigeria was examined and issues pertaining to independent generators acting as reactive power providers in competitive markets were placed in front.

The economics of generating units operating in markets for energy and ancillary services provides the operation rules for facilities that depend on prices of energy and ancillary services with a view on why resources are and should be used intensively for ancillary services provision. The fact that the prices of ancillary services go down dramatically due to strong generating plant resources in these markets suggests profitably ancillary services can be sold to other utilities that do not have much capacity by the transmission authority. The analysis of long run costs of electricity in a competitive market and also evaluation of the possibility and magnitude that competitive advantage techniques could lower the price of electricity has prompted these conclusions presented below:

- There is a large range of cost of service attributed to the various customers in the electricity market. However, complementary traits can enable a customer class to aggregate itself to better electricity prices;
- Aggregation of customer loads provides for extensive opportunity to improve load utilization factors for supplier power plants. Higher plant utilization factors and minimization of capacity allocation lead to reduced electricity costs for all consumers;
- The monetary sharing benefits of aggregation will be determined by supplier and customer bargaining power rather than a centralized utility or regulatory commission; and
- This type of competitive advantage in a competitive electricity market is conditional on the collection, analysis and optimization of large amounts of data. Much of the electricity market competition will be waged at the information level.

References

1. Adegoke, 0. S. "Conventional Energy Resources in Nigeria", 1991, In Adegbulugbe and Seriki Ed Energy Issues in Nigeria: Today and Tomorrow.
2. Anyaka, B. O. (2014). Challenges of Deregulation of Electric Power Sector in a Third World Economy. IOSR Journal of Electricity and Electronics Engineering, 9(3), 19–22.
3. Boniface .O. A. Challenges of Deregulation of Electric Power Sector in a Third World Economy, IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE) e-ISSN: 2278-1676,p-ISSN: 2320-3331, Volume 9, Issue 3 Ver. III (May – Jun. 2014), PP 19-22 www.iosrjournals.org.
4. Blumstein, C. and Bushnell, J. A Guide to the Blue Book: Issues in California's Electric Industry Restructuring and Reform the Electricity Journal September 1994: 18-29.
5. Efuru I. "NIPP Catalyst for Sustainable Power Supply", PHCN News May-August, 2006: Page 5.
6. Godwin, D.T & Dagogo, D. (2003). Proceedings of the 1 Proceedings of the 1st International Technology, Education and Environment Conference (c) African Society for Scientific Research (ASSR), (c), 678–687.
7. K. Bhattacharya, M.H.J. Bollen and J. E. Daalder, Operation of Restructured Power Systems, Kluwer Power Electronics and Power Systems Series, Kluwer Academic Publisher, USA, 2001, ISBN 0-7923-73979.
8. K. Bhattacharya and J. Zhong, "Closure to Discussion by Carson Taylor, on Reactive Power as an Ancillary Service", IEEE Transactions on Power Systems, Vol.17, No.2, May 2002, pp.523-524.

9. Kuye, O. (2012). The Economics of Deregulation and Ramifications for Law and Development Journal of Economics and Sustainable Development, 3(4), 55–61.
10. Loi Lei Lai “Energy generation under the new development; Power System Restructuring and Deregulation- Trading, Performance and information Technology, edited by Loi Lei Lai, John Wiley, Chicester, 2002 pp 1 – 49.
11. M. Ilic, F. Galiana and L. Fink (Eds.), Power Systems Restructuring: Engineering and Economics, Kluwer Academic Publishers, 1998.
12. PHCN News. "Electric Power Reform Law 2005 (VI)", PHCN Review January-April, 2006: Page 17.
13. Steven Stoft, Power System economics: designing markets for electricity, wiley inter-science NY2002.
14. Stankov, P (2010). Deregulation, Economic Growth and Growth Acceleration. A Working Paper Series of the Centre for Economic Research and Graduate Education
15. T. Mc Govern and C. Hicks, “Deregulation and restricting of the global electricity supply industry and its impact power plant suppliers” International Journal of Production, Economic Vol 89, Issue 3.18 June 2004, page 321-337.