

# Evolution of the GCC (Gulf Cooperation Council) Power Grid

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# Evolution of the GCC Power Grid

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GULF COOPERATION COUNCIL  
INTERCONNECTION AUTHORITY



# 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

# 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. (QEWC) Kahramaa responsible for T & D*	Yes	Under Consideration	Privatization of Kahramaa under study. Single Buyer Model planned



\* T and D means Transmission & Distribution

# 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 unbundling	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

# Characteristics of Transmission in the GCC Countries

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

# 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)

# Drivers of Demand Growth

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



# Approximate Route and Layout of the GCC Interconnection



# 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

# 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

# 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

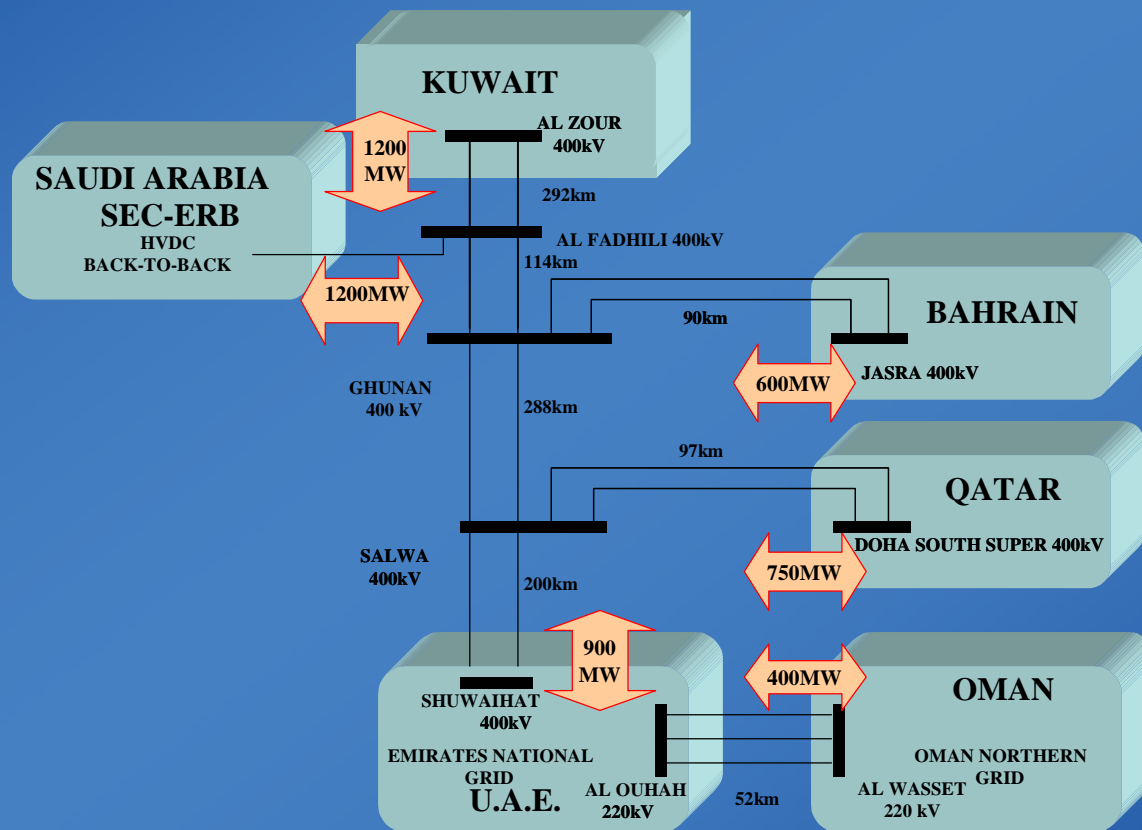
# Phase I of the Interconnection Project

- 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

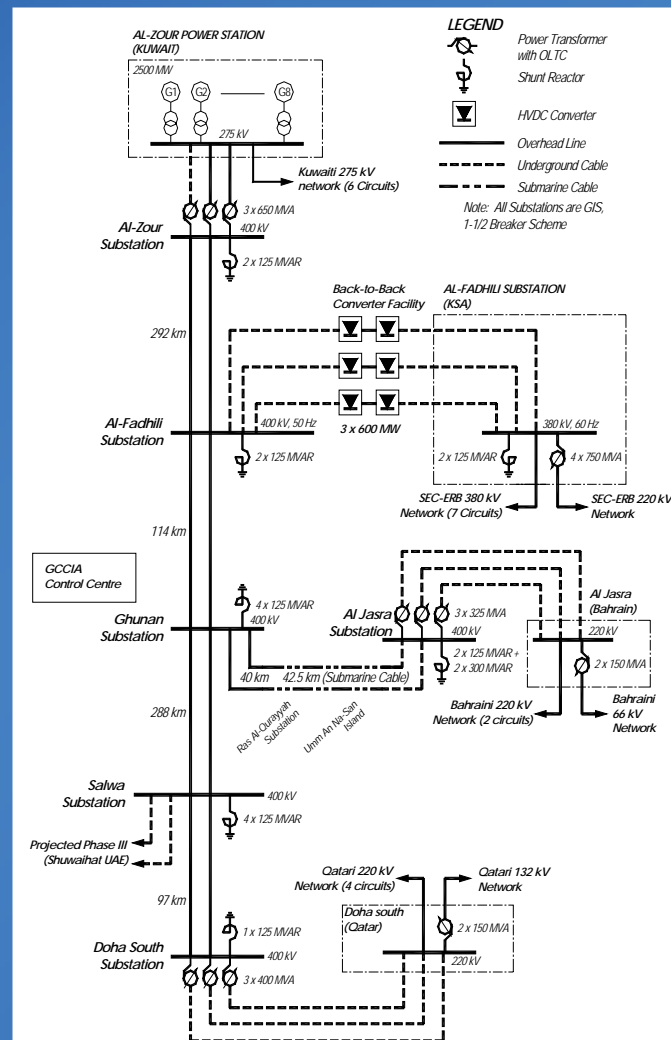
# Phase III of the Interconnection Project

- 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



# Simplified Single-Line Diagram of the Interconnection





# 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

# 400 kV Overhead Transmission Lines

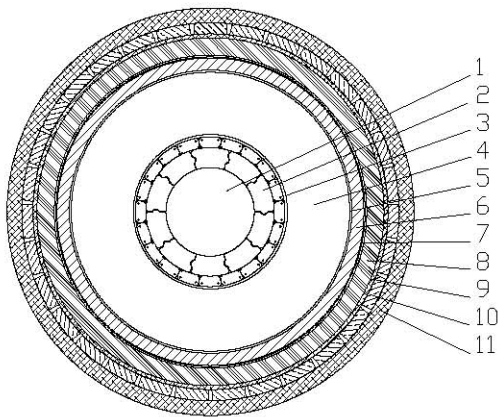
Conductor: 740 MCM, AAAC, Flint  
4 conductors / phase  
Total length  $\approx$  19,500 km

Ground Wire: 2 OPGW  
Total length  $\approx$  1,700 km

# Overview Map of the Cable System



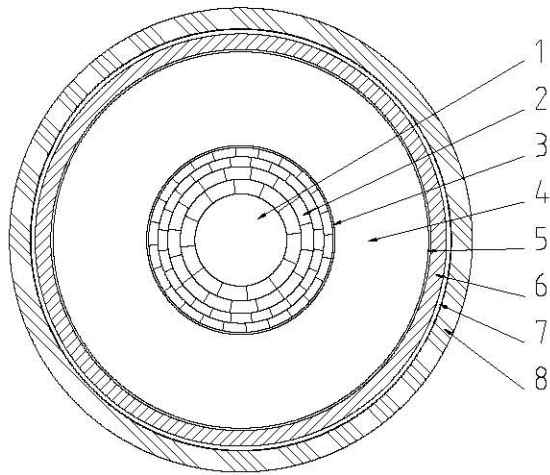
# Submarine Cables - Description



Item	Component	Description	unit	Data
1	Oil Duct		mm	30
2	Conductor	Cross section Self supporting segmental strips of copper	mm <sup>2</sup>	1400
3	Conductor screen	Carbon black papers		
4	Insulation	Special high purity paper tapes impregnated with low viscosity fluid Nominal thickness	mm	24.5
5	Core screen	Carbon black papers copper woven fabric tape		
6	Lead sheath	Extruded lead alloy Nominal thickness	mm	3.8
7	Reinforcement	Bronze tapes		Three layers
8	Anti-corrosion jacket	Extruded polyethylene sheath Nominal thickness	mm	4.3
9	Bedding	Polypropylene yarn		
10	Outer Armour	Copper flat wires armour	Pirelli Nexans	12 x 3 8.5 x 3
11	Serving	Polypropylene yarn Approximate outside diameter	mm	139
Approximate cable weight:				
in air			Kg/m	51
in water			Kg/m	36

Total Length  $\approx 6 \times 40 \text{ km} = 240 \text{ km}$

# Land Cables - Description



Item	Component	Description	unit	Data
1	Oil Duct		mm	30
2	Conductor	Cross section Self supporting segmental strips of copper	mm <sup>2</sup>	2000
3	Conductor screen	Carbon black papers		
4	Insulation	Special high purity paper tapes impregnated with low viscosity fluid Nominal thickness	mm	24.5
5	Core screen	Carbon black papers copper woven fabric tape		
6	Lead sheath	Extruded lead alloy Nominal thickness	mm	3.8
7	Reinforcement	Pirelli cable:	three layers of transversal Bronze tapes	
		Nexans cable:	one layer of longitudinal stainless steel strips plus two layers of transversal stainless steel tapes	
8	Anti-corrosion jacket	Extruded polyethylene sheath	mm	5
		Nominal thickness Approximate outside diameter	mm	134
Approximate cable weight in air			kg/m	48

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

# Cost Sharing Options Considered

- Peak load
- 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

# Sharing of the Costs of the Interconnection Project

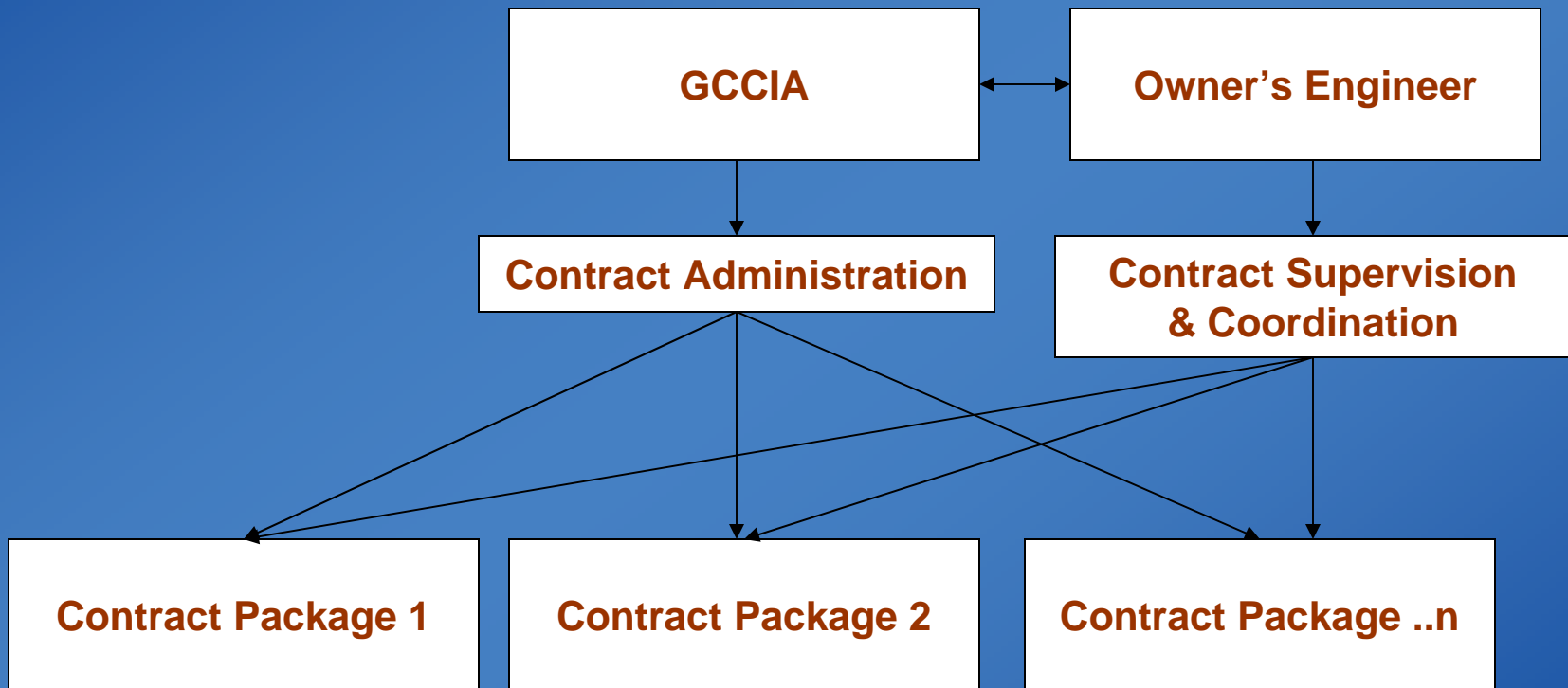
	Phase I (%)	Phases I & III (%)
Kuwait	33.8	26.7
Saudi Arabia (ERB)	40.0	31.6
Bahrain	11.4	9.0
Qatar	14.8	11.7
UAE		15.4
Oman		5.6
Total	100.0	100.0



# 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%

# Implementation Strategy



Functional Relationships

# Contract Packages

- Six – 400 kV Substations
- One – HVDC Converter Station Package
- Four – Overhead Transmission Line Packages
- One – Submarine / Land Cable Package
- Control Centre Package
  - > GCC Control Centre
  - > Telecommunications, Control & Protection

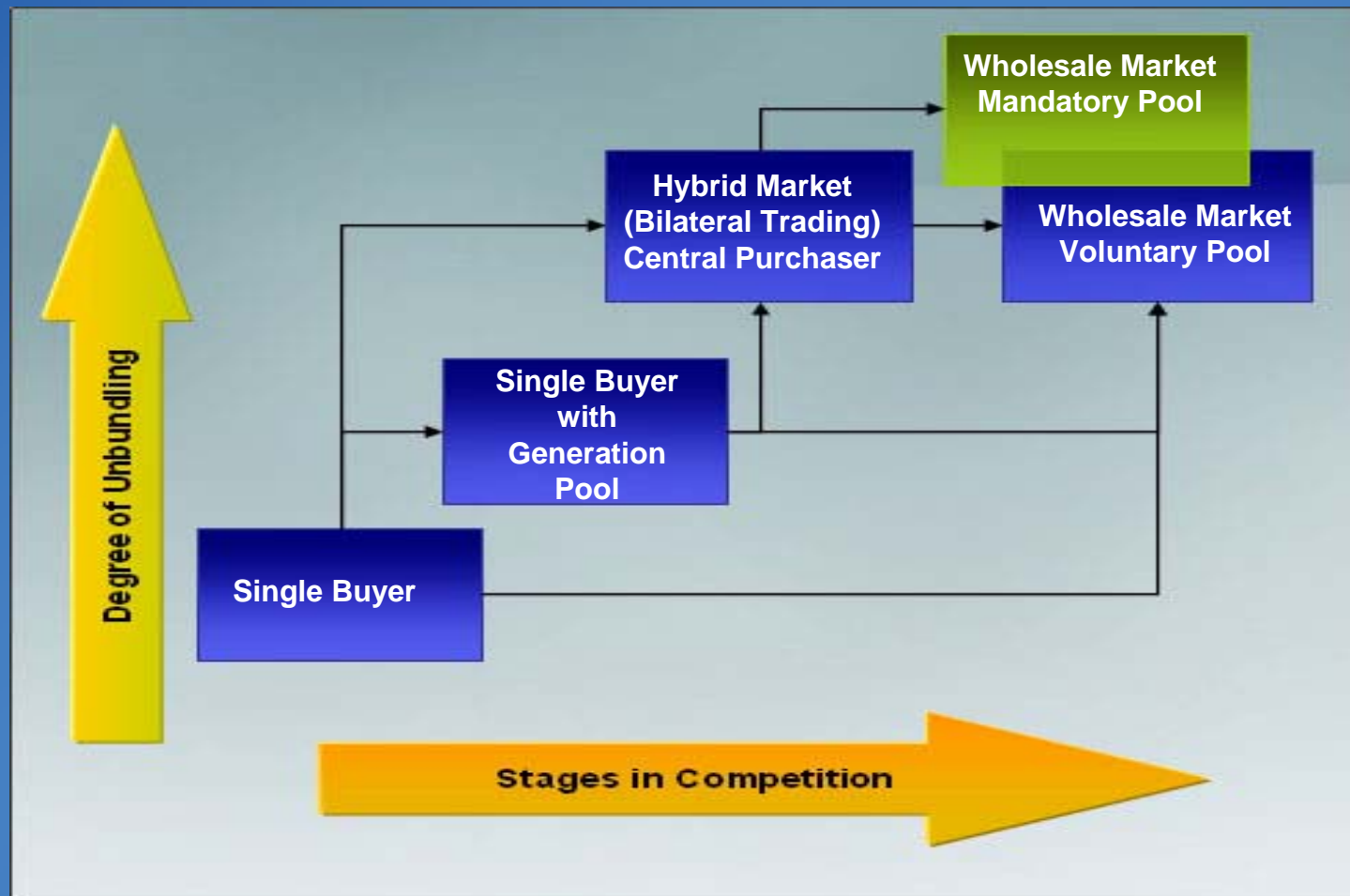
# Project Schedule

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

# 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