

APPENDIX E

POSTER SESSION PRESENTATION

**"CONVERSION OF ASSOCIATED NATURAL GAS
TO LIQUID HYDROCARBONS"**

by

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P. Garfield Cooper**

at the

**FETC NATURAL GAS CONTRACTORS REVIEW MEETING
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CONVERSION OF ASSOCIATED NATURAL GAS TO LIQUID HYDROCARBONS

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Energy International Corporation



OBJECTIVE

Evaluate the economics of applying advanced Fischer-Tropsch technology to the economic utilization of remote associated natural gas.

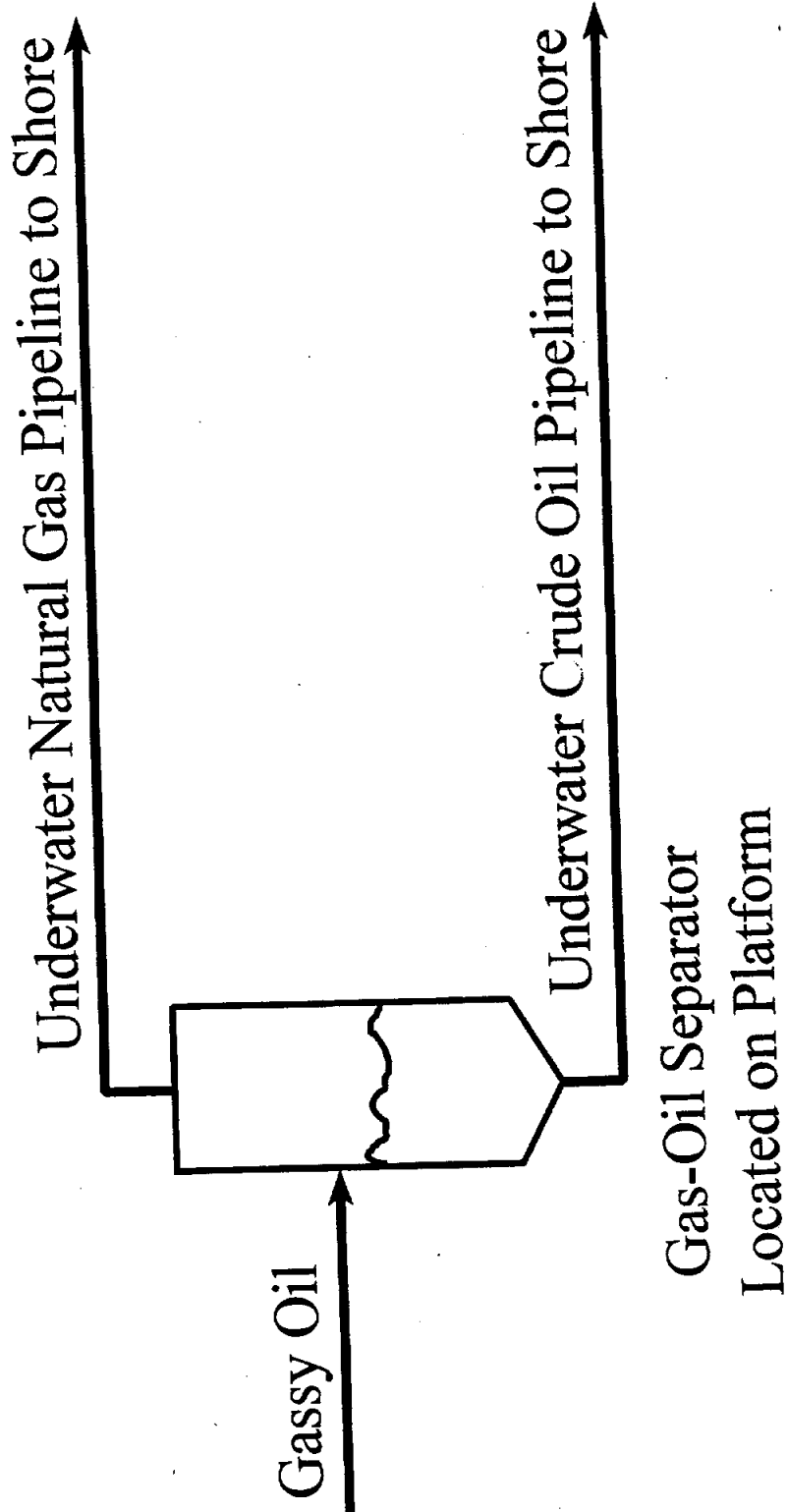


SCENARIO

- ▶ **Gulf of Mexico crude oil and associated natural gas is being discovered and produced in increasingly deeper waters and further from shore**
- ▶ **Current practice is to separate oil and gas on platforms**
- ▶ **Natural gas and crude oil are then transported separately to shore via underwater pipelines**
- ▶ **Capital cost of pipeline for delivering natural gas to market has increased substantially with water depth and distance from shore**
- ▶ **Associated natural gas must be either recovered and utilized or reinjected; flaring is not an option**



UNDERWATER PIPELINES





SCENARIO (Continued)

Fischer-Tropsch technology:

- ▶ has been proven feasible for converting natural gas to petroleum-compatible hydrocarbon liquids
- ▶ has experienced dramatic improvements in catalyst technology
- ▶ has experienced dramatic reduction in reactor size and cost due to slurry bubble column reactor technology
- ▶ can benefit from continuing strides in natural gas reforming technology that have improved the economics of conversion to synthesis gas ($\text{CO} + \text{H}_2$)



PROCESS CHEMISTRY

The first step in natural gas processing:

STEAM REFORMING



*Produces a mixture of carbon monoxide (CO)
and hydrogen (H₂)*



PROCESS CHEMISTRY

(Continued)

The second step:

FISCHER-TROPSCH PROCESS



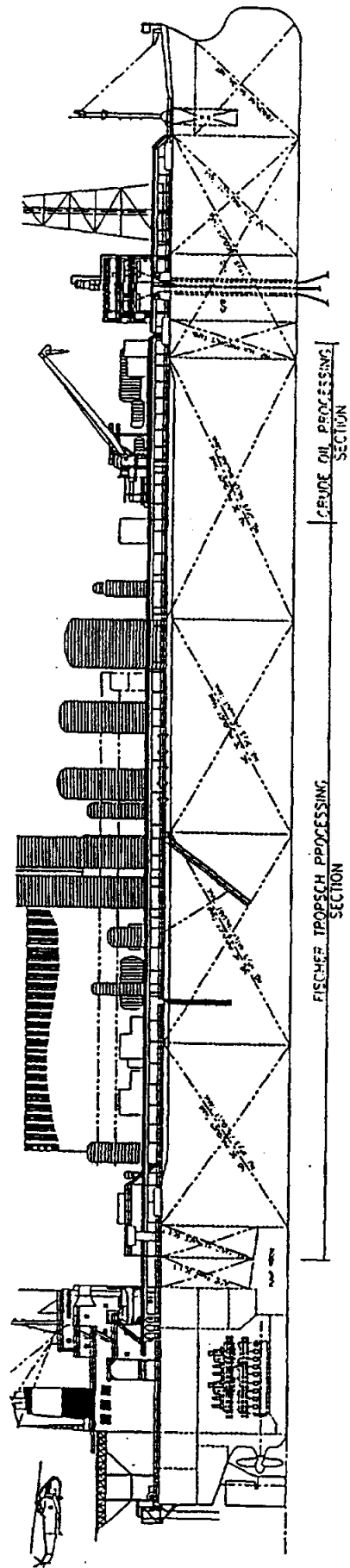
Produces n-paraffin hydrocarbons and water. Using a catalyst like ENERGY INTERNATIONAL's cobalt on alumina catalyst gives a very high proportion of straight chain saturated hydrocarbons which contain no sulfur, nitrogen, or metals.



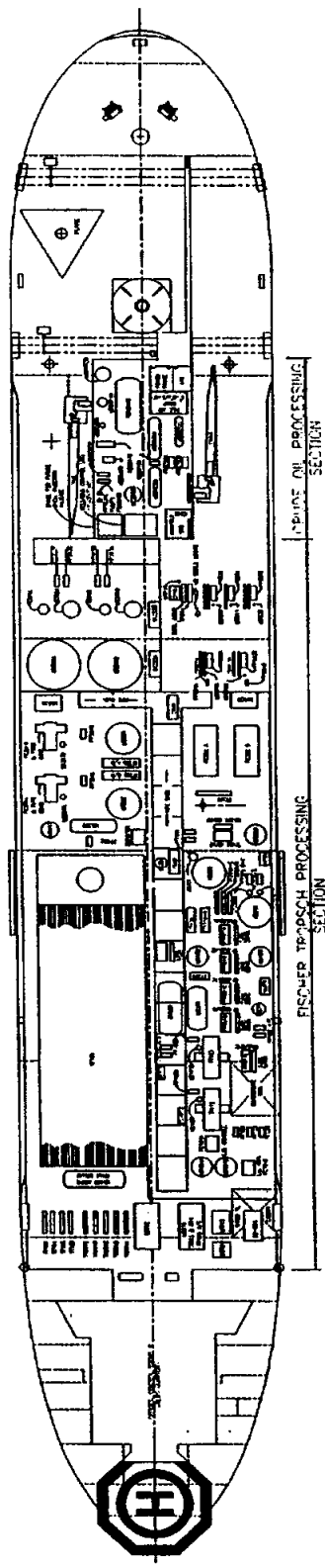
PROCESS CHEMISTRY

(Continued)

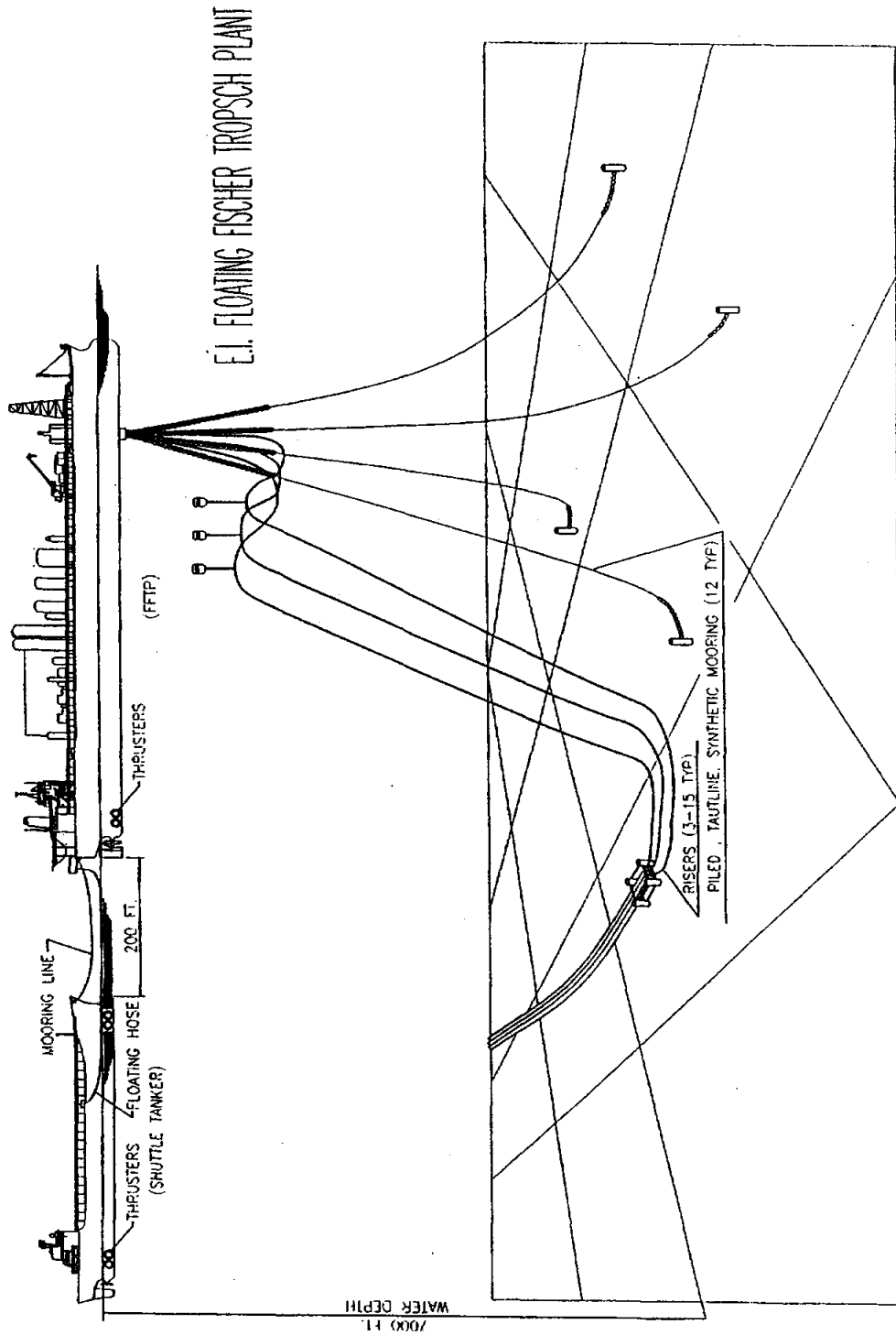
- ▶ The catalyst and the reaction conditions determine the upper limit for n , the number of carbon atoms in the hydrocarbon molecules produced.
- ▶ The "carbon number" of hydrocarbons produced by the Fischer-Tropsch reaction always has a wide range. "n" ranges from 1 to an upper limit of 50, 70, or even 100.
- ▶ Thus, the following products are produced:
 - LPG
 - NAPHTHA
 - DIESEL
 - HEAVY GAS OIL / WAX



E.I. FLOATING FISCHER TROPSCHE PLANT

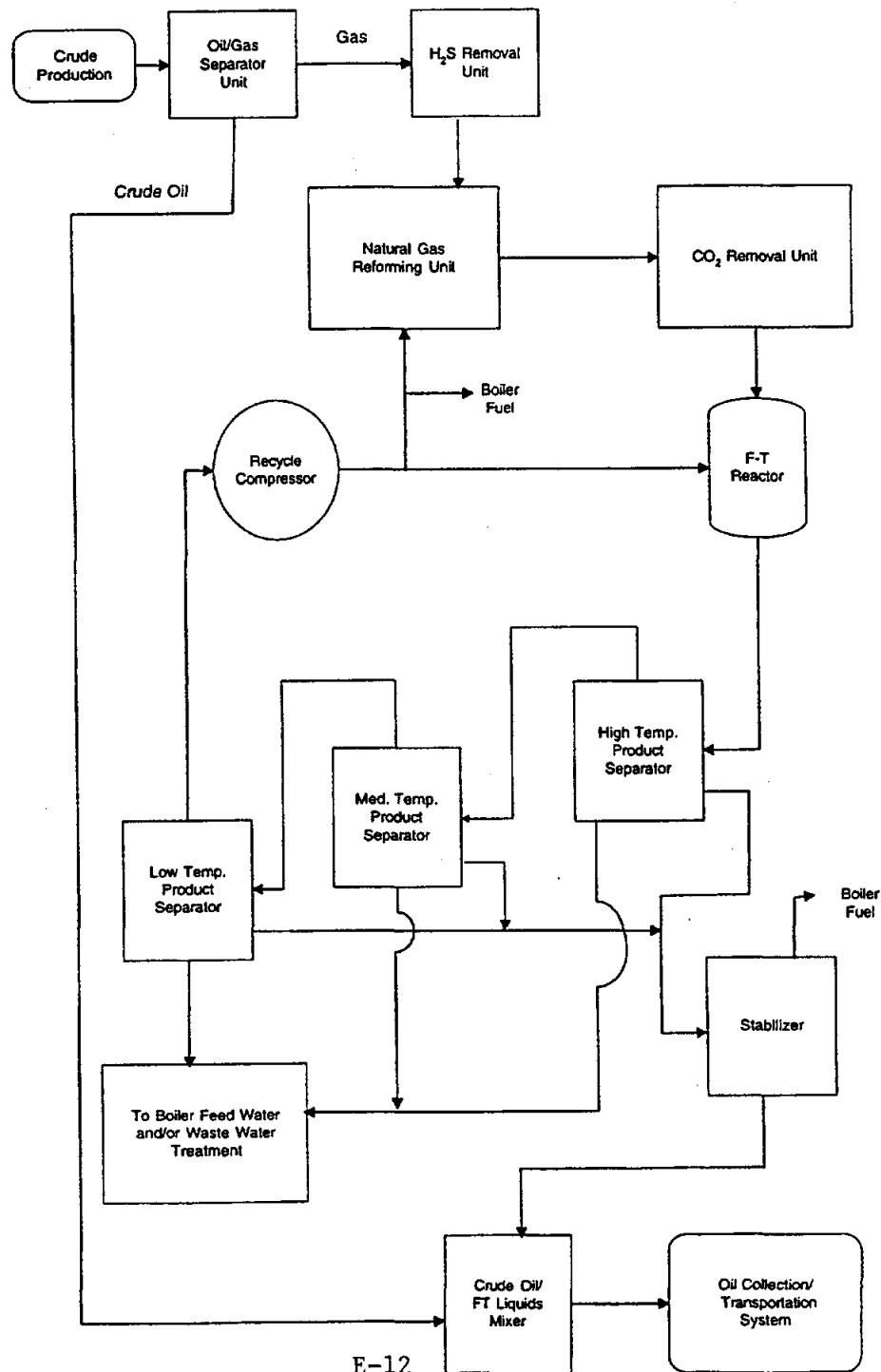


E.I. FLOATING FISCHER TROPSCH PLANT





OFFSHORE FISCHER-TROPSCH PLANT ASSOCIATED GAS TO HYDROCARBON LIQUIDS





CONCEPTUAL CAPITAL COST ESTIMATE FOR A FLOATING F-T PLANT

Gas Consumption, MMSCFD	200
F-T Production, BPD	25,000
Vessel	VLCC (1030')

Cost Estimate, Millions of Dollars

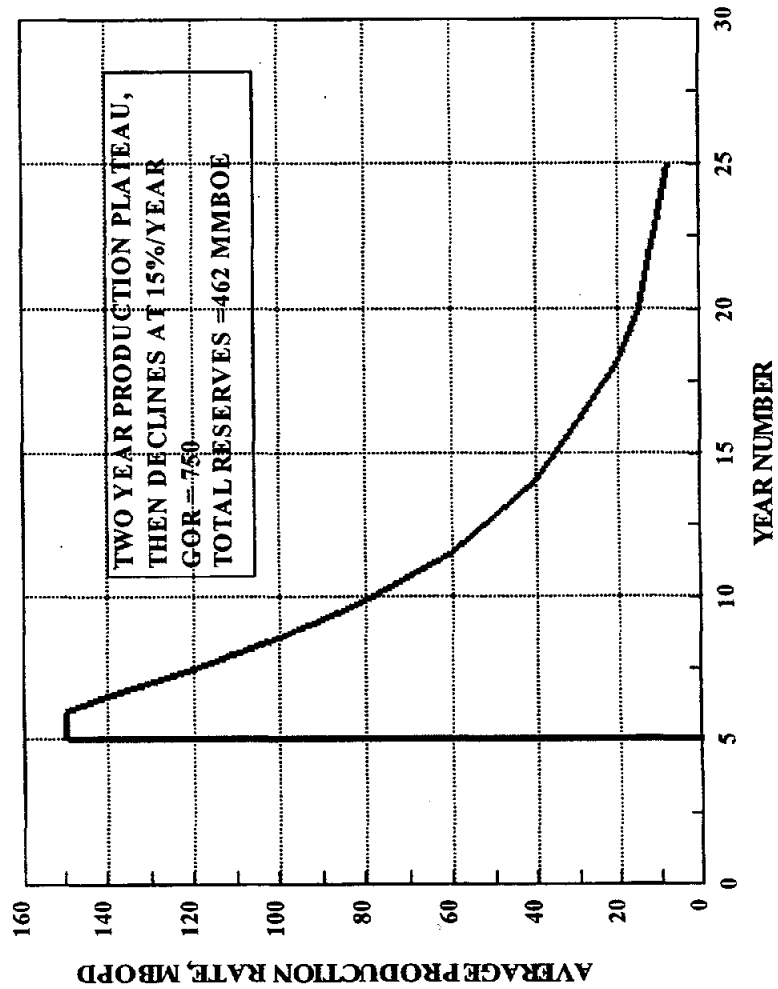
Vessel Acquisition & Amortization	15.60
Life Extension Measures	7.80
Engineering Systems & Structure for F-T Plant	24.00
Upgraded Ship Systems	10.50
Mooring & Internal Turret	65.00
Crude Process & Flare	16.20
Naval Architecture, Marine Engineering, Supervision	<u>2.90</u>
Subtotal	<u>137</u>
F-T Plant	<u>383</u>

Total FFTP/FPSO

525

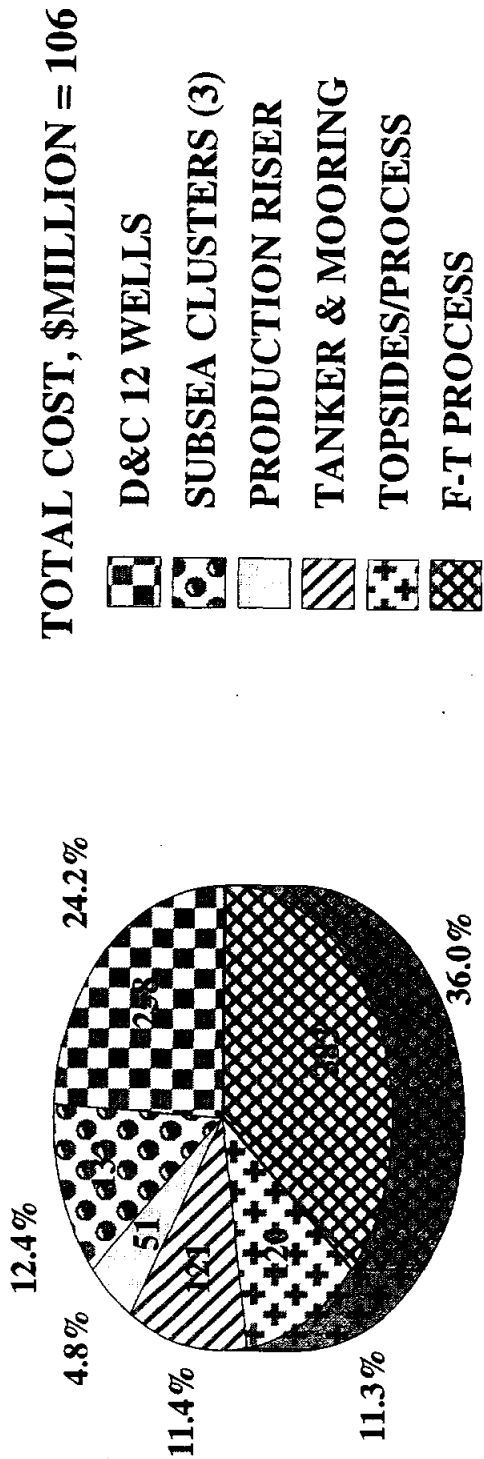


HYPOTHETICAL FIELD DEVELOPMENT PROFILE USED FOR COMPARING PIPELINE AND FFTP OPTIONS



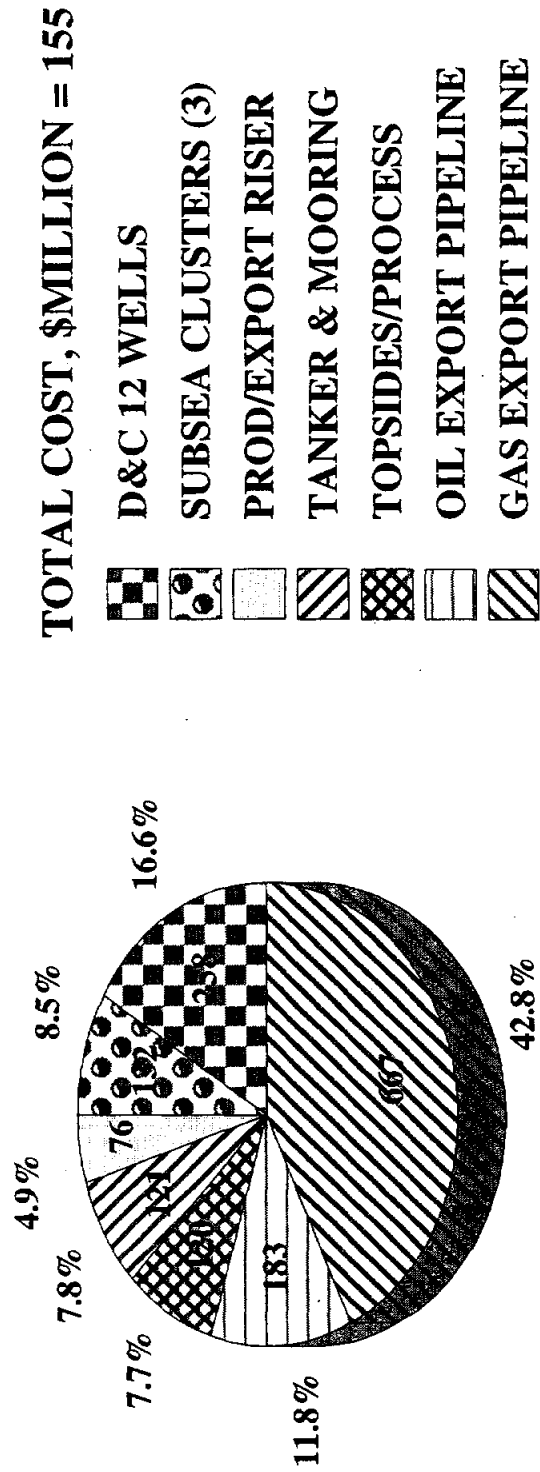


FETP OPTION COSTS



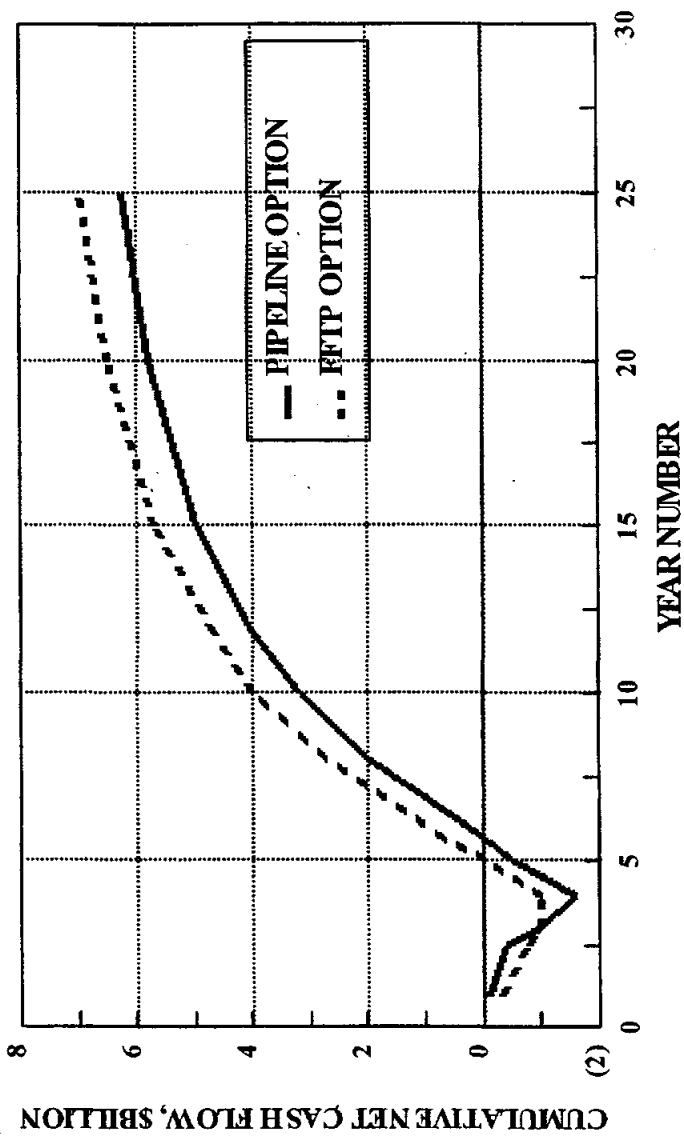


PIPELINE OPTION COSTS





CUMULATIVE NET CASH FLOWS UNDISCOUNTED, UNINFLATED, AND BEFORE TAXES





CONCLUSIONS

- ▶ In many water-based locations such as, but not limited to, the Gulf of Mexico converted tankers (VLCC's) offer an attractive "platform" for combining production operations with Fischer-Tropsch conversion of natural gas
- ▶ At pipeline distances of greater than 200 miles, or with difficult ocean bottom conditions, Fischer-Tropsch conversion of remote associated natural gas may provide superior economics to pipeline delivery of natural gas



CONCLUSIONS (Continued)

- ▶ **Given the availability of a ship mounted production/Fischer-Tropsch facility, one could get an early start on producing a new discovery, i.e., otherwise marginal competitive economics could be made attractive from cash flow considerations**
- ▶ **FFTP is movable/usable for a series of short life projects**
- ▶ **Fischer-Tropsch options are to gas pipelines as coal derived synthetic fuels are to crude oil**



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