Mr. AHMED ALI AL-EBRAHIM, CEO - GCCIA

Ahmed is the Chief Executive Officer (CEO) of GCC Interconnection Authority. He has been with GCCIA for 10 years since he joined in 2007 as Director of Operations & Maintenance. He has 30 years of experience in power systems and infrastructure operation and planning, previously working as CEO of Sintegro International, and earlier as Manager of Operations & Control in the Ministry of Electricity Bahrain.

1. **What makes GCC energy system unique and different from any other?**

   A. **For example, key characteristics: geographic features, fuel mix & generation mix, performance specifications, compliance of market mechanisms with energy system control, network topology (extension, voltage levels etc.).**

GCC countries have been characterized with substantial growth of energy consumption from 1972 to date. Although all GCC countries follow a similar trend, the magnitudes have been different due to several factors, such as population mix, economic development mix, urbanization level and industrialization level. GCC electricity sector has primarily relied on fossil fuels (mainly natural gas and some heavy fuels) for the generation of electricity. Additionally, and as GCC region lacks enough water resources, there has been a huge reliance on desalination of sea water to support and sustain the growth of population and economy. Cogeneration of Electricity and water in GCC power plants with combined cycle (Gas and Steam) turbines has been the norm with technologies such as Multi-Stage Flush (MSF) and Reverse Osmosis (RO) taking a central role. Therefore, the reliability and security of the electricity & water systems has become paramount in GCC.
The GCC interconnection grid, linking the six national grids of the GCC countries since 2009, has been primarily designed as a mechanism to share generating reserves in emergencies, to increase the reliability and security of the power supply through mutual support, and to reduce the investment requirements in reserve capacity. The GCC Interconnection further paves the way for the development of power trade and the eventual evolution of the GCC power market.

The GCC grid today functions as a cross-regional security mechanism that allows the transfer and exchange of electricity between the interlinked countries' national power systems at times of emergency, i.e. when domestic reserve or generation capacity is insufficient to supply demand during Generation trip events. The primary idea behind the GCC grid's emergency mechanism makes use of cross-regional differences in electrical load structures: where one country suffers a power shortage, another country's 'idle' capacity can help support a neighbor's system stability, by providing extra reserve or generation power. The mechanism benefits both parties since the receiving party pays back the electricity in kind, thus supporting another neighbor at times of emergency.

In this context, the GCC Interconnection Grid stands out as being by far the most ambitious and most comprehensive regional approach towards energy security among the GCC states and possibly in the world.

A worldwide trend in development of power systems is to build interconnections with goal to achieve economic benefits. GCC interconnection also builds on similar advantages:

- Sharing of spinning reserve
- Reduced requirement of generating capacity in each system as a result of sharing power reserves
- Emergency power support to prevent black out
- Lowering operating cost
- Provide opportunity for power trading
- Allowing to install large load variation industries such as steel & Aluminum plants
- Integrating Larger Renewable resources

The chosen topology for the GCC interconnection consists of a mix of the two basic topologies that joins the 'common link' or "Back-bone" representing the interconnection of Bahrain, Saudi Arabia, Qatar, Kuwait and the UAE, and the 'neighbor to neighbor link' between Oman and the UAE, forming the 'hybrid link'. This 'hybrid link' provides all countries direct access to any other system except that of Oman, which will require all transactions with the other five GCC countries the use of the UAE power system. The interconnection stands unique in that it is a Hybrid Common-Neighbor-to-Neighbor link. However, currently expansion studies are being carried out which consider extending the concept of the "Back-Bone" grid to Oman too.

The GCC Interconnection links the power systems of all the six GCC Member States of Kuwait, Saudi Arabia, Bahrain, Qatar, Oman and the UAE through a double circuit 400 kV overhead line linking from Kuwait to United Arab Emirate through Saudi Arabia region with taps at Bahrain and Qatar. Bahrain is linked by 400kV submarine cable while UAE and Oman are connected through double circuit 220kV overhead lines. Due to the difference in operating frequencies, the 60 Hz power system of Saudi Arabia is interconnected to other GCC member states' 50 Hz power systems via a set of three 600MW back-to-back HVDC converters which is the first of its kind in the Middle East and the largest Back-to-Back installation in the world. Thus, the physical infrastructure consists of 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.

To enable effective transmission system control, the GCC Interconnector Control Centre ("ICC") undertake defined interconnector transmission system control and coordination functions and also coordinates the operating reserve and energy flows across the Interconnector. Each TSO is responsible for managing the security of operation of its own system. The most relevant rules for the security of interconnected operation are related to the functioning of the TSO's Connection Point to the Gulf Interconnector and the provision of operating reserve by all parties.

To avoid a cascading effect, special protections have been installed to disconnect the faulty country from the GCC system in case of loss of synchronism due to voltage collapse.

Hydrocarbons Oil & Gas are used for power generation in the GCC countries. GHG and other emission reductions controlled by using those hydrocarbons in more efficient plants (i.e., displacing less efficient generation by more efficient generation) or by greater utilization of fuels with lower carbon content per kWh. GCC countries most generation is coming from efficient combined cycle plants and high capacity super critical technology thermal units for economical and environment benefits.

The fossil fuel industry has dominated the economy of the GCC countries during the last few decades. However recent policy initiatives and implementation show that most of the GCC countries are committed

to increase the share of renewable energy (RE) in electrical power production from Solar or Nuclear. It is expected large integration of Renewable energy mix in coming days in GCC interconnection.

Power Trading is one of the primary objectives of the GCCIA interconnector. The Power Exchange and Trading Agreement (PETA) provides provision for Scheduling Energy Trade on the GCCIA interconnector. The PETA sets out rules and procedures required to facilitate commercial power exchange. During summer 2010, the cross border electrical energy trading took place for first time in GCC region by trading electrical energy through GCC interconnection network.

B. **What is the impact of these peculiarities on your energy system management & control? What is the structure or hierarchy of your energy system management & control?**

GCC interconnection is characterized by several blocks connected together by relatively long AC lines. This type of structure is prone to problems of inter-area oscillations. The study is carried out to determine the modes of inter-area oscillations from time to time for the interconnection. WAMS (Wide Area Monitoring System) Oscillation monitoring tool is used in control room for real time alert to operator. The study results and WAMS Modes are then compared to improve any error in study model. The objective of this is to determine the modes of inter-area oscillations which could appear between the various parts of the GCC network and their damping. The required recommendations are proposed to mitigate these oscillations by activation of Power System Stabilizers (PSS) in specific power plant.

This SOG (WAMS System Operation Guide) aims to simplify oscillation information, and provide system operators with a quick reference in taking fast and efficient action to improve the system oscillatory stability produced.

As the interconnection lines are quite long, the maximum power flow limited by the rated power of the elements, but by stability limits. The operational margins of the different cross-sections in the system are evaluated by determining the distance to collapse (determining of the limit of transfer. The reliability of an interconnected power system operated by Member states entities (TSOs) and coordinated by an authority.

2. What are the recent challenges that arise from the operation of your energy system? How do you address them? What problems do they help to pinpoint?

A. HVDC Operation challenges.

During the conversion process harmonics are produced which affect power quality, electronic devices and even lead to system oscillation. While HVDC in service, the appearance of the 13th harmonic is the main contributor to a resonance condition before and after the de-energization of Ghunan-Salwa lines. A dedicated operational procedure has been introduced for switching out and restoration of Ghunan-Salwa lines while HVDC is in de-blocked position. High voltage is observed during Blocking and De-blocking HVDC, for an instance, when voltage crosses the normal limits.

B. Limitations on transfer capabilities through the radial 400kV interconnection grid

As the grid is a radial 400kV grid of distance exceeding 1000km, there are always limitations on transfer capabilities from north to south and vice versa which prevents utilizing the full thermal capacity of the lines. The GCCIA is considering solutions to such limitation through the new expansion study.

C. High voltage and MVAR problem due to Submarine cable.

The submarine cables produce very high MVARs (each around 800 MVArs) resulting high MVARs flow to Bahrain system and high Voltage in RAQUR and Jasra Substations. The GCCIA has recently commissioned

a new project to enhance reactive power compensation for the grid by adding two two new 125 MVArs shunt reactors.

D. Harsh dessert environment

The harsh desert environment with extremely high temperatures exceeding 50°C in shade, strong sand storms and remote locations of the GCCIA substations always present unique challenges to operations and maintenance of GCCIA grid. GCCIA has thus employed the use of technologies and special operation and maintenance processes to combat such harsh conditions.

3. How are market mechanisms embedded in your energy system management & control?

Currently GCCIA caters to the bilateral electricity market only, and every member states take the responsibility to embed the purchased energy in their energy system. The energy is controlled through scheduling the energy between the six member states.

The electricity trade imbalances are managed based on their classification, which is Type 1, and Type 2; where Type 1 imbalances are generally less than 25 MW and beyond that are classified as Type 2. The compensation of Type 1 is on in-kind basis and for Type 2 based on the tariff pre-set by the regulator differentiated for peak and off-peak timings. For excessive imbalances, additional charges are imposed.

However, the GCCIA has launched a plan to introduce the GCC power exchange as part of its road map to develop the GCC power market. New market rules and market procedures have been developed and will be implemented during 2018.

4. What are the main approaches to your energy system development?

A. **For example, main directions of investment flow: networks, generation, modernization, renewables etc. Have these trends changed in the past 10 years?**

B. **How does SO participate in long-term planning of energy system development?**

C. **What is the mechanism to support decision making for regulating investment flows in the industry?**

A. All GCC utilities have single buyer model through Power purchase agreement and responsible for all adequate resources by concern Member state policy for long term strategic balancing of

demand and generation. Capacities of solar PV, wind power and CSP are comparatively small at present, but a number of countries are building new wind power and solar PV projects and developing domestic manufacturing capacity. Projects exceeding 200 megawatts (MW) are under construction in Middle East. This Generation trend towards renewable is changed significantly in recent time from research to implementation. The award of a 250MW pumped hydro project is under development by one utility. There are also recent developments to examine the potential for a 400MW/2,500MWh pumped hydro energy storage site as innovative solution to cope up with renewable variation.

B. The long term planning approach for the GCC interconnected grids targets optimum generation development plan, meeting a target reliability level under an interconnected GCC power system. A study is carried is carried out every year for a rolling five years period. The study , conducted by the GCCIA under supervision of the GCCIA Joint Planning Committee, is to evaluate the Installed Capacity Obligations (ICO) requirements for each Member State to meet the target reliability of the GCC system.

   A common generation planning criterion is defined for all Member States. This generation planning criterion is a target reliability level in the system using a probabilistic approach: maximum Loss-Of-Load-Expectation of 5 hours/year. The same investment options are available in each Member State and international fuel prices are considered in the planning study in order to avoid cross-subsidies between Member States. Finally, Member States have to comply with the required generation development plan to ensure that the target reliability level is met.

   The generation development plan of each Member State is optimized over the study period by minimizing the overall cost of its generation system required to cover the load while respecting the different operating constraints to which an interconnected grid is subjected and particularized to GCC and the planning reliability constraints.

   The generation expansion plan includes the units which are already decided in the latest generation expansion plans received from the Member States. In order to satisfy the demand and the adequacy criteria, investments in additional units are required during the study period. Generic data are used to model the undecided units in order to avoid cross investments between the Member States due to different assumptions for new units.

   The generation expansion plan of the Member States is then optimized in the presence of the interconnection; this generation development plan corresponds to integrate planning among Member States taking into account the GCC interconnection.

C. While GCC governments continue to play a significant role in the generation, transmission and distribution of electricity, all of them are in the process – although at different stages – of reforming their power sectors. This reform can reduce overall demand (and therefore the cost to governments of electricity supply) by incentivizing investment in more efficient technology and reducing end consumer demand. All GCC countries have IPWPs and all are pursuing a structure in which a single buyer purchases electricity from generators. Some member states are much further in the liberalization process. Some, for example, have put in place laws to reform the power structure and established a plan for a spot power trading market while some have approved plans for unbundling the state-owned electricity company, which is anticipated to lower the cost of generation and reduce financial burden on the government.

5. What is the mechanism to upgrade generation and networks in your energy system? Please elaborate.

In order to maintain a certain level of reliability on the interconnected GCC system it is necessary that generation and network adequacy planning be fulfilled by all GCC members, and then supervised by the GCCIA Planning Committee. According to PETA, the GCCIA Planning Committee, with representation from all GCC members, is the body responsible for recommending the minimum level of installed generation capacity required within each Procurement Party's area during a certain Obligation Period in order to meet a set reliability level. The Interconnection General Agreement and PETA clearly define the recommendation of ICO which is supervised and regulated by the Advisory and Regulatory Committee (ARC) being the regulator for the GCC Interconnection.

6. What are the regulatory problems SO faces in the industry? How do you address them?

There are several regulatory and organizational challenges facing the GCCIA such as:

1. The route of the electrical line crosses the international borders of the GCC countries and intersects with several regions with different regulations and Rules. GCCIA have to accommodate such various requirements.

GCCIA has made great efforts in coordination with all concerned parties in the countries, and working to solve the various technical and administrative problems in each country.

2. The GCCIA cross-border back-bone configuration is unique and has not been considered in national regulations of the six GCC countries. This creates a situation that the National regulator would like to apply its National regulation on GCCIA as if it is a local, not a regional interconnection grid. GCCIA have struggled to avoid the possibility of being regulated by six different regulators with six different sets of regulations on the same interconnected grid.

3. The issue of customs duties on electrical appliances and equipment represented another challenge for GCCIA where the Authority has made concerted efforts to obtain customs exemptions for its imports of equipment and constituents of the project from various quarters.

7. What is the role of the Demand Response mechanism in your energy system? What is your understanding of DR potential? In case DR is not introduced yet do you plan to introduce it?

The key objectives of a DR program may include the reduction of environmental impacts from electricity use and construction of new infrastructure; reduce electricity costs; and optimize generation. The methods and approaches to realizing these objectives in the GCC and gaining the benefits follows.

GCC countries have great opportunities to internalize the DR policies in their energy planning and economic growth programs, so as to maximize their use as a tool integrated to energy markets. DR may

allow to deal with the risks associated with system demand and to satisfy the reliability needs of an active and dynamic energy market.

However, it is important to identify the most relevant elements to consider when designing a mechanism to incorporate DR into GCC like emerging markets.

The first task to be performed is the characterization of free customers and their demand profile, identifying the maximum degree of flexibility, possibility of generation resources on the demand side, among other things. The ability to detect the potential reduction of each consumer is a key to the development of plans and programs for the consumer.

In general, DR could bring a range of potential benefits to GCC countries in terms of:

- New network investments,
- Increasing the amount of distributed generation that can be connected to the infrastructure of the distribution network,
- Relieve power transfer problems under limited stress,
- Alleviating congestion at distribution substations,
- Simplifying the management of outages and improvements in quality and safety supply to critical load customers, and
- Reduction of greenhouse gas emissions

Demand response through smart metering is under planning stage. Energy hydro storage is also being deployed in some areas for DR purposes. In the GCC, Energy storage development has priorities above customer DR with increase of renewable energy in coming future.

8. In recent years traditional approaches in the industry are strongly influenced by new technologies. How does your energy system management & control adapt to these changes?

The GCCIA has employed new technologies and approaches in its operation and maintenance. As an example, the GCCIA has established an “Asset Health Center”, a center that brings together in one central accessible location a multitude of different condition monitoring and analysis systems that can continuously evaluate the condition of all components of the GCCIA grid and assist maintenance engineers in early production of abnormalities, and taking action to rectify them, long before a fault can develop. Another example is WAMS (Wide Area Monitoring System) being used in System Operations in the Interconnection Control Center (ICC) for real time envisioning of the operation status of the electrical system, which can alert the operator for any real time discrepancy in frequency, voltage, phase angle and inter area oscillations and prompt changing of operating conditions to alleviate critical system conditions and avoid system disturbances.

9. Integration of new resources into conventional energy mix is widely discussed at present. Is it of high priority to you?

A. **What types of new resources have you adopted already?**

Gulf countries have launched aggressive plans for introducing new and renewable energy into the existing energy mix. For instance, Saudi Arabia, which has recently begun ambitious projects for solar energy production and use, as well as the UAE, which have great expectations and plans in the establishment of nuclear power and renewable energy projects.

For example, the Sheikh Mohammed Bin Rashid Al Maktoum Solar Complex in the UAE has advanced technologies in production and generation, which makes it a major role in providing renewable energy through the latest production systems, especially as the complex plays a vital role in achieving the strategic vision of the UAE 2050, Has contributed to the clean energy goals of the UAE. It is the world's largest solar power project with a capacity of 5000 megawatts by 2030.

Additionally, 2019 may witness the commissioning of the 1st Nuclear Power generation plant in the GCC with Abu Dhabi commissioning its 1st of four 1400 MW generators in Barakah Nuclear Power Plant

B. **How do you address the issue of system operation & management with these new types integrated into your energy system?**

The GCCIA will focus in the next phase on the integration of renewable power resources, as it is one of the strategic directions of the GCC countries to diversify the sources of electric power. It also represents an opportunity to create a public-private investment partnership that enhances energy security in the Gulf and provides sustainable solutions a long-term energy supply and security process.

The trend towards the exploitation of renewable energy has become a vital future option for the Gulf States, thus GCCIA plans to exert strong efforts to support this trend through the organization of events attended by international specialists to share their ideas and recommendations; most recently a workshop was organized in July 2018 under cooperation between the GCCIA and the Gulf Organization for European Renewable Energy , With the participation of specialists from the European Union and the GCC countries in the field of renewable energy and energy trade.

10. The concept 'Power System of the Future' is gaining increasing acceptance in the world energy industry. How you approach this concept?

The GCCIA has already set in its vision to be a “utility of the future”. New untraditional concepts, approaches and technologies have the attention of the GCCIA to help in positioning the GCCIA for the future. The GCCIA mission “Interconnecting Our World” is aiming to transfer the GCCIA from being a local interconnector, to being a regional and global interconnector. That implies a strong emphasis on the collaboration with leading global leaders in grids operations and development. Powerful evolving trends in technology, policy environments, financing, and business models, which are driving change in power sectors globally, can be exploited to enable GCCIA to reach such positioning.

The new environment of change involves complex decision-making across policy goals, technological systems, social contexts, and financial networks. The GCCIA aim for the “utility of the future” have to employ such dynamics to be well-positioned in the “power system of the future”.

For example, cost reductions in renewable energy (RE) are driving rapid deployment and are encouraging both power system interdependence and independence. GCC Interconnection power system

interdependence (e.g., coordination across larger balancing areas to drive down Renewable Energy integration costs) is growing in GCC counties. At the same time, the cost of RE is falling for utility increasingly offer greater choice and resiliency. There are also key trends drivers to diverse hydrocarbon Generation dependency to nuclear and Renewable to reduce environment impact.

11. Which innovative solutions are being looked at in your company to address the future challenges of the power grids of the future (e.g. Storage, Smart Inverters, Bit Chains, etc…)

The GCC countries lay in the so-called Global Sunbelt and boast some of the highest solar irradiances in the world. Close to 60% of the GCC's surface area is found to have excellent suitability for solar PV deployment and developing just 1% of this area could create almost 470 gigawatts (GW) of additional power-generation capacity. The GCC countries have realized that and are thus pursuing huge REN developments. For instance, Saudi Arabia have recently announced a partnership with SoftBank for the development of 200 GW of renewable energy in Saudi Arabia. Combining the opportunities of huge renewable developments and formidable regional interconnection of grids can bring huge opportunities for the GCC region to be a major hub for renewable power export to Asia Africa and Europe.

12. What business models and regulatory changes are necessary to ensure the economic viability of the power system of the future

To ensure the economic viability of the power system of the future, we need business models and regulatory principles that focus on the global and integrated aspect of the grid and not on the local and national aspect. Cross-Border or neighbor to neighbor concepts shall dissolve and make way for an integrated optimal energy system that goes flawlessly across borders and geographic regions. Power exchanges will also need to evolve and employ a more integrated nature rather than fragmented nature. With the introduction of the integrated exchange based markets, the transmission capacity allocation can be optimized to attain the highest cumulative gain for the integrated system. This will drive competition in efficiencies in all the interconnected grids.

13. How do you address the power grid reliability and resiliency needs in the context of a highly decentralized and low carbon power system?

GCCIA focus is to get advantage from Grid Modernization Technologies to Facilitate Grid Reliability and Resilience.

GCCIA focus on enhanced grid visualization (advanced sensing, communications, diagnostics and controls), planning processes and advanced materials that accelerate realization of an advanced, digitally enhanced and dynamically managed "high-performing" electric grid.

This integration is built such that grid will enable more efficient asset utilization and reduced forced outage to improve reliability and resiliency to climate change induced weather events. GCCIA has created asset monitoring control center to monitor & health checks of all critical assets like 400 kV submarine cables, HVDC converters stations and 400 kV substations Transformers and other equipment.