

# The GCC Power Grid: Benefits & Beyond

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*Abstract – Unlike any project, the GCC interconnection power grid has been the focus of attention of governments, businessmen and even the general public in the GCC region and the abroad. The GCC Interconnection power grid which is currently under constructions will link-up all six countries in three phases, with a target date of 2010. With this multi-million dollar asset the GCC countries will have developed an infrastructure considered to be ‘backbone’ of the Gulf Countries High Voltage Grids which can be utilized for numerous purposes. Not only will the grid reduce high long-term investment cost of power systems by reducing the level of generation reserves and provide assistance during emergency situations, but will also provide opportunity for the GCC countries to trade power energy among themselves and eventually with other neighboring power pools (i.e.) EJLIST, UCTE, etc. thus offering a wide range of opportunities for the power sectors in the region and abroad.*

*The objective of this paper is to provide a detailed update of the construction of the interconnection project and the opportunities that lay ahead for the GCC countries with respect to trading power energy; and what steps are or have been taken to set up the proper trading structure which addresses the technical, legal and administrative frameworks in order to ensure that this strategic project delivers significant technical and economical benefits to the GCC countries.*

**Index Terms – energy trading, generation, interconnection, GCC, IWPP, power grids, power sector, legal framework, fiber optic, structuring, transmission, scheduled exchanges, unscheduled exchanges.**

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## I. INTRODUCTION

Realizing the urgent need to meet power requirements in their bustling economies, the GCC Countries, consisting of the six Arab Gulf countries namely, the United Arab Emirates, Bahrain, Saudi Arabia, Oman, Qatar and Kuwait have jointly embarked on several developmental campaigns, one of them being the to develop and interconnect their power systems with each other. With the ‘Second Oil Boom’ underway and increasingly growing population the demand in utility services has become a major concern for these countries.

Although the idea of the power grid was initiated in the early eighties it took many years before the GCC Interconnection Authority (GCCIA) was established, and the project started. This comes as a fact of the economic and political circumstances the region had undergone, especially in the 1990’ despite the study carried out in 1990 which defined the Interconnection Project and determined its feasibility. The study recommended an AC interconnection of the 50 Hz systems of Kuwait, Bahrain, Qatar, UAE and Oman with a back-to-back HVDC interconnection to the 60 Hz Saudi Arabian system. The study concluded that the recommended Interconnection Project for the GCC countries was technically feasible as well as economically and financially viable.

Pursuant to the recommendations contained in the 1990 study, the Gulf Co-operation Council Interconnection Authority (GCCIA) was established in 2001 with the mandate to proceed towards implementing the Interconnection Project.

In light of the time that has elapsed since the 1990 study and in view of the evolution of the power sectors in the GCC countries, it was decided in 2002 to update the study that had been carried out and to re-confirm the feasibility of the interconnection project, carry out a market study, prepare a plan for the financing of the Project, develop the Agreements that have to be reached between the different countries, and prepare an implementation strategy and necessary mechanism in this regard. This work was completed in 2004 with all its pros and cons in consideration and as a result a decision has been taken to proceed with implementation of the project.

## II. FORMATION OF THE GCC INTERCONNECTION AUTHORITY

As a result of the several studies that were conducted by various local GCC and international consultants to analyze the feasibility of the GCC Interconnection, and based on the recommendations of the 1990 study, which has demonstrated that the interconnection among the GCC member countries is technically feasible as well as economically viable, the GCC Interconnection Authority was established in Dammam, Saudi Arabia as a joint Gulf stock company by Royal Decree No. M/21 dated 8/5/1422 (29 July 2001) signifying the realization of the GCC leaders vision towards the creation of an integrated economy among the gulf countries.

It has been long recognized that electricity is the engine of development of all nations. In this context Governments, economists and utility experts have concluded that the most suitable approach towards the development and efficient use of resources of electricity generation, transmission and distribution should be based on a competitive basis, to bring about lowering of electricity costs. A regionally integrated electricity market can be the solution.

Although the GCC Interconnection studies have shown a benefit to cost ratio of 1.77, it only reflected savings in investments in Installed Generation Capacity that would be realized based on the possibility of sharing Operating Reserves through the Interconnection. However, the formation of the GCC Interconnection Authority is considered the first step in achieving a regionally integrated electricity market where the consumers in the gulf would be the ultimate beneficiaries by the most economical resource allocation. The Interconnection will open the doors to independent power producer (IPP) and independent water and power producer (IWPP) to select the best plant site to serve more than one GCC country, optimizing the investment returns and minimizing transmission costs.

## III. PHASES OF THE PROJECT

The Interconnection Project is being implemented in three phases and consists of the following principal elements:

*Phase I: Interconnection of the Northern Systems (Kuwait, Saudi Arabia, Bahrain and Qatar) to be completed in early 2009:*

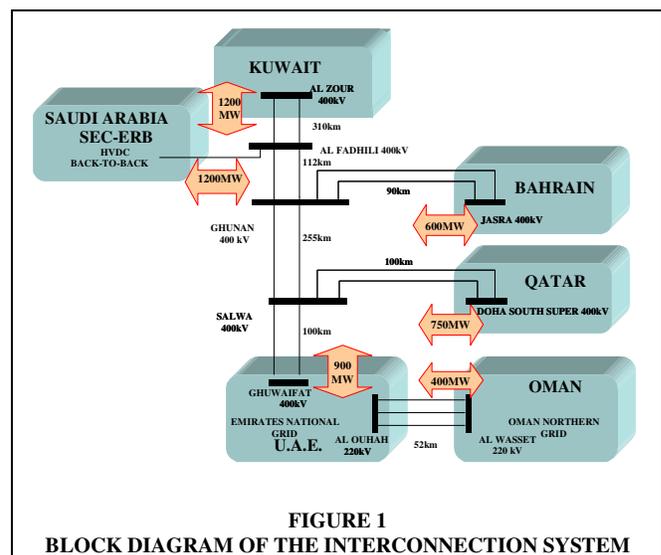
- A double-circuit 400 kV, 50 Hz line from Al Zour (Kuwait) to Ghunan (Saudi Arabia) with an intermediate connection at Al Fadhili (Saudi Arabia) and associated substations.
- A back-to-back HVDC interconnection to the Saudi Arabia 380 kV, 60 Hz, system at Al Fadhili.
- A double circuit 400 kV, 50 Hz comprising overhead lines and submarine link from Ghunan to Al Jasra (Bahrain) and associated substations.
- A double circuit 400 kV, 50 Hz line from Ghunan to Salwa (Saudi Arabia) and associated substations.
- A double circuit 400 kV line from Salwa to Doha South (Qatar) and associated substations.
- An Interconnection Control Centre (ICC) located at Ghunan.

*Phase II: The internal interconnection of the Southern Systems (UAE and Oman) to form the UAE National Grid and the Oman Northern Grid (GCCIA is not involved in this Phase).*

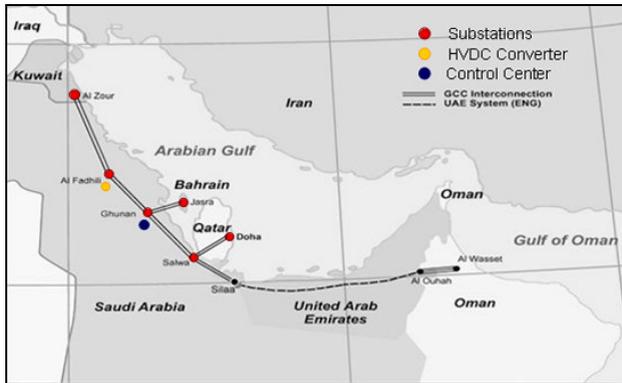
*Phase III: Interconnection of the Northern and Southern Systems in 2010.*

- A double circuit 400 kV, 50 Hz line from Salwa to Al-Silaa (UAE) and associated substations.
- A double and a single circuit 220 kV, 50 Hz line from Al Ouhah (UAE) to Al Wasset (Oman) and associated substations.

A block diagram of the Interconnection Project is shown in Figure 1.



The electrical grid system interconnection between the GCC states is shown geographically in Figure 2.



**FIGURE 2  
GEOGRAPHICAL ROUTE AND LAYOUT OF THE GCC  
INTERCONNECTION**

#### IV. ELEMENTS & STATUS OF THE POWER GRID

The estimated capital cost of Phase I is \$1.095 billion. The Zurich-based ABB which includes ABB Contracting Company of Saudi Arabia won the Contract for the six substations. The total value of ABB contract was \$222 million making it one of the largest substation orders ever won by the company. ABB is responsible for design and manufacturing of the equipment, system engineering, installation, commissioning and civil works. Till October 2007 works completion has ranged between 50% and 95%. Figure 3 shows 400kV switchgear installation works inside Al-Fadhili substation.



**Figure 3 - 400kV Switchgear installation works at New  
GCCIA Al-Fadhili Substation, KSA**

A consortium of worldwide leaders in the cable industry, Prysmian Cables & Systems and Nexans won the largest of the contracts worth \$343 million to install the submarine cable and land cables that will link Bahrain to Saudi Arabia. One circuit of the cable is scheduled to be completed within 37 months with the second circuit to be completed in 50 months. Approximately 12% of the works for this project has been completed by October 2007. These links will run from Al Jassra substation in Bahrain to Ras Al Qurayyah in Saudi Arabia via Umm Na'san Island. The submarine sections will be 40 km long and the underground sections 7 km long. The overall weight of the cables to be delivered for this project will be over 12,000 tones.

Areva T&D and Cogalex were awarded two contracts worth \$234 million. Under the first contract, Areva will deliver the region's first back-to-back 1800 MW HVDC converter station. The station will consist of three 600 MW converters including thyristor valves, 375 MVA converter transformers as well as 380 kV and 400 kV circuit breakers. More than half of the works for this facility has been completed.

Under the second contract, Areva T&D will design and build the GCCIA grid's entire protection, Control & telecommunications solution. It will construct a new Interconnection Control Center (ICC) equipped with a SCADA and Energy Management System (EMS) based on Areva's e-terraplatform software. The centre is designed to remotely operate and monitor all GCCIA 400kV grid and substations, with emphasis on the efficiency and safety of the power grid, and to coordinate its operations with other GCC Control Centers, enabling energy exchange between GCC countries national grids, and managing the recording and billing of energy transactions between the different countries. Areva will also develop a fibre optic based telecommunications infrastructure spread across approximately 800-km that will relay control commands and retrieve key substation information to the control center via a fiber optic high-speed network and backup digital power line carriers. Figure 4 below depicts an artist impression of the completed Interconnection Control Center at Ghunan, which will control and coordinate all GCC Interconnection activities.



**Figure 4 – Artist's Impression of the GCCIA ICC**

For the 400kV Overhead Lines, National Contracting Company (NCC) and Middle East Engineering & Development Company (Meedco), an affiliate of South Korea's Hyundai Engineering & Construction Company, both won two each of the four lots on the overhead line package, totaling around \$280 million. Till date more than half the works have been completed.



**Figure 5 - Construction of Tower near Ghunan Substation**

SNC Lavalin International received the final contract covering the supervision work and is also acting as the project consultant. SNC Lavalin has been involved with the GCC Grid project since it was first conceived, including preliminary studies and detailed engineering. This latest \$16 million Engineering contract involves supervision of the final designs and suppliers, as well as of the construction of the project itself.



**Figure 6 - Completed GCCIA 400 kV towers**

Lots	Tender Winners	Contract value (\$ million)
Substations (6)	ABB (including ABB Contracting Co, Saudi Arabia)	221.98
HVDC	Areva-Cogelex	205.89
OHL	NCC & MEEDCO	280.40
Submarine cables	Prysmian-Nexans	343.10
Control centers	Areva-Cogelex	27.60
Supervision	SNC-Lavalin	16.30
<b>TOTAL</b>		<b>1,095.27</b>

**Table 1 - Value of Contracts in the First Phase**

## V. COSTS OF THE POWER GRID

It was agreed amongst the countries to share the costs of the Interconnection in proportion to the reserve capacity savings. Considering the time value of money and that the capacity savings occur at different points of time, it was agreed to share the costs in proportion to the present value of the capacity savings proportionately.

It was agreed to share the costs for the Project as follows:

Country	Phase I %	Phase I & III %
<b>Kuwait</b>	33.8	26.7
<b>Saudi Arabia</b>	40.0	31.6
<b>Bahrain</b>	11.4	9.0
<b>Qatar</b>	14.8	11.7
<b>UAE</b>	---	15.4
<b>Oman</b>	---	5.6
<b>TOTAL</b>	<b>100</b>	<b>100</b>

## VI. BENEFITS AND OPPORTUNITIES

No doubt the interconnection will provide a lot of operational, economical, environmental and technological benefits. The main economic benefits of the project have been to provide improved security of the power supply and better economic efficiency through savings in the operating reserves installed capacity.

In essence, interconnections between states provide opportunities for the linked countries with an alternative source of operating reserves and support during emergencies. It can also provide diversity to the available sources of energy supply - instead of depending on domestic resources for energy (ex.) fossil fuels, gas etc., the interconnection can increase system efficiency through the diversification of energy resource such as importing power from more economic nuclear or hydro power to the receiving country. In the case of certain fuels or resources such as hydropower and other renewable resources, an interconnection is the only feasible means of making such resources available to other areas leading to the development of these diverse energy resources for the benefits of the entire region, thus allowing less costly power to be delivered from distant locations, often displacing important, expensive fossil fuels and utility projects. Apart from providing security of power supply, interconnections have gained importance as a mechanism to improve the economic efficiency of power systems. With the development of power interconnections, individual power systems can be operated and expanded as part of a larger regional system, thereby providing countries with income through the export of excess power to other countries and regions. Due to the large availability of gas and crude oil for power generation in some GCC countries, the potential of exchanging economic energy between the power systems exists."

However, for the GCC Countries the purpose of the interconnection is to also share generation reserves and installed capacity in order to reduce additional investments in generation infrastructure; a matter of great concern which has topped the agendas of the 6 member states.

## VII. BEYOND THE POWER GRID

Though the investment is huge, the Authority envisions that the GCC Grid system could be expanded to trade energy not only within the GCC but also with other interconnected regions like North Africa, Europe (UCTE) and EJLIST.

The GCC Interconnection grid will make it possible to create a common GCC electricity market, which will

ultimately provide a number of advantages to the GCC countries. The newly reformed regulations in the GCC states have been promoting participation of local and international investors in the power sectors, resulting in lower production costs as a way to achieving lower electricity prices. In addition, private investors are now allowed to develop mega projects with access to expanding market, including not only the GCC but also other power pools such as the EJLIST and the UCTE.

The existence of the grid, or commonly known as the 'back-bone', will also provide opportunities for the establishment of power plants close to resources such as fuels, thus giving freedom for IPP's or IWPP's to select a strategic location realizing the potential in dealing with a large size market with facing little risks. By extending the GCC grid to other grids such as the EJLIST or the Maghreb Arab Grid will provide an opportunity for the export of surplus power to other regions. For instance, during the winter when demand for power is low in the GCC, there will be an advantage of exporting power from this block to regions in Europe where power demand is high during the same period. The market will also encourage energy interchange during seasonal diversity when demand for power in the GCC region during the hot summer seasons is high and this high demand can be met by importing from regions where demand is low during the period.

## VIII. OTHER OPPORTUNITIES

The transmission line which forms most part of the infrastructure will extend from Kuwait to Oman will comprise of a fiber optic overhead ground wire (OPGW) consisting of 48 fibers. The OPGW will have a capacity of 0.19 to 0.35 db/km used as an efficient mode of telecommunication transmitting huge data efficiently.

Other than acting as a transmission network owner and transmission system operator for a 400 kV and 220 kV system connecting six countries, the GCC Interconnection Authority (GCCIA) is currently studying the potential means of utilizing the extra capacity provided by the fiber optic cable to enhance the telecommunication grid in the GCC and thus provide other opportunities of economic benefit to the region. The study will comprise of a market analysis of the telecommunications industry in the GCC region leading to identifying market opportunities and estimated revenues that can be realized within the current telecommunication industry and in tandem with the GCC telecommunication Regulatory structure.

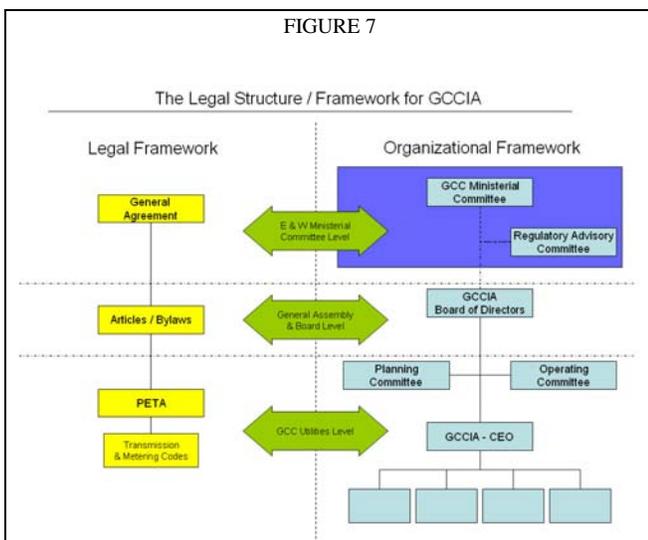
## IX. LEGAL FRAMEWORK

Among other matters regarding the completion of the interconnection are the legal agreements which set the basis of usage and transaction between the countries that will be physically linked to the grid. The Authority, with the consultation of international legal firms, will develop two main documents:

1. **General Agreement:** This is a high level Agreement that sets out the terms between the Member States that own the interconnection.
2. **Power Exchange & Trading Agreement (PETA):** sets out the terms in establishing a framework on which the trading parties will exchange and trade energy between their national electrical transmission systems through the GCC power grid. The document is comprised of four sections, namely:
  - a. Common Legal Terms & Conditions;
  - b. Connectivity and Usage;
  - c. Trading Terms;
  - d. and Interconnector Transmission Code (including the Metering Code).

The Transmission Code has been developed to lay down the technical rules and provisions as well as the planning requirements for the connection and use of the GCC Interconnector. The Metering code sets out the metering requirements for the points of connectivity of the Interconnector with the National Grids.

Figure 7 shown below summarizes the Legal framework the Authority will apply and the relationship between the legal documents and the organization. A Regulatory Advisory Committee, with representation from every member state, will act to guide the Authority on high-level policies and procedures.



As these documents are intertwined with all levels of authority of the GCCIA they will become the basis for the entire interconnection. In its initial term the GCC Interconnection Authority will play the role of the Transmission System Operator (TSO) for the GCC Interconnector facilities, facilitating bilateral trading between the various parties and ensuring a reliable and secure Interconnector system. The mechanism for power exchange and cross-border trade will cover two different areas:

1. *Unscheduled Exchanges of Energy:* Which are energy transfers across the Interconnector that diverges from the scheduled transferred amounts. This can be in the form of actual transfer of energy occurring without any transaction being scheduled; or a scheduled transfer taking place beyond the scheduled transaction amount; or an actual transfer in one direction, while the scheduled transaction was in the other direction.
2. *Scheduled Exchanges of Energy:* Where Member States will be able to schedule energy transfers amongst themselves by concluding any contract terms they wish for the energy sale, simultaneously providing the required details to the Authority to avail the required Interconnector transmission capacity and validate the proposed transaction on the basis of destination, duration and energy quantity.

Member States can make planned energy transfers between their systems, as long as they can secure a) bilateral contracts arranged between them; b) allocation of available Interconnector capacity. Prior to a proposed scheduled exchange between Member states the following steps will have to be taken:

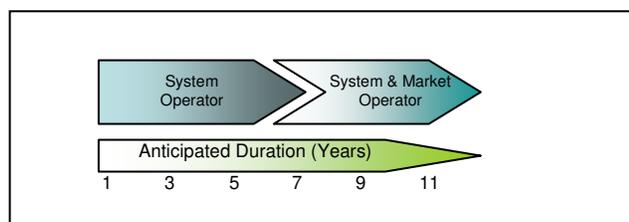
- Obtain the necessary Interconnector capacity from GCCIA;
- Agree the terms of the proposed energy exchange between themselves;
- Notify the Authority;
- Obtain confirmation of the proposed exchange from the Authority

For unscheduled exchanges of energy the method of compensating has been proposed to be through 'repayment-in-kind' between the parties. This approach is adopted between some Transmission System Operator's in the United States and Europe. In this event there is no specific charge for use of the Interconnector. Regarding scheduled exchanges, the Contracts and related settlements will be between the concerned parties and would not be handled by the Authority, however a fee for wheeling services will be charged to the parties by the Authority.

## X. TRADING BEYOND THE GCC

In addition, to the development of the legal agreements the Authority had undergone an organizational structuring exercise. The exercise involved the creation of vision and corporate objectives, followed by detailed organizational structures and job descriptions. The newly designed structures have been designed to fulfill the short-term vision requirements of the Authority which is to act as a System Operator; and the long-term vision which is to engage as a Market Operator. As depicted in figure 8, initially, the Authority will be responsible for the administration of the reserve sharing allocations in addition to providing emergency assistance with the anticipation of it evolving into a complete wholesale electricity market player in the near future. As a System Operator, the Authority will be responsible for the interconnector's system operations, planning, engineering and maintenance services.

FIGURE 8



The GCC interconnection would pave the way towards a proper electricity trade between GCC countries and eventually with Middle East countries, requiring strong interconnections, a common electricity trade structure as well as capacity expansion guidelines. Such interconnections would make it possible to access the European (e.g. UCTE) electrical systems opening up a vortex for a change of economical structure based on the possibilities of new channels of energy export. This also opens the way for a higher regional energy efficiency that makes use of the seasonal as well as the daily diversity of loads between different areas in the region. It also opens the way for new renewable energy sources (Solar, Wind, etc) to be set up where appropriate and transferred across the region to load centers.

In addition, a comprehensive compensation and grading scheme has been prepared giving the Authority the initiative in hiring well qualified personnel. In that, the Authority has recently embarked on a 3-year recruitment plan to meet its immediate and long-term requirements. Simultaneously, another contract has been awarded to a reliable I.T company to conduct a comprehensive ERP software selection exercise. The results of this will then allow the Authority to select the most suitable ERP

system to meet its functional and technological needs for its short and long term requirements.

## XI. CONCLUSIONS

The GCC power grid interconnection has finally been conceived thanks to the will of the GCC leaders to see such realization of GCC cooperation in the electricity sector. The study conducted in the 1980's by a committee from the GCC Countries in cooperation with the Kuwait Research Institute & King Fahd University of Petroleum & Minerals has been instrumental in creating the vision which has eventually become a reality. Since its establishment, by *Royal Decree*, in year 2001 the GCC Interconnection Authority had not only made the Interconnection reality but also has achieved much in completing many crucial tasks in a short period and is currently seeking other opportunities both in its core service line of energy exchange and trade and other business lines such as telecommunications.

The development of the legal and organizational frameworks will further enhance the authority to embrace a more elating task of becoming a broker between regional and international utilities and regulators. The presence of the GCC Interconnection Authority will thus enhance further cooperation between the member country's utilities and regulators leading the way to establishing a common market in the region.

As the GCC local electricity industries evolve in a more market-base structure, the GCC interconnection will act as a gateway towards achieving a regional and pan-Arab power pools, thus promoting social, economic and environmental development and cooperation in the Middle East and North African countries. With this esteemed accomplished not only will the GCC Interconnection Authority be a symbol of unity and cooperation between the six GCC Countries but will be a 'launch-pad' for other cooperative projects such as the water and railway interconnection grids.

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### XIII. BIOGRAPHIES

**Hassan K. Al-Asaad** graduated in 1994 with a bachelor’s degree from the University of Manitoba, Canada and a Masters of Business Administration in 1999 from Sheffield Hallam University in the United Kingdom. He had worked as a business and management consultant for Arthur Andersen & Co. in the GCC region for several years, during which he had engaged in providing a range of consultancy services from organization re-structuring to I.T systems implementation to various industries in the GCC region, specifically to the oil & gas and utilities industries. In 2002 he moved on to be one of the first and core employees of the GCC Interconnection Authority playing a major role in developing it from its dormant phase to its construction phase, during which he managed and coordinated several projects of which the most significant were the organizational development project and the legal agreements project. He is currently in-charge of corporate affairs and sits on several internal committees for the Authority. He also co-authored a paper on energy trade in the GCC at the GCC Cigre conference and has represented the Authority at several conferences and conventions.

**Ahmed A. Ebrahim** received his B.Sc. in Electrical Power Engineering from the University of Texas at Austin – USA in 1986. He received his M.Sc. in Electrical Power Engineering (with Distinction) from the University of Strathclyde in Scotland in 1999. He has completed the Gulf Executive Development Program from Darden Business School – University of Virginia – USA in 2001. He has received his MBA in Business Administration (with Distinction) from DePaul University, USA in 2003. He is presently the Director of System Operations & Maintenance in the GCC Interconnection Authority, and has more than 20 years of power system operations lately as Manager of Operations and System Control Division in the Ministry of Electricity and Water – Bahrain. He is a Board member and Technical Committee member of GCC Cigre, and member of Cigre Study Committee SC B3 “Substations”. He has authored more than 14 papers in several regional and international Conferences, mostly in the field of restructuring of electricity markets and possible ESI market models.