PROSPECTS FOR DEVELOPMENT OF ALASKA NATURAL GAS: A REVIEW

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Alaska contains approximately 27 trillion cubic feet (Tcf) of known natural gas reserves—equal to 16% of U.S. reserves. Gas reserves in southern Alaska (Cook Inlet) have been exported in limited quantities for over 30 years. The much larger gas reserves in northern Alaska are stranded by the lack of a means of transportation to market.

Four percent (1 Tcf) of Alaska's remaining exportable gas reserves occur within fields in the Cook Inlet basin of southern Alaska. Ninety-six percent of Alaska's gas reserves (26 Tcf) occur within fields in or near the Prudhoe Bay field in northern Alaska and these stranded reserves are presently attracting many proposals for development. In addition to the Prudhoe Bay-area reserves, the Mackenzie delta area in Canada (300 miles east of Prudhoe Bay) contains 9 - 12 Tcf of stranded gas reserves in fields mostly under 1 Tcf in size that are also a focus of emerging proposals for development.

The known gas reserves are dwarfed by the potential for undiscovered gas in Arctic Alaska and nearby areas of the Mackenzie delta of northwest Canada. If the undiscovered gas resources in the Mackenzie delta (53 Tcf) are added to those of the North Slope (64 Tcf) and Federal submerged lands on the Beaufort (32 Tcf) and Chukchi shelves (60 Tcf), the Arctic regional gas resource potential totals 209 Tcf—a quantity equal to 33% of the total U.S. undiscovered conventional gas resource base (626 Tcf). Arctic Alaska and the Mackenzie delta seem destined to someday become major producing areas for natural gas. For the long-term outlook, the undiscovered gas resources may be overshadowed by the immense potential for gas extracted from methane hydrates in the northern regions. For northern Alaska, 590 Tcf of gas (in place) are estimated to be sequestered in methane hydrates associated with permafrost.

The Prudhoe Bay-area reserves and the discovered reserves in the Mackenzie delta are the key assets that will drive near-term strategic decisions about how to transport and market stranded natural gas from the Arctic. To date, the natural gas in the oil fields of the Prudhoe Bay area has been re-injected to increase oil recovery and used to fuel production facilities. Therefore, there has been no urgency for any decision about the ultimate disposition of the gas—an energy asset equivalent to 4.6 billion barrels of oil or $130 billion U.S. Now, Prudhoe Bay oil production is falling rapidly (10% per year) while annual gas production at Prudhoe Bay has risen to 3 Tcf—a remarkable quantity equal to the domestic gas consumption of either Germany, the U.K., or Canada, and equal to 14% of current U.S. gas consumption. Limited gas sales could begin at any time from the Prudhoe Bay-area fields without affecting long-term oil recovery and gas sales may help avoid capital outlays for new gas-handling equipment.

At present, three concepts are in the forefront for commercializing the stranded gas resources in northern Alaska and Mackenzie delta:

- ***New gas pipelines that link to existing pipelines in Canada.*** Build new gas pipelines to carry the gas from Prudhoe Bay and Mackenzie delta to northern Alberta or British Columbia, where the new pipeline would join the Canadian pipeline network and supplement ongoing transmission gas exports to the U.S.

- ***Liquefied natural gas (LNG) to Asian Pacific Rim or U.S. West Coast.*** Build a conventional or high-pressure gas pipeline that carries the gas from Prudhoe Bay-area fields to a port in southern Alaska, where the gas is chilled to liquefied natural gas (LNG) and loaded on special LNG tankers for transport to the Asian Pacific Rim or U.S. West Coast.
- ***Gas to liquids (GTL) and tankers to U.S. West Coast.*** Build a new facility in the Prudhoe Bay area and use GTL technology to convert natural gas to middle-distillate (diesel-like) liquids. The GTL product could be pumped in segregated batches through the Trans Alaska oil pipeline and then transported by tankers to the U.S. West Coast.

Publicly available economic studies from 1995 suggest that all three concepts would be economic in the recent high-price environment (U.S. Midwest gas >$5.00/mcf; World Oil >$30) but not today. Forecasts for rapidly expanding gas consumption in the U.S. domestic market provide some confidence in a future sustained high-price environment, support for continuing pipeline system engineering and viability studies, and some political momentum for a pipeline system carrying gas to the U.S. Lower 48.

ALASKA NATURAL GAS

Prospects for Development: A Review

Kirk W. Sherwood
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DOE-NETL
Methane Hydrates Interagency R&D Conference
Renaissance Washington DC Hotel
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REPORT AVAILABILITY

- **ALASKA REPORT** at ***http://www.mms.gov/alaska/re/reports/rereport.htm***

- **CD available here or can request CD at 907-271-6060**

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Purpose of the MMS Report

***PREMISE*:** **U.S. Domestic Natural Gas Demand Will Rise Sharply**

***QUESTION*:** **Can Natural Gas Exports from Alaska Help Meet This Rising Demand?**

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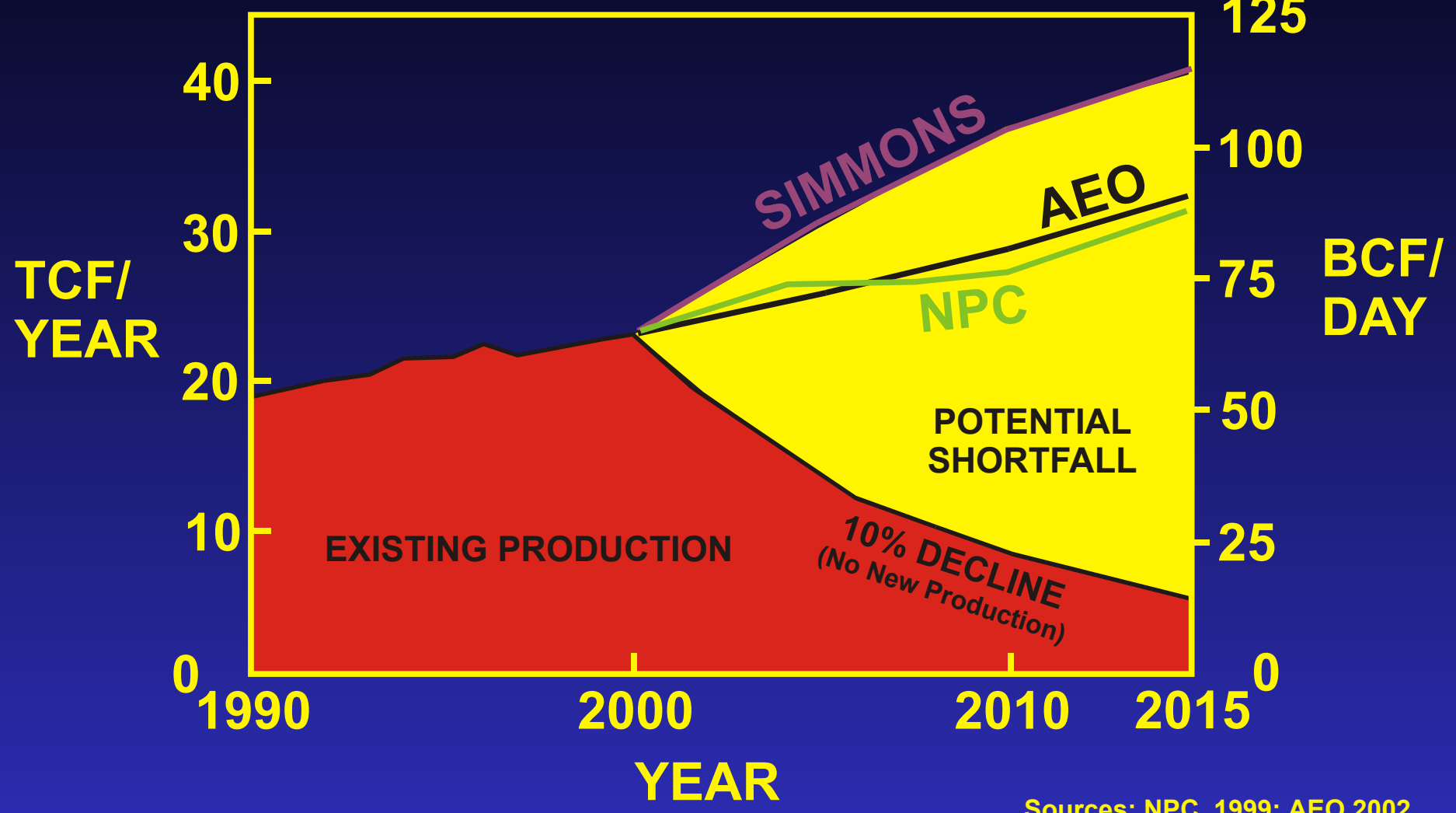
U.S. DOMESTIC GAS DEMAND FORECASTS



Sources: NPC, 1999; AEO 2002, Hart E&P, May 2000

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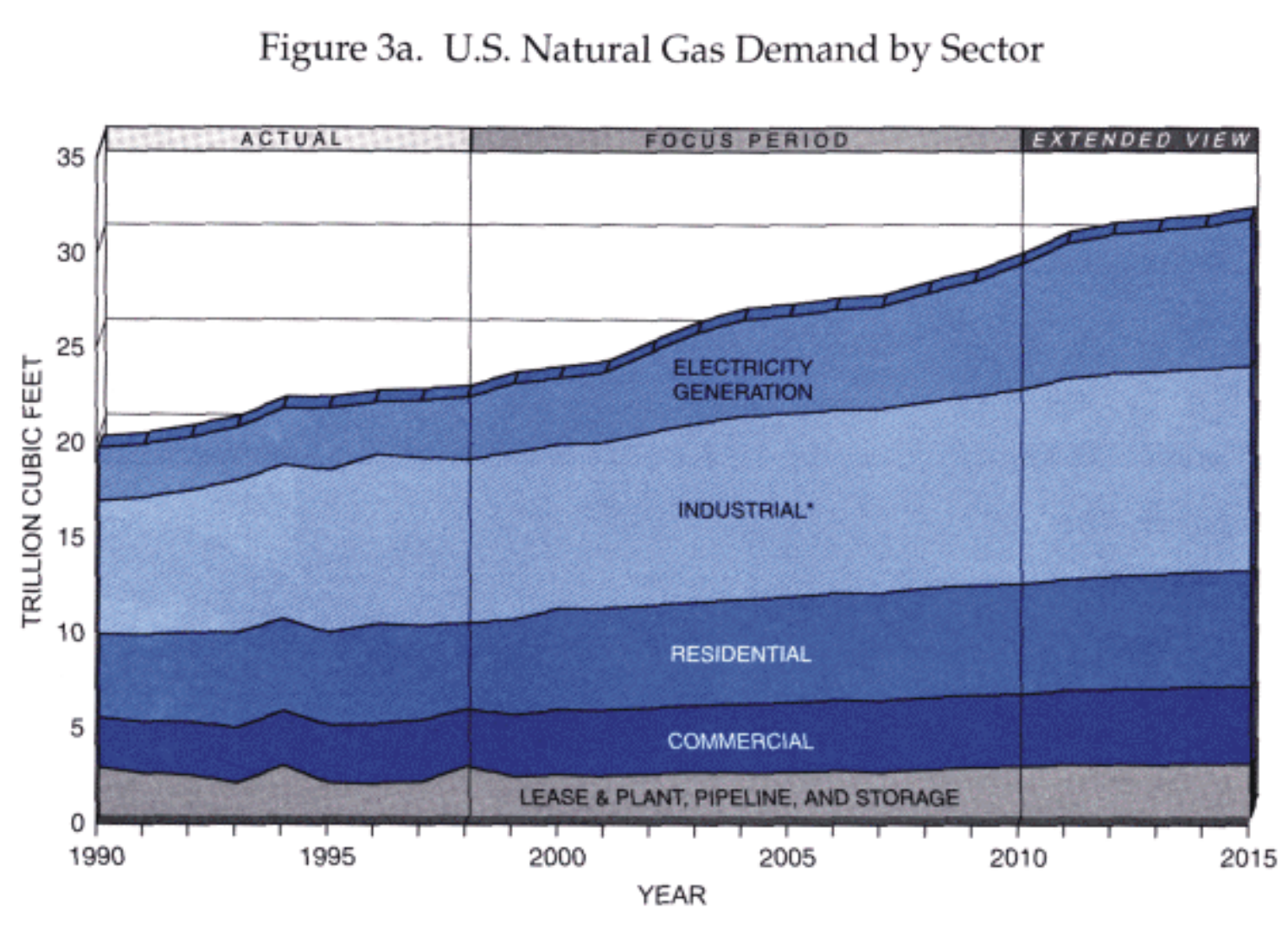
AREAS OF DEMAND GROWTH



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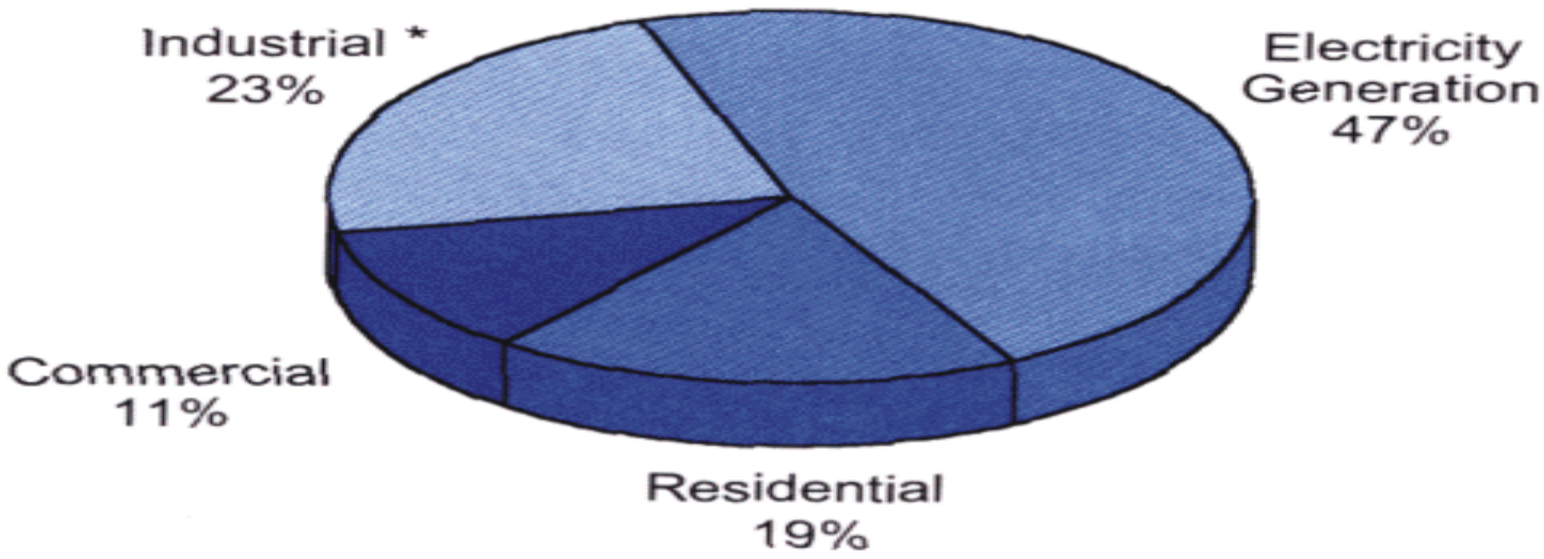
From NPC, 1999

POWER GENERATION GROWTH DRIVES GAS DEMAND GROWTH

Figure 3b. Growth in Reference Case Demand, 1998–2010
(Distribution of 7 TCF Increase by Sector)



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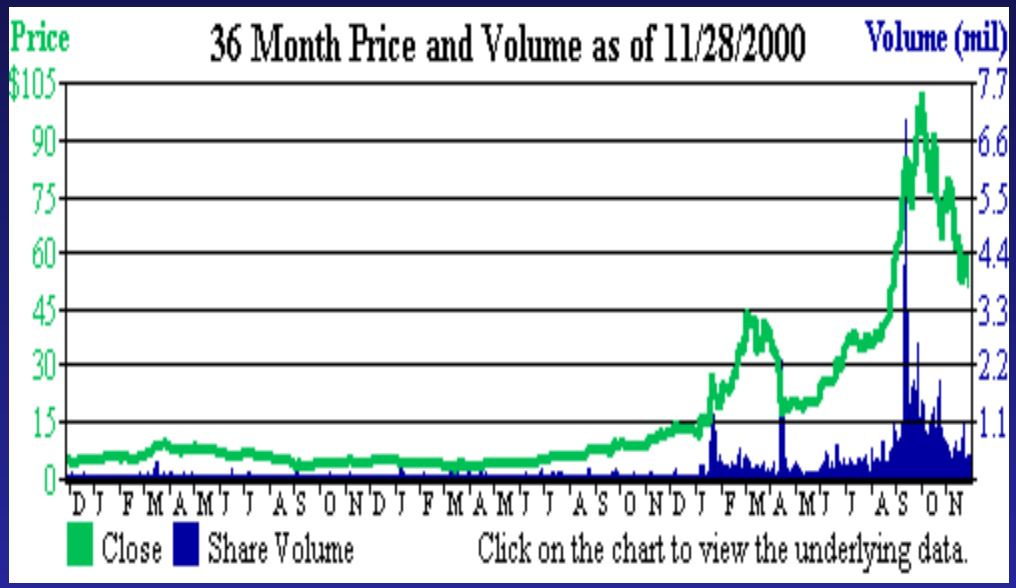
From NPC, 1999

WILL FUEL CELLS DECENTRALIZE POWER GENERATION?

From *Worth*, Sept 00

Stock Price History, Fuel Cell Energy, Inc.



From *NASDAQ*
$16 as of Feb 02

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BASICS OF ALASKA GAS

- THERE'S LOTS OF GAS
- THE GAS IS REMOTE AND EXPENSIVE TO GET

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HOW FAR TO MARKET?

- 800 miles to Valdez
- 1,600-2,100 miles to Canadian pipeline network
- 4,100 miles to Chicago
- 3,200 miles by land and sea to Los Angeles, California
- 4,800 miles by land and sea to Japan

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BUT ALASKA IS A GAS EXPORTER!

- **Only U.S. exporter of LNG (0.074 TCF/A) (LNG shipped to Yokohama, Japan)**

- **Manufacture and export Ammonia-Urea (fertilizer) (0.052 TCF/A) to Pacific Rim**

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Source: AKDO&G, 1998

HIGH PRICE PREMIUM ALLOWS EXPORT

- **Japan pays $3.48/mcf for LNG imports (1993-1997 average)**
- **U.S. pays $2.43/mcf for LNG imports from Algeria (1993-1997 average)**
- **U.S. wellhead receives $1.99/mcf (1993-1997 average)**

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Sources: DOE, 1999, 2000; Swain, 1999

HOW MUCH GAS IN ALASKA?

- **Reserves: 40 TCF or 23% of U.S. reserves (172 TCF)**
- **Undiscovered "conventional" gas: 191 TCF or 31% of U.S. resources (622 TCF)**
- **Coalbed Methane: 57-1,000 TCF (Lower 48 = 50 TCF)**
- **Gas hydrates: 169,039 TCF (53% of U.S. Total [320,222 TCF])**

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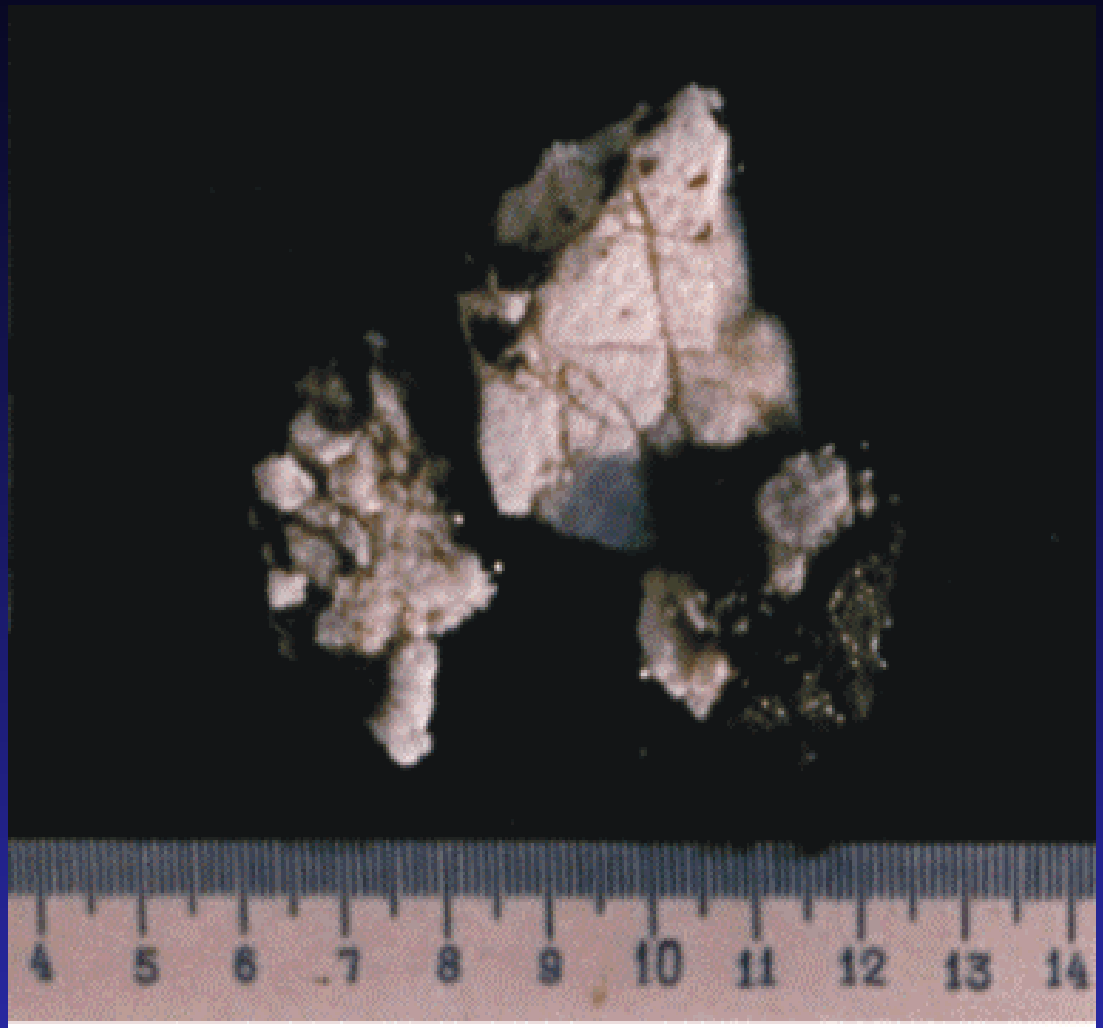
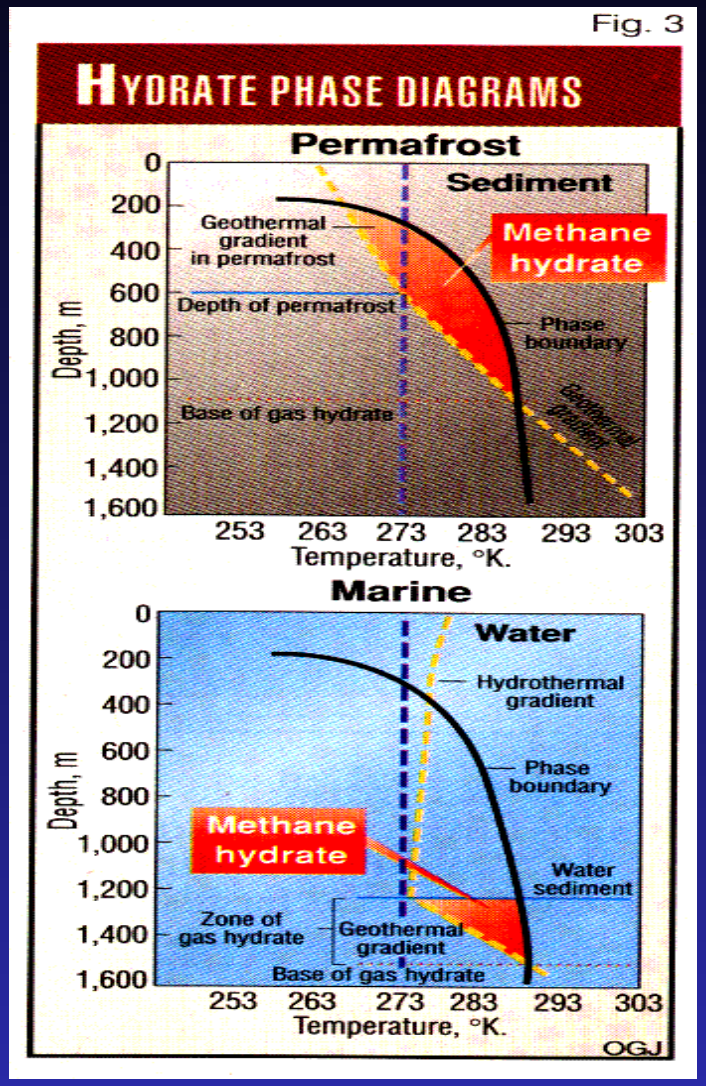
Sources: AK DOG, 2000; MMS, 2000; USGS, 1995, Circ. 1145; PGC, 1999

GAS HYDRATES/METHANE CLATHRATES



Massive Methane Clathrate, Sea of Okhotsk, Continental Slope Offshore Sakhalin Island
Source: USGS Website



From Collet & Kuuskraa, O&GJ, 5/11/98

1 CUBIC FOOT OF HYDRATE YIELDS
165 CU. FT. GAS & 0.5 CU. FT. WATER

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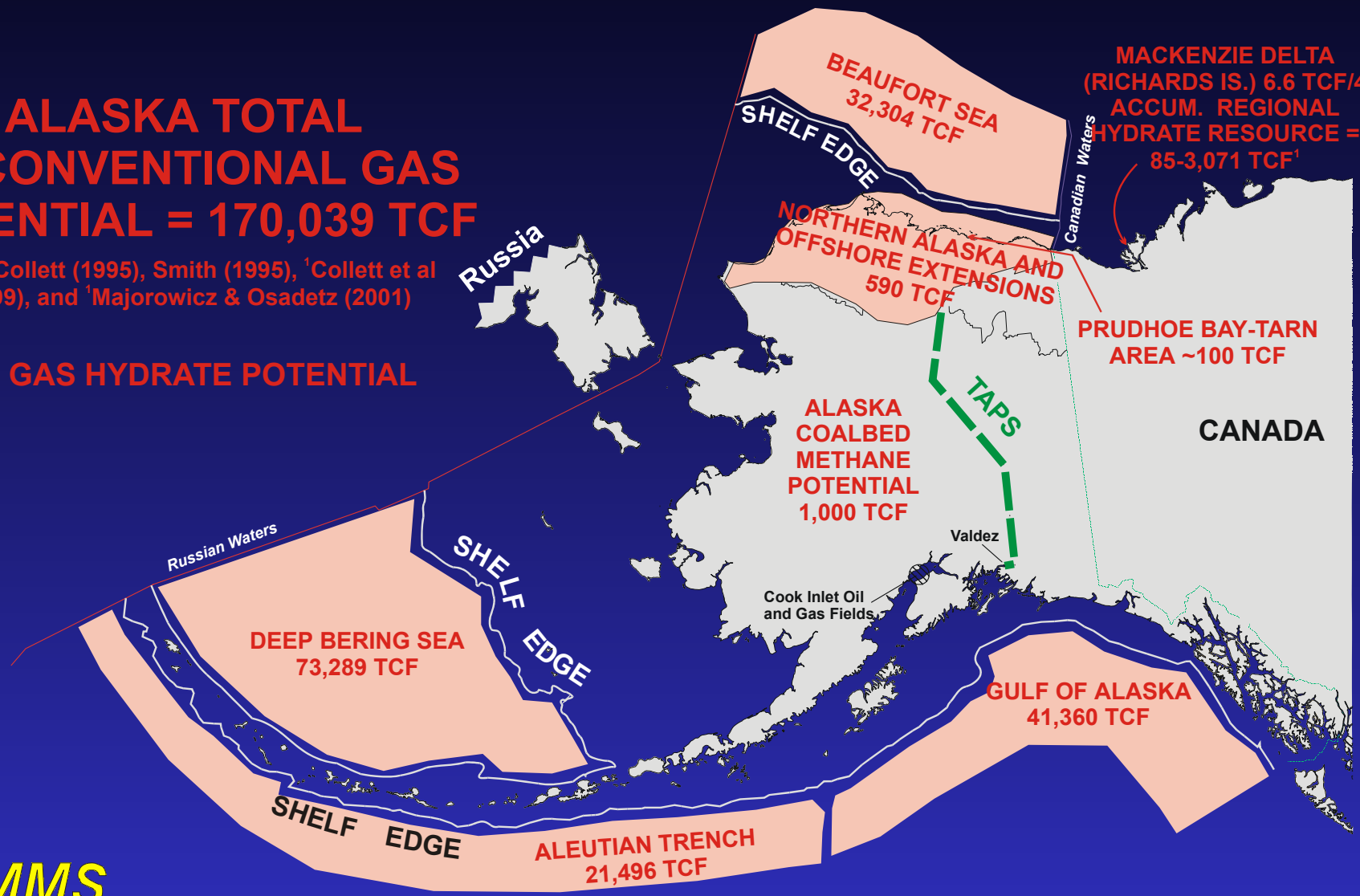
UNCONVENTIONAL GAS RESOURCES

ALASKA TOTAL UNCONVENTIONAL GAS POTENTIAL = 170,039 TCF

After Collett (1995), Smith (1995), [1]Collett et al (1999), and [1]Majorowicz & Osadetz (2001)

GAS HYDRATE POTENTIAL



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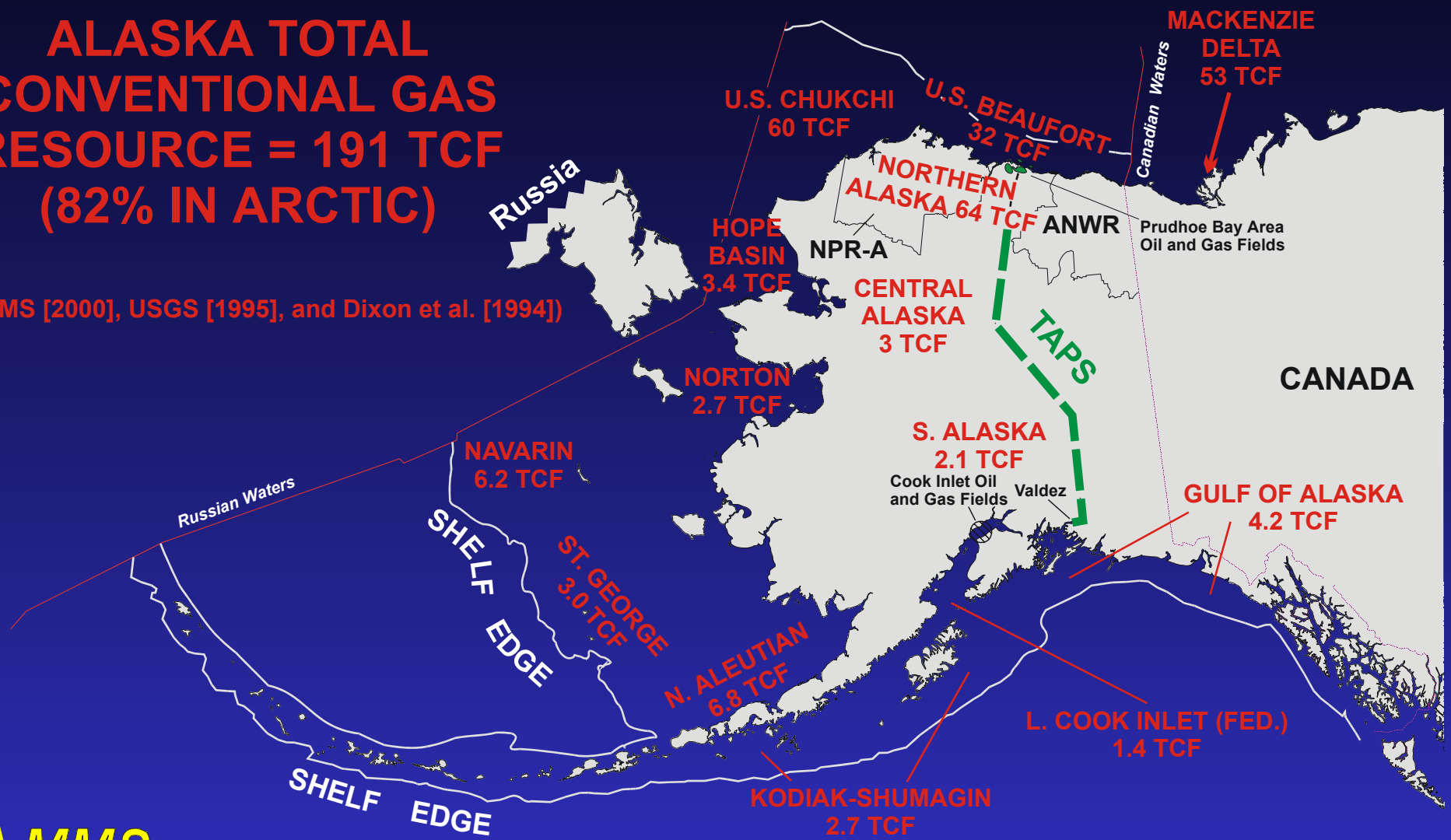
UNDISCOVERED CONVENTIONAL GAS RESOURCES

ALASKA TOTAL CONVENTIONAL GAS RESOURCE = 191 TCF (82% IN ARCTIC)

(After MMS [2000], USGS [1995], and Dixon et al. [1994])



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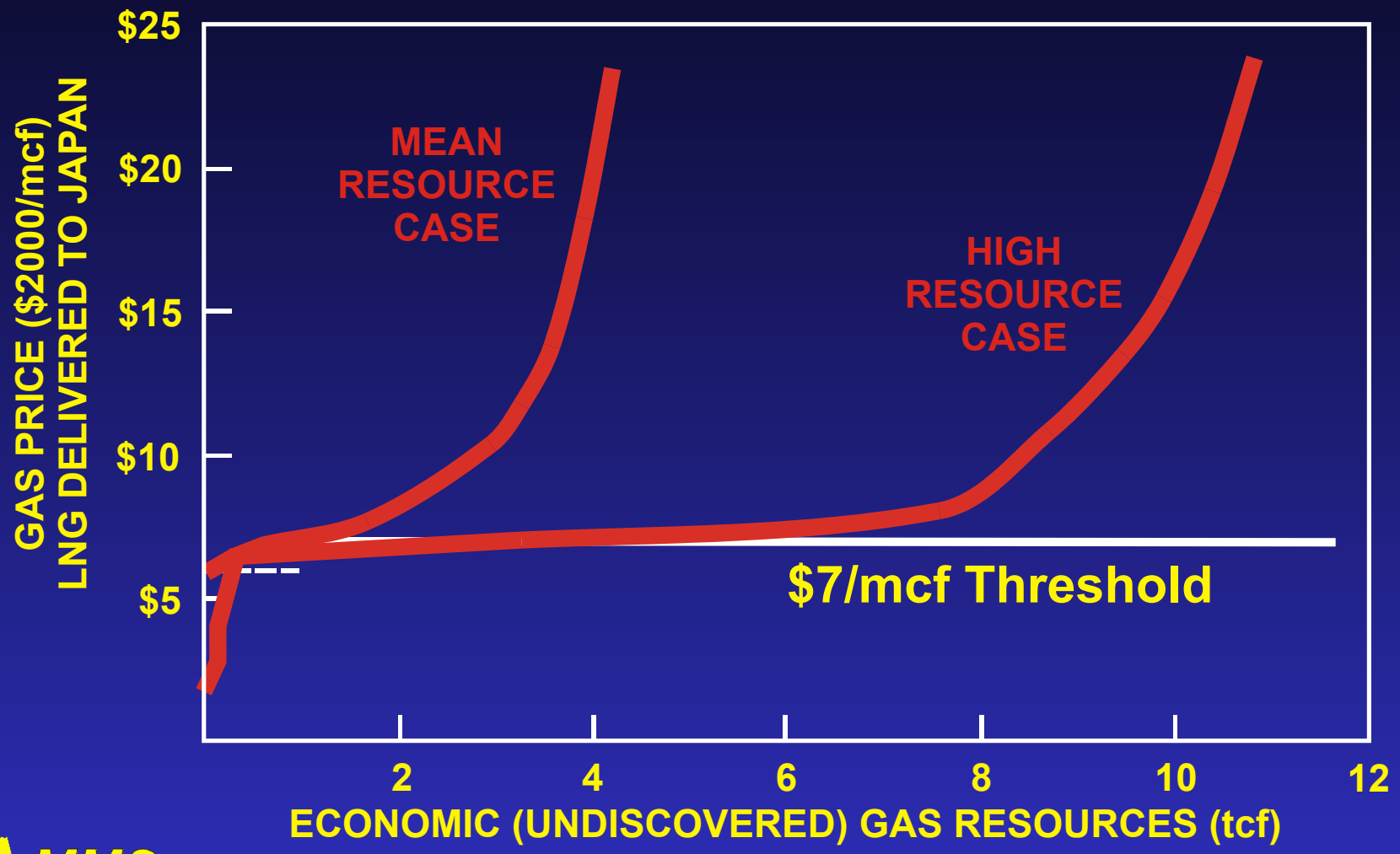
NAVARIN BASIN

Undiscovered Economically Recoverable Gas

(Mean Undiscovered Gas Endowment = 6.15 tcf)



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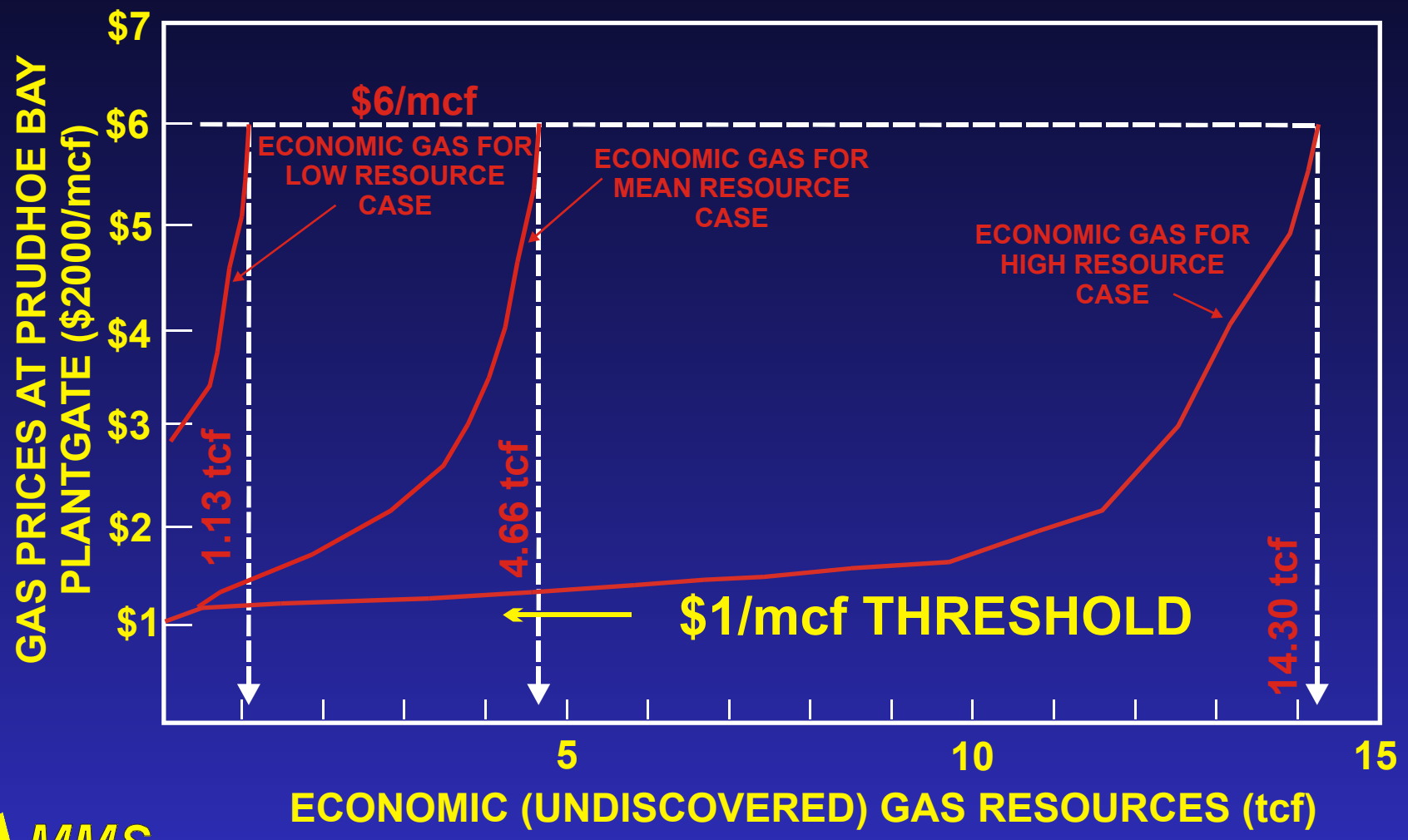
Transportation system includes 700 mile pipeline to south side of Alaska Peninsula and 3,000 mile tanker route to Japan

BEAUFORT SEA

Undiscovered Economically Recoverable Gas

(Total Undiscovered Gas Endowment = 32.1 TCF)



Gas is piped tens of miles to Prudhoe Bay and sold

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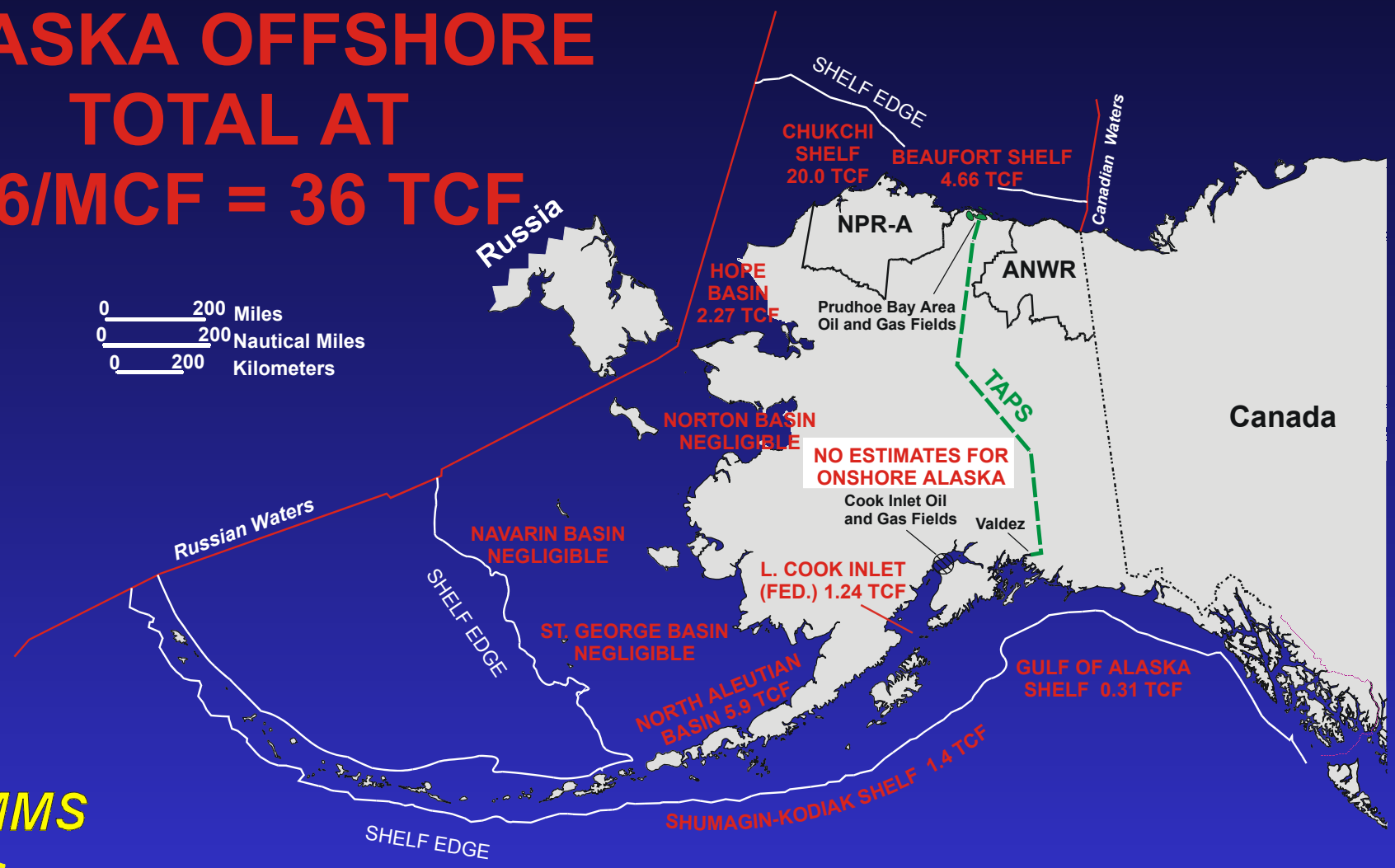
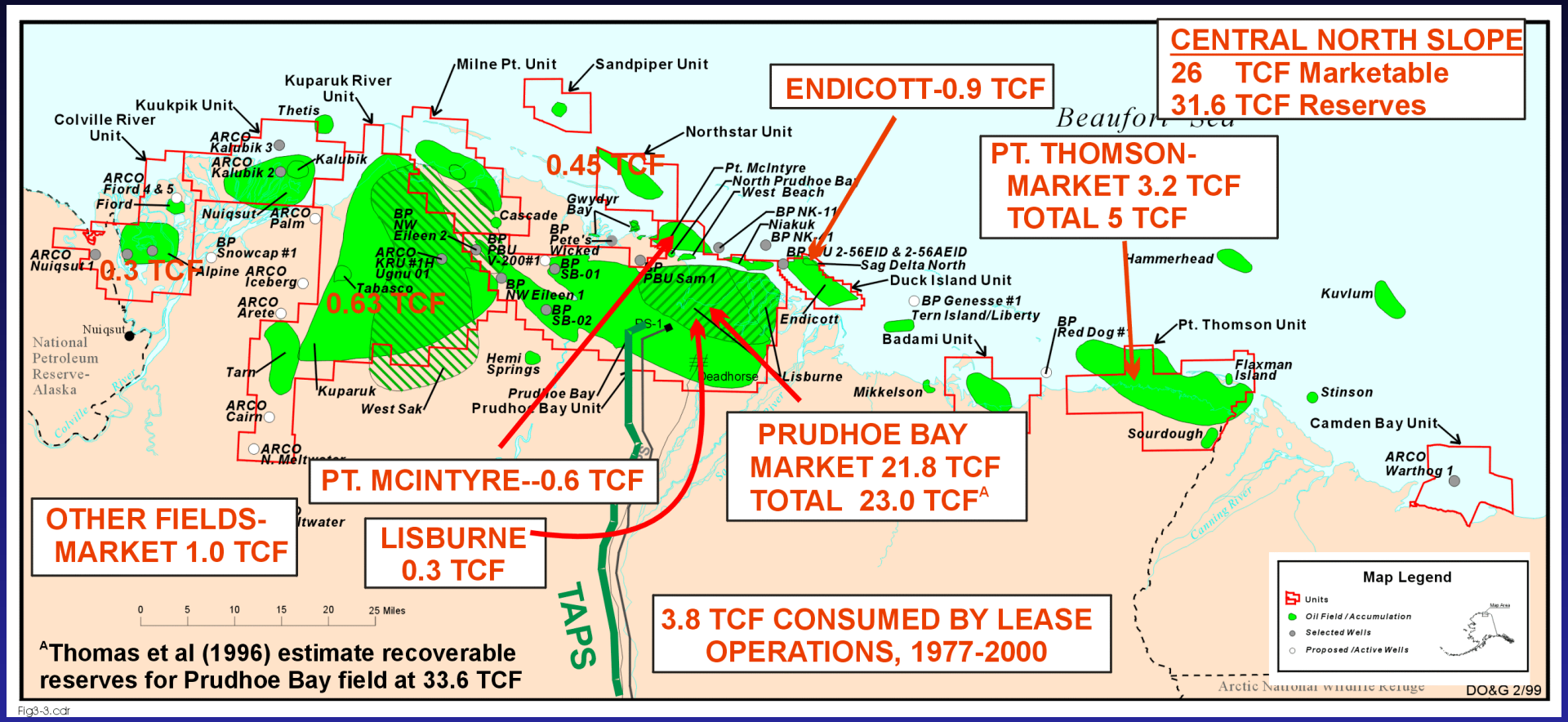
OFFSHORE GAS ECONOMIC AT $6/MCF ($2000)

ALASKA OFFSHORE TOTAL AT $6/MCF = 36 TCF



North Slope-26 TCF for Market



[A]Thomas et al (1996) estimate recoverable reserves for Prudhoe Bay field at 33.6 TCF

Marketable gas volumes from Thomas et al., 1996, tbl. 2.3

Map from State of Alaska, *http://www.dnr.state.ak.us/oil*

Recoverable (total) gas reserves from AKDO&G, 2000

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CONCEPTS FOR MARKETING NORTHERN ALASKA GAS

- **TRANSMISSION PIPELINE.** Pipe the gas to Canadian pipeline system, then to U.S.
- **LNG.** Pipe the gas to a southern Alaska port, liquefy (freeze) it, then ship it to Pac Rim.
- **GTL.** Convert the gas to liquid, then use existing pipeline and tankers to ship it to the U.S. West Coast.

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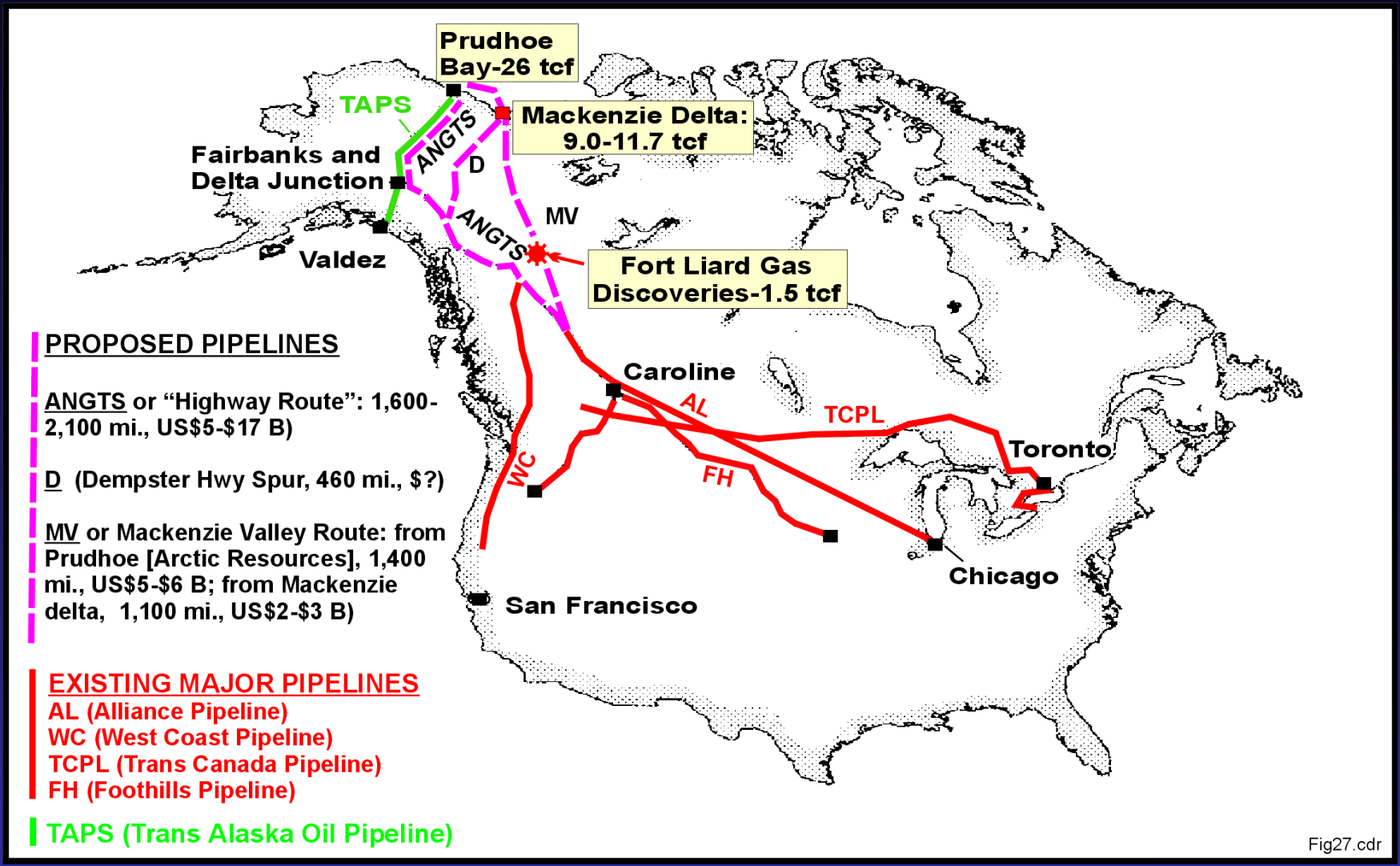
TRANSMISSION PIPELINES



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After Attanasi (1995) and Speiss (ADN, 2000)

TRANSMISSION PIPELINES

Major Positives: 28+ Tcf U.S. Market (2010)
Proven Technology

Major Negatives: Price Volatility
High Costs?
$11 B (Pipeliners est.)
$17 B (Owners est.)

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ECONOMICS OF GAS EXPORT OPTIONS

PIPE TO U.S. VIA CANADA

- Delivery Costs $2.35 /mcf [5] min. $3-$4 for economic project
- Henry Hub Gas in January 2001 >$9/mcf[2] ($2.70/mcf-Feb02)

LNG TO PACIFIC RIM

- DOE 1995 Breakeven (NPV_{10}=0) LNG Price = $4.39/mcf (in $2000)[4]
- Port Authority--0.7 tcfa--profitably delivered Japan for $3.10/mcf
- Japan Price Paid For Southern Alaska Gas = $4.50/mcf (December 2000)[3]. Now ~$3.50/mcf?

GTL FUELS TO U.S. WEST COAST

- Breakeven (NPV_{10}=0) World Oil Price = $23.23/bbl (in $2000)[4]
- World Oil Price = $23.07/bbl (31 Mar 01)[3]

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[1] ANGTS (1995)
[2] O&G J online, 11dec00
[3] E.I.A Website, Apr 01
[4] DOE Model; Thomas et al. (1996)
[5] Meyers, Ziff. Conf. Oct 00

CONCLUSIONS

- Given high sustained prices ($3-$4/mcf), known gas reserves may be economic to develop by 2008-2015 time frame.
- Undiscovered gas may wait additional 8-26 years before excess capacity develops in pipeline.
- All gas export schemes are subject to risk from price volatility.
- U.S. energy politics will probably favor a pipeline through Canada accessing the lower 48, but economic viability is undemonstrated.

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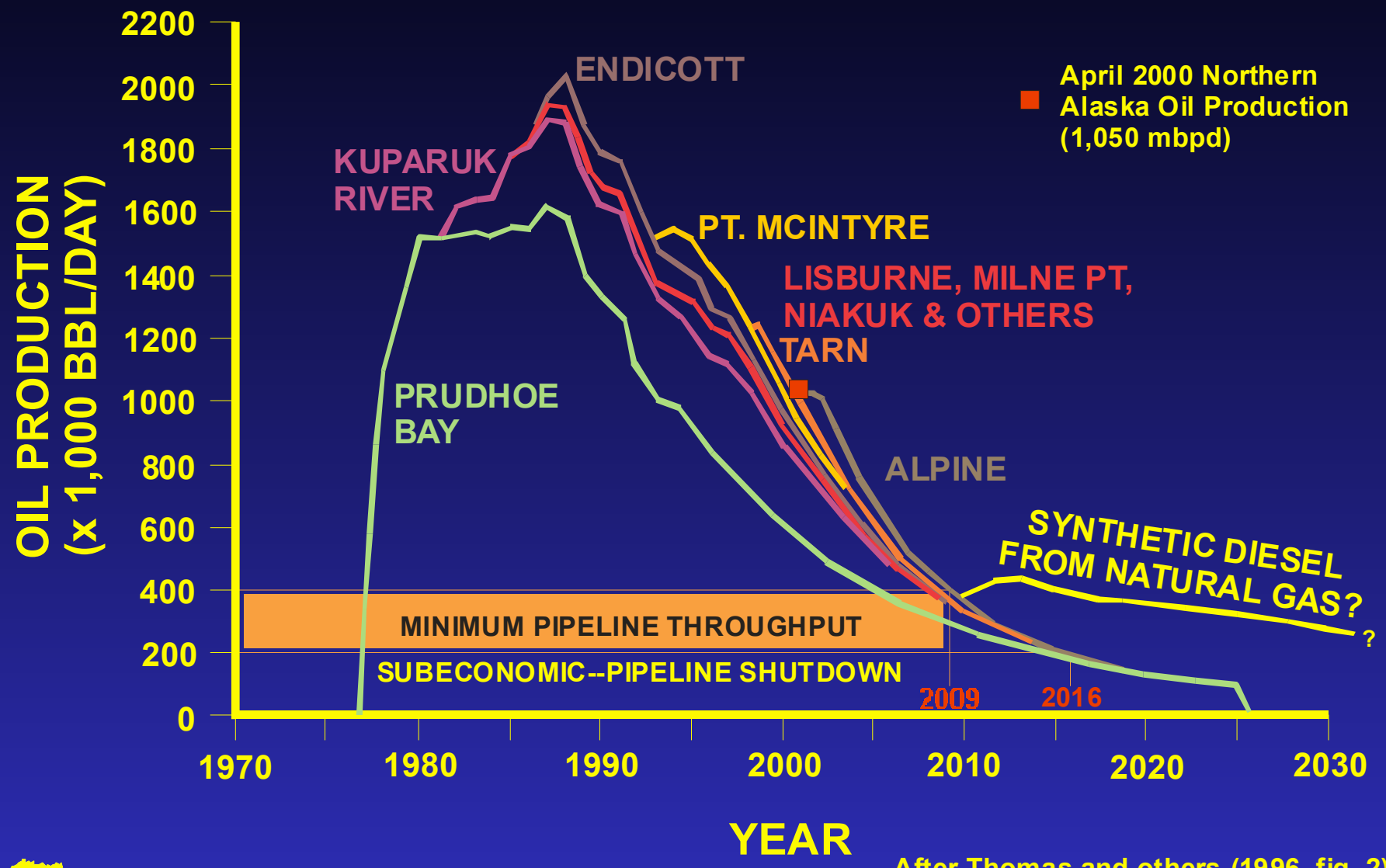
BACKUP SLIDES

IS PIPELINE SHUTDOWN IMMINENT?



After Thomas and others (1996, fig. 2)

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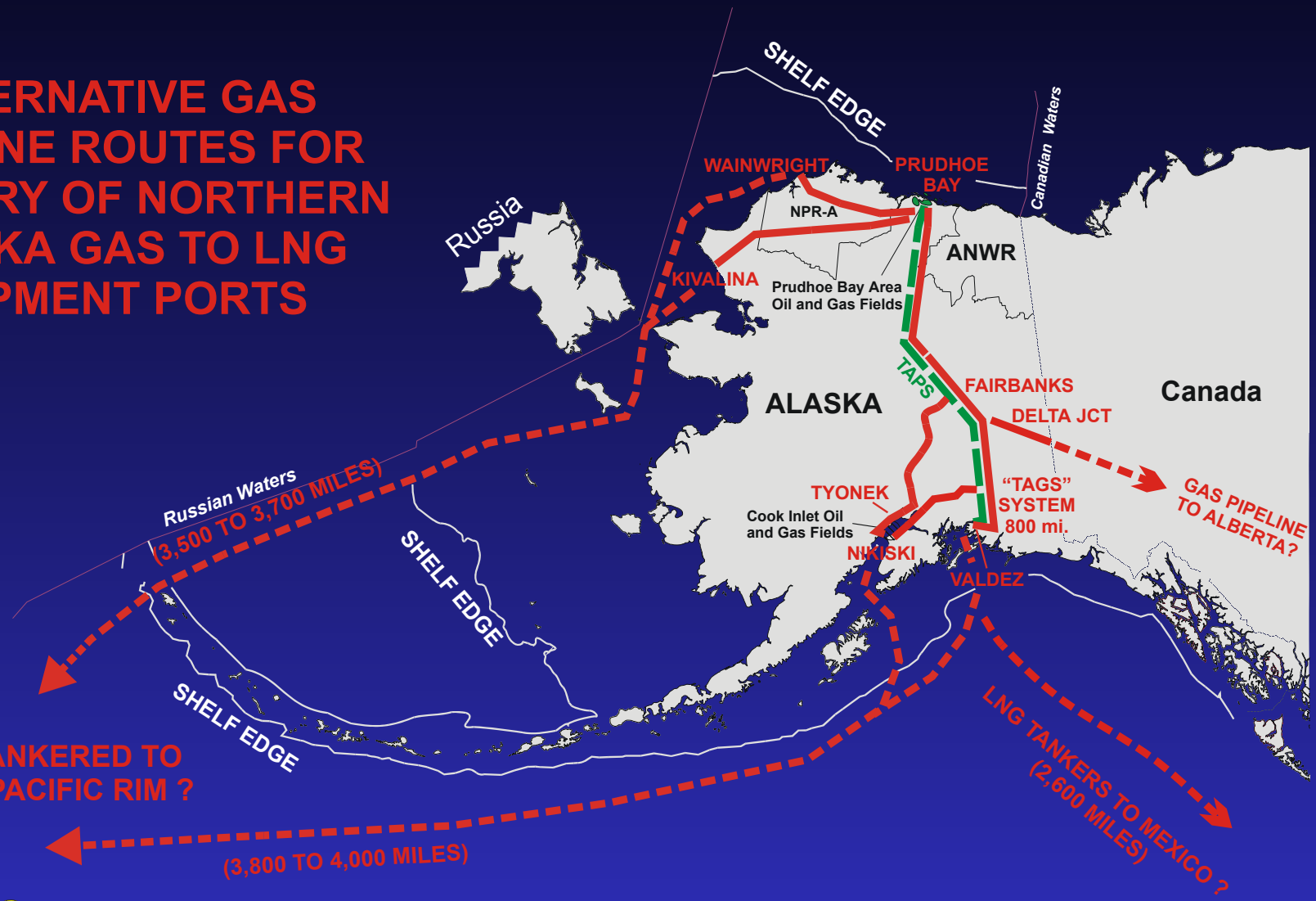
LNG TO PACIFIC RIM

ALTERNATIVE GAS PIPELINE ROUTES FOR DELIVERY OF NORTHERN ALASKA GAS TO LNG SHIPMENT PORTS



LNG TANKERED TO ASIAN PACIFIC RIM ?

LNG TANKERED TO MEXICO, THEN PIPE GAS BACK TO U.S.?

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LNG TO PACIFIC RIM

Major Positive: Proven Technology

Major Negatives: 800-mile Pipeline
Small LNG Market

0.7 Tcf/y (2 Bcf/d) Alaska Project = 22% of Asian Pacific Rim Imports (3.2 Tcf/y in 1998)

YPC LNG Model #1: 0.7 Tcf per year
Model #2: 0.2 Tcf per year
Model #3: 0.46-0.9 Tcf per year and ship some to Mexico

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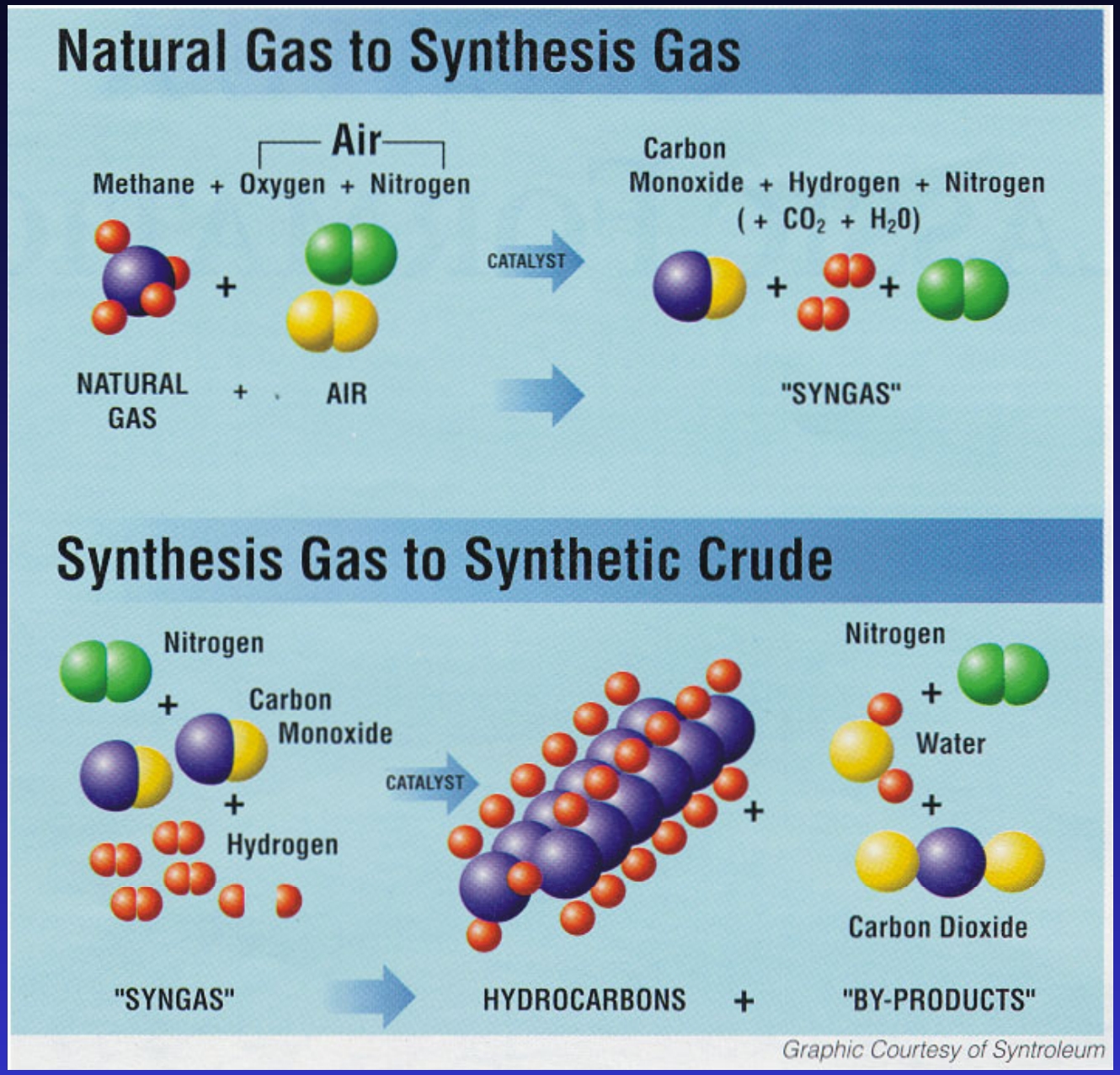
GAS TO LIQUIDS (GTL)



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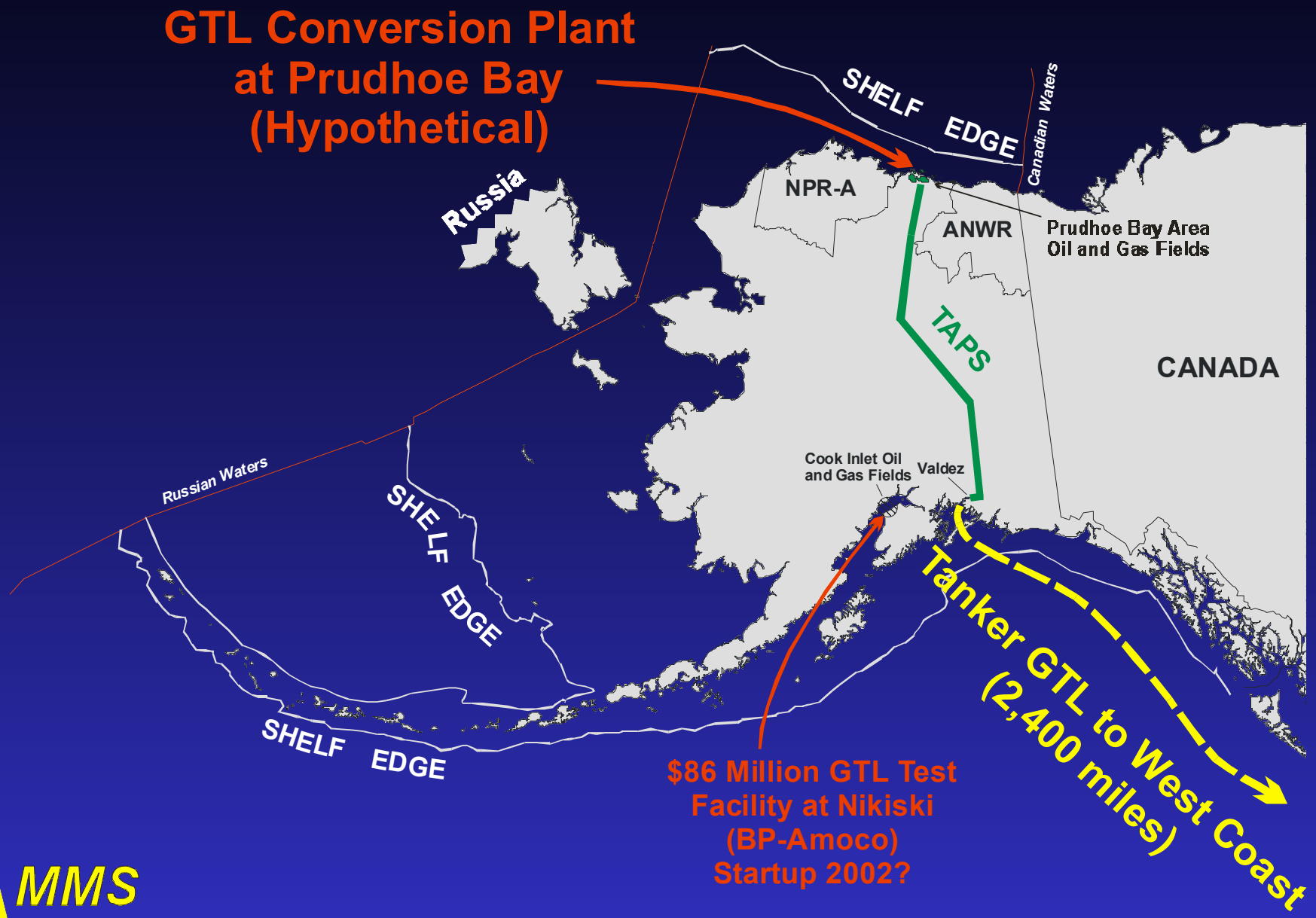
GAS TO LIQUIDS (GTL) EXPORT SYSTEM



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THE GAS TO LIQUIDS (GTL) OPTION

Major Positives:

- Use Existing Transportation System
- Extend Operating Life of Oil Pipeline
- Large, Receptive Market

Major Negative: Unproven Technology at Commercial Scale

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