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GASOLINE FROM NATURAL GAS

by

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I. INTRODUCTION

SLIDE 1: SCOPE OF PAPER

Synfuels from competitively-priced natural gas are today a viable alternate to crude-derived products. This paper examines the major factors that will influence such projects. Particular emphasis is given to the prospects for gas-based synfuels to supply domestic product markets in Thailand. Some market and resource assessment data are given for other Pacific Basin countries.

Although the assigned topic of the paper concerns gasoline production, available technology offers the option of maximizing either gasoline or distillate product. Because this flexibility is potentially important, the paper includes both product options. In the discussion, references to transport fuels should be understood to include both gasoline and distillate fuels.

SLIDE 2: PROCESS OPTIONS

Liquid transport fuels can be produced from natural gas by three major routes:

- Methanol-to-Gasoline (MTG)
- Fischer-Tropsch
- Methanol (for fuel use)

The MTG process was developed by Mobil Corporation. The first commercial operation will start up in New Zealand in 1985. Gasoline production capability of that plant will be 14,000 BPD.

Operation of the Arge and Synthol Fischer-Tropsch processes began by Sasol in South Africa in 1955; two major capacity additions using the Synthol technology were completed in the early 1980s under Fluor project management. All of that capacity is based on syngas produced by coal gasification. The Synthol Process is owned by Sasol and the Arge Process is owned by Ruhrchemie, Lurgi, and Sasol. A number of developers have current programs aimed at new catalysts or reactor designs for the future.

Although methanol is the subject of another paper, it is included here to illustrate its relationship to the "standard" fuel options. Modern methanol processes are available from several licensors.

II. MARKETS

SLIDE 3: THAILAND CRUDE OIL AND NATURAL GAS BALANCE

The demand and supply of crude oil and natural gas in Thailand is shown in Slide 3, as forecasted by the World Bank. The forecast indicates a slow and controlled growth in oil use with a major increase in the use of domestic gas and a smaller increase in domestic oil production as envisioned by current exploration prospects. The forecast assumes increased use of hydroelectric power and lignite-based power production. Crude oil supply is primarily by imports; this suggests that an opportunity exists for import displacement.

SLIDE 4: POTENTIAL IMPACT OF SYNFUELS

The distribution of Thai oil products consumption is shown here for the purpose of comparing the petroleum product substitution capabilities of the synthetic fuel options.

Methanol (MeOH) has two distinct market uses for auto fuel. One is as a low volume blend (less than 5%) in gasoline with cosolvents and additives. The other use is as medium or high volume blends in gasoline where it can substitute for up to about 85 percent of the gasoline. Methanol used in high volume blends with gasoline is often called "neat" methanol. Low volume blends can be marketed interchangeably with gasoline as is being done today in the U.S. However, medium and high volume blends require fuel system and/or engine modifications. Since these blends cannot be used in automobiles that have not been designed or modified to accept them, they would become a new grade of fuel. This factor introduces a complexity in storage, distribution, and marketing that is not present in any of the other options.

The amount of methanol which can be used domestically in Thailand in low volume blends is quite small, at about 5 percent of the gasoline market. Neat methanol could replace a large volume of the domestic gasoline demand. A potential for methanol which is not shown may eventually exist in diesel fuel applications, which are currently under test.

Gasoline from the MTG Process has the potential to satisfy all domestic gasoline requirements, since this product is fully interchangeable with crude oil-derived gasoline. The current commercial configuration of the MTG Process does not provide distillate product capability.

Fischer-Tropsch processes yield products with the highest potential to substitute for petroleum products in the Thai market. They offer the potential to produce both gasoline and distillates which are interchangeable with oil-derived products. Synthetic light fuel oil could also be substituted for residual fuel oil if an overall benefit to the country resulted.

Current refinery nameplate capacity in Thailand is 176,000 BPSD and product imports amount to about 50,000 BPD.

Also shown on the slide to establish perspective is the nominal 15,000 BPD output of a single natural gas-to-synfuels plant. A single unit of this type would be small in comparison with either the total Thai market or existing refinery capacity. As a result, the installation of such a facility should not disrupt existing operations. A logical initial objective would be displacement of product imports.

III. NATURAL GAS RESOURCES

SLIDE 5: POTENTIAL FOR TRANSPORT FUELS FROM NATURAL GAS IN SELECTED PACIFIC BASIN COUNTRIES

The potential for producing transport fuels from natural gas in selected Pacific Basin countries is indicated in Slide 5. The potentials are shown in terms of the number of 15,000 BPD plants which could be built based upon uncommitted gas or on replacement of imported oil. Uncommitted gas quantities are based upon proven reserves less thirty years of current domestic and LNG - dedicated usage.

It is clear that the potential for domestic utilization of synthetic fuels to replace oil imports is quite large in Australia, Thailand, and New Zealand. The estimated currently uncommitted gas reserves are large enough to support large-scale domestic synfuels programs in each country shown, but Malaysia and Indonesia have a current surplus of oil for export. The long-term potential that may emerge with those exporters as oil production declines was not analyzed. Thailand, Australia, and New Zealand appear to have the best balance between gas availability and oil import substitution potentials.

It is not expected that these maximum synfuels potentials will be realized. Other uses are planned and will be selected for some of this uncommitted gas. On the other hand, a single 15,000 BPD synfuels plant requires only 150 MM SCFD of gas feed, giving a reserve requirement of 1.5 trillion cubic feet for thirty years of operation. Since this requirement is small relative to potential reserves in each of the countries shown, there is a good possibility for future synfuels projects to be developed in parallel with other gas-based projects.

The effect on world transport fuel markets of building a large number of these synthetic fuel plants would be small, as shown in the insert table on Slide 5.

SLIDE 6: SPECIFIC THAILAND NATURAL GAS AVAILABILITY

This is a more detailed review of the Thai potential for synthetic fuels from natural gas than that shown on Slide 5.

The first bar shows the reserves available as described in the Petroleum Authority of Thailand (PTT) brochure on The Gas Plant Project. Reserves are separated into proven, probable, and possible. Other sources contain higher estimates of reserves. The World Bank estimates a high total potential of 35 trillion cubic feet as compared to the PTT total of 24 trillion cubic feet. Some sources estimate a proven reserve of 13 trillion cubic feet. In spite of recent deratings of some natural gas reserves, the potential for increasing proven and probable reserves appears high considering the current high level of exploration.

The second bar represents thirty years of reserves assumed committed for domestic uses at 1983 levels, which amounts to 1.9 trillion cubic feet or about 30 percent of the proven reserves shown. A single 15,000 BPD synfuels project would require commitment of 1.5 trillion cubic feet for thirty years of operation, as shown in the third bar. This quantity would fit easily into the remaining uncommitted but proven reserves.

IV. TECHNOLOGY

SLIDE 7: BLOCK FLOW DIAGRAM

In each of the process options, the first step is the conversion of natural gas into syngas, a mixture of hydrogen and carbon oxides. This can be done by tubular steam reforming, autothermal reforming, or partial oxidation. The commonly used steam reformer reacts steam and hydrocarbon over a fixed bed of nickel catalyst within the radiant tubes of a furnace. Typical outlet operating conditions are 800-900°C and atmospheric to 35 atm pressure.

Fischer-Tropsch synthesis is the direct conversion of syngas into hydrocarbons. Typical reaction product liquid is a mixture of paraffins, olefins, aromatics, and oxygenates (alcohols, ketones, acids). Upgrading processes are used downstream to increase the yield and quality of transport fuels. Relative yields of distillate to gasoline can be highly influenced by the selection of the upgrading processes as well as the Fischer-Tropsch synthesis process. Downstream processing can include some combination of alkylation, oligomerization, cracking, catalytic reforming, and hydrotreating processes.

Methanol synthesis is the other primary conversion step for transport fuels from syngas. Methanol product can be blended with gasoline and additives as a substitute fuel, or can be converted to gasoline in the MTG process. Reaction product from MTG is a mixture of paraffins, olefins, and aromatics. Alkylation is used downstream to increase the yield and quality of the gasoline product.

SLIDE 8: TYPICAL SYNTHESIS PARAMETERS

Operating conditions of each of the synthesis processes are moderate, as shown here. Each process uses a solid catalyst and is exothermic. Temperature control in current commercial processes is achieved using specialized reactor designs, including:

- Entrained-bed
- Fixed-bed with gas quench
- Tubular fixed-bed with steam generation outside the tubes

The fixed-bed MTG Process is carried out step-wise. The first stage converts a portion of the methanol to dimethyl ether (DME) and water. Effluent from the first stage is converted to gasoline in a second stage.

The present commercial Fischer-Tropsch processes are the entrained-bed Synthol Process and the fixed-bed Arge Process, each using iron-based catalysts. Development programs now under way offer the potential of new catalysts and reactor designs for the future. One example of this work is the development of multifunctional catalysts combining zeolites with metals. Shape selectivity and water-gas shift activity can be achieved in addition to Fischer-Tropsch activity in this way. Alternate reactor systems are also being piloted or demonstrated, as shown on the next slide.

Methanol synthesis is the only option shown in which the per-pass conversion to syngas is equilibrium limited. The conditions shown represent the modern low temperature process, although some modern plants have design pressures as low as 50 atm.

SLIDE 9: EXAMPLES OF NEW TECHNOLOGY PROGRAMS

While this is only a sampling of the numerous efforts being carried out worldwide in synthetic transport fuels technology, it does identify several major publicly-announced programs.

The fluid-bed version of MTG is expected to offer an improved service factor and thermal efficiency over the fixed-bed design. This program is sponsored by Mobil, URBK, Uhde, the U.S. Department of Energy, and the West German Ministry of Research and Development.

While objectives of the Fischer-Tropsch programs vary, most programs are geared to achieve at least some of the following:

- High per-pass conversions of synthesis gas
- Minimum formation of methane and light ends
- Minimum formation of oxygenated by-products
- Flexibility to alter the distillate/gasoline mix in the product

The Mobil and Union Carbide programs shown are being carried out under contract from the U.S. Department of Energy, while the Sasol and Gulf/Badger programs are privately funded.

In the product upgrading area, the Mobil Olefins to Gasoline and Distillate (MOGD) process can be used to maximize either gasoline or distillate production from olefins produced in the synthesis step. This process which is the subject of another paper, has been tested commercially in refinery-scale equipment. It is based on a shape-selective zeolite catalyst.

SLIDE 10: DISTILLATE/GASOLINE FLEXIBILITY

The importance of process flexibility to alter the relative production of gasoline and distillate fuels is illustrated here.

The horizontal lines show the market demand for distillate as a percent of gasoline plus distillate. Values range from about 80 percent in Thailand, Indonesia, and Malaysia to 30 percent in the U.S.

The vertical bars show the approximate practical range of product slate design flexibility in the combined synthesis and upgrading sections for MTG and Fischer-Tropsch technology. While the current version of the MTG Process produces all gasoline, current Fischer-Tropsch processes produce both gasoline and distillate, with distillate ranging from about 35 percent to 75 percent of the liquid product. Developing Fischer-Tropsch technology offers the prospect of extending that range in both directions.

Fischer-Tropsch technology is therefore better able to match the aggregate product mixes of the existing markets in Thailand and the other Pacific Basin countries shown. While a single project would not have to match the national mix, it is expected that the desired mix will vary substantially from project to project. For example, Thailand's current 50,000 BPD of product imports are nearly all distillate materials. If an initial objective were displacement of product imports with synfuels, it appears that this would require high yields of distillate from natural gas.

V. ECONOMICS

SLIDE 11: DEFINITION OF CASES

An economic case study was made of the three major process options for producing transport fuels from natural gas. In all cases, the natural gas feed rate was set at 150 MM SCFD as methane. Methanol capacity in the methanol and MTG cases is 5,000 metric tons per day.

Product capacities shown are expressed as BPD gasoline equivalent, which includes credit for by-product LPG in the MTG and Fisher-Tropsch cases. In addition, the Fisher-Tropsch cases were credited for distillate co-product at its gasoline Btu equivalent. The thermal efficiencies shown likewise include credit for gasoline and distillate fuels as well as LPG. On this basis, product BPD is directly proportional to thermal efficiency.

Methanol has the highest thermal efficiency of the three options. The lower value for MTG, which includes both the methanol and gasoline production steps, reflects losses for processing of methanol to gasoline. Fisher-Tropsch processes cover a range of thermal efficiencies on either side of the MTG Process.

In the development of these cases, current generation technology was used as a basis for the MTG and methanol options. However, for the Fischer-Tropsch option, the cases span a range from current generation technology to processes that could emerge in the next few years from development work underway in that field.

SLIDE 12: MAJOR ECONOMIC ASSUMPTIONS

The major economic assumptions which are consistent with Symposium guidelines are displayed on Slide 12. All base case runs were at 100 percent equity, but one financed case with 75 percent debt at 10 percent interest was developed for comparison. Debt repayment in the financed case is on an eight year basis with level principal payments. All rate-of-return calculations are on a constant dollar after tax basis.

Operating costs were also calculated consistent with Symposium guidelines.

SLIDE 13: THAI PETROLEUM PRODUCT PRICES

These mid-1983 plant fence and dealer (retail) prices for gasoline, diesel and fuel oil in Thailand are shown here as a point of reference for comparison to the calculated prices of the study cases.

SLIDE 14: CAPITAL COSTS

The capital costs, including working capital, for the various processes to convert natural gas to transport fuels are shown in Slide 14.

Plant facilities costs are based on factored estimates (USGC basis). These estimates are for self-sustaining grass-roots facilities, including:

- All process units, including product upgrading units to make unleaded regular gasoline in the MTG and Fisher-Tropsch cases
- Utility supply and distribution

- All offsites, including product storage and shipping facilities
- Contingency

Depreciable capital includes plant facilities plus the following owner's cost items:

- Initial charge of catalysts and chemicals
- Startup and organization expenses

Methanol has the lowest capital cost. The capital cost for Mobil MTG falls within the range for Fischer-Tropsch processes.

SLIDE 15: REQUIRED PRODUCT PRICES AT PLANT FENCE

The prices required at the plant fence to develop a 10 percent constant dollar after tax ROI are shown in Slide 15. The $/gallon prices were calculated with credit for all non-gasoline products at their gasoline Btu equivalent. Natural gas prices were varied from $2/MM Btu to $4/MM Btu to establish the bottom and top of the price ranges shown for each option.

Methanol is the cheapest alternate based on calculated prices at the plant fence. It has an advantage of $0.29/gallon over MTG with $2/MM Btu feed gas and $0.35/gallon with $4/MM Btu feed gas. This price advantage would be reduced in distribution, storage, and marketing of the new grade of fuel that would result from use of methanol in medium and high volume blends. As stated earlier, a small volume of methanol could be used for low volume blends without creating the need for a new product infrastructure.

The calculated prices at the plant fence for the MTG and Fischer-Tropsch options are higher than for methanol, but the products in these cases are fully interchangeable with crude-derived products. Since the Fischer-Tropsch band represents the projected results from developing processes as well as from commercial processes, it covers a wider price range than the other options. Although current Fischer-Tropsch technology yields a somewhat higher gasoline price than that calculated for the MTG Process, the potential for cost reduction appears to be good. The greater product flexibility of the Fischer-Tropsch processes was described in the Technology section of this paper.

Mid-1983 Thai gasoline prices at the plant fence and at the dealer are shown for reference on the slide. The methanol, MTG, and Fischer-Tropsch options all show at least some calculated prices falling within the range between plant fence and dealer prices. The upper range of the prices based on Fischer-Tropsch cases exceeds the dealer prices.

None of these results consider the potential benefits of natural gas based synfuels development to the Thai economy. Ultimate project feasibility could be highly influenced by policies on gas pricing and taxation.

SLIDE 16: MOBIL MTG COST COMPONENTS

This is a breakdown of the calculated product cost components for the MTG Process, based on achieving a target 10 percent ROI (100 percent equity). The natural gas cost at $4.00/MM Btu is $200 MM per year, or about half of the total. Capital recovery requirements are a third of the required selling price. Operating costs and taxes amount to about 20 percent of the total required price. The total revenue required to achieve this ROI goal is $394 MM per year at a sale price at the plant fence of $1.73/gallon of gasoline produced.

SLIDE 17: SENSITIVITY OF ROI AND ROE TO PRODUCT PRICE - MOBIL MTG PROCESS

This plot showns rate of return as a function of product price for the MTG Process. For the 100 percent equity cases at $2/MM Btu and $4/MM Btu gas prices, each $0.25/gallon change in gasoline price causes a 4-5 percent change in ROI.

A single debt-financed case is shown at the $4/MM Btu gas price. It assumes a 75/25 debt/equity ratio and a 10 percent debt interest rate. Each $0.25/gallon change in gasoline price in this case causes about an 8 percent change in ROE.

SLIDE 18: SENSITIVITY OF ROI TO CHANGES IN MAJOR ECONOMIC VARIABLES - MOBIL MTG PROCESS

This shows the sensitivity of rate of return to changes in major economic variables for the MTG Process on a 100 percent equity basis. A range of ±20 percent is shown on each variable so the relative importance of the variables can be compared.

A given change in product price has about twice the impact on ROI as the same percent change in gas feed price or capital cost. Changes in operating costs have the lowest ROI effect of the major variables.

VI. CONCLUSIONS

SLIDE 19: COMPARISON OF TECHNOLOGIES

This slide summarizes key aspects of the alternate technologies studied. Although each of the processes is available for license, it is worth reiterating that only the Fischer-Tropsch and methanol processes are commercially demonstrated. Since operation of the first commercial MTG unit will not begin until 1985, all information presented in this paper on that process reflects predicted, rather than actual, performance.

Methanol has the lowest calculated price at the plant fence based on today's technologies, but has the highest limitations in the marketplace. Its use in low volume blends would be limited to a maximum penetration of about 5 percent of the Thai gasoline market. High volume blends, or neat methanol, could penetrate over time up to about 85 percent of the gasoline market; however, in this application, methanol would be a new grade of fuel requiring new infrastructure for storage, distribution, and marketing. Required additives to neat methanol fuel would be an added cost component. Specially designed or modified automobiles would also be required to accept neat methanol fuel. Costs and potential delays in developing the market for neat methanol were not analyzed here, but would be important in the final evaluation of that option.

The calculated price at the plant fence for gasoline via MTG is about 25 percent above that for methanol, reflecting the cost of converting methanol to gasoline. This process will produce gasoline which is interchangeable with crude-derived product.

The Fischer-Tropsch processes include a range of options from those now commercial to those projected from development programs. Calculated prices at the plant fence span a relatively wide range above and below those for the MTG Process. These processes produce fuels that are interchangeable with crude-derived products. Since they can be designed to produce both gasoline and distillate in varying proportions, Fischer-Tropsch processes offer the greatest potential to substitute for crude-derived products in the marketplace. The high level of development activity on these processes should have a positive future impact on this option.

SLIDE 20: OVERALL CONCLUSIONS

This slide shows the overall conclusions concerning the potential for synfuels from natural gas in Thailand.

The impact of a current and projected high dependence on imported oil for transport fuels provides an incentive to search for substitute fuels. Although the degree of import displacement could ultimately be very large, this can be carried out stepwise to avoid disruption of existing operations. A stepwise approach would also minimize any strain on domestic manpower and financial resources.

Proven but uncommitted domestic natural gas resources as of today would support at least three 15,000 BPD synfuels projects, which would approximately displace current product imports. When probable and possible reserves are also considered, the synfuels potential exceeds the total Thai oil import requirement, including crude oil imports.

Three technology options are available for these synfuels projects. The calculated synthetic gasoline prices at the plant fence for each of these are higher than comparable prices for gasoline from crude oil but generally lower than dealer prices. Product price is the economic variable having greatest impact on project ROI.

Further evaluation, including a full cost/benefit analysis of project impact on the Thai economy, is needed to establish the viability of synfuels from natural gas. Benefits at the national level will increase the competitive strength of such projects.

SLIDE 21: BENEFITS OF SYNFUELS DEVELOPMENT TO THAI ECONOMY

Important factors for consideration in a full cost/benefit analysis of synfuels development are shown on this concluding slide.

The primary financial impact of such projects on the Thai economy would be due to retention of product revenues within the nation. Earnings from natural gas would flow to the producers and the Central Government. Tax revenues would be generated as royalties on gas production and as corporate income taxes.

The cost of oil imported to Thailand in 1983 was in the region of $2 billion. Since synthetic fuels from domestic natural gas would be a substitute for imported oil, the balance of payments would improve with synfuels development. In addition, Thailand's energy independence would increase. Economic dislocations such as those caused by soaring international oil prices in 1973 and 1979 would be lessened.

Employment opportunities would increase in conjunction with engineering and construction as well as operation of new facilities from the wellhead through the synfuels plant.

While there are many alternates for natural gas utilization that would produce some of these benefits, synfuels production can do so with very low market risk. It does not depend on either growth of domestic product markets or on export markets to assure required revenue flows to a worldscale operation. The market exists today.

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SLIDE 1

SCOPE OF PAPER

- MARKETS
- NATURAL GAS RESOURCES
- TECHNOLOGY
- ECONOMICS
- CONCLUSIONS

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SLIDE 2

PROCESS OPTIONS FOR TRANSPORT FUELS FROM NATURAL GAS

	STATUS
METHANOL-TO-GASOLINE (MTG)	1985 STARTUP
FISCHER-TROPSCH	COMMERCIAL (ARGE AND SYNTHOL PROCESSES)
METHANOL	COMMERCIAL

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SLIDE 3

THAILAND CRUDE OIL AND NATURAL GAS BALANCE*

1981-1995 (MILLION BOE)

	1983	1985	1990	1995
CONSUMPTION				
CRUDE OIL	68	69	73	86
NATURAL GAS	9	17	50	66
DOMESTIC PRODUCTION				
CRUDE OIL	3	7	17	17
NATURAL GAS	9	17	50	66
NET IMPORTS				
CRUDE OIL	65	62	56	69

* World Bank Data

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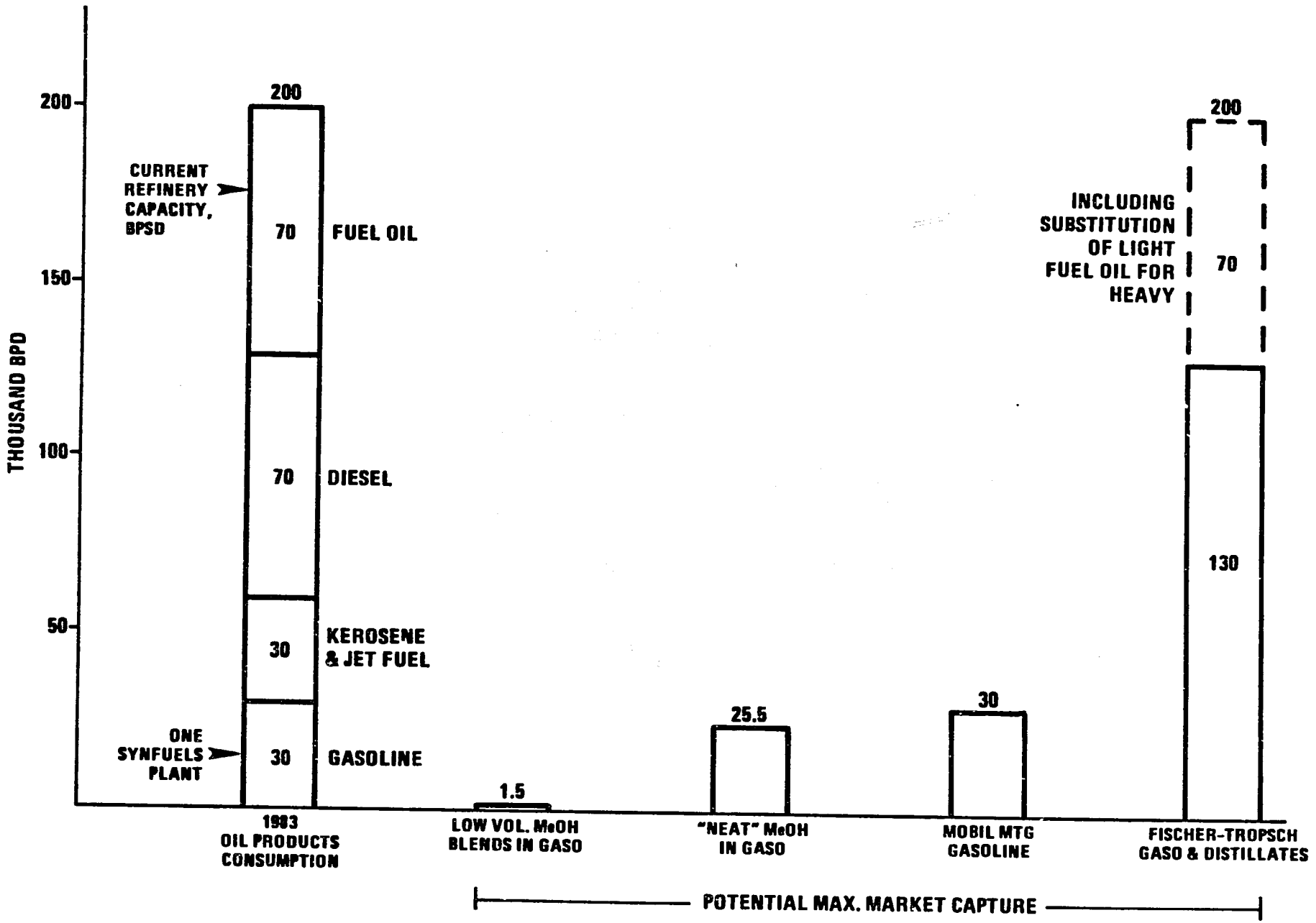
SLIDE 4

POTENTIAL IMPACT OF SYNFUELS IN THAI PETROLEUM PRODUCT MARKET



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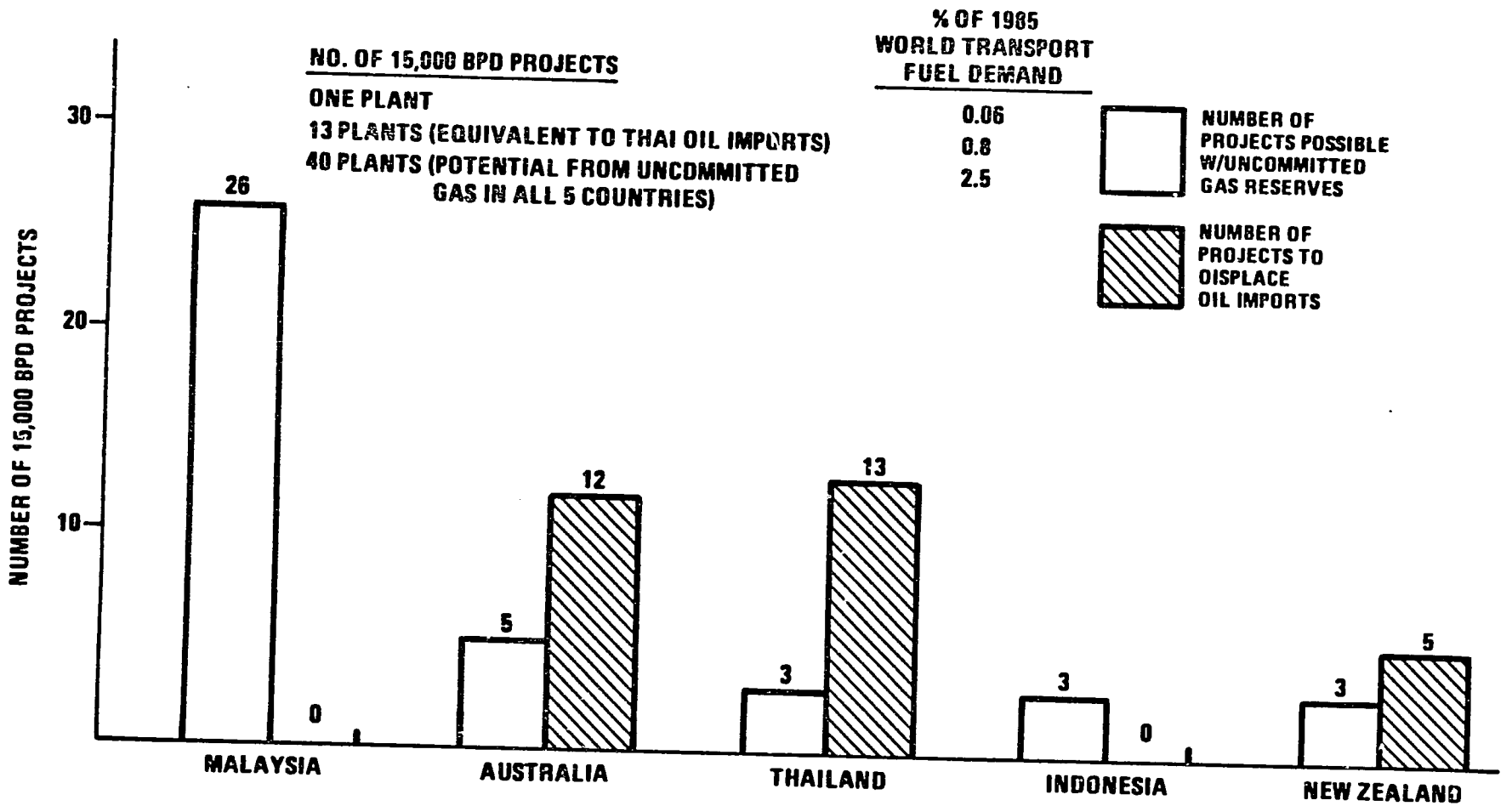
SLIDE 5

POTENTIAL FOR SYNTHETIC FUEL FROM NATURAL GAS IN SELECTED PACIFIC BASIN COUNTRIES



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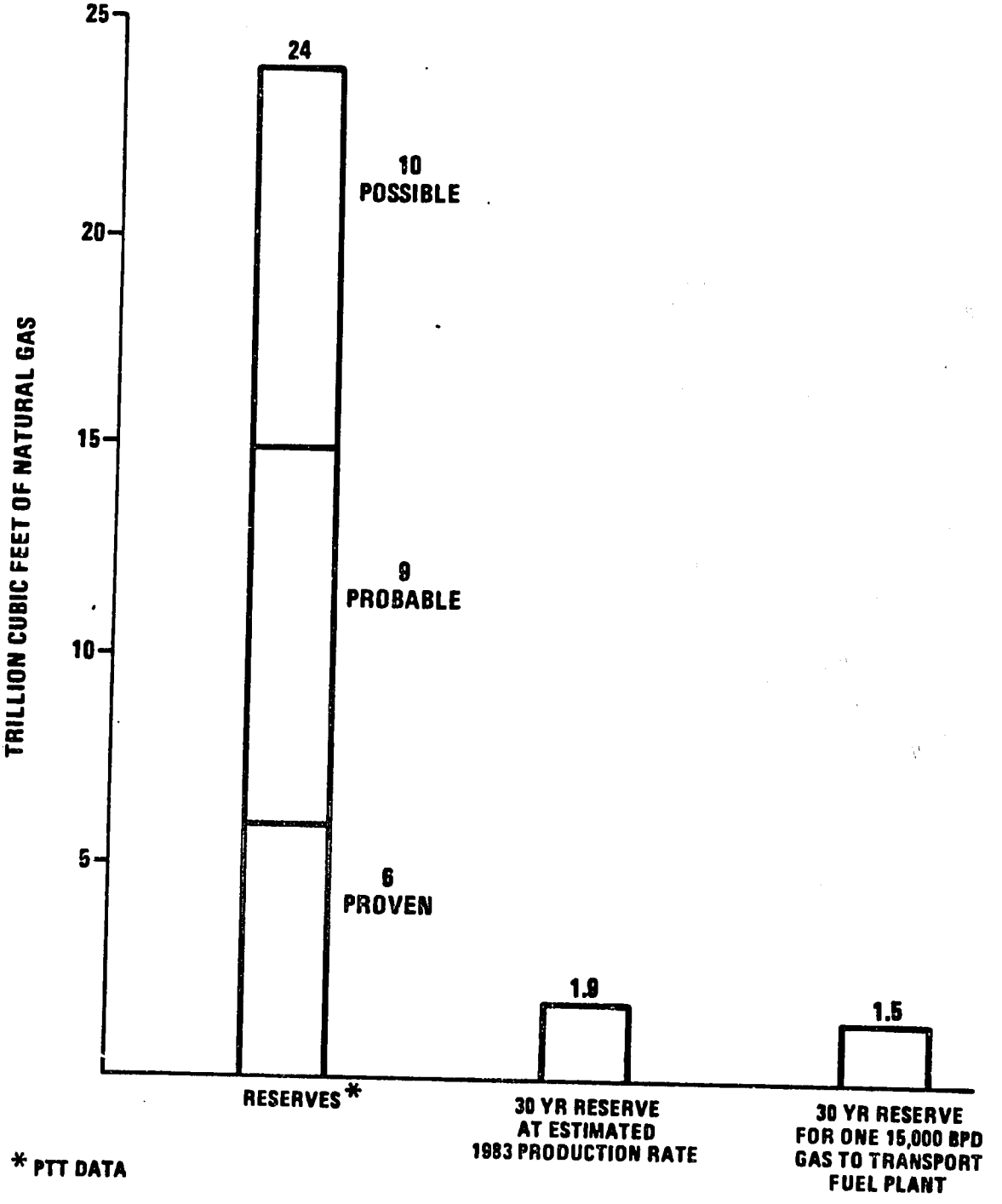
SLIDE 6

SPECIFIC THAILAND FEED AVAILABILITY FOR NATURAL GAS TO TRANSPORT FUELS

@ 30 YEARS RESERVE LIFE



* PTT DATA

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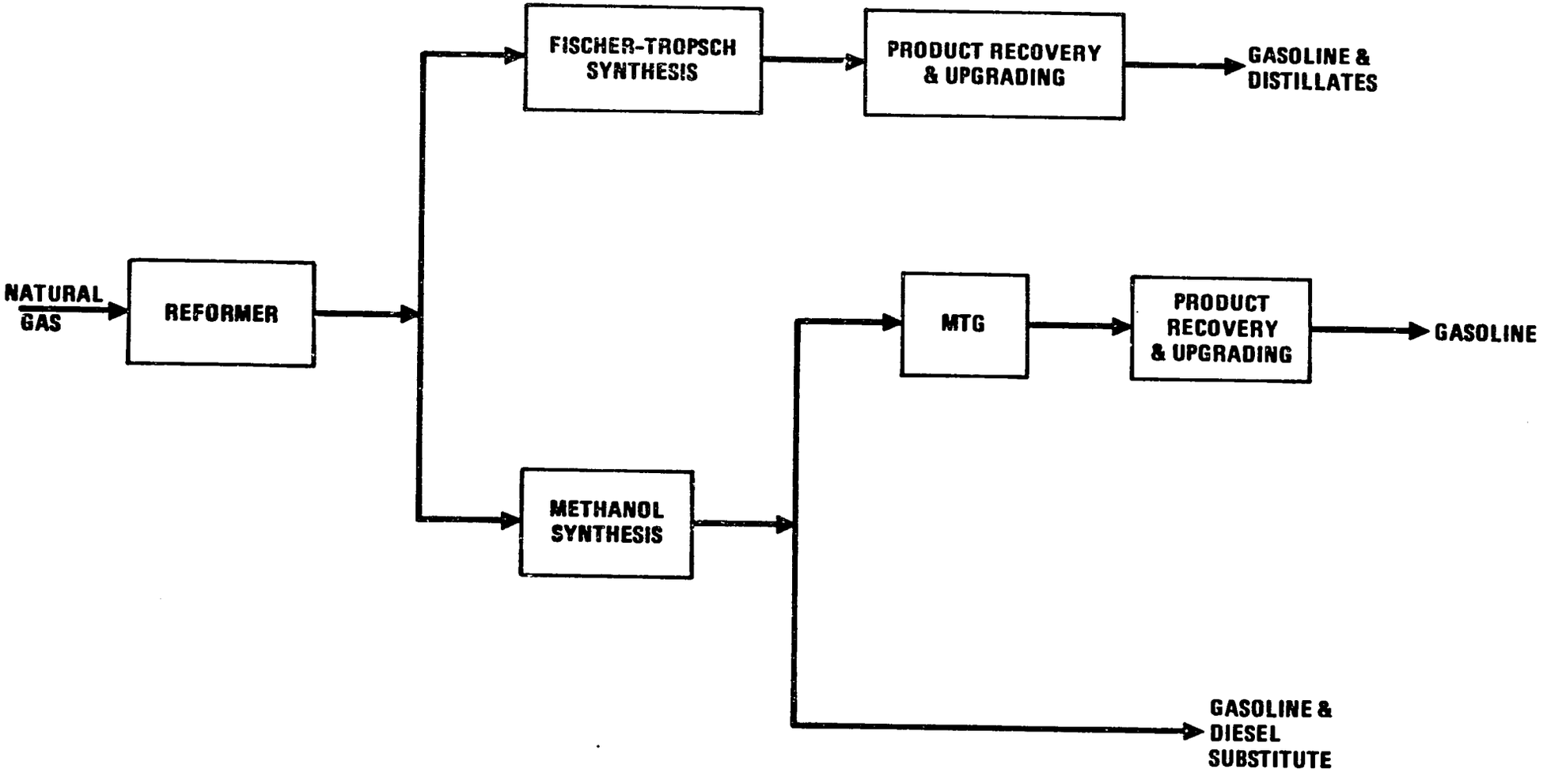
SLIDE 7

BLOCK FLOW DIAGRAM OF PROCESS OPTIONS

TRANSPORT FUELS FROM NATURAL GAS



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SLIDE 8

TYPICAL SYNTHESIS PARAMETERS

	MTG *	FISCHER-TROPSCH CURRENT	FISCHER-TROPSCH DEVELOPING	METHANOL
TEMPERATURE, °C	360/400	220-325	220-325	250
PRESSURE, ATM	20	20-25	20-30	85
CATALYST	ZEOLITE	IRON	METAL/ZEOLITE	COPPER/ALUMINA/ ZINC OXIDE
REACTOR TYPE	FIXED-BED	ENTRAINED-BED FIXED-BED	FLUID-BED SLURRY	FIXED-BED

* Two-Step Process

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SLIDE 9

EXAMPLES OF NEW TECHNOLOGY PROGRAMS

MTG

- 100 B/D FLUID-BED PILOT OPERATION IN WEST GERMANY

FISCHER-TROPSCH

- SASOL FIXED FLUIDIZED-BED AND SLURRY PILOT PROGRAMS; MID - 1983 STARTUP FOR FIXED FLUID-BED DEMONSTRATION PLANT
- MOBIL SLURRY PILOT PROGRAM
- GULF/BADGER FIXED AND FLUID-BED PILOT PROGRAMS; 37 B/D DEMONSTRATION PLANT UNDER CONSTRUCTION
- UNION CARBIDE CATALYST DEVELOPMENT PROGRAM

UPGRADING

- MOBIL SHAPE-SELECTIVE OLEFIN OLIGOMERIZATION (MOGD) PROCESS

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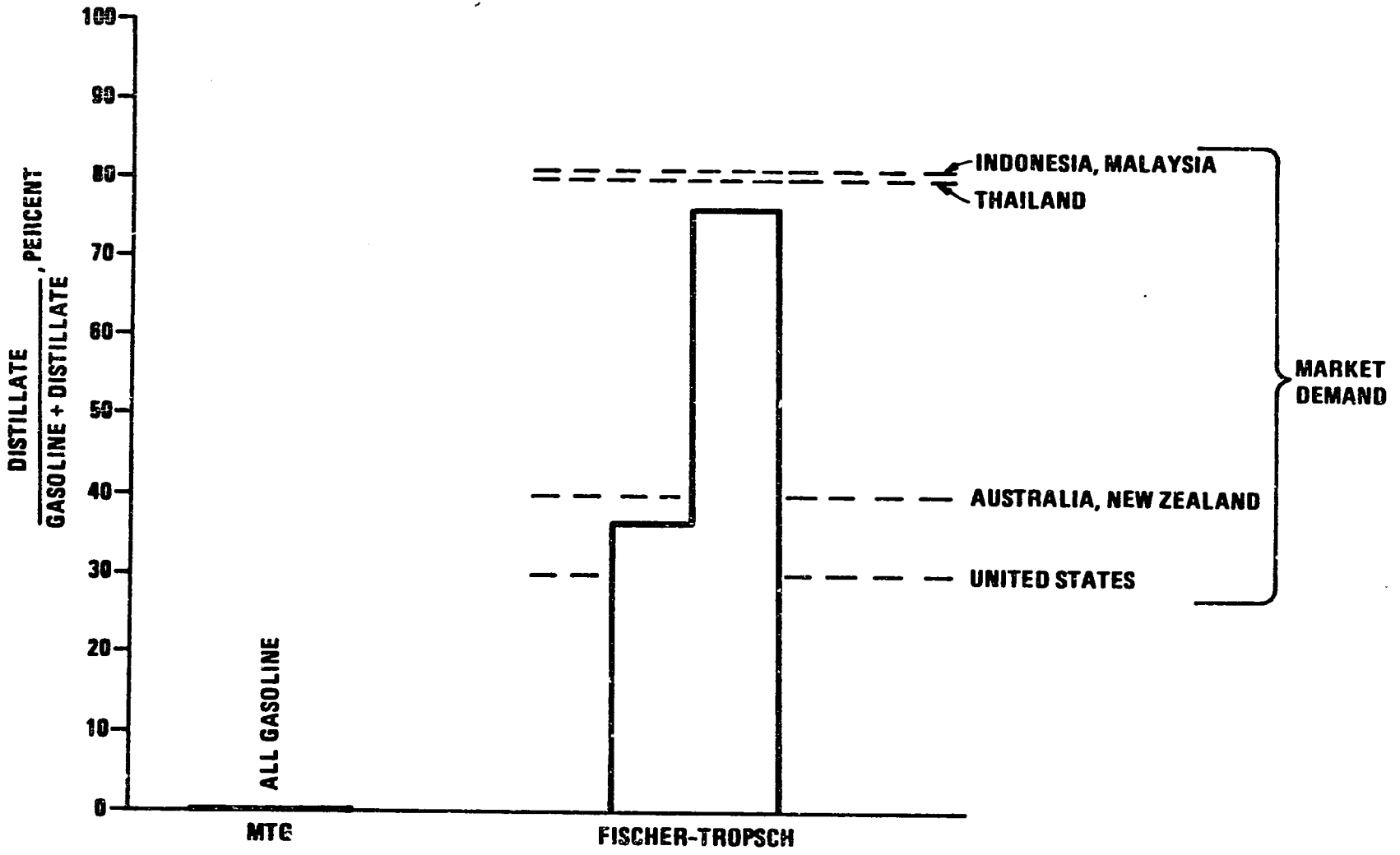
SLIDE 10

DISTILLATE/GASOLINE PRODUCTION FLEXIBILITY COMPARED WITH MARKET DEMAND



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SLIDE 11

DEFINITION OF CASES

	MOBIL MTG	FISCHER-TROPSCH	METHANOL
NATURAL GAS FEED, MM SCFD AS METHANE	◄---------- 150 ----------►		
FUELS PRODUCTION CAPACITY, BPD GASOLINE EQUIVALENT *	16,600	15,100–18,700	18,800
THERMAL EFFICIENCY TO GASOLINE, DISTILLATE & LPG, PERCENT	57**	52–64	65

* Based on gasoline HHV = 5.2×10^6 Btu/B

** Covers combined methanol and methanol-to-gasoline processes

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SLIDE 12

MAJOR ECONOMIC ASSUMPTIONS*

DURATION OF ENGR., PROC., & CONSTR.	3 YRS
ECONOMIC OPERATING LIFE	15 YRS
TIMING OF COSTS & PRICES	MID-1983
CAPITAL COSTS	USGC DOLLARS
PRICE & COST UNITS	US DOLLARS
NATURAL GAS PRICE	$4.00/MM BTU
OPERATING FACTOR	330 DAYS/YEAR
INCOME TAX RATE	35%
DEPRECIATION TYPE	10-YR ST. LINE
CAPITAL CONTINGENCY	20%
STARTUP & ORGANIZ. EXPENSE	2% OF INVESTMENT
DEBT INTEREST RATE FOR ROE	10%

*Assumptions (Except ROI Goal) Set By Symposium Guidelines

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SLIDE 13

THAI PETROLEUM PRODUCT PRICES
(MID-1983)

	PLANT FENCE		DEALER	
	BAHT/LITER	U.S. $/GAL*	BAHT/LITER	U.S. $/GAL*
PREMIUM GASOLINE	5.49	0.89	11.70	1.90
REGULAR GASOLINE	4.98	0.81	10.80	1.75
DIESEL	4.96	0.81	6.70	1.09
LT. FUEL OIL	4.07	0.66	4.32	0.70

*At 1 BAHT = U.S. $0.043

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SLIDE 14

CAPITAL COSTS

	MOBIL MTG	FISCHER-TROPSCH	METHANOL
PLANT FACILITIES COST $MM (1983 USGC)	580	540 TO 800	470
TOTAL DEPRECIABLE CAPITAL *	600	560 TO 860	500
WORKING CAPITAL	165	160 TO 215	150

* Includes initial catalyst/chemicals, startup and organization expenses

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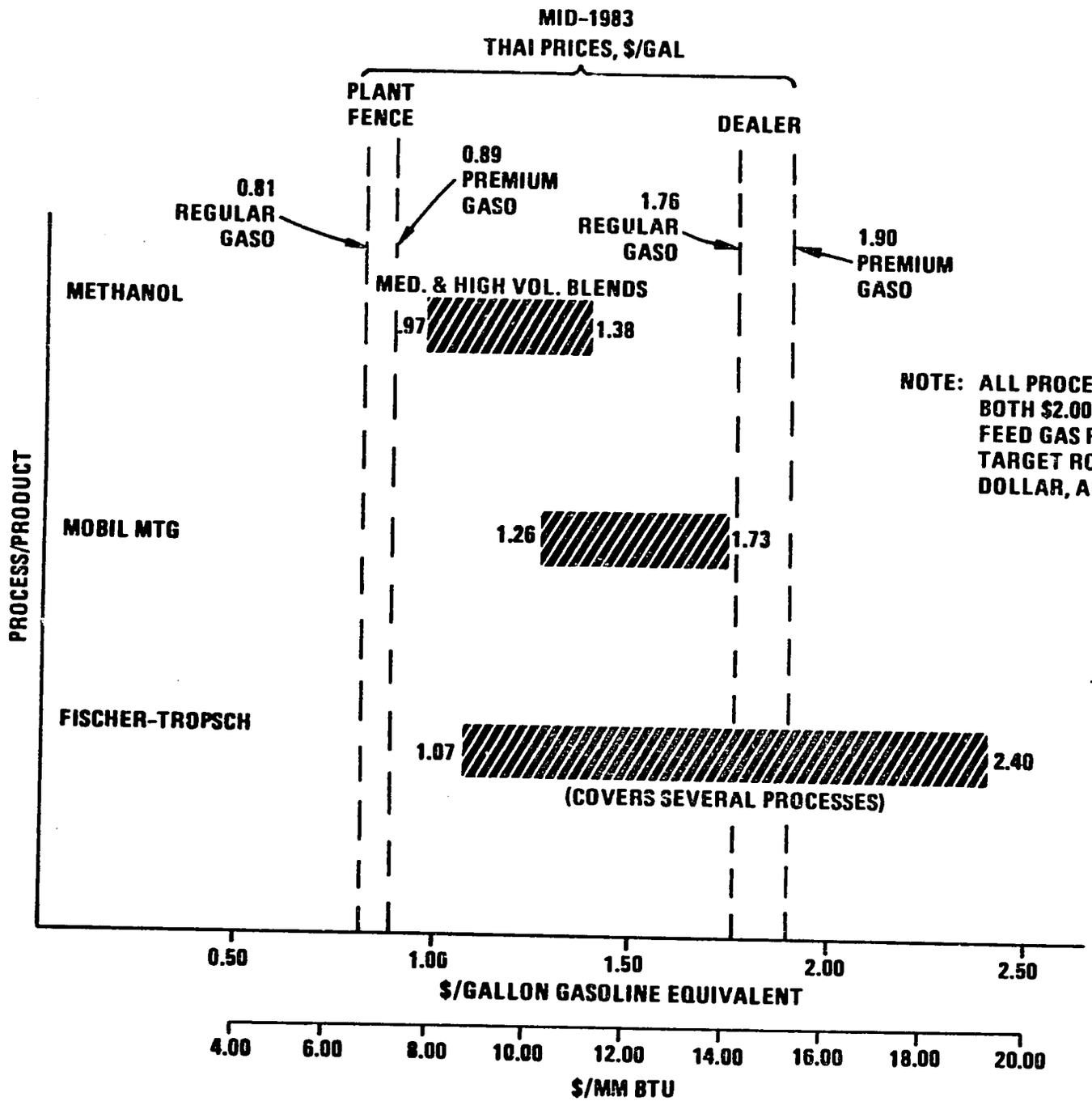
SLIDE 15

REQUIRED PRODUCT PRICES @ PLANT FENCE



NOTE: ALL PROCESSES EVALUATED AT BOTH $2.00 AND $4.00/MM BTU FEED GAS PRICES AT A 10% TARGET ROI (CONSTANT DOLLAR, AFTER TAX).

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SLIDE 16

MOBIL MTG

COST COMPONENTS

	@ $4.00/MM BTU GAS			
	$ MM/YR	$/GAL GASO PRODUCED	$/MM BTU	% TOTAL
NATURAL GAS (@ $4.00/MM BTU)	200	0.88	7.09	51
OPERATING COSTS	60	0.26	2.09	15
CAPITAL RECOVERY	125	0.55	4.45	32
INCOME TAX @ 35% (W/10 YR. ST. LINE DEPR.)	26	0.11	0.84	6
BY-PRODUCT CREDITS (PROPANE & BUTANE)	(17)	(0.07)	(0.56)	(4)
REVENUE REQ'D @ 10% CONST. DOLLAR AFTER TAX ROI	394	1.73	13.91	100

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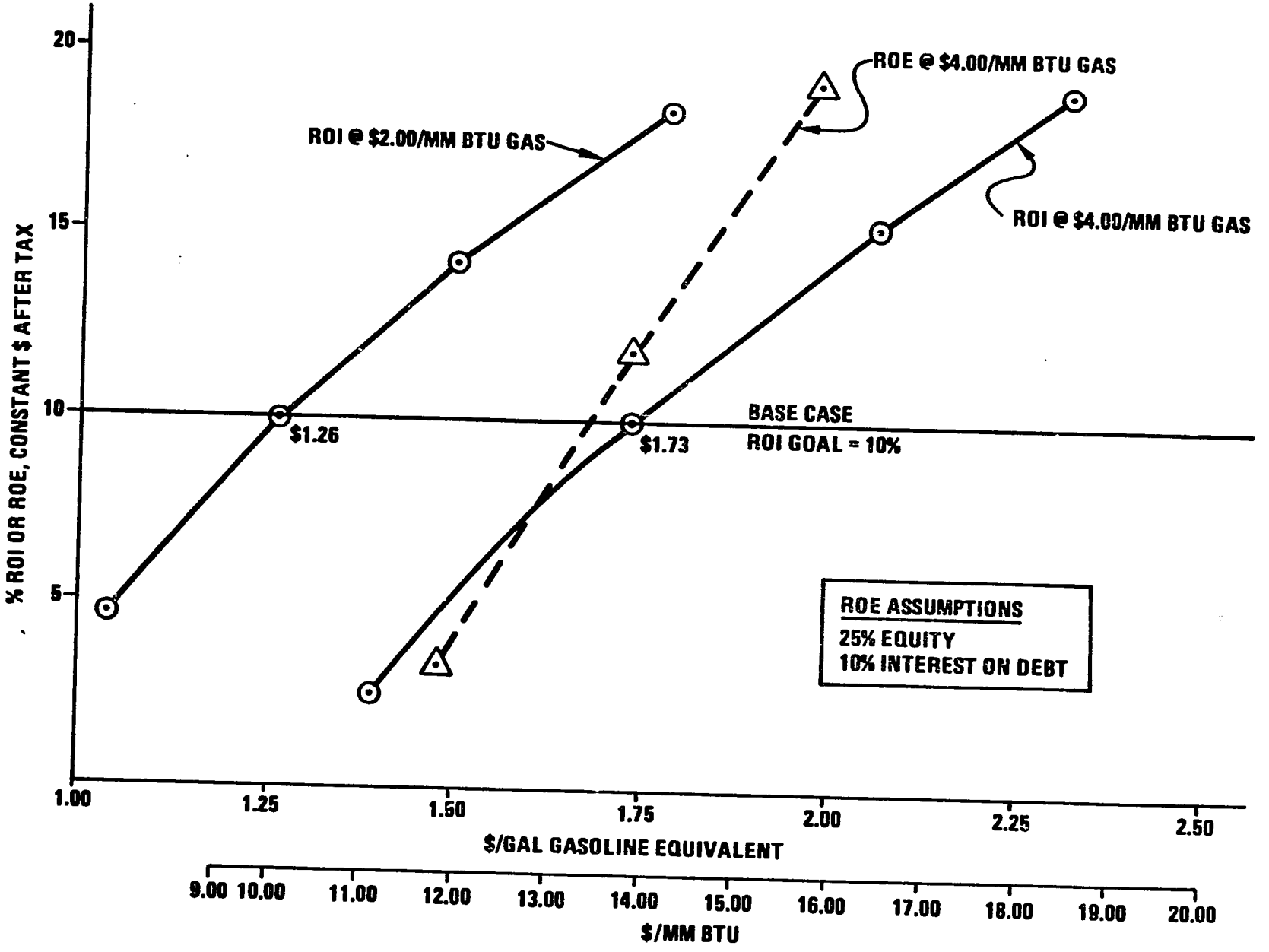
SLIDE 17

SENSITIVITY OF ROI & ROE TO PRODUCT PRICE

MOBIL MTG PROCESS



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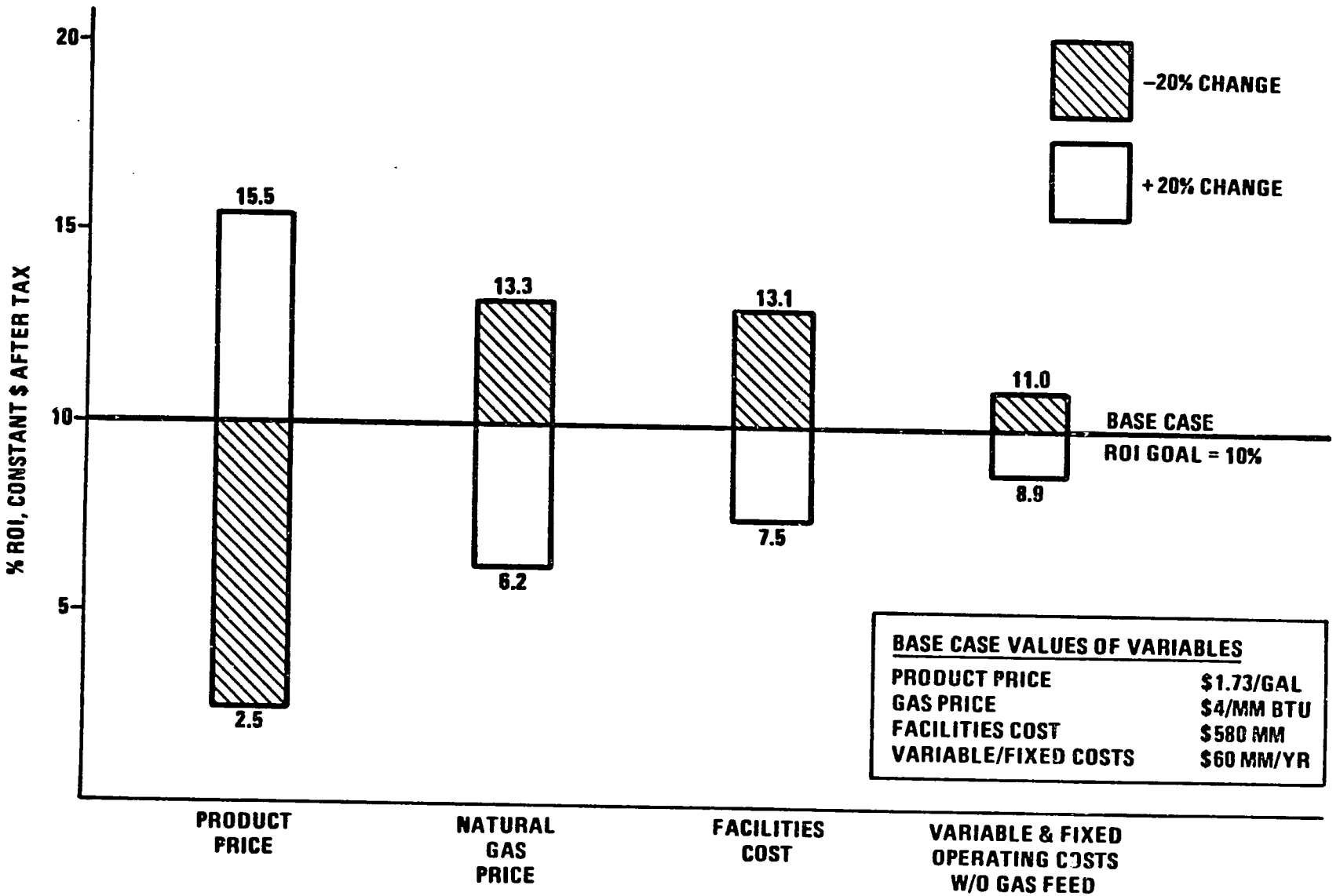
SLIDE 18

SENSITIVITY OF ROI TO CHANGE IN MAJOR ECONOMIC VARIABLES

MOBIL MTG PROCESS



BASE CASE VALUES OF VARIABLES

PRODUCT PRICE	$1.73/GAL
GAS PRICE	$4/MM BTU
FACILITIES COST	$580 MM
VARIABLE/FIXED COSTS	$60 MM/YR

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SLIDE 19

COMPARISON OF TECHNOLOGIES

Methanol

- Lowest Cost at Plant Fence Today
- Non-Standard Fuel Requires New Infrastructure
- Lowest Substitution Potential in Marketplace

Methanol-To-Gasoline (MTG)

- Higher Cost Than Methanol at Plant Fence
- Standard Gasoline Fuel

Fischer-Tropsch

- Costs Span Range Above and Below MTG
- Standard Gasoline and Distillate Fuels
- Highest Product Flexibility
- High Substitution Potential in Marketplace
- Highest Level of Development Activity

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SLIDE 20

OVERALL CONCLUSIONS

- Incentive For Oil Import Displacement
- Natural Gas Reserves Adequate To Support Synfuels Production
- Proven Technology Available To Convert Natural Gas To Transport Fuels
- Calculated Synthetic Gasoline Prices Higher Than Plant Fence Prices for Gasoline From Crude Oil But Generally Lower Than Dealer Prices
- Full Analysis of Benefits To Thai Economy Will Increase Competitive Strength of Synfuels

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SLIDE 21

BENEFITS OF SYNFUELS DEVELOPMENT TO THAI ECONOMY

- Stimulates Revenues From Domestic Resource
- Creates Tax Revenues
- Positive Effect on Balance of Payments
- Increases Energy Independence
- Stimulates Employment

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