

Evolution of the GCC

(Gulf Cooperation Council)

Power Grid

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presented by

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GULF COOPERATION COUNCIL
INTERCONNECTION AUTHORITY



Dr. Pierre Kayoun, Session Chairman:

Now we come to the last paper of the session. For the first time we are going to speak about the Middle East and in particular about the GCC which is the Gulf Cooperation Council and look at the power grid there. The presentation will be given by Mr. Satish Sud from SNC-Lavalin on behalf of Mr. Adnan Al-Mohaisen, from the GCCIA, namely the Gulf Cooperation Council Interconnection Authority. He is the General Manager of that authority. Mr. Sud has also a very long experience of more than 30 years in power networks. He has worked for more than 35 years with SNC-Lavalin working on interconnectors and on electrification in some emerging countries. Since 1989 he has worked on the GCC IA Project. So he knows it very well. He is currently the Vice President and the principal advisor of the Transmission and Distribution Division at SNC-Lavalin. Thank you very much Satish for giving this presentation.

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Mr. Satish Sud:

Thank you Pierre. I will try to cover several subjects in this, but I think a lot of you may not know SNC-Lavalin, so let me introduce who we are.

We have a highly skilled and flexible labor force, 11,000 employees speaking some 50 languages, representing some 80 nationalities. With our worldwide project experience we carry out on-going projects in over 100 countries.

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The head office of the company is in Montreal, Canada.

Evolution of the GCC Power Grid

- Project background
- Evolution of power sectors in the GCC countries
- Characteristics of transmission in the GCC countries
- Demand growth
- The Interconnection Project
- Benefits of interconnection
- Components of the Interconnection Project
- Capital cost of the project (Phase I)
- Sharing of the costs and financing
- Implementation strategy and project schedule
- Future development of GCC power market
- Conclusions

Now, to return to the GCC Power Grid, as was mentioned, the project has been around for many years. In this presentation, I will present the background of this project, indicate the structure of the power grids in the various GCC countries and the level of growth of demand as well as the drivers of that demand recently.

Interconnection was an obvious need. I will go into how we got there and the benefits which were gained. These may be obvious to many people, but there were still a number of hurdles to be overcome, in order to implement the project.

Then I will describe some of the components of this project: The GIS substations, the overhead transmission lines, the submarine cable links, as well as the control center. We also came up with the capital costs of the project which amount to more than \$1 billion. Remember there are six GCC countries. There is always an issue when deciding who will pay what. We know this from Europe. Part of the problem is, whenever there is an interconnection between countries, questions arise about what is to be covered and who will finance it. Once these decisions were made, we developed an implementation strategy. I will present it, the current projects and the future developments we anticipate in the GCC area and power market.

Project Background

- Gulf Cooperation Council (GCC) between Kuwait, Saudi Arabia, Bahrain, Qatar, United Arab Emirates and Oman formed in 1981
- Recognized benefits of interconnection of electricity grids of the countries
- Initial study in mid-eighties
- Preliminary project definition study in 1990 confirmed technical, economic and financial feasibility, recommended formation of GCC Interconnection Authority
- GCCIA established in 1999
- Project technical, economic and financial feasibility updated in 2003/04
- Countries decided to self-finance project in 2004
- Project tendered and awarded in 2005

We begin with a look at the project background. The Gulf Cooperation Council was set up in 1981, joining Kuwait, Saudi Arabia, Bahrain, Qatar, the United Arab Emirates and Oman. This already makes the intent clear to promote cooperation between the economies of these countries. Most of them are small, so a common market of sorts was needed to aid the development of the area. An obvious area for cooperation was the creation of an electric grid, others are water, telecommunications and other sectors. The benefits of interconnection to create larger systems and economies of scale became evident early on. However, it was not until the mid-80's when the GCC was formed, that the first set of studies were done. A proper feasibility study was done in 1989/90. I was the project manager of that study at that time. We considered the technical, economical and financial feasibility of the project and recommended the formation of the GCC Interconnection Authority.

In order to realize this interconnection there must be someone who is the sponsor of this project. So we recommended this authority. Right after that, the first Iraq War intervened and set back things. It was not until 1999 that the principal authority was formed, which was one of the main recommendations of the study in 1990. Then it took another three or four years to decide to update the study. Because so much time had elapsed, we did an updating of that study. The countries discussed how to share the cost and finance it. In 2004 the decision was made to self-finance it. Once that decision was made, the project went forward quickly and was tendered out in 2005, awards were made and are now under implementation.

Evolution of the Power Sector in the GCC Countries

Country	Vertically Integrated Structure	Independent Regulator	Degree of Unbundling	IPPs Allowed	Single Buyer Model	Reform Efforts
Kuwait	Yes	No	Unbundling not planned	No	No	No reforms planned
Saudi Arabia	Partial separation	Yes	Partial unbundling	Yes	Yes	Private sector investment in Generation
Bahrain	Yes	Independent Regulator is planned	Unbundling under consideration	Yes	No	Plans to privatize electricity
Qatar	Partial separation	No	Separate generation co. (QEWG) Kahramaa responsible for T & D*	Yes	Under Consideration	Privatization of Kahramaa under study. Single Buyer Model planned

- T and D means Transmission & Distribution
- IPP = Independent Power Producers

First let's look at the power sector of the various countries. This chart shows the structure in these countries. Some of them are vertically integrated, some are partially separated, some have regulators and some have not. When the initial studies were done, they were all vertically integrated. That happened to make life easier in terms of the economics and analysis of the project. At the moment there are various degrees of unbundling. However, there are many of them who still don't believe that they should be unbundled. For instance, in Kuwait there are no reforms planned in terms of vertically unbundling or separation of generation and transmission & distribution. In Saudi Arabia there has been some of it done. In Bahrain private power plants can now be built. Even in Saudi Arabia some of this private sector investment is being allowed. Qatar, they have done some unbundling, but the people running the transmission they are also the regulator.

Evolution of the Power Sector in the GCC Countries (cont'd)

Country	Vertically Integrated Structure	Independent Regulator	Degree of Unbundling	IPPs Allowed	Single Buyer Model	Reform Efforts
<u>UAE</u>						
ADWEA	No	No	Separate G, T & D*	Yes	Yes	Reform in Abu Dhabi
DEWA	Yes	No		No	No	No reforms planned
SEWA	Yes	No	No unbundling	No	No	No reforms planned
FEWA	Yes	No	No unbundling	No	No	No reforms planned
UWEC	Yes	No	No unbundling	No	No	No reforms planned
OMAN	No	Yes	Separate G, T & D	Yes	Under study	Laws in place to facilitate reform. Plans to privatize T & D

* G, T and D means Generation, Transmission and Distribution

If you look at the Emirates, it is only Abu Dhabi which has done some separation in generation, transmission & distribution. All the other Emirates like Dubai, Sharjah and the Federal Electric and Water Authority (FEWA) and Union Water and Electric Co. (UWEC) have not done any reforms and none are planned. In Oman they have done some separation and they are trying to run it as separate companies.

Characteristics of Transmission in the GCC Countries

	Frequency	Principal Transmission Voltages
Kuwait	50 Hz	275 kV
Saudi Arabia	60 Hz	230 kV, 380 kV
Bahrain	50 Hz	220 kV
Qatar	50 Hz	220 kV
UAE	50 Hz	220 kV, 400 kV
Oman	50 Hz	220 kV

What do the transmission systems look like? The first thing you see is that Kuwait is 50 cycles as is Bahrain, Qatar, the Emirates and Oman, whereas Saudi Arabia is 60 cycles. So right away that presents a very specific problem. Even the voltages are different in the different countries. The highest voltage in Kuwait is 275 kV, Saudi Arabia has 230 and 380 kV, Bahrain and Qatar have 220 kV, the Emirates had 220 kV and now have 400 kV, because they are beginning to integrate the Emirates, which were independent before, and Oman has 220 kV.

If you like, this is part of what had to go into the mix of how the interconnection had to be developed.

Demand Growth (MW)

Year	Kuwait	Saudi Arabia*	Bahrain	Qatar	UAE	Oman	Total
2003	7 685	9 910	1 547	2 308	9 137	2 160	32 747
2008	10 284	13 945	2 070	3 184	12 780	2 662	44 925
2010	11 555	14 745	2 325	3 387	14 383	2 824	49 219
2020	18 998	18 800	3 645	4 212	22 383	3 723	71 761
2028	27 017	23 210	4 989	4 649	29 348	4 558	93 781

* Saudi Arabia demand supplied by SEC – ERB (represents about 38% of total load in Saudi Arabia)

When the studies were updated, these are numbers we got from the utilities for the projected demand growth.

Over the 25 year period the demand is about tripling. It will go from around 30,000 MW to over 90,000 MW, but just a word of caution. For Saudi Arabia this is only the eastern region demand, not the whole country. Even in Saudi Arabia the networks are not interconnected. The western region and the southern region are completely separate. There is one link between the central and the eastern region.

The first line shows the numbers as we saw them in 2003, but what has happened since that time? In fact the demand has accelerated and in Qatar the growth rates of the last 5 years is predicted to be over 14% per year.

Drivers of Demand Growth

- High oil and gas prices
- Fiscal surplus
- Increased public spending
- Attracting foreign investments
- Diversification
 - > Financial services
 - > Building industrial parks
 - > Petrochemical industries
- Need for job creation
- Recent demand growth in region 7 to 14%/year

What are the drivers of this demand growth? One of the things is the high oil and gas prices. It has brought in a lot of more cash into this region. There is a big problem in these countries, namely the need to create jobs for their citizens. There is increased public spending. All of this leads to attracting additional foreign investments. They also begin to diversify into financial services, building industrial parks and petrochemical industries. The recent demand growth in the region is 7% to 14% per year. In Qatar a lot of the growth has been driven by the development of the gas fields.

Approximate Route and Layout of the GCC Interconnection



Here you can see the layout of the interconnection project. The route runs from Kuwait through Saudi Arabia to a place called Ghunan, from where we tap off to Bahrain, an island. So there is a submarine link. There is also a line branching off to Doha in Qatar. This is phase I. In this phase the 4 countries Kuwait, Bahrain, Qatar and Saudi Arabia will be connected.

The next phase would interconnect Salwa to the Emirates and then the Emirates are interconnected to Oman. The dotted line is an internal system of the Emirates themselves.

Saudi Arabia is at 60 cycles and all the other countries are at 50 cycles. There is a back-to-back link HVDC to the Saudi Arabian system.

This is the main project. Any reinforcements which are required within the countries are the responsibility of the countries themselves.

Benefits of the Interconnection Project

- Result in the requirement for a lower installed capacity in each of the systems (due to reserve sharing) while still supplying the load with the same (or better) level of reliability
- Permits larger and more efficient generating units to be installed on the individual systems
- Enables systems to share operating (spinning) reserves so that each system can carry less spinning reserve
- Enables interchange of energy between systems resulting in a lowering of total operating costs
- Permits assistance from neighboring systems to cope with unforeseen construction delays and unexpected load growth
- Permits emergency assistance between systems to mitigate the effects of unforeseen contingencies such as catastrophic multiple outages

The first point is the principle benefit on which the interconnection system was justified. It is based on avoided costs. In other words, generation that is not needed to be built in the different countries.

The interconnection allows larger units, because when you connect systems, you are sharing the reserves.

There are other benefits being listed on the slide. Some of these benefits are fairly obvious. The main thing to retain is the fact that it was justified based on sharing reserves between these countries.

There were certain constraints put on how much we could back them up on their reserves. These reserves should not be reduced less than about 50% of what they would be if they were not interconnected. That ensures them independence in terms of capacity installations in their countries.

Principle Issues that had to be Resolved

- Agreement and participation by six GCC countries
- Demonstration of feasibility
- Creation of the GCC Interconnection Authority
- Agreement on cost sharing and financing

Our calculations for the project showed that the savings could pay for the interconnection in less than 5 years. In spite of that the project took a long time, because agreement and participation had to be agreed upon between the 6 countries. You can imagine, when 6 countries sit down and decide on something, it does take a bit longer.

We had to demonstrate the feasibility, technically that it would work , economically and financially.

Then we said that we need an authority, looking at the whole interconnection as one body and not as 6 bodies looking after pieces of the interconnection. This led to the creation of the GCC IA (Gulf Cooperation Council Interconnection Authority).

But then there remains the question: How do we share the cost of this interconnection? There has to be an agreement of sharing the costs and of financing them.

All of these points took time to resolve.

Phase I Development Plans

- Kuwait
 - Saudi Arabia-ERB
 - Bahrain
 - Qatar
 - Year of Interconnection  2008
- Phase II Development Plans
- UAE – Formation of Emirates National Grid
 - Oman – Formation of Oman Northern Grid
- Phase III Development Plans
- UAE
 - Oman
 - Year of Interconnection  2010

In terms of Phase I it is foreseen the interconnection of the first 4 countries. This will be in service by the end of 2008 or early in 2009. The project is at the moment on schedule for that.

Phase II was the development of the internal networks within the Emirates and Oman. This has largely taken place. This phase was set up when we did our 1990 studies. Some of these went ahead. They didn't have to go sequentially. So the Emirates are basically integrated or are in the final stage of completing their interconnection.

In Phase III the top countries will be connected to the Emirates and Oman. This will be foreseen for 2010. Discussions are ongoing that this could be advanced, in fact take place at the same time as Phase I.

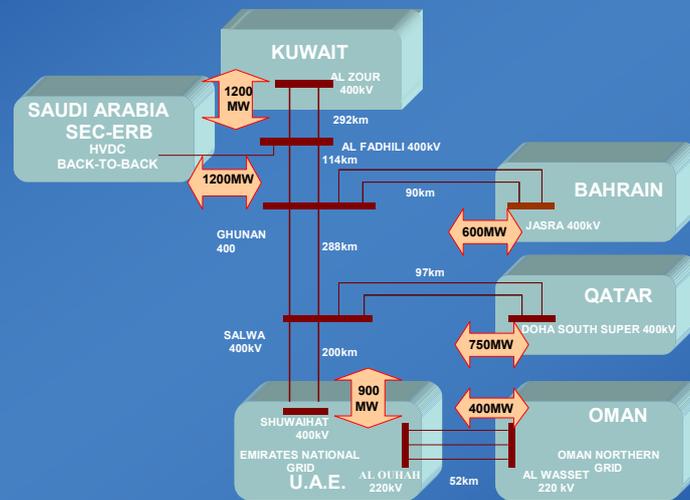
Phase I of the Interconnection Project

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

Phase III of the Interconnection Project

- A double circuit 400 kV, line from Salwa (Saudi Arabia) to Shuwaihat (UAE) and associated substations
- A double circuit 220 kV, line from Al Ouhah (UAE) to Al Wasset (Oman) and associated substations
- A single circuit 220 kV, line from Al Ouhah to Al Wasset and associated substations

Conceptual Diagram of the Interconnection System



Conceptually it means that Kuwait is tied in with the other countries with a link whose capacity is of the order of 1200 MW. Saudi Arabia will be tied in with that capacity as well. Bahrain would have a capacity of 600 MW, Qatar about 750 MW, the Emirates 900 MW and between the Emirates and Oman about 400 MW.

Where do these capacities come from? This was part of the criteria to develop this project, which was at that time half of the size of the largest plant, which was in those countries. If it was done today, it could be that the link to the Emirates would also have been about 1200 MW, because the Emirates have grown considerably in the last 10 to 15 years.

Principal Components of Phase I

- Six GIS substations
- 830 km of 400 kV transmission line
- Two - 50 km of 400 kV submarine and land cables
- 3 x 600 MW HVDC back-to-back converter facility
- Control, protection & SCADA and telecommunication system

In Phase I we will build 6 GIS substations, in Kuwait, in Saudi Arabia (there are 3 of them), in Bahrain and in Qatar. There is 830 km of 400 kV double circuit transmission lines. There is 50 km of 400 kV cables, comprising 40 km submarine and 10 km land cables.

There are 3 x 600 MW HVDC converter facilities.

There is a control center, where all the telecommunication and protection was put in, so we could use the latest protocols.

The 400 kV overhead transmission lines consist of:

Conductor: 740 MCM, AAAC, Flint

4 conductors / phase

Total length \approx 19,500 km

Ground Wire: 2 OPGW

Total length \approx 1,700 km

Overview Map of the Cable System



400 kV Oil Filled Submarine and Land Cable

Submarine Cable: 1400 mm² copper
2 circuits, 3 cables/circuit
Total length $\approx 6 \times 40 \text{ km} = 240 \text{ km}$

Land Cable: 2000 mm² copper
2 circuits, 3 cables/circuit
Total length $\approx 6 \times 9 \text{ km} = 54 \text{ km}$

Capital Cost of the Project (Phase I)

	M\$US
GIS Substations	222
400 kV Overhead Transmission Lines	280
HVDC Back-to-Back Converter	206
Submarine and Land Cables	343
Control, Protection & SCADA and Telecommunication System	28
Total	1079

The cost sharing options considered peak load and the following points:

- Installed capacity
- Interconnection capacity
- Capital investments on service territory
- Reserve capacity savings
- Reserve investment savings
- O&M savings
- Investment and O&M savings
- Present value of reserve capacity savings

At the end of analyzing all these criteria, the different countries said: We should use the present value of the reserve capacity savings, because they were the most representative of the benefits, including the time value of the benefits for those countries.

Sharing of the Costs of the Interconnection Project

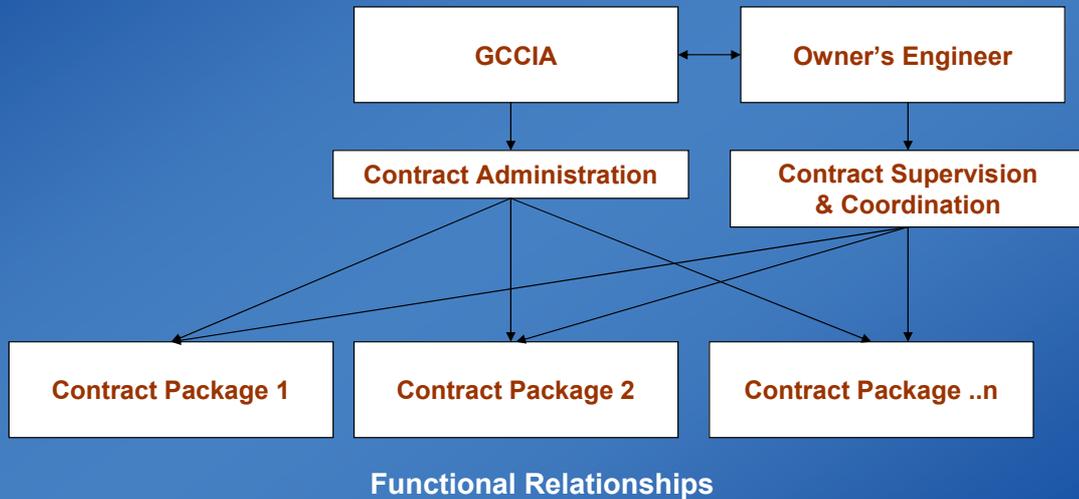
	Phase I (%)	Phases I & III (%)
Kuwait	33.8	26.7
Saudi Arabia (ERB)	40.0	31.6
Bahrain	11.4	9.0
Qatar	14.8	11.7
UAE		15.4
Oman		5.6
Total	100.0	100.0

Financing Options Considered

Finance Options	Ownership		Sources of Finance		
	Government	Private Sector	Capital		Loans
			Government	Private Sector	
1	100%	--	100%	--	--
2	100%	--	35%	--	65%
3	--	100%	--	35%	65%
4	50%	50%	17.5%	17.5%	65%
5	50%	50%	25%	25%	50%

In terms of financing there were issues of government versus private. Considering that most of the savings of the benefits were related to avoided costs and the private sector wanted all the guarantees from the government, therefore instead of doing what the government said, we will finance it all. Each country is responsible for finding the money of its share.

Implementation Strategy



In terms of implementation they wanted to have a very competitive bidding process. So we went to international bidding on this. We were the owner's engineer looking at the overall packaging of the project and analyzing the bids and awarding them.

These are various contract packages which went out:

- Six – 400 kV substations
- One – HVDC converter station package
- Four – Overhead transmission line packages
- One – Submarine / Land cable package
- Control center package:
 - GCC Control Center
 - Telecommunications, Control & Protection

Project Schedule

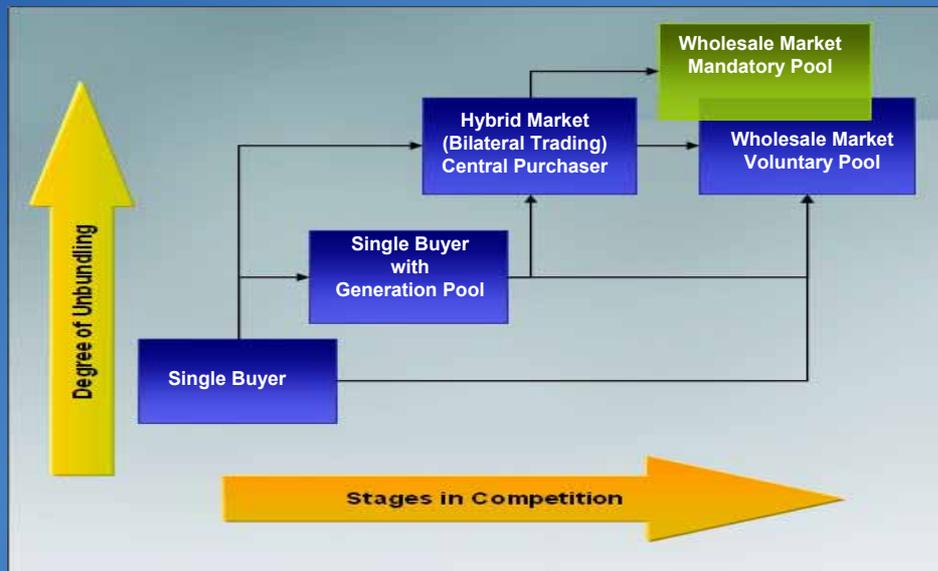
Update Technical and Economic Feasibility	2003 / 2004
Approval of Project Financing	May 2004
Issue of Tender Documents	February 2005
Tenders Received	June 2005
Tenders Evaluated and Recommendation for Award	September 2005
Contracts Awarded	November 2005
Project Operation	Early 2009

You can see from the schedule it took years to go through this process.

Future Development of the GCC Power Market

- Once the GCC Grid is in place this will enable the GCC electricity market to develop in a step-by-step manner:
 - > Allow competition in generation in the countries through IPPs and set up a single buyer
 - > Establish vertical separation to enhance competition
 - > Establish open access to transmission to allow generators to sell to other countries
 - > Form a national and ultimately regional power market
- Link to other regional grids

Evolution of the Market from Single Buyer to a Wholesale Market



Conclusions

- Project under-study since mid-eighties
- Agreement and participation required by six GCC countries
- Principal issues that had to be resolved
 - > Demonstration of feasibility
 - > Agreement between countries
 - > Creation of the GCC Interconnection Authority
 - > Agreement on cost sharing and financing
- Project is now under implementation
- Once implemented the project will enable development of a GCC electricity market

Thank you!