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M. KING HUBBERT CENTER
FOR PETROLEUM SUPPLY STUDIES

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CANADA'S FUTURE OIL PRODUCTION: Projected 2000-2020

by L. F. Ivanhoe

Canada, in addition to its own substantial petroleum needs for its vast cold areas (1,775,000 B/D(4/), is a most important source of oil and gas for the U.S. (imports= 1,576,000 B/D(5/). The U.S. is extremely interested in the probable size of Canada's near-term "Synthetic Oil" production.

The "Hubbert Production Peak" for Western Canada's conventional oil was reached in 1973, soon after the US/48 Hubbert Peak in 1970. Since then, Western Canada's conventional oil production from wells has declined steadily and today is less than half that in 1973. The new Atlantic Ocean production will offset Western Canada's future oil decline. By 2020, Newfoundland's offshore conventional crude is expected to equal Western Canada's production of some 360,000 B/D (barrels per day).

The huge (+300 recoverable billion barrels in place) Alberta Tar Sands will be the backbone of Canada's long-term oil production. Tar Sands production began in earnest after 1982, and "Synthetic Oil" is expected to grow from 400,000 B/D (2000) to 1,000,000 B/D (2020). Tar sands production is more like coal mining than production from oilwells and is not cheap; it is a deep-pocket game for major oil companies and/or the government. An investment of more than $1,000,000,000 ($1 billion) is required to set up production of 100,000 B/D – a white poker chip in the world oil business. Winters in the region are sub-arctic with bad mosquitoes in the summers. There is no local infrastructure except for the Tar Sands. **It is not possible to expand much on Synthetic Oil production in emergencies**.

The accompanying graph (Figure 1-B) was compiled from Canadian National Energy Board (NEB) 1999 reports and statistics (2/3/) and is naturally subject to change. Projected production after year 2000 was compiled from Case 1 (2/) NEB graphs for each product. A second Hubbert Peak of the combined Tar Sands plus conventional oil is projected about 2006 at 2.9 million B/D.

PRODUCTION CONSTRAINTS

All crude oils are not created equal. Bitumen/Tar/Asphalt (B/T/A) will henceforth be a significant part of Canada's crude oil production. The NEB 1999 (2/) report says: "The proposed supply of heavy oil, bitumen, and upgraded crude oil is dependent on the installation of additional upgrading capacity either in Canada or in the U.S. markets." In short, new refineries will be required to meet the NEB's optimistic projections. A refinery is designed to process a specific type/quality of crude and cannot efficiently handle much heavier oils. Most existing refineries can presumably use Alberta's Synthetic Oil, but few can improve the Heavy Oil and B/T/A byproduct for which the principal current use is for road asphalt or boiler fuel. If there is no market for such Bitumen, then it may be left to form huge stockpiles on the surface. The projected 2010 B/T/A supply of 550,000 B/D = 200,000,000 B/Year is a lot of road asphalt, which can also be burned as a boiler fuel replacement for gas/coal or coke.(Should such solid boiler fuel be listed by Canada as "oil" or with coal as "solid fuels"?)

There is another constraint. The NEB 1999 report also warns: "The largest use of Pentanes-plus (condensate/NGL) is for diluents in the blending of heavy crude and bitumen to facilitate its transportation to market by pipelines. Typically, raw bitumen requires the addition of approximately 40 percent of diluents, while conventional heavy crude requires about 7 percent. It is estimated that about 4000 m^3/D (25,000 B/D) of Pentane-plus will not be available for use as diluents…a substantial shortfall occurs by 2018…" This suggests that a shortage of Canadian condensate (a by-product of natural gas) may be a major bottleneck of the projected amount of Synthetic Oil. **Natural Gas and condensate deplete at the rate of the gas fields – not at the rate of the Tar Sands.**

Natural Gas Constraints

Tar Sands production is heat intensive. Lots of heat is required to separate the Tar from the underground sandstone. Large volumes of underground heavy oil must be heated to liquefy the oil and get it to the surface. Then additional heat is used to convert the heavy oil to light Synthetic Oil. Currently, surplus natural gas is available and is used as the main source of heat at an average of 1 MCF/barrel of Synthetic Oil (6/), or about 20% of Canada's natural gas production. The local price of natural gas is a major factor for the price/profit of the operation. There does not seem to be enough natural gas in sight to supply both the oil and the gas desired by the U.S. above Canada's internal needs. **Within a few years Canada may have to choose between selling part of their natural gas vs Synthetic Oil to the United States**.

Canada Oil Consumption Statistics

Canada's Oil Supply/Consumption curve (Fig. 1A) can be used for comparison with Canada's Future Oil Supply (Fig. 1B). Canada's internal consumption is from all liquid fuels on Fig. 1-B.

Caveat BP Statistics

Any statistics depend on their sources and what is included therein. Oil statistics from different sources rarely match up. BP's annual "Statistical Review of World Energy" (4/) is the basis for CSM/HC "Oil Supply" graphs, to provide long-term consistency between selected countries. CSM/HC normally assumes that the difference between BP's numbers for any nation's annual Production and Consumption will be due to significant local Imports/Exports. However, there are some countries for which this assumption is not quite accurate due to that nation having both substantial IMPORTS and EXPORTS. Such countries include those that import crude oil which is refined and exported, (including: Bahrain; Aruba; Virgin Islands, Netherlands; Canada, etc.)

Canada is one of the exceptions. (Ref 1/). BP's Canadian (2000) "Internal Consumption" (4/) plus U.S. "Import" numbers (5/) add up to some 640,000 B/D more oil than Canada produces. Part of the problem is the difference between "OIL PRODUCTION" vs "OIL SUPPLY" as used in CSM/HC graphs. NEB's numbers (3/) are the best Canadian data, but their "Production" numbers do not include "Imports". (NEB's numbers use "scientific" rather than U.S. oilmen's terms, so there may be some problems in translations.)("Upgraded Crude" = "Synthetic Crude".)

Something does not correlate between BP's two sets of statistics. This may be due to the old Canadian practice of importing Venezuelan heavy crude oil into Eastern Canada where established refineries were designed to handle this heavy crude, while selling more expensive Western Canadian light crude to the Western U.S. Some Canadian statistics (the source of BP's data) may show the Venezuelan oil as "imports", or "exports" or "omitted" (since it is not part of Canada's oil production?).

Another problem is BP's practice of including "NGL" (natural gas liquids) with any nation's "oil" production. Total Canada oil supply numbers per (4/) (Fig. 1A) are a bit greater than Canada's NEB data (3/) (Fig. 1B). The difference may be due to BP's inclusion of all NGL in their totals, with possible repetition of "Pentane-Plus"/Condensate in BP's numbers, ignoring its inclusion by NEB into "Synthetic Crude".

CONCLUSIONS

Canada's oil production from wells and tar sands should cover all of Canada's needs while maintaining current exports to the U.S. through 2020. Increased exports to the U.S. may depend on converting large volumes (= 0.2 billion barrels per year) of "Bitumen"/Tar into "Synthetic Crude Oil". Use of natural gas as the principal sources of heat to produce Synthetic Crude Oil will decrease the amount of gas available for export to the U.S.

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2/ Canada National Energy Board (NEB), 1999; Canadian Energy Supply and Demand to 2025.
3/ R. Dulik/NEB, 2001; Estimated Supply of Canadian Crude Oil and Equivalent 1978-2000.
4/ BP Petroleum, 2001; BP Statistical Review of World Energy (2000) June 2001.
5/ BP Petroleum, 2001; BP Statistical Review of US Energy (2000), June 2001.
6/ Haines, L., 2001; Alberta's Heavy Oils; Oil and Natural Gas Investor, Oct. 2001, p. 31-40.

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Ivanhoe is a practical oil man with more than 50 years of worldwide oil-finding experience in all sizes of oil companies. Education included: Mining Engineering (S. Dakota School of Mines); Geology (Stanford); Oceanography (UCSD/Scripps Inst. Oceanography). Registration/Certification as a Mining Engineer, Geologist, Geophysicist, wherever required by local laws. Employment 1942-1957 was in various responsible positions in North and South America with geophysical contractors and oil corporations. From 1957-1973 he provided technical consulting services to the public, conducting projects throughout the world for foreign oil companies and government agencies. From 1974-1980 he was employed by Occidental Petroleum Corp. as a one-man department for global prospect search, basin evaluations, operating problems etc. Public consulting services were resumed in 1981-1992 as the president of Novum Corp., an international oil exploration service company. Ivanhoe is the author of numerous practical papers on an unusually wide variety of technical subjects. In 1984, the BBC of London selected Ivanhoe and M. K. Hubbert to be anchormen for an Open University science film on the earth's future oil supply. In 1996 he helped set up the M. K. Hubbert Center for Petroleum Supply Studies at the Colorado School of Mines, since which date he has been the Coordinator of the quarterly CSM/HC Newsletter.

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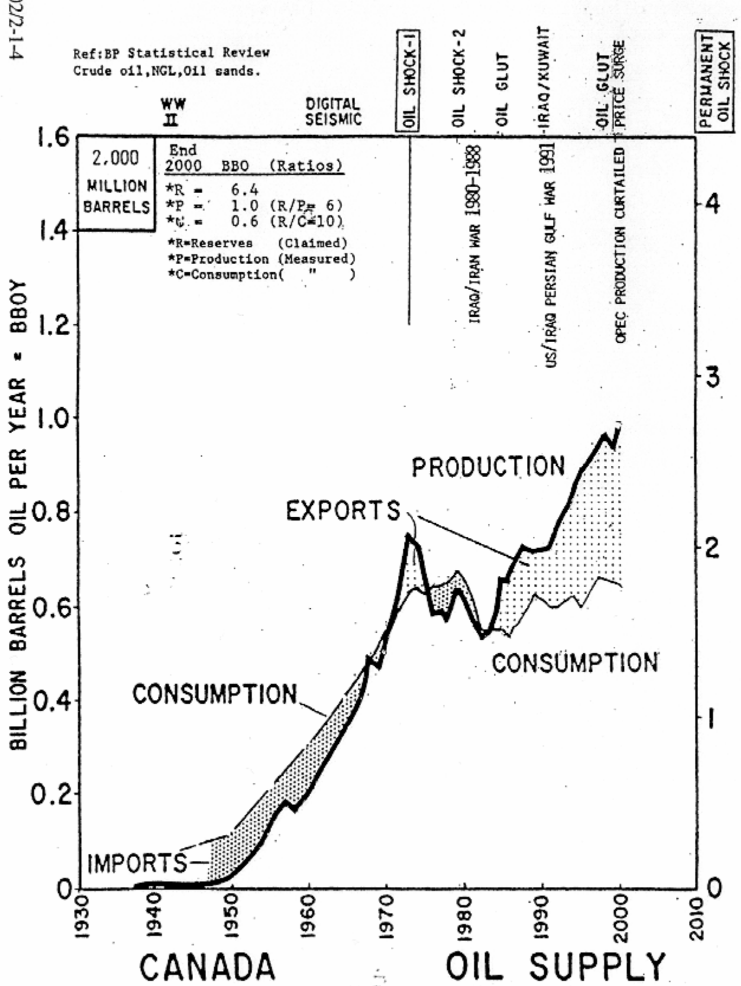
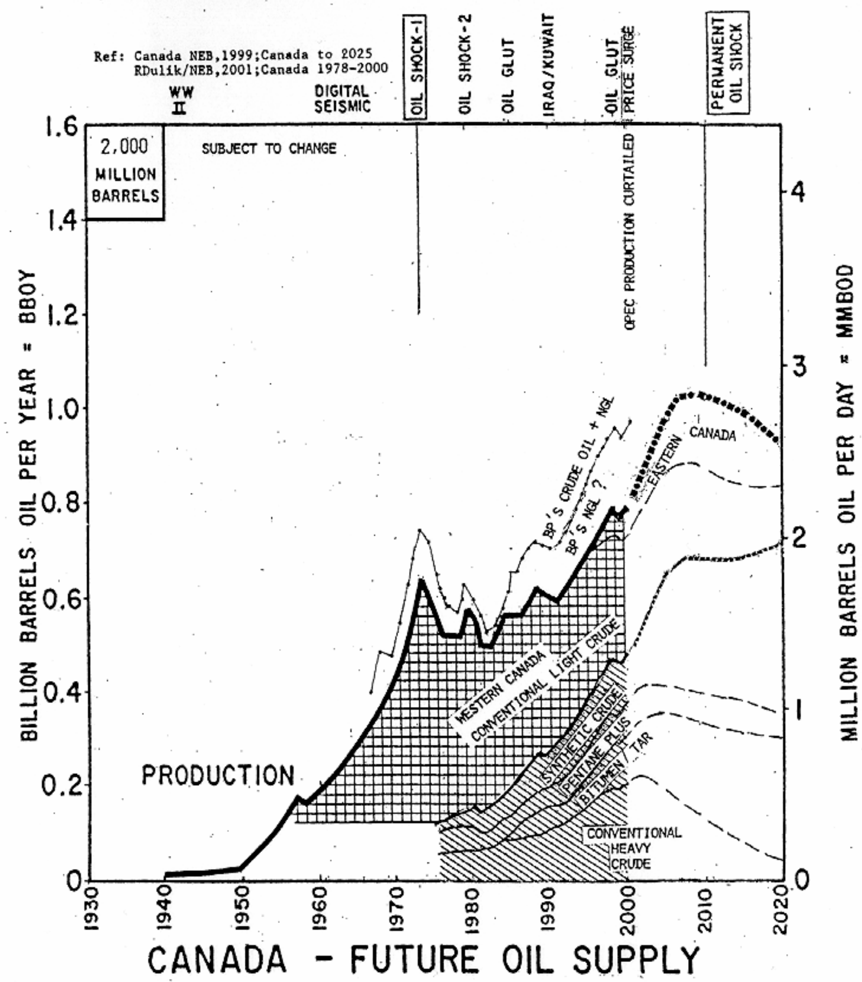


IVANHOE FIGURE I-A



IVANHOE FIGURE I-B

CANADIAN GAS, OUR ACE IN THE HOLE?

by Joseph P. Riva

In the United States the demand for natural gas is projected to rise substantially in the coming years, as it is the environmentally preferred fossil fuel and therefore the fossil fuel of choice for new electric power plants. The 275 new gas fired power plants scheduled to come online in the next five years will add 8.5 tcf (trillion cubic feet) per year to a current domestic gas demand of 24 tcf. U.S. natural gas production rose by about 2 percent in 2001 (to about 20.5 tcf) while demand declined by about 5 percent, as high prices, fuel switching, and lower economic output suppressed industrial demand, while deliveries to commercial and residential consumers were affected by above normal temperatures. The arrival of mild temperatures and the continued slowing of the economy magnified the weakening gas demand response and produced a reaction that was so strong that perceptions of a supply constrained market have been replaced by impressions of excess supply. However, the moderating gas prices and increased economic activity are expected to revive gas demand in each of the three sectors in 2002. In addition, the new gas fired power plants scheduled to be online by the end of the year will add 4 tcf per year to gas demand.

Increased domestic natural gas production is officially projected to meet most of the increased demand. But, in the United States, new gas fields are small and large gas fields are old. In the previous decade, only 14.8 tcf of natural gas was discovered in new fields. The 100 largest domestic gas fields hold almost half of proved gas reserves and 73 of them are over 20 years old. Currently, an average domestic natural gas well produces only a third as much gas as in 1973. Gas extracted from U.S. wells, on average, declines by about 24 percent per year. In the Gulf Coast, which accounts for more than one-quarter of domestic gas production and contains more than half of assessed undiscovered natural gas resources, new wells decline by more than one-half the first year and are depleted in less than 6 years. **If lower-48 State proved gas reserves are reported to the Department of Energy with reasonable accuracy, and field growth and undiscovered gas resources as assessed by the Department of the Interior prove generally reliable, it will not be possible to increase domestic gas production sufficiently to meet projected additional demand, especially with the addition of the new gas fired power plants.** It is probably over-optimistic even to project sustainable lower-48 State gas production over the next decade. Our southern neighbor Mexico has no gas surplus and imports gas from Texas.

The problems associated with increasing domestic natural gas production to counterbalance the pressures of rising demand have fueled expectations of increasing imports of Canadian gas, which have risen by a factor of five since the mid-1980s. With an additional increase of 5 percent in 2001, Canada now exports 3.9 tcf of gas to the United States, which is more than half of its total gas production. However, Canada also needs natural gas. The vast majority of Canadians heat with natural gas and it is also utilized in the commercial and industrial sectors of the economy. Canada produces 6.2 tcf of gas per year, which barely meets domestic and export demand. The Alberta Energy and Utility Board, in its supply outlook for the next decade, projected that conventional natural gas production in the province, Canada's key gas producer, will peak in 2003 at 5.3 tcf, and than decline by 2 percent per year. Currently, it takes 20 new wells per day just to sustain Alberta's gas production. At the same time, there will be a rising industrial demand for Alberta's gas driven by the processing of Alberta's oil sands. **By the end of the decade, oil sand operations, which are heat-intensive, are expected to consume some 25 percent of Alberta's (20% of Canada's) gas production, about 1.3 tcf/year.**

This fall, the Canadian Gas Potential Committee, a volunteer group of geologists and engineers with long experience in the gas industry, released the report "Natural Gas Potential in Canada – 2001" (1/) which detailed the conventional natural gas endowment in Canada, including discovered reserves and undiscovered resources. The committee did not undertake an economic analysis, but its supply studies were based on geological estimates of resource potential. One hundred seven exploration plays were established by gas discoveries and then assessed, using a combination of geological judgment and statistical methodologies, to estimate the volume of undiscovered gas and the size of the undiscovered gas accumulations in each play. The committee used data on all 29,063 gas accumulations and fields across Canada and utilized as many as 42 parameters, including location, depths, reservoir characteristics, and gas analyses for the assessments. The discovered gas accumulations in a play were used as a sample to predict the total population of accumulations, but no economic cutoffs were assumed and each play area was assumed to be fully accessible.

Where no discoveries had been made, conceptional exploration plays were defined based on the geological configuration of potential traps and source rocks. The Committee defined 77 conceptional plays. Thus, a total of 184 exploration plays were recognized across Canada. Undiscovered gas in place was estimated for each play, which is the volume of hydrocarbon and non-hydrocarbon gases in a reservoir rock in the subsurface. Of most interest, however, is the volume of gas available for market. This amount was estimated for each play by using the percentage of the gas in place that is marketable in the discovered accumulations. The Committee used the term "Nominal Marketable Gas" to describe these estimates because not all of this gas will be available, since not all of the predicted gas accumulation will be found. There will be no exploration in certain areas for environmental reasons, not all accumulations will be economic to develop, and not all fields (particularly in frontier areas) will have access to production and transportation infrastructure. Thus, the actual amount of marketable gas will be less than the estimated amount of Nominal Marketable Gas. No estimates of Nominal Marketable Gas were made for conceptual plays where no discoveries have been made, since there is a very high risk that a play will fail completely. **The credibility of all of the assessments was enhanced by government and industry peer review.**

Discovered reserves of Canadian conventional natural gas were estimated by the Canadian Gas Potential Committee at 70 tcf in western and central Canada and the near frontiers. Included in this number is 10 tcf of gas in the Mackenzie-Beaufort region. Thus, a proved gas reserve would be about 60 tcf, as reported by the Oil and Gas Journal. **The R/P (Reserves/Production) ratio of 10/1 indicates that the reserves are being exploited efficiently, but that there is not much room for increased production unless reserves are significantly increased.** The magnitude of reserve increase needed to support additional production is not always appreciated. Normally R/P ratios in gas producing regions range around 8/1 or 9/1, but in very intensively exploited regions where gas fields are large and have high delivery rates, such as the offshore Gulf Coast of the U.S., the ratios can be as low as 5/1. This means that for any increase in production, from 5 to 9 times as much gas must be added to proved reserves.

For the Western Canada Sedimentary Basin, the remaining discovered gas is 54 tcf, with an undiscovered nominal marketable gas assessed at 88 tcf. This indicates a remaining gas endowment of 142 tcf which can be compared to 107 tcf of gas that has already been produced. Future production is likely to depend on maintaining an R/P ratio of around 8/1, since the area is mature and future reserves will increasingly be found in smaller, short-lived fields that will require intensive exploratory drilling. Each year's production must be replaced, but for a production increase about 8 times the increased output must be added to reserves. With this constraint, 88 tcf of gas is not a lot of gas to work with, especially since the larger undiscovered fields face the greatest risk of being located in areas where exploration is not possible or they likely would have been discovered by now. **Thus, from 10 to possibly more that 20 percent of assessed nominal undiscovered gas may not be available.** This could lower the amount to below 70 tcf, which is one of the factors in the projected decline of Alberta's gas production after 2003.

Frontier Basins include the sedimentary basins outside of the Western Canada Basin and Southern Ontario and Quebec. The Southern Ontario and Quebec region contains about 0.4 tcf of gas reserves, with some 1.4 tcf of assessed nominal undiscovered gas resources. The region has not been a major gas producer, with a total production of only 0.6 tcf. The near Frontier Basins are those which are relatively accessible for exploitation. Those with established plays are the shelf off Nova Scotia, the Mackenzie Corridor and Eagle Plain, and the Mackenzie-Beaufort Basin. Marketable gas in these basins are: Nova Scotia Shelf – 6 tcf discovered, 5 tcf nominal undiscovered; Mackenzie Corridor and Eagle Plain – 1 tcf discovered, 5 tcf nominal undiscovered;

and the Mackenzie-Beaufort Basin – 9 tcf discovered, 21 tcf nominal undiscovered. The new Deep Water Slope play off Nova Scotia may be analogous to the pull-apart basins of Brazil and West Africa, but an assessment could not be made because of proprietary seismic data.

The more remote Frontier gas plays in the Arctic Islands (16 tcf discovered, 9 tcf nominal undiscovered), Newfoundland (4 tcf discovered, 4 tcf nominal undiscovered), and Labrador (5 tcf discovered, 4 tcf nominal undiscovered) face severe technical and economic constraints before any gas is forthcoming. In addition, the 44 tcf endowment of nominal remaining marketable gas in these remote Frontier plays is less than the 46 tcf of nominal remaining marketable gas in the near Frontier Basins. **While large and highly productive gas fields have been found in the Frontier regions and more are expected to be discovered, the total gas resource in the Frontiers may not be as large as previous estimates have suggested.**

Canada's 60 tcf of conventional gas reserves can be compared to the 177 tcf of mostly conventional gas reserves in the United States, both experiencing about the same intensity of exploitation. In addition, Canada contains about 36 tcf of discovered gas that is marketable, but not as yet online due mainly to location in frontier areas. The total Canadian nominal marketable undiscovered conventional gas was assessed by the committee at 138 tcf. This can be compared to 259 tcf of undiscovered conventional gas in the United States as assessed by the Department of the Interior. In addition, in the United States gas field growth is expected by the Department of the Interior to eventually total about 290 tcf.

The Canadian Gas Potential Committee did not estimate marketable gas volumes for such unconventional gas sources as coalbed methane, tight or shale gas, pending the results of pilot projects involved with these resources. In the United States some 358 tcf of undiscovered recoverable gas has been estimated for such deposits. **However, the recovery of unconventional gas will be more expensive than that of conventional gas and individual wells are not as prolific.**

As the United States struggles to find sufficient domestic production to meet the escalating demand for natural gas for new power plants as well as for residential, commercial, and other industrial needs; as in the past there likely will be a turn to Canada for increasing gas imports. Only this time Canada will be struggling too, trying to meet its increasing gas demand with a relatively modest and widely dispersed gas resource. The Canadian ace in the hole could become a joker. As for all those U. S. gas fired power plants, it would be very wise to build them with a fuel switching capability.

* *

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After receiving an M.S. in geology in 1959, J. P. Riva worked as a exploration geologist in the Rocky Mountains for the Tenneco Oil Company and then as a geological consultant worldwide. In 1966 he joined the Smithsonian Institution, specializing in energy and water resources research. In 1974 he moved to the Congressional Research Service of the Library of Congress to become a non-partisan congressional advisor on world oil and gas. During 1980 he worked as a senior research geologist with the U.S. Geological Survey in the World Energy Program. He has testified before Congress and has authored over 200 publications including the Fossil Fuels section of *Encyclopaedia Britannica* and the following four books: *World Petroleum Resources and Reserves* (1983), and *U.S. Conventional Oil and Gas Production Prospects to the Year 2000* (1985) both from Westview Press; and *Exploration Opportunities in Latin America (1992)* and *Petroleum Exploration Opportunities in the Former Soviet Union* (1994) both from PennWell Books. He has served on the Committee on Offshore Hydrocarbon Resource Estimation Methodology and on the Committee on Undiscovered Oil and Gas Resources (both of the National Research Council, National Academy of Sciences) and on the Interagency Coordinating Committee of the World Energy Program of the U.S. Geological Survey. He is a member of the AAPG, and AIPG, and Sigma Xi. In 1996 he retired from the Library of Congress and now writes and consults on world petroleum geology.

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The Oilman's Column #11 - by L. F. Ivanhoe

A. GLOBAL OIL DISCOVERIES, DEVELOPMENTS, AND PRODUCTION 1990-1999

H. S. Pettingill* reported that in the decade 1990-1999, global discoveries of giant oil and condensate fields, and the development thereof totaled:

1990-1999	Global discoveries oil & condensate	=	42 Billion barrels
	Global development oil & condensate	=	15 Billion barrels
	Global production **	=	250 Billion Barrels

Ratios: Production/discoveries = 6x (=250/42)
Production/developments = 16x (250/15)

* from: AAPG 2000 Convention
** BP Statistical Review 2001.

So much for the argument that new technologies are keeping discoveries and development abreast of global oil production/consumption. Discoveries are not all developed – for various reasons.

B. ACADEMICS NOT EXPERTS OUTSIDE THEIR TRAINING/EXPERIENCE

"When academics operate outside their areas of specialization, and particularly when they write for the general public about issues of (or fraught with) politics or ideology, they operate without guidance from their training and experience…without any significant constraints; there is nothing to call them to account."

(From: Public Intellectuals by Richard Posne.)

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H.C. NEWSLETTER

The M. KING HUBBERT CENTER FOR PETROLEUM SUPPLY STUDIES
located in the Department of Petroleum Engineering
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Golden, Colorado

The Hubbert Center has been established as a non-profit organization for the purpose of assembling and studying data concerning global petroleum supplies and disseminating such information to the public.

The question of WHEN worldwide oil demand will exceed global oil supply is stubbornly ignored. The world's oil problems, timing and ramifications can be debated and realistic plans made only if the question is publicly addressed. A growing number of informed US and European evaluations put this crisis as close as now to 2014. The formation of this center is to encourage a multi-field research approach to this subject.

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