Fixed Versus Disconnectable Turret System for F(P)SO's for Gulf of Mexico

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Case Assumptions
Gulf of Mexico

- **Water Depth: 500 meters**
- **FPSO: 1,200,000 bbls storage**
- **Offloading Tanker Parcel: 1,000,000 bbls**
- **Field Life: 20 years**
- **Oil Production Rate: 100,000 bopd**
- **Offloading Rate: 50,000 bbls/hr**
- **Parcel Size Maximum: 1 million bbls**

Design Criteria Factors

- **Environment**
- **Field Characteristics**
- **Production Criteria**
- **Field Life**
- **Flexibility**
- **Operability**
- **Risk**

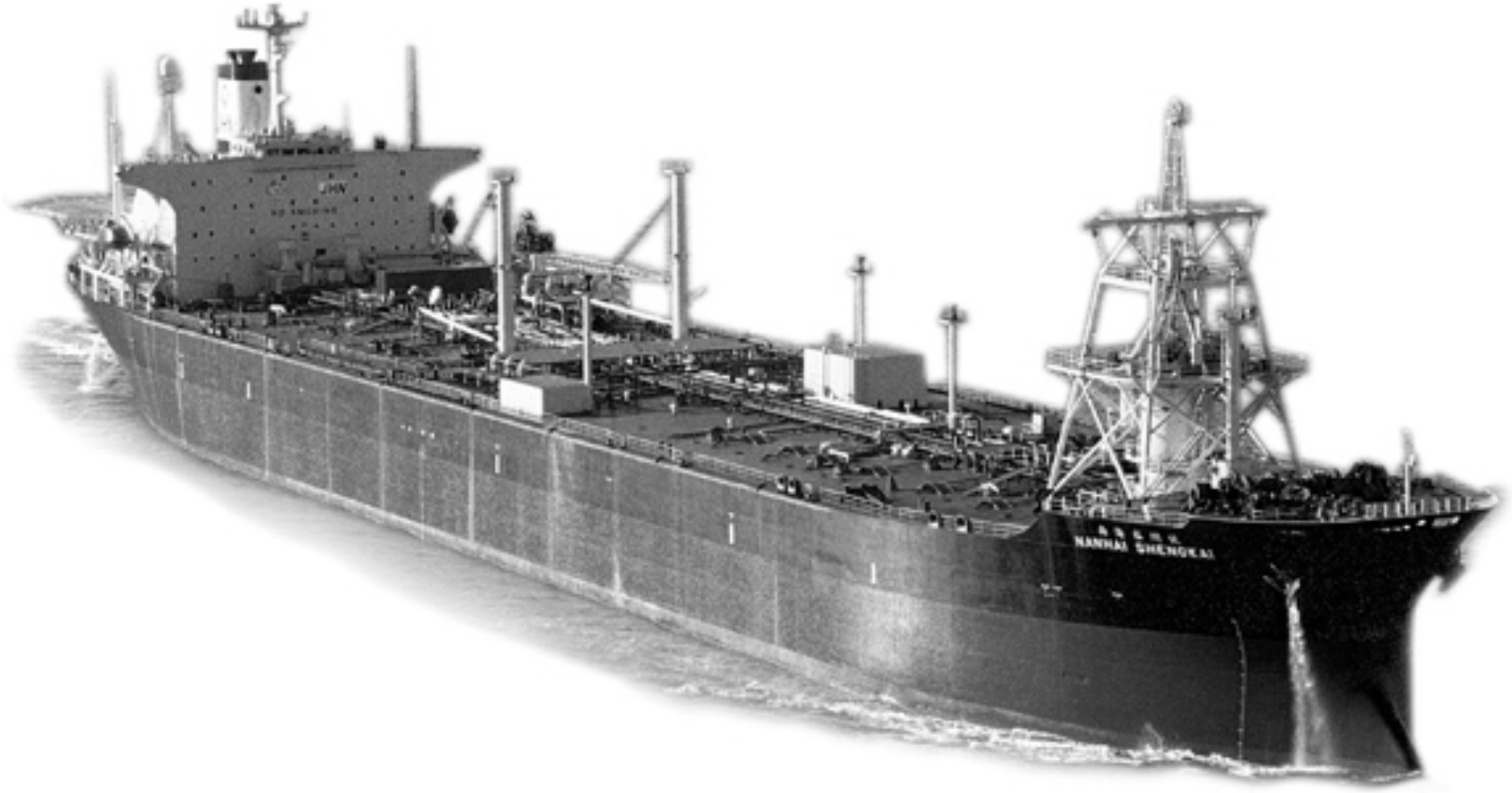
Case Comparison

- **Case 1 – Fixed Internal Turret Mooring System with Tandem Offloading**

- **Case 2 – Disconnectable Internal Turret Mooring System with Tandem Offloading**

Fixed Turret for Amoco Orient Petroleum Co., People's Republic of China, Liuhua 11-1

Disconnectable Turret for JHN, People's Republic of China, Lufeng 13-1



FSO's and FPSO's in the Gulf of Mexico

- **Fixed Turret Systems** **9**
- **Disconnectable Turret Systems** **8**

Case Design Basis

- **Water Depth:** **500 meters**
- **Service Life:** **20 years**
- **Vessel:** **170,000 dwt**
- **Storage:** **1,200,000 bbls**
- **Maximum Offloading Parcel:** **1,000,000 bbls**
- **Oil Production** **100,000 bopd**
- **Gas Production:** **130 MMsfd**
- **Pressure at Vessel:** **285 Psig**
- **Offloading Rate:** **50,000 bbls/hr**

Case-Risers

- **12” Production:** **3 Lines**
- **Umbilicals:** **3 Lines**

100-Year Survival Hurricanes Conditions

100-YEAR SURVIVAL HURRICANE CONDITIONS				
STORMS / DIRECTIONALITY		100-YEAR TYPHOON		
		Collinear	Option 1	Option 2
CURRENT	Velocity @ Surface (m/s)	2.33	2.33	2.33
	Direction (deg)	180	210	225
WIND	Velocity (m/s, 1 minute)	52.1	52.1	52.1
	Direction (deg)	180	180	180
WAVE	Significant Height (m)	12.1	12.1	12.1
	Peak Period (s)	13.8	13.8	13.8
	Peak Parameter	3.3	3.3	3.3
	Direction (deg)	180	180	180

- **Collinear: Wind and current collinear with waves**
- **Crossed Option 1: Current acting 30 degrees to wind and waves**
- **Crossed Option 2: Current acting 45 degrees to wind and current**

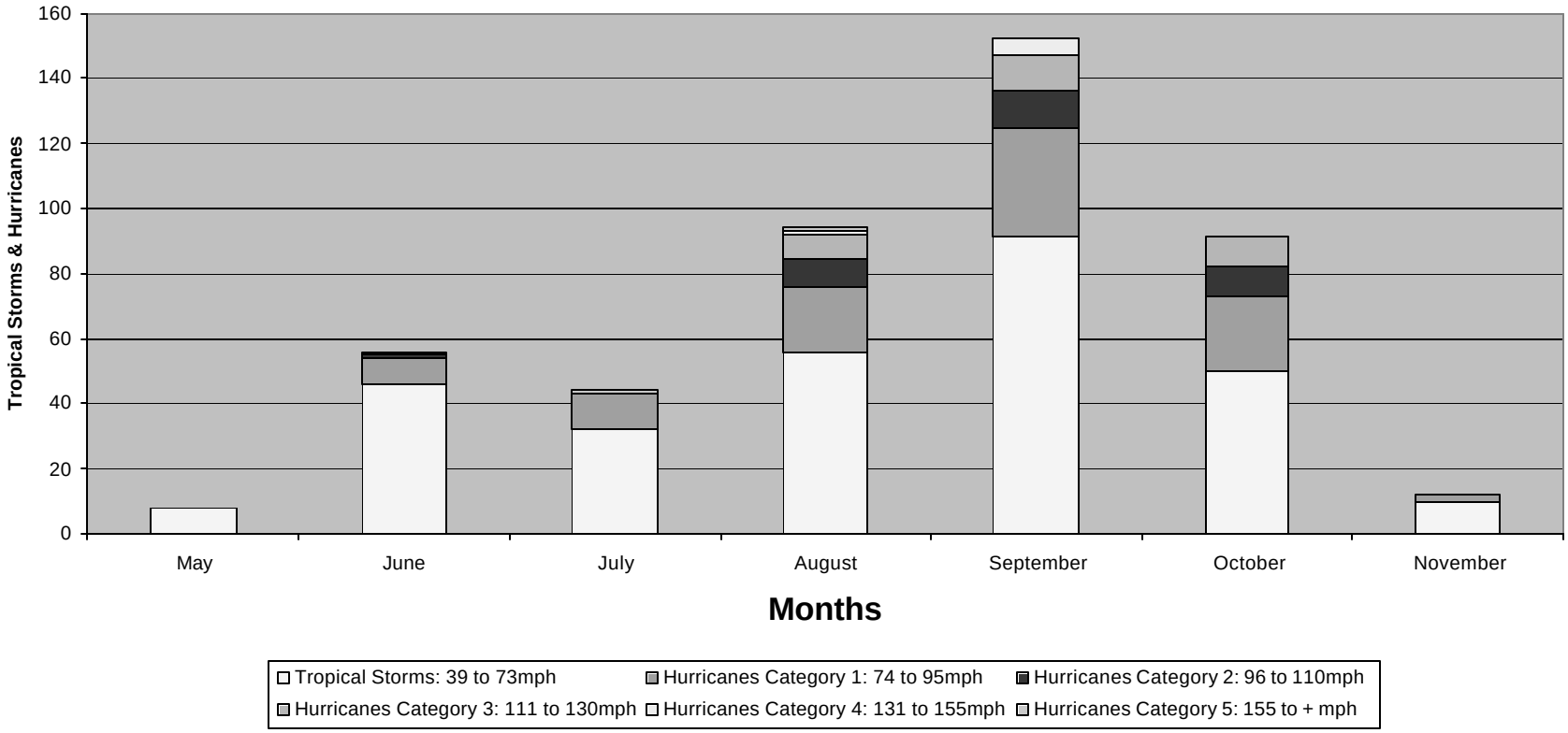
Hurrican Gulf of Mexico Area 1851 – 2002 151 Years

by National Hurrican Center (NHC)

Tropical Storm < 39 mph with sustained surface winds during its lifetime

Hurricane < 74 mph with sustained surface winds during its lifetime

Gulf of Mexico Hurricane Seasons 1851 to 2002 by Month



Subtotal Average Tropical Storms Year	1.9
Subtotal Average Hurricanes Year	1.2
Total Average Tropical Storms & Hurricanes Year	3.1

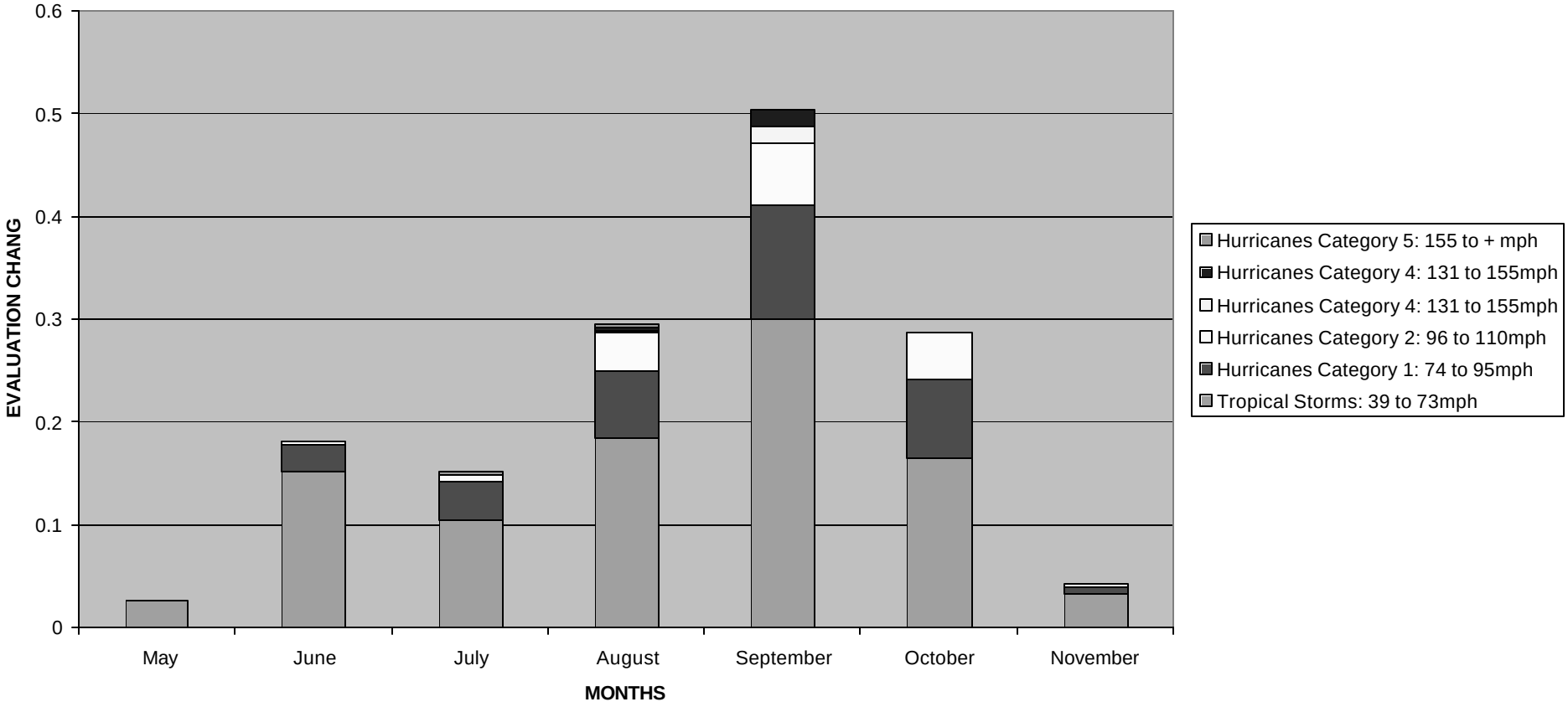
FSO and FPSO Tropical Storm or Hurricane Evacuation

- **First Alert:** **Tropical Storm or Hurricane within 400 nautical miles**

- **Second Alert:** **Evacuate FSO or FPSO when tropical storm or hurricane within 350 nautical miles**

Second Alert happens approximately 50% of the time for tropical storm or hurricanes entering the Gulf of Mexico

Tropical Storms and Hurricanes Gulf of Mexico
Annual Change of Evacuations



Case 1 – Fixed Internal Turret Mooring System with Tandem Offloading

Anchor Legs: 9 Leg 3x3 Grouping

Top Chain – 117mm R4 Studless: 10m

Riser Wire – 111mm Spiral Strand: 510m

Dip Zone Chain – 117mm R4 Studless: 100m

Excursion Limiter

Primary Chain – 127mm R4 Studless: 100m

Attached Chain – 152mm Any Grade: 151m

Ground Wire – 111mm Spiral Strand: 900m

Ground Chain – 127mm R4 Studless: 100mm

Case 1 – Fixed Internal Turret Mooring System with Tandem Offloading (Contd.)

Pull-in Winch:	**250mt**
Anchors:	**9**
Drag Anchors:	**27mt**
Chain Stoppers:	**9**
Offloading Lines:	
1 x 20” Offloading Hose System from FPSO	**520m**

Case 2 – Disconnectable Internal Turret Mooring System with Tandem Offloading

Anchor Legs: 8 Leg Symmetrical

Top Chain – 87mm R4 Studless: 10m

Riser Wire – 81mm Spiral Strand: 510m

Dip Zone Chain – 87mm R4 Studless: 100m

Excursion Limiter

Primary Chain – 100mm R4 Studless: 100m

Attached Chain – 142mm Any Grade: 155m

Ground Wire – 81mm Spiral Strand: 900m

Ground Chain – 87mm R4 Studless: 100mm

Case 2 – Disconnectable Internal Turret Mooring System with Tandem Offloading (Contd.)

Pull-in Winch:	**200mt**
Anchors:	**8**
Drag Anchors:	**16mt**
Chain Stoppers:	**8**
Offloading Lines:	
1 x 20” Offloading Hose System from FPSO	**520m**

CAPEX Cost Estimates

Cost: +1 – 15% Accurately

- **Mooring**
- **Fluid Transfer**
- **Hull Systems**
- **Topside System**
- **Installation**
- **Service and Administration**

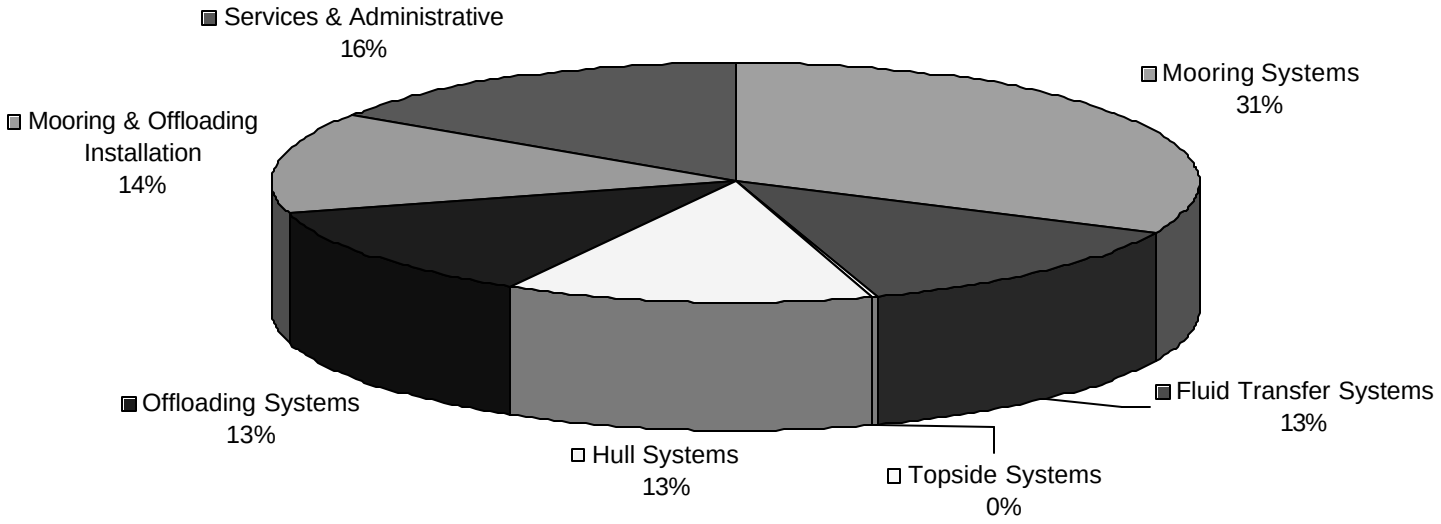
OPEX Cost Estimates

Cost: +1 – 15% Accurately

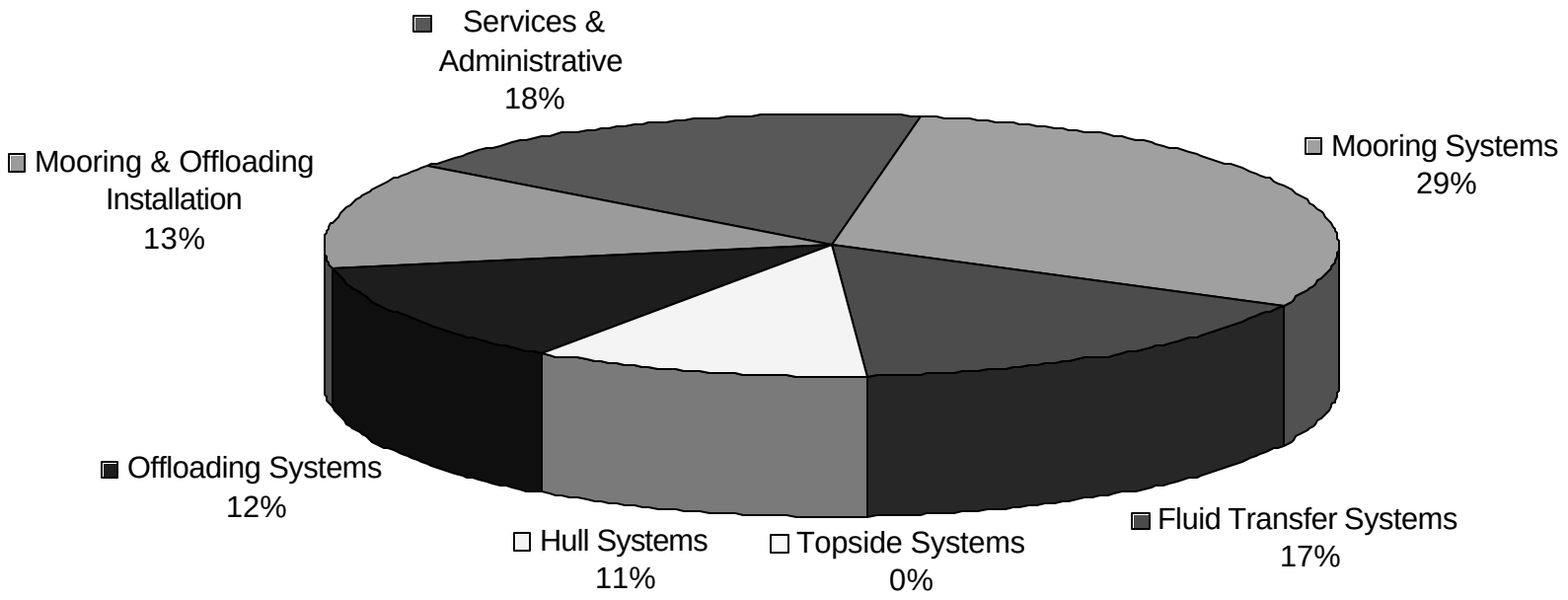
Inflation Rate	**20% per Year**
Present Value (PV)	**10.5% Discount rate computed from first oil milestone**

- **Demurrage**
- **Offloading Tug and Pilots**
- **Offloading Hoses and Hawsers**
- **Tropical Storm or Hurricane Shutdown Helicopter Evacuation**
- **Maritime Crew Requirements**
- **Turret Maintenance**

CAPEX - CASE 1 GULF OF MEXICO
FIXED INTERNAL TURRET MOORING SYSTEM w/ TANDEM OFFLOADING



CAPEX - CASE 2 GULF OF MEXICO DISCONNECTABLE INTERNAL TURRET MOORING SYSTEM w/ TANDEM OFFLOADING



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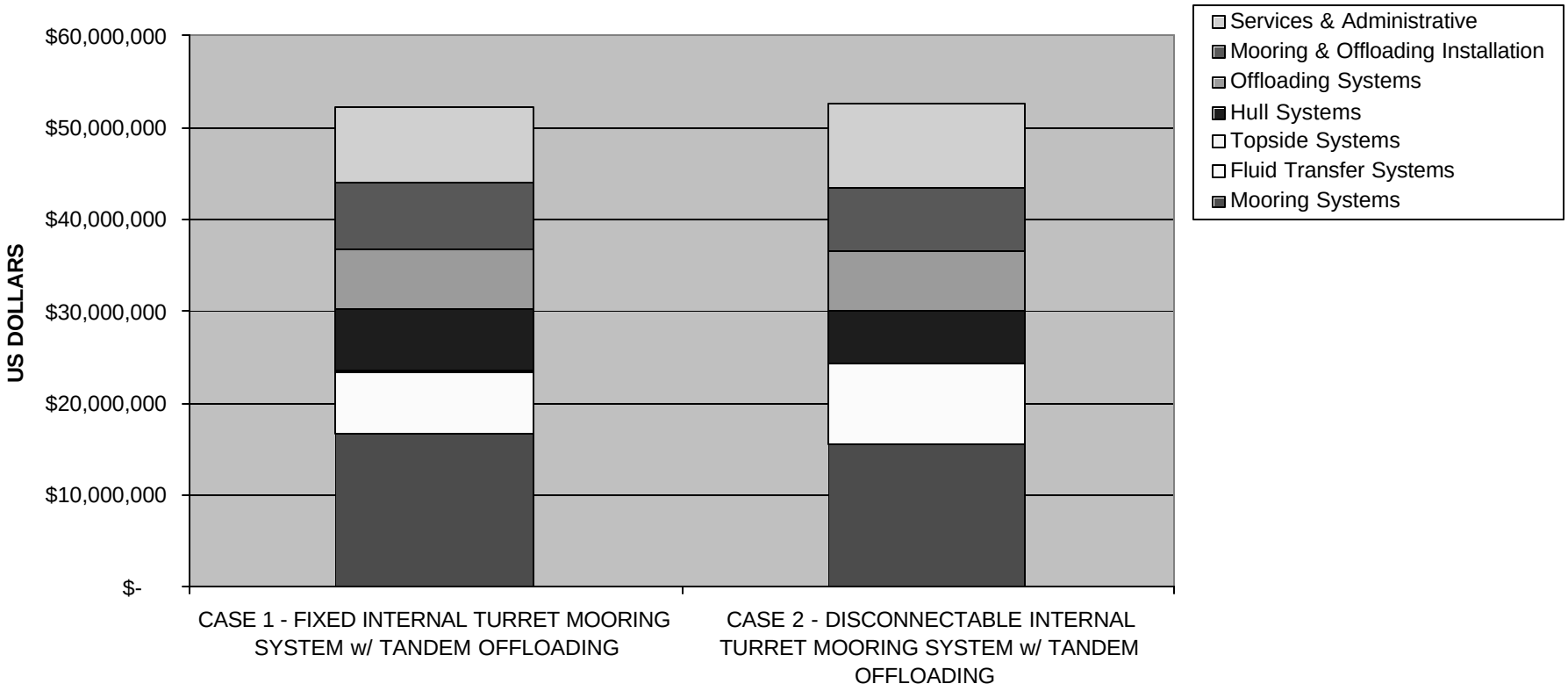
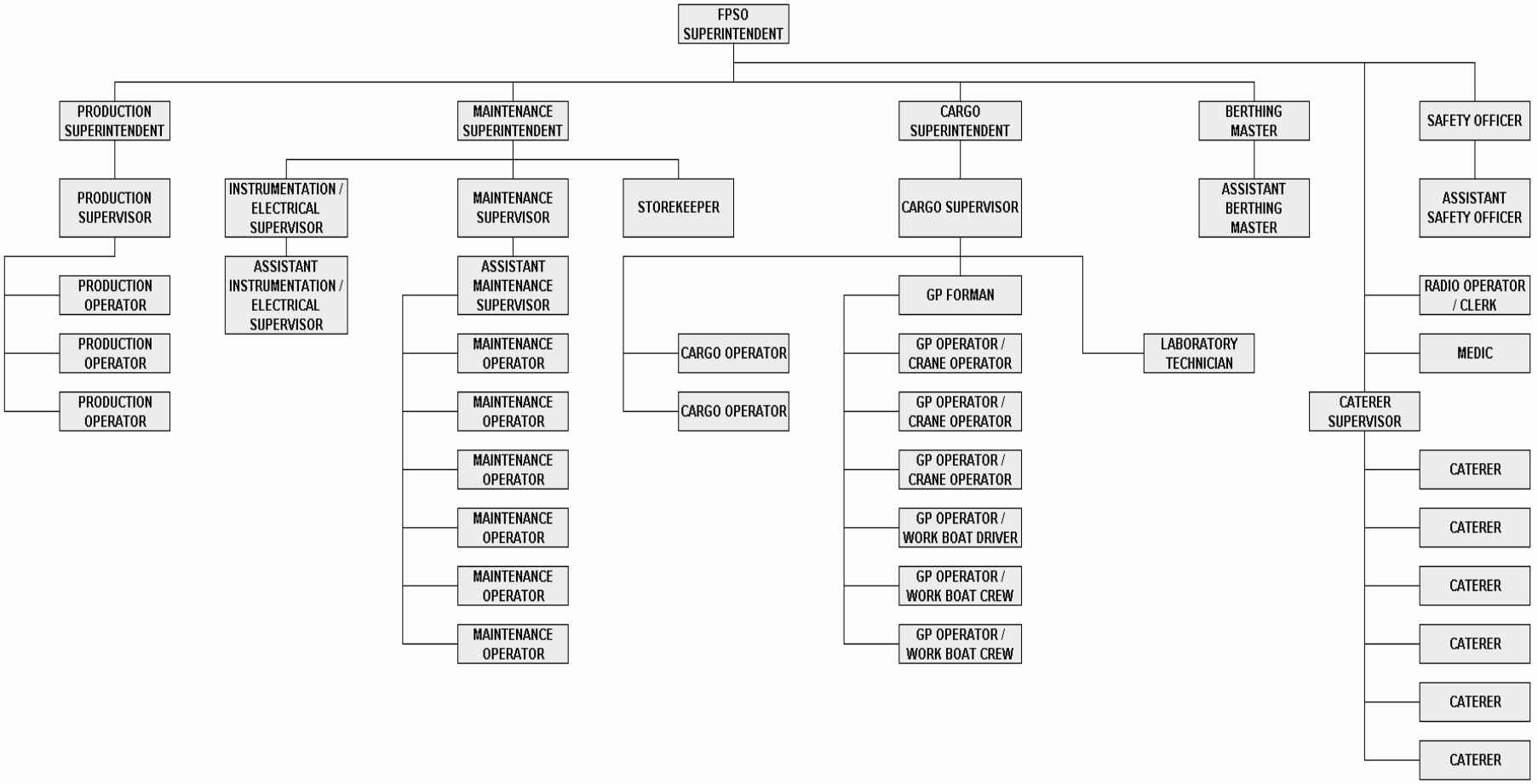
CAPEX - CASE GULF OF MEXICO



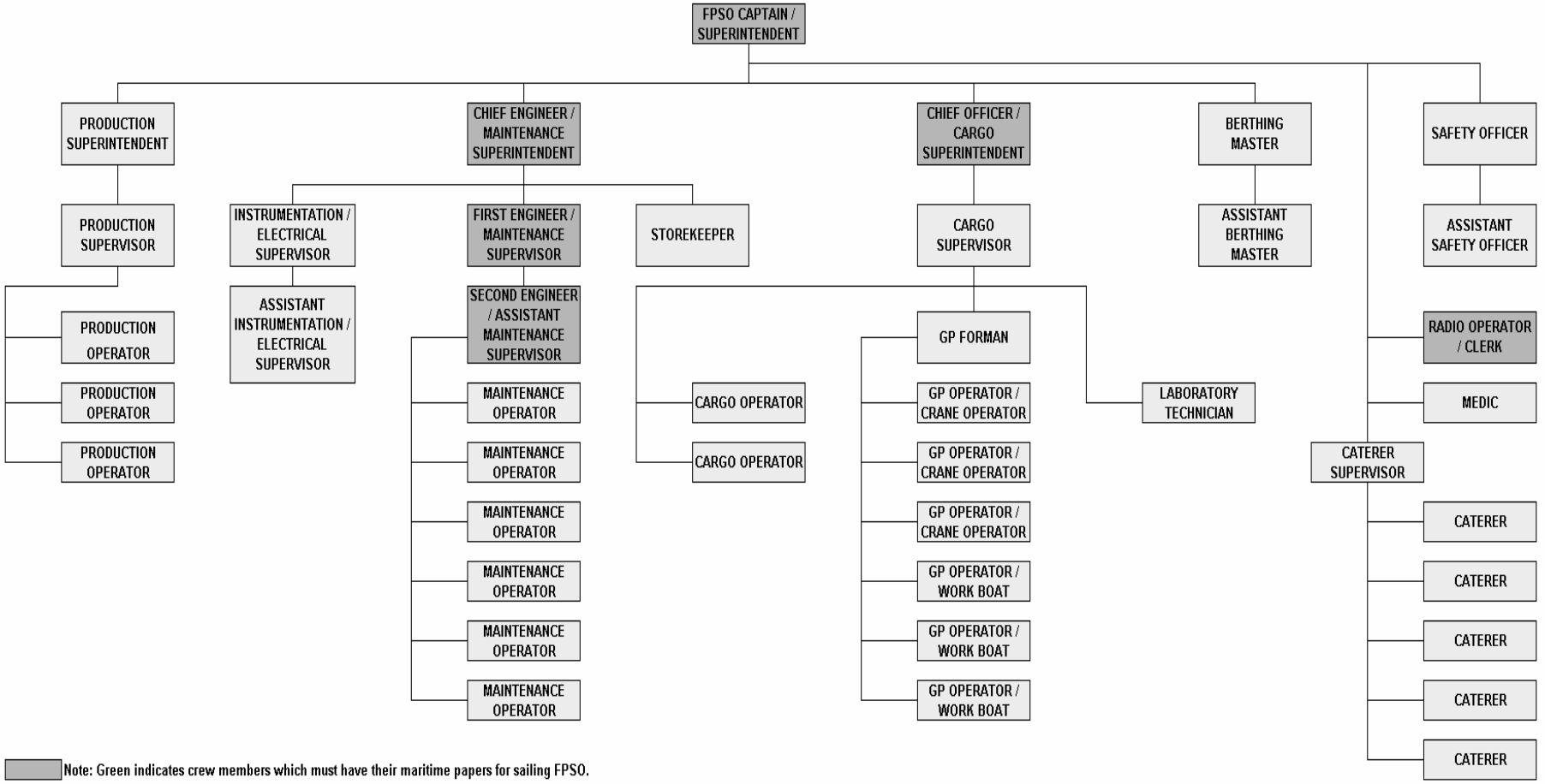
CASE 1 - FIXED TURRET SYSTEM

FPSO CREW COMPLEMENT (43)

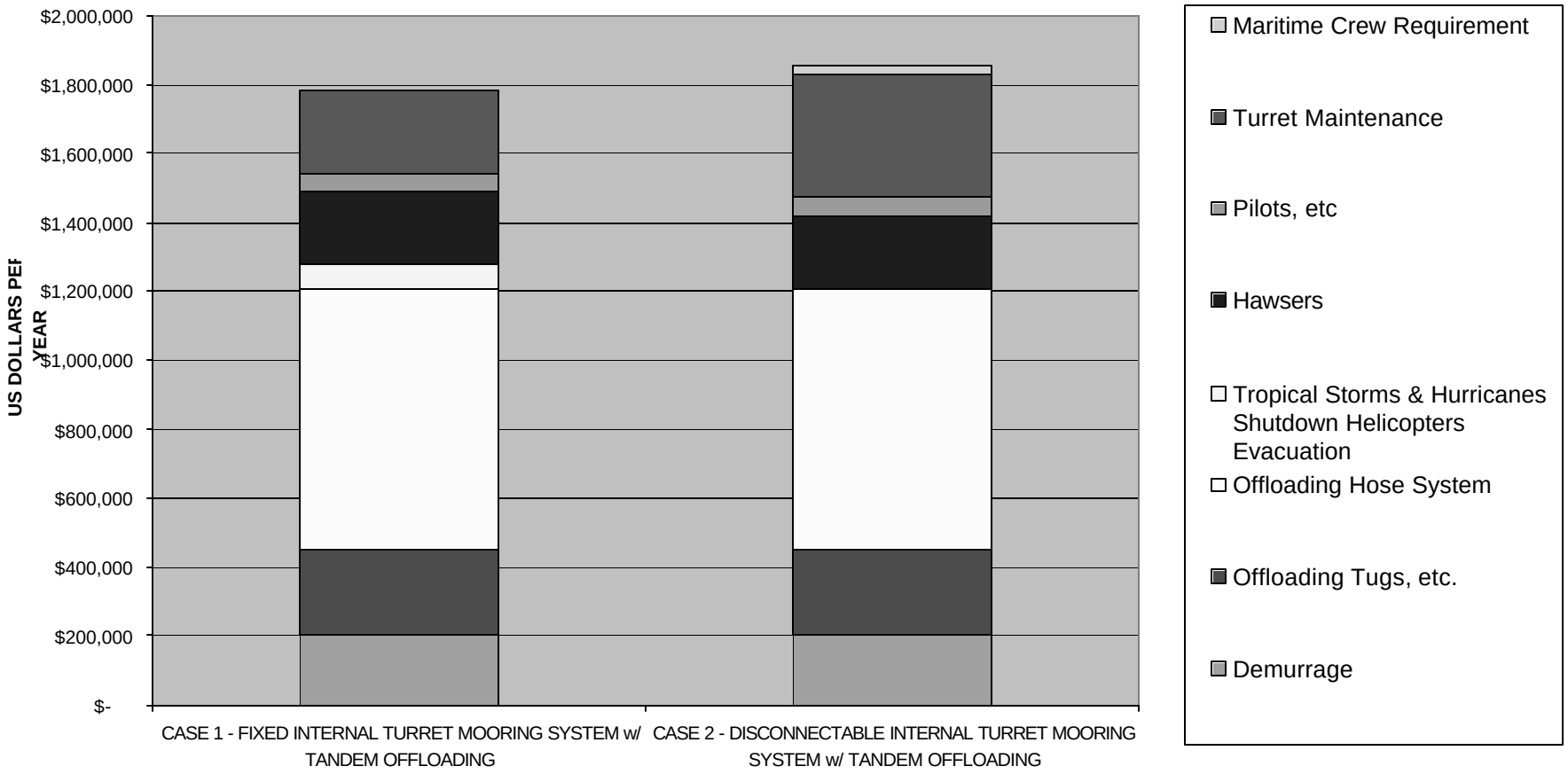


CASE 2 - DISCONNECTABLE TURRET SYSTEM

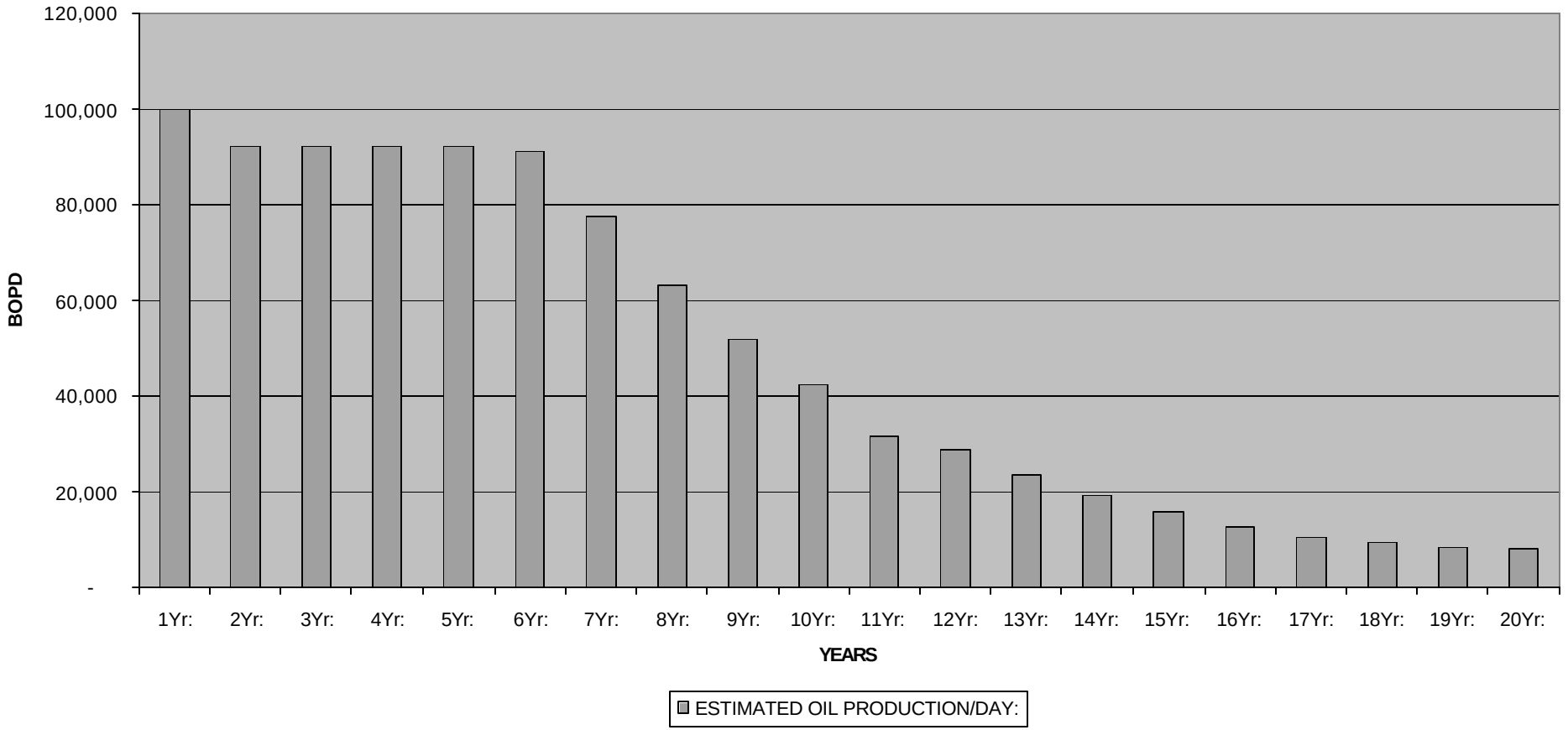
FPSO CREW COMPLEMENT (43)



OPEX AVERAGE TWENTY YEAR OPERATION



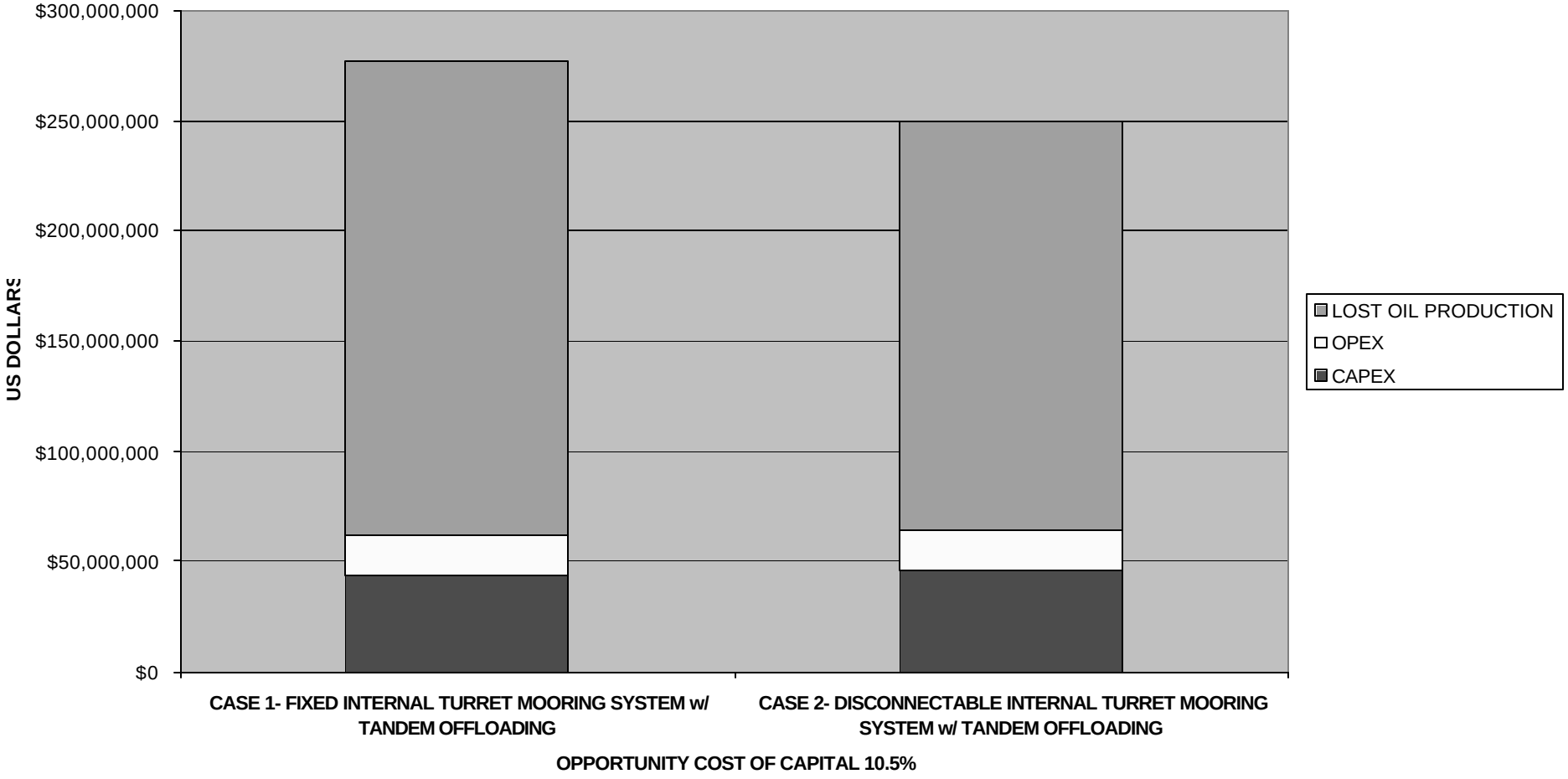
CASE OIL PRODUCTION - GULF OF MEXICO
100,000 BOPD OVER 20 YEARS



Lost Production

	Case 1 – Fixed Turret System	**Case 2 – Disconnectable Turret System**
Process Facilities Maintenance	4 Days	4 Days
Well Major Workover	.5 Days	.5 Days
Downtime Due to Shortage Limitations	4 Days	4 Days
Downtime Due to Tropical Storms or Hurricanes (3 Times)	6 Days	4 Days
Annual Average Lost Production	14.5 Days	12.5 Days

Present Value at First Oil



RISK FACTORS

Description	Case 1 – Fixed Internal Turret System	Case 2 – Disconnectable Internal Turret System
FSO or FPSO	Hull, topside equipment and mooring system must be designed for 100-year survival hurricane conditions and stay on location for 20 years with all maintenance done offshore.	Since the vessel leaves the site as the tropical storm or hurricane approaches, the hull, topside equipment and mooring system will be designed for much lower load conditions than the 100 year huricane conditions. Also the vessel has the additional option of leaving for drydock maintenance such as every five years or in an unexpected maintenance requirement.
Crew	Crew must be evacuated by helicopters as the tropical storm or hurricane approaches.	Crew will sail on vessel as the tropical storm or hurricane approaches.

Conclusion

- **Cost:** **Case 1 Fixed Internal Turret System has the lowest cost for both CAPEX and OPEX by approximately 4% for this case.**

  Case 2 “Disconnectable Internal Turret System” has the least lost production by approximately 5% for this case

Conclusion (Contd.)

- **Risk: Case 2 “Disconnectable Internal Turret System” has the lowest risk on design, crew safety and the flexibility of possible drydocking over the field life**

Conclusion (Contd.)

Note:

- **As the field you are evaluating water depth increases the turret mooring system CAPEX for the fixed system will increase significantly faster than the disconnectable system**

- **For each crew evacuation for a fixed turret system how many helicopters are required and the distance they must travel and what other offshore facilities are they also committed to evacuate**