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OUR CHANGING ENERGY OPTIONS

by

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Introduction

It is recognized by most people that we are entering a new energy era but too few realize the rapid rate at which it may be thrust upon us. The implications are far reaching because enery problems impact on our economy and soon thereafter on policies that guide social, agricultural and industrial activities; even on our foreign policy.

We have read much on the subject lately and we have been presented with an array of strategies and manoeuvers that have done little more than to confuse us.

I would like to discuss with you this evening my explanation of why the energy crisis arose in the United States, why it will happen in Canada, and to give some reasons why our options for effectively dealing with the situation seem to be changing.

How Did the Energy Crisis Happen?

The energy crisis originated in the 1950's when coal began to lose all of its traditional markets except for thermal power generation and steel production. This was the beginning of what I call "the era of fuel highgrading" because oil and natural gas were sold at prices below their true, long term value resulting in rates of consumption to-day that bear no relationship to reserves. Under these circumstances we have witnessed the rapid depletion of premium fuels as a convenience in protecting the environment and through false economics.

As an example, based on economic evaluations which conveniently overlook thermodynamic realities, we have seen natural gas used for raising steam and generating electricity for heating homes and other services whereas the same gas could be used to perform the end services three to six times more efficiently.

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Economic analyses conveniently forget the large and complex network of natural energy flows. Every change man makes in these natural energy flows is a biological and social act -- but nature adjusts and we do not worry about our little part in the drama. So,we continue to make day out of night, summer out of winter, winter out of summer and shrink the world with supersonic flight.

The energy crisis as we know it, is a situation in which fuel is in short supply for our lavish use-patterns and there is no immediate substitute. This happened first in the United States where the total per capita fuel resources are greater than in Canada. This is illustrated in Slide 1. Why it happened is explained in Slide 2 where it is shown that the United States has drawn on 10% of its fuel resources for 78% of the fuel it uses. In Canada, we are drawing on 23% of our fuel resources for 80% of the fuel we use. This is not unlike the city of Ottawa drawing its water supply from Dow's Lake.

Anticipated Life of Fuel Reserves

How long, then, will our fuel resources last? A simple mathematical exercise, summarized in Slide 3, reveals that if current trends continue even the maximum potential reserves will be depleted in the brief span of 34 years for conventional oil, and 77 years for coal. Technology does not yet exist whereby most of this can be recovered. As an example, many of our conventional oil wells do not respond to tertiary recovery techniques.

Therefore, our immediate interest is the probable life of presently remaining proven reserves. A concensus of proven reserves is summarized in Slide 4. This is sufficiently optimistic to be yesterday's dream and,as such, it should give us cause to be gravely concerned because oil and natural gas will last a maximum of 22 years or by conserving, utilizing the tar sands, and cutting off exports they could be made to last 62 years. To-day's reality is that Alberta's proven oil reserves have declined to 14 years supply at 1970 rate of consumption and about 12 years supply at 1970 rate of production.

Arctic exploration has shown that there may be a significant amount of frontier gas and oil but before it can supply our needs new northern technology must be developed. Furthermore, it may take 10 years to put new sources on stream and, as we have seen, shortages are close at hand. Actually, prospects are that temporary shortages of gas will be felt in Ontario in 1977 and continuous shortages will occur in the 1980's to the extent of 200 million cu ft/day unless, of course, new sources are miraculously brought on line.

The experts warn that we will be a net importer of oil in two or three years. This, of course, has spurred development of the tar sands deposits where Syncrude and others propose to follow the pioneering efforts of Great Canadian Oil Sands Limited (GCOS).

Development of the tar sands seemed to me, until now, to be an essential component of a Canadian Energy Development Program. But, recent events have cast some doubt on the viability of Syncrude's plans. Can it be escalating costs alone that have caused Syncrude to reconsider its commitment?

When construction costs were estimated at less than $1 billion, Syncrude estimated the cost of oil production to be $3.00 per bbl. Now that the plant costs have doubled, possibly production costs have risen to over $6.00 per bbl. At the present time the world price is $11.40 per bbl including taxes which I assume are in the $5.00 per bbl range. This means that the producer has only about $6.00 per bbl in which to operate. On the other hand, GCOS have been quoted as saying that they need $8.50 per bbl to make 15% profit on their investment. Possibly there <u>is</u> a price squeeze. What are the investment alternatives?

Let us consider nuclear power, because electricity is a viable option for space heating and mass transportation. Slide 5, taken from a recent AECL report, establishes the 1973 cost of a nuclear station to which I added 30% for inflation during 1974. Thus, the $2 billion investment proposed by Syncrude could purchase 8 nuclear units of 514 MW each for a total of 4000 MW. Such a plant would produce 13.6×10^9 Btu/hr of useful energy in the form of electricity which now costs the consumer about $3.51 per million Btu.

The same investment in crude oil production from the tar sands would provide 125,000 bbl/day, roughly equivalent to 31×10^9 Btu/hr of potential energy in the form of liquid fuel. Refining the crude to finished products represents a 10% energy loss and assuming an average 50% conversion efficiency to useful work, the $2 billion investment would provide us with 14×10^9 Btu/hr of useful energy, about equal to that from nuclear plants of the same cost. An average cost to the consumer of the petroleum products from tar sands crude is about $3.31 per million Btu based on crude entering the refinery at about $6.50 per bbl, compared to $3.51 for nuclear energy.

It would seem that Syncrude is facing a cost squeeze as has GCOS from the very beginning of its operation. Syncrude's decision to scrap its plans was a severe blow to a program that I considered to be essential. That decision came on 24 January and within 10 days it could be reversed by Government intervention. We shall see.

Loss of the crude oil from tar sands might have the negative effect of encouraging advocates of synthetic fuels from coal. Much publicity has been given to research on methanation of coal gas but in my opinion this arises either from desperation or optimism that is difficult to substantiate.

As an example, 50% of the cost of upgrading a low quality fuel by hydrogenation can be directly attributed to hydrogen input. As shown in Slide 6, the production of methane from either coal or bitumen requires significantly more hydrogen than any of the liquid fuels. Furthermore, high-Btu gasification is both capital and energy intensive. By comparison, coal liquefaction is less energy intensive and liquid fuels, being a more concentraded form of energy, are cheaper to transport by pipeline and store.

Processes for coal liquefaction are not as close to commercial realization as are processes for gasification. Indeed, processes have been in use for some 30 years which produce a low-Btu gas fuel but they suffer a 30% loss of energy in conversion and because of the low calorific value of the fuel it cannot support pipeline transportation costs. Therefore, this class of coal gasifier should be considered only as an ancillary in an industrial complex based on coal.

Coal in the Energy Forecast

When we examine and re-examine our energy options we come back inevitably to nuclear in the long term and coal in the short term while doing the best we can to exploit natural gas and oil resources by whatever techniques apply, such as pipeline construction, tertiary recovery of conventional oil and others. At the same time, it is only natural that we should look to coal as an assured source of fuel; one fuel that could provide stability at a time of rapidly changing options.

To what extent, then, can we rely on coal and how will it be used without impacting on the environment?

It has been the general practise to forecast energy requirements on the basis of past experience in both fuel consumption and production. This has been done in preparing Slide 7. The projections to the year 2000 are those of the standard forecast while those beyond are my own. These projections have already been revised downward by 30 to 40% and are no longer valid. This comes at a time when oil and gas shortages are imminent but still a steady increase in total energy consumption is expected. Eventually, it will be supplied largely by nuclear thus, we are moving toward a new life style based on electricity. When our life style is shaped by electricity what need will there be for pipeline gas from coal? As a chemical feed stock CO and H_2 from coal, i.e. low Btu gas, is all that will be needed.

A shortfall of 1% in the projected supply of oil and natural gas represents 7 million tons of coal equivalent in 1994. The downward revision of the standard forecast is interpreted to mean a reduction in the use of oil and natural gas by saving and not by substituting coal. Nonetheless, a shortfall in these fuels can only result in increased pressure on coal and it is suggested that we will be safe if we plan to use 1.9×10^{15} Btu/yr coal equivalent in 1994 according to the standard forecast. This is 70 million tons of coal which is 2.7 times the 1970 level of 26 million tons. It is questionable that imported coals can be increased 2.7 times the 1970 level of 16 million tons, so, let us assume that imports will stabilize at 20 million tons per year. Then, our 1994 coal consumption could be 50 million tons of Canadian and 20 million tons of imported coal. If we are to be energy self-sufficient the total 70 million tons will be Canadian.

According to the electrical energy forecast, nuclear power will equal our hydro electric generation in 1994 which represents an installed capacity of 46,000 MW, assuming a load factor of 0.8. If we subtract the 6000 MW nuclear capacity now installed and under construction there remains 40,000 MW of capacity to be erected by 1994. The lead time for a nuclear plant is about 8 years which means that we must start immediately to schedule the commissioning of one 3000 MW nuclear station each year from 1982 to 1994. Perhaps this is possible but there is room for reasonable doubt.

If it should happen that there will be a nuclear shortfall of 50% this would mean another 70 million tons of coal that we will need or a total of 140 million tons in 1994.

It appears, then, that the demand for Canadian coal, which was 10 million tons in 1970, could escalate to a minimum of 60 million tons and could rise to 150 million tons in 20 years.

Revised Life of Coal Reserves After 1994

If it should happen that we will become dependent in 1994 on coal to this extent, we will reduce the anticipated life of proven reserves after 1994 to between 6 and 7 years and potential reserves to between 70 and 79 years as shown in Slide 8. In other words, without major conservation measures and without changing our insatiable demand for energy, proven coal reserves could, by this model, be depleted in the year 2000 and potential reserves between the years 2064 and 2073. If coal must substitute for oil and natural gas in the meantime, as the foregoing strongly suggests, even potential reserves, which are now either difficult or impossible to recover, may have difficulty getting us through to the promised nuclear era.

At the beginning I stated that it has been the practise to forecast on the basis of past experience in both fuel consumption and production. In the discussion so far I assume that coal will be mined as it is required. That may not be the case in future because the producing provinces gave notice at the 26th Canadian Coal Conference that they are not about to scar their beautiful country-side with strip mines just to keep the fires burning in Ontario. More benefit must accrue the producing provinces than in the past and so we have a new dimension in pursuing our energy options.

Conservation

These options, of which I have mentioned but a few, have become so complex, inter-dependent and costly that we sorely need some back-up stabilizing strategies. One that comes to mind is for the experts, i.e. technologists, engineers and scientists to be objective when advising administrators and policy makers. Too often the specialists feel compelled to press their personal projects which can only confuse. Another stabilizing strategy, in which we can all participate, is conservation.

Ad hocery has been successful in expanding our fuel and energy uses to the point that we do not fully understand the proper role of energy in society. Surely, we have gone beyond a reasonable level of dependence on energy and from now on we need to identify what we must not do and thereby conserve.

Many energy problems have no solution; some are controversial with the result that national and world energy strategies are exploratory rather than definitive and cosmetic rather than exhaustive. If we had endless wealth this might not concern us too much. The fact is that financial resources become a limiting factor of increasing magnitude in the face of inflation and imbalance of trade.

The classical economist, until now, believed that recession is a natural check on inflation. With lessening demand, large inventories and rising unemployment, prices should either remain steady or decline.

This is not happening to-day because we have a cost-push inflation brought about by governments fixing prices, as OPEC countries have done for oil, by wages getting ahead of inflation through organized negotiations, by wholesalers and retailers raising prices in anticipation of rising costs for new stock, and by reduced productivity per man year. The current recession seems to be adding to the inflationary pressures but in balance, many feel that it is most urgent to stem a deep recession.

Therefore, we can expect, at best, a period of controlled inflation maybe at the rate of 6 to 7% per annum if we are lucky. This, together with shortages of fuel supply and substitution of higher cost, lower quality fuel will leave us no alternative but to conserve and in doing so, change our energy-use patterns.

We could choose many conservation examples but let us look at the automobile. It has no equal as an energy user although as a means of transporting five people to the grandparents 150 miles away it is probably the most efficient of all modes. This is illustrated on Slide 9. But for most passenger traffic the bus and the street car are so much more efficient than other modes that we have a responsibility to encourage their expansion. Not only will this relieve the pressure on our petroleum resources, it will permit the substitution of electricity for liquid fuels and it will help to keep rising transportation costs in check. The negative effect on the automobile industry is a matter to contend with and the sooner we deal with it the better.

Another important place for conserving is in thermal and nuclear power generation where 50% of fuel input is wasted in cooling water that condenses steam. By combining thermal power generation with either district heating or food production, enormous fuel savings could be realized.

I could go on to include combined gas-turbine steam power generation, improved home heating and efficiently designed and insulated homes that could result in large fuel savings, possibly 25%. There are also, at our disposal, large sources of equilibrium energy, i.e. solar, wind and tidal.

Having mentioned tidal power it may be appropriate to point out that we have one of the best natural settings in the world for development. I refer, of course, to the Bay of Fundy where the Minas Basin has a maximum tidal amplitude of 53 ft and Chignecto Bay 46 ft. These sites have a potential of 16,000 Gwh per annum which is equivalent to the production of a conventional thermal or nuclear plant of 2200 MW capacity. By comparison, the tidal plants will be much larger because of the fluctuating flows and for this reason alone they do not appear to be a viable option for the 28 x 10^6 bbl of oil equivalent that they could save.

As I have tried to illustrate, our energy options seem to be changing and yet nothing has changed. The finite limits of our conventional oil and natural gas have not changed, we are only facing up to their realistic management; we have the world's largest single source of oil in the tar sands; we have a large source by hydro power; we have one of the best settings in the world for developing tidal power; we have the world's best fusion process in Candu, and we have a significant coal resource.

I am quite certain that many countries of the world would like to share our embarrassment of having so many energy and conservation options.

Fossil Fuel Reserves

	Canada[1/2/]		U.S.A.[3/4/]		World[4/]	
	Remaining Proven	Potential	Proven	Potential	Proven	Potential
Coal,Q [5/]	0.196	2.386	4.800	70.400	18.0	170.0
Petroleum,Q (conventional)	0.0543	0.464	0.260	1.260	3.6	13.0
Natural Gas,Q	0.0529	0.712	0.300	1.227	2.0	10.0
Tar Sands,Q	0.168	1.854	neg	neg	2.0	20.0
Oil Shale,Q	neg	neg	.298	9.700	15.7	
Total Fuel,Q	0.4712	5.416	5.658	82.587	41.3	213.0

1/Computed from Reference 1
2/Computed from Reference 2
3/Computed from Reference 3
4/Computed from Reference 4 and 5
5/Q = Btu x 10^{18}

	Population	Fossil Fuel Reserves Proven	Fossil Fuel Reserves Potential
USA	10	13	15
Canada	1	1	1

Fossil Fuel Sources and Consumption[1/2]

	Canada (1970)		U.S.A. (1970)		World (1972)	
	% Total Proven Fuel Resources	% Total Fuel Consumption	% Total Fuel Resources	% Total Fuel Consumption	% Total Fuel Resources	% Total Fuel Consumptio
Coal	41.6	16.6	84.8	21.5	43.6	38.8
Petroleum	11.5	55.6	4.6	44.1	8.7	40.8
Gas	11.2	25.6	5.3	34.4	4.8	20.4
Tar Sands and Oil Shale	35.7	2.2	5.3	neg	42.9	neg

1/ Does not include exports
2/ Computed from References 3,4,5 and 6.

Life of Canada's Potential Recoverable Fuel Reserves[1/]

	Coal	Oil		Natural Gas
		Conv	Conv + TS	
Potential Reserves, Q[3/]	2.386	0.464	1.854	0.712
1970 Cons, Btu x 10^9	780,818	2,719,040		1,202,250
1970 Prod, Btu x 10^9	366,314	3,128,116		2,767,781
Life of Potential Reserves[3/]				
at 1970 Cons, yrs	3,056	170	682	592
at 1970 Prod, yrs	6,514	148	593	257
at 1970 Cons increasing at 5%/annum, yrs	77	34	53	51
at 1970 Cons increasing at 3%/annum, yrs	113	46	76	72

1/ Calculated from References 1 and 6
2/ Q = Btu x 10^{18}
3/ To the nearest full year.

Conv = Conventional
TS = Tar Sands
Cons = Consumption
Prod = Production

Note: Hydro consumption in 1970 was 535,841 x 10^9 Btu equivalent.

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Life of Canada's Remaining Proven Fuel Reserves[1]

	Coal	Oil		Natural Gas
		Conv	Conv + TS	
Remaining Proven Reserves, Q[2]	0.196	0.0543	0.168	0.0529
1970 Cons, Btu x 10^9	780,818	2,719,040		1,202,250
1970 Prod, Btu x 10^9	366,314	3,128,116		2,767,781
Life of Proven Reserves[3] at 1970 Cons, yrs	251	20	62	44
at 1970 Prod, yrs	535	17	54	19
at 1970 Cons, increasing at 5%/annum, yrs	39	12	22	19
at 1970 Cons, increasing at 3%/annum, yrs	53	14	28	23

1/Calculated from References 1 and 6.
2/Q = Btu x 10^{18}
3/To the nearest full year.

Conv = Conventional
TS = Tar Sands
Cons = Consumption
Prod = Production

Note: Hydro consumption in 1970 was 535,841 x 10^9 Btu equivalent.

Extra slide

Residential Heating

Energy Consumption for Same 31 Day Period Dec 4-Jan 4/74-75

	House Volume	Energy Consumption Btu x 10^6	Unit Consumption Btu/ft^3 day	Heating Cost $¢/ft^3$	Total Heating Cost $
TDB	21600	29.6	44.3	.310 + 55%	66.88
FDF	21600	19.2	28.7	.200 - Base	43.28
GKL	14400	22.3	50.0	.349 + 74.5%	50.31
ERM	14040	17.1	39.2	.274 + 37%	38.44
BCP	18000	23.8	42.7	.298 + 49%	53.68
B Gow	19200 electrically heated	12.7	21.3	.242 + 21%	46.50

Unit Consumption (TDB–BCP): Ave 41.0; Heating Cost (TDB–BCP): Ave .286

Oil @ 37.5 ¢/gal

Electric Heating 1.25 ¢/kwh

Slide 5

TABLE 4 ONTARIO HYDRO COMPARISON

	Pickering (nuclear)	Lambton (coal)
PARAMETERS		
Capacity	4 X 514 MW	4 X 495 MW
Life	30 years	30 years
Interest rate	8%	8%
Capital cost	$746M	$264M
Station capacity factor	80%	80%
UNIT ENERGY COST	m kWhr	m kWhr
Capital	4.6	1.69
Operation and maintenance	.54	.53
Heavy water upkeep	.20	---
Fuel	.88	4.82
TOTAL	6.22	7.04

Slide 6

FUEL UPGRADING BY HYDROGEN

FUEL	Specific Gravity	Sulfur % wt	Hydrogen % wt	
COAL		1.5	5-6	
BITUMEN TAR		4.5	9-10	
				H_2 to Produce Fuel Scf/bbl equiv
Methane	–	>0.1	25	14,000 - 17,000
Gasoline	0.73	>0.1	15.7	5,000 - 7,000
Fuel Oil No. 1	0.82	0.1-0.2	13.7	2,400 - 2,800
" " No. 2	0.85	0.2-0.3	13.2	2,200 - 2,600
" " No. 3	0.87	0.3-0.4	12.9	1,800 - 2,200
" " No. 4	0.90	0.6	12.5	1,400 - 1,800
" " No. 5	0.94	0.9	11.9	800 - 1,100
" " No. 6	0.98	>1	11.3	>800

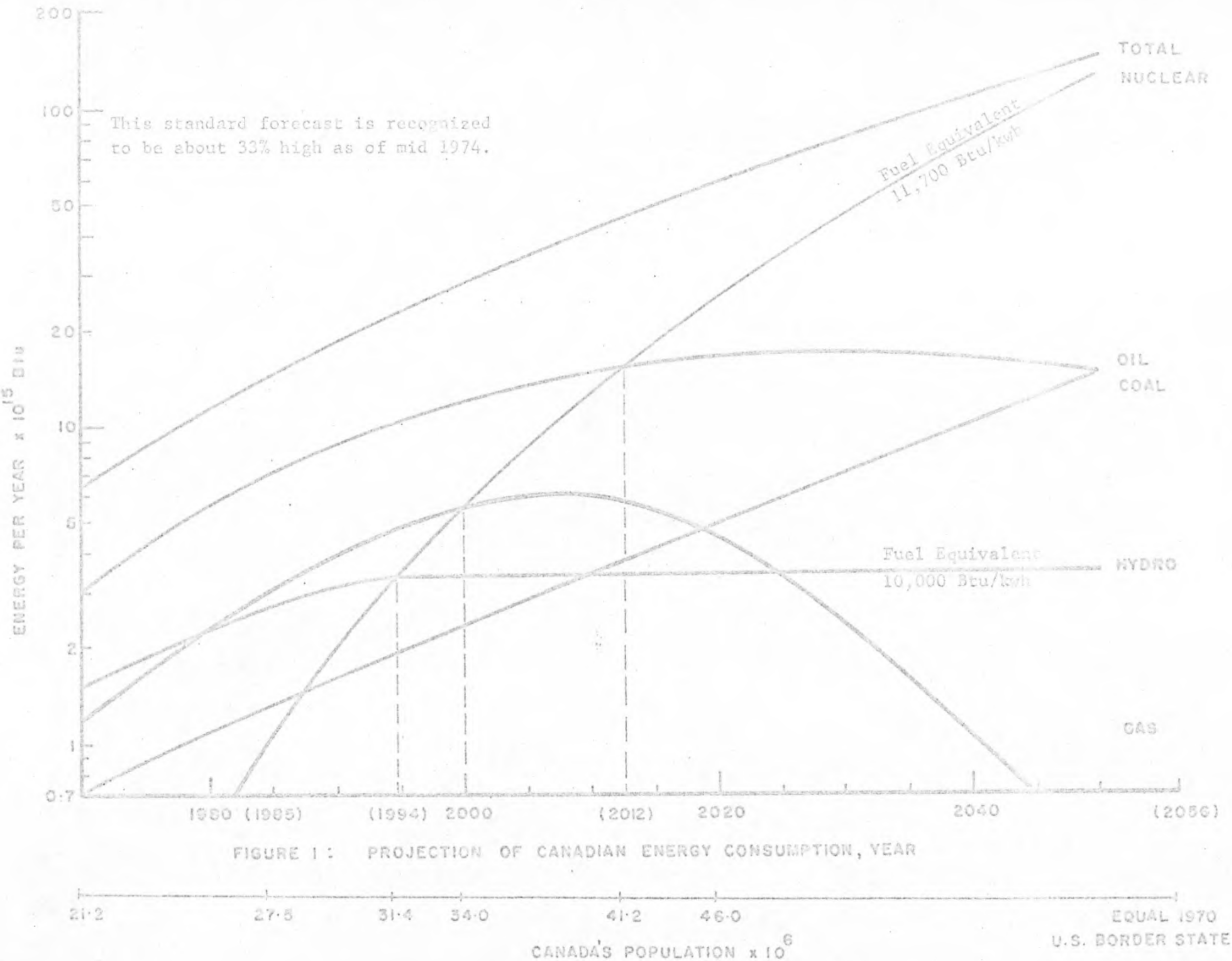

FIGURE 1: PROJECTION OF CANADIAN ENERGY CONSUMPTION, YEAR

Revised Life of Remaining

Coal Reserves at Accelerated

Production Rate After 1994

	Proven Reserves	Potential Reserves
Remaining Reserve, Q1/	0.194	2.382
(1) Assume 1994 Cons, Btu x 10^9	1,200,000	1,200,000
(2) Assume 1994 Cons, Btu x 10^9	3,000,000	3,000,000
Life of Reserves, yrs2/		
Assumption (1)	163	1985
Assumption (2)	65	794
Assumption (1) increasing 5%/annum	6	70
Assumption (2) increasing 3%/annum	7	79

1/Q Btu x 10^{18}
2/To the nearest full year.

ENERGY EFFICIENCY IN TRANSPORTATION

Inter-City Passenger Traffic

Mode	Btu/Passenger Mile
Bus	1,090
Train	1,700
Car	4,250
Aircraft	9,700

Urban Passenger Traffic

Bus	1,240
Electric SC	1,250 est
California Electric Car	600
Car	5,060

Inter-City Freight Traffic

	Btu/Ton Mile
Pipeline	450
Waterway	540
Train	680
Truck	2,340
Aircraft	37,000

FUEL AND ELECTRICITY CONSUMPTION 1970

	10^{15} Btu	% Total
Coal	0.6	13
Petroleum	2.6	56
Natural Gas	1.0	22
Hydro + Nuclear	0.4	9