# Natural Gas in Relation to the Industrial Development of Alberta

*Submission Prepared for the Joint Hearing of the Petroleum and Natural Gas Conservation Board of the Province of Alberta*

—*by*—


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## Summary


1. Alberta's potential industrial development is probably greater than that of any other Canadian province because of its reserves of energy in the form of coal, oil, natural gas, bituminous sand, and hydropower: its deposits of limestone, shale, clay, sand, salt, etc., and because it is a rich agricultural province well able to support a growing population.

2. Canada's population is now increasing at the rate of about 1 1/2 percent per annum. Thus a population of 25 million people for Canada by the year 2000 should not be too much to expect. The rate of growth in Alberta with its extraordinary industrial potential should be greater than that of the country as a whole. Altogether it would seem unwise to allow for the requirements of less than double the present population in Alberta fifty years from now.

3. Generally speaking, natural gas is cheaper than either coal or oil for the production of heat and power. The prices of both coal and oil have increased in recent years largely because of the rising costs of labour. In addition to the lower cost of gas, its use is favored by convenience, cleanliness and efficiency of utilization.

4. The need for conservation from wastage of liquid petroleum gas (L P G) separated from wet gas in preparing dry gas for export, is emphasized. Propane and butane are the most valuable fractions of wet natural gas for the production of organic chemicals. They can be used also as a fuel for heat and power, and in internal combustion engines. The present market for them in Alberta is limited but the liquefied petroleum gas industry in the United States is developing very rapidly.

5. Developments in the petrochemical industry have been so rapid in recent years that it would be well nigh impossible to predict what new developments may become economically feasible in Alberta in the next ten years, let alone the next fifty. Sustained research, resulting in technological improvements, will continue to turn laboratory curiosities into everyday products and will continue to transform uneconomical and marginal processes into profitable ones. The two most promising processes for Alberta at present appear to be decomposition of dry natural gas to form carbon black, and partial oxidation of the butane fraction to form oxygenated organic chemicals.

Dry natural gas, the main raw material for carbon black, is also an ideal source of cheap acetylene, cheap synthesis gas and possibly cheap ethylene. These gases themselves are raw materials for other synthetic chemicals.

6. Agents for converting natural gas to power include gas engines, gas turbines, and steam turbines either with or without waste heat recovery. Best efficiencies are generally secured by gas engines up to 1500 KW and steam turbines 1500 - 15,000 KW. Gas turbines at present will be competitive with steam turbines at about 15,000 KW but for larger sizes the steam turbine only is available at present. Steam turbines require large quantities of cooling water whereas the gas turbine will require only about one third the water required for the steam set of the same output.

The generating capacity of power plants in Alberta utilizing natural gas as fuel, was approximately 13,000 KW in 1949, but it will be increased to nearly 70,000 early in 1951. The increase is largely due to conversions at the Edmonton and Lethbridge power plants and of a number of government plants.

If 50% of the total 1949 consumption of electrical energy in Alberta, amounting to over 868 million KW Hr., had been generated from natural gas, assuming 20 cu.ft. gas to one KW Hr., then the amount of gas consumed would have been of the order of 9 billion cu.ft. Growth of gas consumption to this level for power generation in Alberta is quite possible and should be provided for.

7. Because natural gas will be used both as a fuel and as a raw material, it seems safe to assume a rate of increase of natural gas consumption higher than either the rate of population or industrial growth in Alberta. Its use of a chemical raw material could represent immense quantities. For example, the Alberta Nitrogen Co. Ammonia Plant uses approximately one quarter as much natural gas as the City of Calgary.

It is suggested that the industrial activity of the province will be at least doubled and possibly tripled in the next 50 years. Likewise the consumption of gas will increase to two or three fold, possibly fourfold, of the present consumption because of its multifold uses, cheapness, and convenience.

# NATURAL GAS IN RELATION TO THE INDUSTRIAL DEVELOPMENT OF ALBERTA

## I INTRODUCTION

It is generally agreed, that in our present civilization, industrial development will be greatest in those areas in which energy can be most economically produced and efficiently used, where raw materials are abundant, where labour is in adequate supply and markets for the products of industry are available. Alberta, a rich agricultural province, has potential reserves of energy in the form of coal, oil, natural gas, bituminous sand and hydropower. In addition, large areas of forest occur in the western and northern parts of the province and deposits of limestone, shale, clay, sand, salt, etc. occur in other sections of the province. But being a young province with a limited population, Alberta is as yet not industrialized to any great extent. The combination of agriculture and industry, however, points to a bright future. Every effort should be made therefore to develop the natural resources efficiently, to avoid waste, and so far as possible to see that the immediate program ensures a sound basis on which to build an orderly and systematic development in the future. In this way, the economic welfare of the people of the province can be better provided for, and the province thereby contribute to the welfare of Canada as a whole.

Therefore, in making a summary appraisal of the future role of natural gas in the industrial development of Alberta, it is suggested, that as the population and income of the province continues to increase, an abundance of cheap natural gas will facilitate the introduction and/or expansion of many different industries whose growth is economically feasible. This is because natural gas is not only a prime source of heat and power but also an important raw material for chemical industries.

In supporting this thesis it is hardly necessary to state that economists have highlighted the relationship of cheap energy to industrial development, pointing out on the basis of assembled data, that in the last century the ratio of total energy output to national income in the United States, measured in comparable dollars, has remained relatively constant. As income rose so rose energy consumption. Thus as new technological advances were made and new sources of income developed, the energy industries have been called upon to furnish the necessary increase in prime moving force to power our economy. In like manner natural gas, because of the versatility of hydrocarbon conversion processes and of the wide variety of chemicals which can be made from its constituents, is of growing importance to any region so fortunate as to have reserves of this valuable resource. According to G. H. Smith[1], Assistant Managing Director, American Gas Association, Natural Gas in 1949 supplied 19.4% of all energy used in the United States. This figure is almost double the percentage of natural gas used in 1937 and is a 6.1 overall increase over 1947. Keith W. Johnson[2], Industrial Economist, Federal Reserve Bank of Dallas, Texas in commenting

1 - Smith, George H. Transportation, Storage and Peak Load Supply of Natural Gas - Fourth World Power Conference, London, 1950

2 - Johnson, K.W. The Natural Gas Industry of the Southwest and Its Significance to Industrial Development, Monthly Business Review, March 1, 1949.

on the natural gas industry of southwestern United States and its significance to industrial development stated:

> "Natural gas has contributed significantly to the industrial development of the southwest and should play an important part in the further growth and diversification of industry within the region." - - - "The conservation of this resource, its utilization within the area and elsewhere, and the extent of its potential contribution to the industry of the area are of important concern to the economy of the Southwest".

Accurate estimates of population growths are difficult to ascertain. However an examination of recent trends in population growths have shown that the decennial rate of increase, 1940-50, in the United States was about 15 per cent, not much less than it had been in 1910-30 and more than double the rate in 1930-40. In consideration of this and other evidence, Davis[3] estimates an increase from the present population of about 150 millions to at least 200 millions by the century's end. The population of Canada is also growing at the rate of about 1 1/2 per cent per annum, and since our saturation point must be more distant than that of the United Stats, it seems not impossible that this rate may be maintained during most of the remainder of this century. Even assuming some tapering off, a population of 25 millions by the year 2000 should not be too much to expect. The rate of growth in Alberta, with its extraordinary industrial potential, should be greater than that of the country as a whole. Altogether it would seem unwise to allow for the requirements of less than double the present population in Alberta.

3 - Davis, J. S. Fifty Million More Americans. Foreign Affairs, 28: 412-426 April, 1950.

## II NATURAL GAS, CONSTITUENTS, PROPERTIES AND INTERFUEL RELATIONSHIPS

Natural Gas is considered in this submission as:

A mixture of gaseous hydrocarbons consisting predominantly of those containing not more than four carbon atoms. It occurs in natural reservoirs separately as gas or may be found with or in solution in non-gaseous hydrocarbons. The composition of natural gas may differ from field to field and also with production methods. Methane is the hydrocarbon usually present in greatest volume, with ethane, propane and heavier hydrocarbons successively next in order. The composition of a "wet" gas typical of much of that produced lies within the following limits in volume percent: methane 80-90 percent; ethane 5-10 percent; propane 3-5 percent; isobutane and butane 1-2 percent; pentanes and heavier hydrocarbons 1-2 percent. Nonhydrocarbon components including nitrogen, hydrogen sulphide, traces of organic sulphur compounds, carbon dioxide and helium may occur in natural gas. Certain of these may be extracted from natural gas either as impurities or for individual utilization.

The Analyses of the Natural Gases occurring in various gas fields in the province, are given in the report "Natural Gas Reserves of Prairie Provinces", G. S. Hume and A. Ignatieff, Ottawa, 1950. A number of the physical properties of the major constituents of natural gas which may be of assistance in evaluating the importance of natural gas to industrial development are given in Table I.

## TABLE I

### Physical Properties of Some Hydrocarbons

| Hydrocarbon | Formula | Boiling Point (at 1 atm) | Liquid Density in Vacuo at 60°F | Vapor Pressure at 0°F | Vapor Pressure at 70°F | Vapor Pressure at 90°F | Vapor Pressure at 100°F | Vapor Pressure at 105°F | Vapor Pressure at 130°F | Total Heating Value at 60°F and 14.4 psia | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | °F | lb/gal. | psia | psia | psia | psia | psia | psia | Btu/lb. | Btu/cu.ft. |
| Methane | $CH_4$ | -258.68 | --- | --- | --- | --- | --- | --- | --- | 23861 | 989 |
| Ethane | $C_2H_6$ | -127.53 | 3.145 | 219.3 | 559.6 | 707.7 | --- | --- | --- | 22304 | 1747 |
| Propane | $C_3H_8$ | - 43.73 | 4.233 | 38.4 | 124.8 | 165.1 | 188.6 | 201.1 | 273.2 | 21646 | 2506 |
| N. Butane | $C_4H_{10}$ | 31.10 | 4.872 | 7.2 | 31.2 | 43.9 | 51.6 | 55.8 | 80.8 | 21293 | 3305 |

Data adapted from Natural Gas & Natural Gasoline, R.L. Huntington

First Edition, McGraw Hill Book Co. Inc., 1950

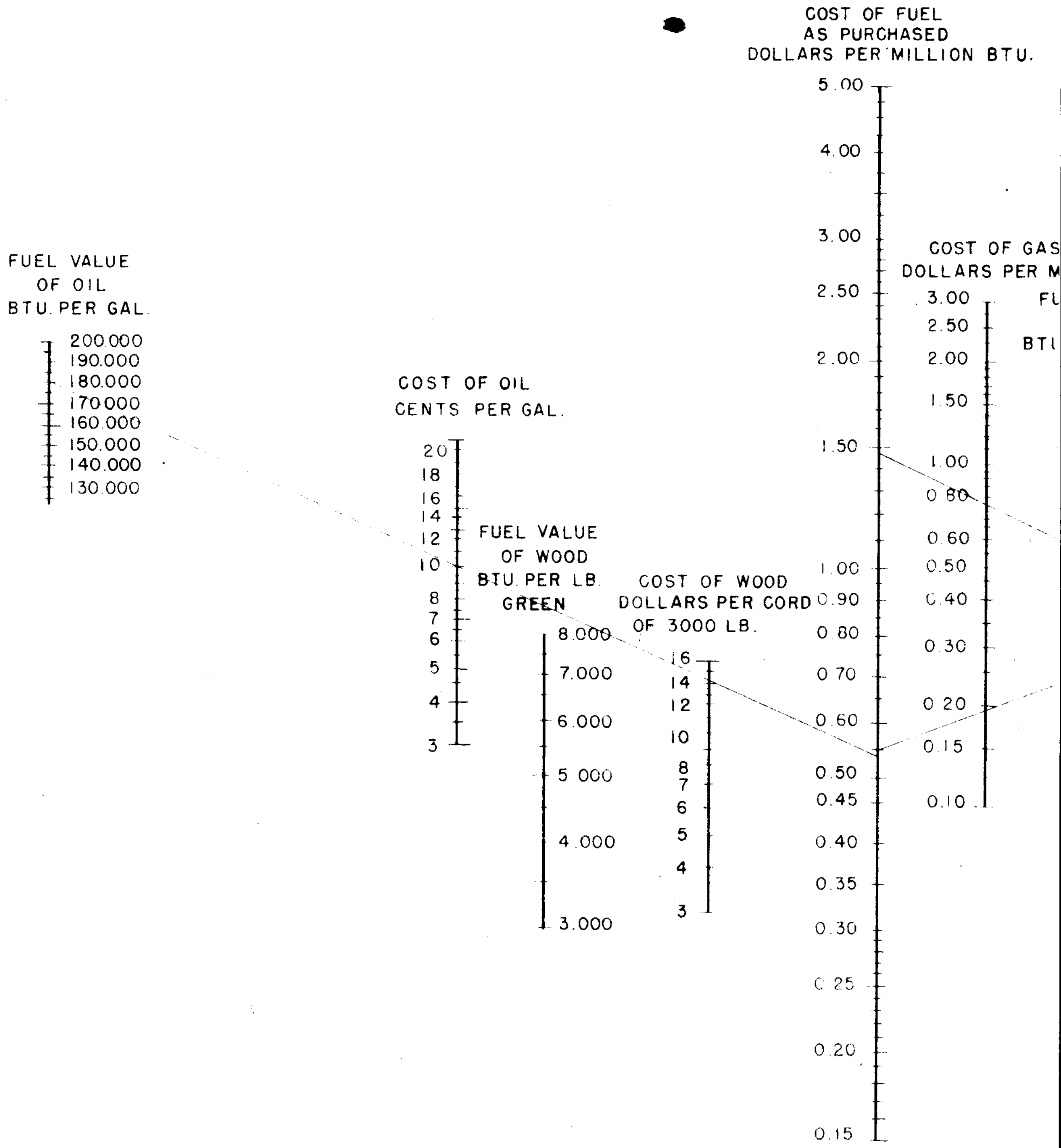
Interfuel competition is a factor requiring consideration in any assessment of natural gas for use in the production of heat and power for industry. The ultimate selection of the fuel should depend on: the suitability of the fuel for the purpose for which it is to be used: its availability and reliability of supply: its convenience and cleanliness, and its cost. Cost factors include the unit cost of the fuel, its calorific value, the efficiency of utilization, the capital and maintenance costs of the combustion equipment, and the cost of labour and equipment for handling the fuel and refuse.

The relative prices of the fundamental fuels - natural gas, coal, and fuel oil - are better seen when reduced to a common denominator and reported in cents per million B.t.u. These values can be calculated directly using the unit heat value of the fuels and the cost per unit of each fuel, and/or by the use of nomograms such as shown in Figures 1 and 2. The relative efficiencies with which each fuel can be utilized are necessary in determining ultimate cost of the fuel. It is a truism that a fuel can be no better in the results of its use than the equipment in which it is burned and technical efficiencies of equipment and appliances vary greatly.

In order that comparisons between the heat values of natural gases and those of coal and oil can be readily made, typical calorific analyses for the various ranks of coal mined in Alberta and for different grades of oil are given in Tables II and III respectively. The calorific values of the constituents of natural gas were included in Table I and are shown in Hume's[4] report for the raw gas from various gas fields in Alberta. No estimate is given of the relative efficiencies with which the different fuels can be utilized, but in general it can be said that the efficiencies with gas and oil are higher than those with coal.

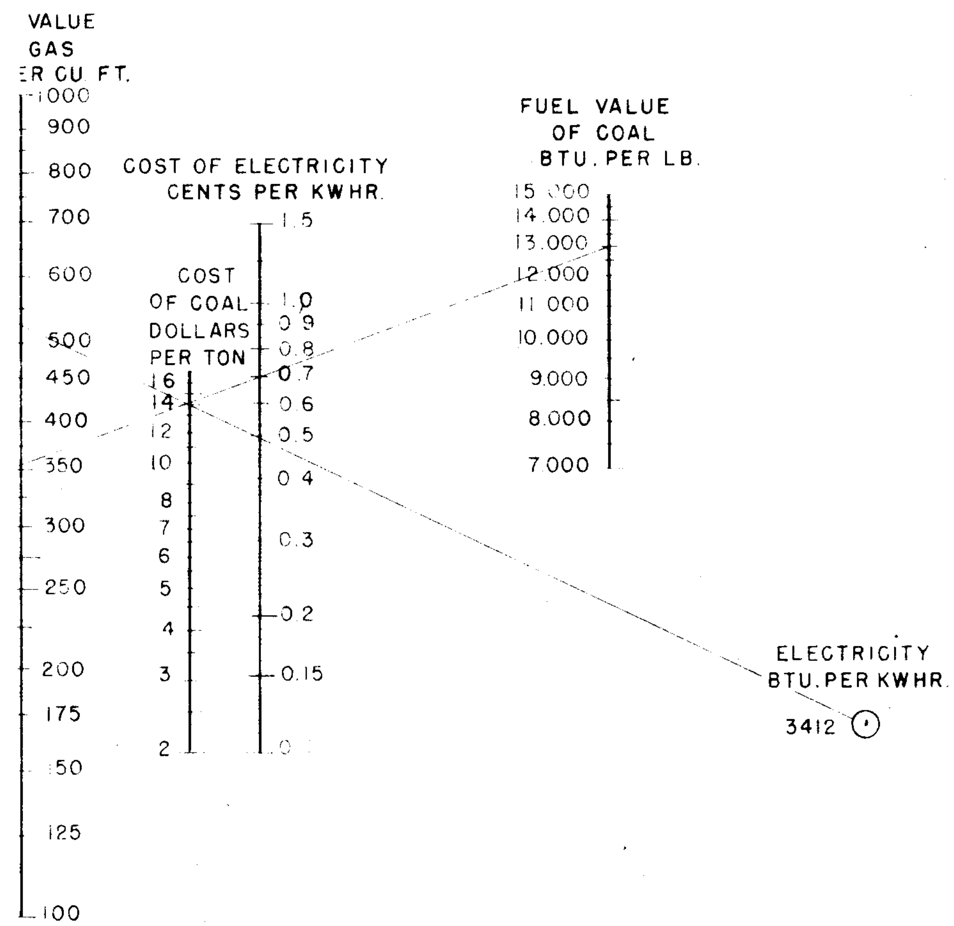
4 - Hume, G.S. & Ignatieff, A. Natural Gas Reserves of Prairie Provinces, Bureau of Mines and Technical Surveys, Ottawa, 1950

# FIGURE I




NOMOGRAMS FOR CALCULATION OF COST OF HEAT

ADAPTED FROM "SURVEY ON WASHINGTON FUEL REQUIRMENT AND SUPPLIES" BATTELLE MEMORIAL




ERGY IN VARIOUS FUELS

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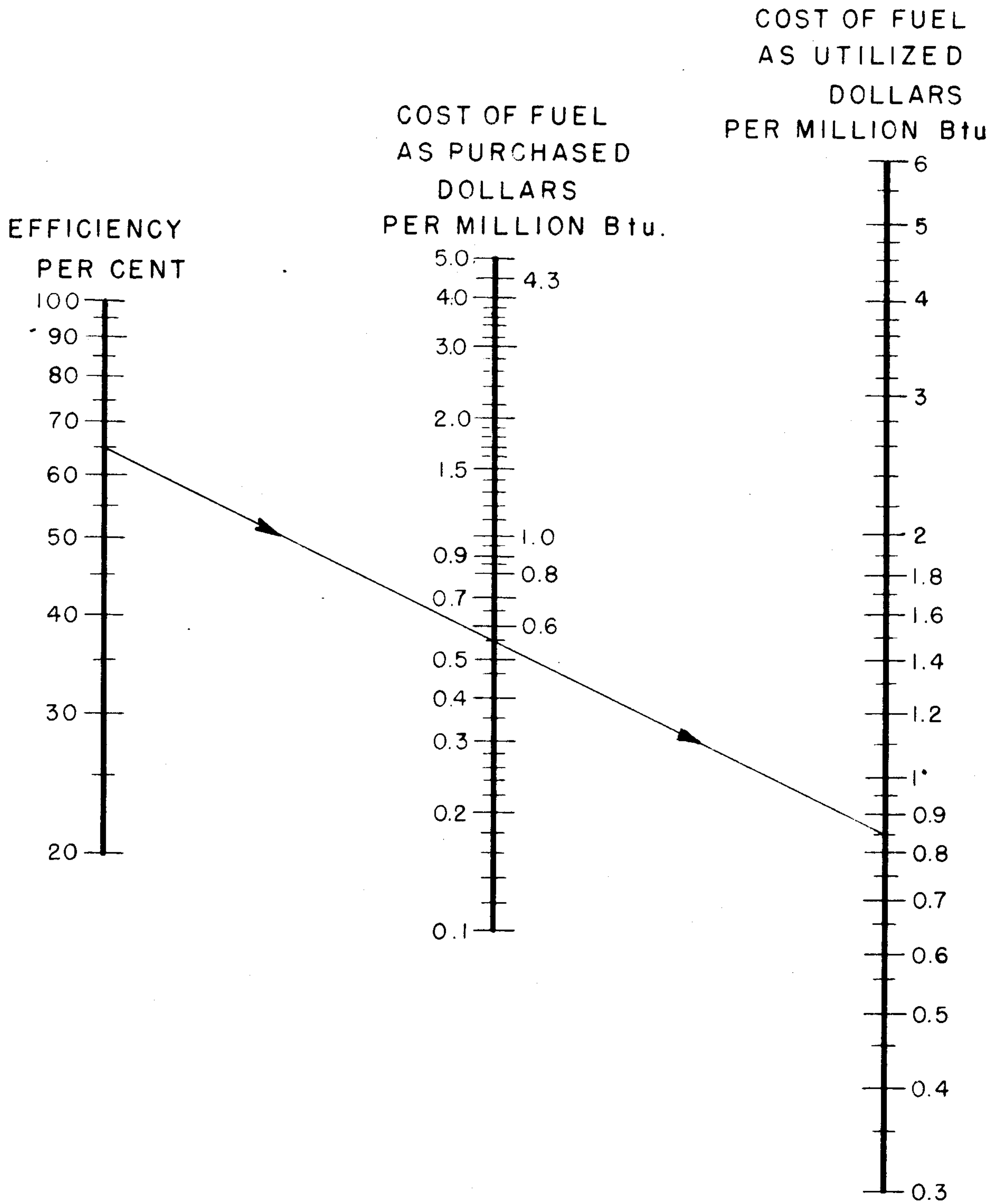



NOMOGRAM FOR CALCULATION OF COST OF HEAT UTILIZED FOR VARIOUS EFFICIENCIES

FIGURE 2

## TABLE II

### Alberta Coals Summarized for Ready Reference*

### (Five Groups--Characteristics and Analysis)

The classifications of coal are somewhat complicated and the layman is apt to become confused. The following grouping is offered as simple and easily remembered. The five groups here described are referred to in a number of the following sections of this report.

It may be noted that the first two groups are commonly classed as steam coals and the last three as domestic coals. However, the smaller sizes of domestic coals are widely used for steam raising in Alberta and Saskatchewan.

The coals in each group show notable variations in analysis. The typical analysis given has been selected as representative of large production. Mines with coal cleaning plants may ship a cleaner coal. Detailed analyses of all the coals are given in the analysis section of this report.

### Group I

Low volatile, non-coking, bituminous coals from mountain areas.

Canadian Classification: Low volatile and medium volatile bituminous, and some semianthracite.

Important areas: Cascade, Nordegg, Mountain Park (Luscar Mine). If the Highwood area is developed it will be included in this group.

Characteristics: A good storage, weather resistant, coal. Burns with a short, slightly smoky flame. Used for railways and steam raising in general. This coal, when briquetted, is also used for domestic heating.

Output: Total for group, 645,981 tons in 1949. Two coal cleaning and two briquetting plants are operated.

Typical Analysis: Moisture%, 1 1/2; Ash %, 8 1/2; Volatile matter %, 15; Fixed carbon %, 75; Heat value, B.t.u./lb., 14,000.

Group II

High volatile, coking, bituminous coals from mountain areas.

Canadian classification: High volatile A and B bituminous coal.

Important Areas: Crowsnest, Mountain Park (Cadomin and Mountain Park mines).

Characteristics: A good storage, weather resistant coal. Burns with a medium to long, smoky flame. Used for railways and steam raising in general. Also used for making coke, as smithy coal, and in cement industry.

Output: Total for group, 3,594,329 tons in 1949. One briquetting, one coking and four coal cleaning plants are operated.

Typical Analysis: Moisture %, 1 1/2; Ash %, 12 1/2; Volatile matter %, 25; Fixed carbon %, 61; Heat value, B.t.u./lb., 13,200.

Group III

Subbituminous coals, principally from foothills areas.

Canadian classification: High volatile C bituminous.

Important areas: Coalspur, Lethbridge, Prairie Creek, Saunders.

Characteristics: A good storage, weather resistant coal. It is a free-burning, non-coking coal that burns with a long, slightly smoky flame. Used for domestic and steam raising purposes. It is a strong coal and can be shipped and stored reasonably well.

Output: Total for group, 1,255,017 tons in 1949. Two coal cleaning plants are operated.

Typical Analysis: Moisture %, 10; Ash %, 10; Volatile matter %, 34; Fixed carbon %, 46; Heat value, B.t.u./lb., 10,900.

Group IV

Domestic coals--fair storage. From prairie areas.

Canadian classification: Subbituminous A, B and C.

Important areas: Carbon, Drumheller, Edmonton, Pembina, Taber.

Characteristics: Can be stored, with care, under cover. It is a free-burning, non-coking coal, that ignites easily and burns with a long, smokeless flame. Used for domestic heating and also for steam raising. It can be shipped in box cars.

Output: Total for group, 2,645,591 tons in 1949.

Typical Analysis: Moisture %, 19; Ash %, 7; Volatile matter %, 30; Fixed carbon %, 44; Heat value, B.t.u./lb., 9,700.

Group V

Domestic coals--poor storage. From prairie areas.

Canadian classification: Subbituminous B and C.

Important areas: Camrose, Castor, Sheerness, Tofield.

Characteristics: Will not store well. It is a free-burning, nc coking coal, that ignites easily and burns with a long, smokeless flame. Used for domestic heating and also for steam raising. It can be shipped in box cars.

Output: Total for group, 476,065 tons in 1949.

Typical Analysis: Moisture %, 27; Ash %, 7; Volatile matter %, 28; Fixed carbon %, 38; Heat value, B.t.u./lb. 8,300.

* Data taken from Research Council of Alberta Report No. 35 with output revised to 1949.

TABLE III

Heat Values of Petroleum Products

| Petroleum Product | Gravity Petroleum Product Degrees A.P.I. | Heat Value in B.t.u. | | | |
|---|---|---|---|---|---|
| | | Per Pound | | Per Imperial Gallon at 60° F. | |
| | | gross | net | gross | net |
| Naptha | 80 | 20,630 | 19,180 | 138,100 | 128,400 |
| Gasoline | 70 | 20,460 | 19,050 | 143,800 | 133,800 |
| " | 60 | 20,260 | 18,900 | 149,800 | 139,680 |
| Crude Oil distillate, Kerosene etc. | 50 | 20,020 | 18,720 | 156,100 | 146,040 |
| Crude Oil distillate, Kerosene etc. | 40 | 19,750 | 18,510 | 163,000 | 152,760 |
| Crude Oil, Diesel Fuel etc. | 30 | 19,420 | 18,250 | 170,200 | 159,960 |
| Crude Oil | 20 | 19,020 | 17,930 | 177,700 | 167,520 |

* Data adapted from U.S. Bureau of Standards, Miscellaneous Publication 97, 1929.

Cost data, for the various fuels used in Alberta, are not given in this submission since recent values are not available, in the files of the Council, for all fuels. However adequate examples, for comparative purpose, of relative values of coal, oil, and natural gas when used for domestic, commercial and industrial purposes in Alberta were included in the Report of The Province of Alberta Natural Gas Commission.

An overall picture of the cost of mineral fuels at points of production in the United States between 1930 and 1948 is given in Table IV[5]. It will be seen that there has been substantial increases in the price of coal and fuel oil although natural gas prices have decreased or remained the same. In the very few instances where natural gas has increased in price, there has been a much greater increase in the price of coal and fuel oil. As a result, the relative advantages in the price of coal and oil for domestic and industrial use has been narrowed to the point that in many cases natural gas is now cheaper than either fuel oil or coal.

It has not been found feasible to prepare a similar table of the relative values of mineral fuels at points of production in Alberta, but judging from data available similar conditions apply in Alberta. The reason for the increasing cost of oil and coal stems largely from the increase in the cost of labour during recent years.

In commenting on the relative value of fuels in Texas, W. J. Murray, Jr.[6], Chairman, Texas Railway Commission stated:

5 - Bituminous Coal Annual, Facts and Figures 1949, Bituminous Coal Institute

6 - Murray Jr., W.J. - Natural Gas Problems in the Territory of Greatest Reserves. Proceedings Natural Gas Department of the American Gas Association

"Many producers argue that natural gas is grossly underpriced at the well head at the present time. They point out that this admittedly superior fuel on a B.t.u. or heat value basis is priced much lower than coal at the mine or oil at the well head and that after taking into account the relative transportation costs of these three fuels, the disparity still exists. At a well head price of five cents per M.C.F., which is above the average in Texas, an equivalent heat content price would be thirty cents per barrel for oil and $1.25 per ton for coal. Because of this disparity and an assumed rapid increase in demand, most economists predict steadily increasing prices for gas over a fairly considerable period in the future and nearly all long term contracts contain an esculator clause on price".

The consumption of coal in Alberta 1945-49, by groups is shown in Table V, and domestic consumption of gasoline and fuel oils from 1940-47 is given in Table VI. It should be noted that Table V does not include coal sold to the railroads, used under colliery boilers, and used in the making of coke or briquets. The heading "Domestic Consumption of Gasoline and Fuel Oils" is confusing in that it includes oils consumed for commercial and industrial purposes. The consumption of propane and of electric power are given in Tables VII and VIII respectively. Data on gas consumption have not been included since they are available to the Board.

## TABLE IV

### VALUE OF MINERAL FUELS AT POINT OF PRODUCTION

(Coal and Coke Per Ton, Natural Gas Per Thousand Cubic Feet, Petroleum Per Barrel)

| | Value Per Unit | | | | | Value Per Million Btu's (Cents) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Bituminous[a] | Anthracite[a] | Coke | Natural Gas (Cents) | Crude Petroleum | Bituminous | Anthracite | Coke | Natural Gas | Crude Petroleum |
| 1930 . . . . . . | 1.70 | 5.11 | 4.36 | 7.6 | 1.19 | 6.5 | 18.8 | 17.2 | 7.1 | 19.8 |
| 1931 . . . . . . | 1.54 | 4.97 | 4.83 | 7.0 | 0.65 | 5.9 | 18.3 | 19.0 | 6.5 | 10.8 |
| 1932 . . . . . . | 1.31 | 4.46 | 4.79 | 6.4 | 0.87 | 5.0 | 16.4 | 18.9 | 6.0 | 14.5 |
| 1933 . . . . . . | 1.34 | 4.17 | 4.46 | 6.3 | 0.67 | 5.1 | 15.3 | 17.6 | 5.9 | 11.2 |
| 1934 . . . . . . | 1.75 | 4.27 | 5.01 | 6.0 | 1.00 | 6.7 | 15.7 | 19.7 | 5.6 | 16.7 |
| 1935 . . . . . . | 1.77 | 4.03 | 5.03 | 5.8 | 0.97 | 6.8 | 14.8 | 19.8 | 5.4 | 16.2 |
| 1936 . . . . . . | 1.83 | 4.16 | 5.02 | 5.5 | 1.09 | 7.0 | 15.3 | 19.8 | 5.1 | 18.2 |
| 1937 . . . . . . | 1.94 | 3.81 | 4.98 | 5.1 | 1.18 | 7.4 | 14.0 | 19.6 | 4.7 | 19.7 |
| 1938 . . . . . . | 1.95 | 3.92 | 5.14 | 4.9 | 1.13 | 7.4 | 14.4 | 20.3 | 4.6 | 18.8 |
| 1939 . . . . . . | 1.84 | 3.64 | 4.80 | 4.9 | 1.02 | 7.0 | 13.4 | 18.9 | 4.6 | 17.0 |
| 1940 . . . . . . | 1.91 | 3.99 | 4.80 | 4.5 | 1.02 | 7.3 | 14.7 | 18.9 | 4.2 | 17.0 |
| 1941 . . . . . . | 2.19 | 4.26 | 5.41 | 4.9 | 1.14 | 8.4 | 15.7 | 21.3 | 4.6 | 19.0 |
| 1942 . . . . . . | 2.36 | 4.50 | 6.03 | 5.1 | 1.19 | 9.0 | 16.5 | 23.8 | 4.7 | 19.8 |
| 1943 . . . . . . | 2.69 | 5.06 | 6.54 | 5.2 | 1.20 | 10.3 | 18.6 | 26.2 | 4.8 | 20.0 |
| 1944 . . . . . . | 2.92 | 5.57 | 7.13 | 5.1 | 1.21 | 11.1 | 20.5 | 28.1 | 4.7 | 20.2 |
| 1945 . . . . . . | 3.06 | 5.90 | 7.56 | 4.9 | 1.22 | 11.7 | 21.7 | 29.8 | 4.6 | 20.3 |
| 1946 . . . . . . | 3.44 | 6.83 | 8.32 | 5.1 | 1.41 | 13.1 | 25.1 | 32.8 | 4.7 | 23.5 |
| 1947 . . . . . . | 4.16 | 7.25 | 10.57 | 5.8 | 1.91 | 15.9 | 26.7 | 41.6 | 5.4 | 31.8 |
| 1948 Preliminary | 4.95 | 8.07 | 11.47 | 6.4 | 2.59 | 18.9 | 29.7 | 45.2 | 6.0 | 43.2 |

a – Figures for bituminous prior to 1936 and for 1939, as well as all Anthracite figures, exclude selling costs.

Source: U.S. Bureau of Mines

TABLE V*

Consumption of Coal in Alberta. 1945 - 1949
(Short tons)

| Year | Gr.I** | Gr.II | Gr.III | Gr.IV | Gr.V | Total |
|---|---|---|---|---|---|---|
| 1945 | 10,249 | 71,386 | 259,347 | 942,162 | 284,796 | 1,567,940 |
| 1946 | 14,622 | 72,980 | 271,402 | 994,350 | 254,942 | 1,608,296 |
| 1947 | 13,261 | 134,471 | 270,954 | 1,014,244 | 238,200 | 1,671,130 |
| 1948 | 29,490 | 85,937 | 249,839 | 937,463 | 290,639 | 1,593,367 |
| 1949 | 24,296 | 80,841 | 250,871 | 1,015,018 | 243,280 | 1,614,306 |

* Data taken from Annual Reports, The Mines Division, Department of Mines and Minerals of Alberta.

** Gr. = Group.

TABLE VII

Production of Propane in Alberta

| Year | Gallons | Value |
|---|---|---|
| 1948 | 297,001 | $ 24,400 |
| 1949 | 1,895,544 | 162,196 |
| 1950 (First 7 Months) | 1,835,760 | 162,942 |

## TABLE VI

Domestic Consumption of Gasoline and Fuel Oils, Alberta

| Year | Aviation Gasoline gallons | Other Gasoline gallons | Total Gasoline gallons | Tractor Distillate gallons | Kerosene gallons | Light Fuel Oils, Etc. gallons | Heavy Fuel Oils gallons | Total gallons |
|---|---|---|---|---|---|---|---|---|
| 1940 | 1,022,035 | 91,144,935 | 92,166,970 | 5,574,520 | 2,262,330 | 3,159,450 | 20,367,690 | 123,530,960 |
| 1941 | 7,931,875 | 93,236,850 | 101,168,725 | 9,840,180 | 2,370,690 | 4,711,490 | 23,788,940 | 141,880,025 |
| 1942 | 18,949,350 | 89,629,015 | 108,578,365 | 10,936,730 | 2,228,415 | 5,956,685 | 28,569,240 | 156,269,435 |
| 1943 | 27,607,615 | 95,167,065 | 122,774,680 | 10,127,180 | 2,415,665 | 6,914,390 | 37,871,820 | 180,103,735 |
| 1944 | 22,026,340 | 98,785,540 | 120,811,880 | 10,205,020 | 2,370,480 | 4,894,260 | 52,746,015 | 191,027,655 |
| 1945 | 7,006,265 | 106,300,425 | 113,306,690 | 9,688,455 | 2,447,585 | 5,908,735 | 45,944,290 | 177,295,755 |
| 1946 | 3,944,325 | 125,428,030 | 129,372,355 | 11,590,110 | 2,859,710 | 10,314,500 | 52,702,020 | 206,838,695 |
| 1947 | 4,504,395 | 137,925,515 | 142,429,910 | 13,139,945 | 2,927,225 | 18,409,685 | 59,364,375 | 236,271,140 |
| Total (8 years) | 92,992,200 | 837,617,375 | 930,609,575 | 81,102,140 | 19,882,100 | 60,269,195 | 321,354,390 | 1,413,217,400 |
| Per Cent of total | 6.58 | 59.27 | 65.85 | 5.74 | 1.41 | 4.26 | 22.74 | 100% |

* Data taken from Alberta Facts & Figures, Bureau of Statistics, Department of Industries & Labour

TABLE VIII*

Generating Capacity and Power Consumption

in Alberta 1947 - 1949

| Source | Generating Capacity K.W. | Consumption K.W. Hr. 1947 | 1948 | 1949 |
|---|---|---|---|---|
| Hydro | 80,610 | 382,645,589 | 432,203,810 | 364,530,515 |
| Coal | 117,026 | 256,449,487 | 288,761,086 | 463,830,397 |
| Gas | 12,200 | 28,902,000 | 33,696,763 | 31,208,133 |
| Diesel | 4,240 | 4,883,916 | 6,453,877 | 7,939,179 |
| Not Identified | 3,730 | 1,000,000 | 1,000,000 | 1,000,000 |
| Total | 217,806 | 673,879,992 | 762,115,536 | 868,508,224 |

* Data adapted from Annual Report of Alberta Power Commission for 1949.

## III Natural Gas as a Source of Power for Industry

When considering natural gas it is impossible to overlook its use as a fuel for power purposes in that, once the capital expenditure for gas mains is made to take gas to or by any location, it can be effeciently converted into electrical power by either large or small power producing units. Thus, when supplies of natural gas are made available to any community, it can be stated that a source of power has been taken there.

When considering the production of power from fuel not only must the relative cost of fuel be looked at but also the availability of large quantities of water for boilers and for cooling purposes and, hence, in the following both of these factors are commented upon.

### A Methods for the conversion of natural gas to power

1. Gas Engines:

For small power, gas driven alternators form the most efficient method of converting gas energy to power. The fuel cost per K W Hr. will vary according to the size of engine and its load, being approximately as follows:-

TABLE IX

Cost of Generation of Power in Small Gas Engines

| Fuel Cost | Cents per KW Hr. | |
|---|---|---|
| | Large Engines | Small Engines |
| 5 c/1000 cu. ft. | 0.071 | 0.102 |
| 10 c/1000 cu. ft. | 0.142 | 0.204 |
| 15 c/1000 cu. ft. | 0.215 | 0.306 |

Gas engines can be obtained in sizes from about 1 KW to 1500 KW giving very efficient power conversion for all sizes but especially above 10 KW. This facility means that small communities can have their power sources extended as they themselves extend and in an economic manner - i.e., without high initial capital expenditure which is uneconomic until the load builds up. Where electricity is not generated in sufficient quantities to supply local power needs, gas engines can be used for local industries as power drives. Water, however, is required for cooling the cylinder jackets and, hence while small sizes require very simple cooling systems and small quantities of water, the larger sizes must have ample cooling water supplies.

2. Gas turbines:

Where the aggregate power requirements are large enough, power generation could be generated by gas turbine driven alternators. These can now be supplied in the smaller sizes varying from 2000 to 15,000 KW units and they present a very convenient power source.

Gas turbines for power demands of 2000 KW to 5000 KW maximum are available and require no cooling water other than a small quantity for the lubricating oil system. Hence they could be installed anywhere in the province irrespective of there being relatively large quantites of water available such as required for steam plants or large gas engines.

From the efficiency data available, the fuel cost per KW Hr. should be quite low as can be seen from the table below which shows the probable range of costs using gases of known quality and with various fuel costs.

TABLE X

Cost of Generation of Power in Gas Turbines

| Fuel Cost | 3000 KW Set | | 5000 KW Set | |
|---|---|---|---|---|
| | Cents per KW Hr. | | | |
| | At Full Load | At 20% Full Load | At Full Load | At 20% Full Load |
| at 5 c/1000 cu.ft. | 0.094-0.106 | 0.18-0.205 | 0.083-0.096 | 0.154-0.182 |
| at 10 c/1000 cu.ft. | 0.184-0.212 | 0.36-0.410 | 0.163-0.192 | 0.306-0.364 |
| at 15 c/1000 cu.ft. | 0.282-0.318 | 0.54-0.615 | 0.249-0.288 | 0.462-0.546 |

For power demands requiring up to 15,000 KW sets, a more complicated heat cycle can be used giving much higher efficiencies but about 250,000 gallons of water per hour would be required as against about 720,000 gallons of water per hour for an equivalent steam set. The fuel costs per KW Hr. would be about 69% of those given for the 3,000 KW set.

3. Steam turbine and boilers:

Natural gas provides probably the most convenient fuel for steam boilers and it is being so used in power stations, public institutions, packing plants and factories in the Province. Where large quantities of cooling water are available the steam turbine with its boilers is more efficient than a gas turbine up to the 15,000 KW size but below 1,500 KW gas engine driven alternators should be preferable from an efficiency point of view. Steam units up to 60,000 KW output are available with optimum efficiency. The convenience of control where gas is used is exceptional and trouble free plants are readily built. The freedom from soot and from ash disposal problems gives also a great advantage. The elimination of coal storage and coal and ash handling facilities represents in this province a real capital saving. It is in this field only that coal becomes a competitor to natural gas.

With bulk supply gas at 5, 10 and 15 cents/1000 cu. ft., for 990 Btu/cu. ft. (net) gas, coal prices per ton (2000 lb.) delivered would require to be.

| | | | |
|---|---|---|---|
| $1.60 | $3.19 | $4.79 | respectively for 13,000 Btu/lb. (net) |
| 1.21 | 2.42 | 3.63 | respectively for 10,000 Btu/lb. (net) |
| 1.00 | 1.99 | 2.99 | respectively for 8,200 Btu/lb. (net) |

in order to be competitive.

Even at these coal prices the advantages would still be with the gas fuel because of lower labour cost in boiler houses, while the cost of sidings and ash disposal plants would be eliminated.

4. Gas engines with waste heat recovery:

When large gas engines are installed, waste heat is available in the exhaust gases and, by appropriate capital expenditure, use can be made of this for local heating.

5. Gas turbines with waste heat recovery:

Gas turbines present an ideal proposition for developing waste heat utilization in that exhaust gases are available at 375° to 475°F. in a steady flow which can be used for hot water heating or low pressure steam heating. For example - the heat cycle efficiency of a 3000 KW Set can be lifted from 20% to 74.5% with a slight reheat giving 370 Therms per hour for heating - i.e. 37,000,000 B.t.u. per hour.

6. Steam turbine with waste heat recovery:

While the various steam turbine generating stations generally do not supply waste heat, many small electric generating stations exist in works, packing plants, and institutions where electricity is generated mainly as a by-product from the heating system. Throughout Canada heating is a primary need in order to enable living to be possible, hence, where local heating loads exist of adequate size, electricity can be generated by producing steam at 180/200 lbs. per sq. inch or more and expanding down to about 5 lbs. per sq. inch in either steam turbines or steam engines giving a very high overall efficiency. Actually only about 40 B.t.u. per lb. are available for generating electricity under such circumstances but, when it is remembered that the boilers are installed primarily for heating, the cost per unit generated is extremely low. The combination of power generation and waste heat recovery gives extremely efficient and economic heating schemes.

B Generating capacity and power consumption

The generating capacity, and power consumption between 1947 and 1949 have been givin in Table VIII. It will be noted that in 1949, the relative generating capacities were hydropower 37%, coal 54%, natural gas 6% and diesel 3%, and that power production from hydroplants was 42%, coal 53%, natural gas 4% and diesel 1%. The percentage of both generating capacity and power production from natural gas should be materially higher in 1950 since the City of Edmonton power plant converted their three boilers with a generating capacity of 45,000 KW from coal to natural gas. The City of Lethbridge with a generating capacity of 8,000 KW is presently converting to gas, and it is reported that five Provincial Government power plants with total capacities of about 1800 KW will be converted from coal to gas. The power production from these government plants was over four million KW Hr. in 1949. In addition the power plant at the University of Alberta with generating capacity of 800 KW and production of nearly two million KW Hr. uses natural gas. This plant has not been specifically designated in the Alberta Power Commission Report as using natural gas. This fuel will be installed in other power plants when pipelines are extended to other parts of the province.

## C Future requirements of natural gas for power

It would be impossible to predict the future power requirements for the province from the present curve of growth of power generation, and similarly it is not possible to estimate what portions of that requirement will be served by any particular fuel, since research development, availability of reserves of particular fuels, and the price structure of various fuels and of various products derived from or with these fuels will alter the prevailing situation from time to time. It is realized, when hydro-power projects now under development will be completed, that the consumption of hydropower will be larger than it is at present. Whether its proportion of the total consumption will be greater is still uncertain.

If 50% of the total 1949 consumption of 868,508,224 KW Hr. had been generated from natural gas, assuming that 20 cu. ft. of gas was required to generate 1 KW Hr. of electricity, then the amount of gas consumed would have been of the order of 9 billion cu. ft. This estimation alone serves to illustrate the importance of gas in the future development of the province since it is easily conceivable, at the present growth of power production and of conversions from coal to natural gas, that generation of at least 500 million KW Hr. per year from natural gas is a distinct possibility.

## IV Natural Gas as a Chemical Raw Material

The potentialities of natural gas as a high grade economical fuel have long been realized but it has only been in the last few decades that natural gas has begun to be used extensively as a basic raw material in the synthesis of organic compounds. While the total consumption of natural gas for chemicals is not great in comparison with that used for fuel, the quantities are still impressive, and the dollar values of the products even more so.

In trying to assess this phase of natural gas utilization and its future potentialities in Alberta one naturally turns to the experience of the United States. While different market and economic conditions make it dangerous to draw a complete analogy between Alberta and Texas, nevertheless the path of development and the trends in the United States are of particular interest. The bulk of natural gas used in the United States for chemical manufacturing thus far has been accounted for by the carbon black industry, five or six synthetic ammonia plants, and several synthetic methanol plants using dry natural gas both as feed stocks and as fuel. The heavier hydrocarbons (propane and butane) recovered from natural gas form a raw material source for several synthetic organic chemical plants and for some synthetic rubber plants. The utilization of natural gas for conversion to synthetic liquid fuels, as distinguished from synthetic chemicals, has not yet begun commercially, but when it does it will consume large quantities of natural gas.

It is therefore worthwhile to examine the present processes using natural gas, try to assess their significance within the framework of Alberta conditions, and speculate on future developments.

## A. Recovery of non-hydrocarbon constituents

Natural gas may contain, in varying amounts, four main impurities, namely, nitrogen, carbon dioxide, hydrogen sulfide and helium. Of these, nitrogen and carbon dioxide are detrimental in that they lower the heating value of the gas, and have little or no intrinsic worth by themselves. The other two, hydrogen sulfide and helium, may in certain cases be profitably extracted and sold.

### 1. Sulfur

Before natural gas can be sold to the domestic consumer, the hydrogen sulfide content must be removed. Many satisfactory methods have been devised for this purpose, all of them involving the absorption of $H_2S$ in a weakly alkaline solution, followed by regeneration of the absorbing solution, usually by heating. The absorbing solutions used include ethanolamines (Girbitol Process), tripotassium phosphate (Shell Development Co.), sodium phenolate or sodium carbonate (Koppers Co.), and sodium thioarsenate (Koppers Thylox). The hydrogen sulfide in solution can be oxidized to elemental sulfur and recovered as such, by treating with oxides of iron or nickel.

In many cases recovery of sulfur is unecomical and the $H_2S$ is merely driven off by heat and flared.

There are several "sour" gas fields in Alberta which are potential sources for sulfur (Jumping Pound, Pincher Creek, Turner

Valley). In the early 1930's when the gas from Turner Valley was being flared there was considerable interest in sulfur recovery. The main difficulty, then as now, was lack of a close market, and high transportation costs to potential users. The market situation has not improved appreciably in the intervening years.

Clark [7] has recently surveyed the economic factors and gives the following information. Sulfur from the Gulf States of the U.S. costs about $35. a ton at Canadian seaports. On the basis of a freight rate of 1.5 cents per ton mile, it would appear that the market for Alberta sulfur would be confined to plants in British Columbia and in Northern Ontario. The maximum market is estimated to be 60,000 tons a year, which represents only 15% of the total Canadian consumption. A large scale, economic sulfur recovery plant must evidently await the establishment of a heavy chemical and/or pulp industry in Alberta which could use sulfur or sulfur compounds in large quantities.

2. <u>Helium</u>

The U.S. Bureau of Mines is currently operating several plants in the southwestern United States (Amarillo, Texas, and Exell, Texas) for the commercial recovery of helium from natural gas by a refrigeration process involving very low temperatures (-310°F.) and relatively high pressures (up to 2700 psi.) [8]. The main demand has come from the Defence Department, but helium has also a promising future for

7. Clark, K.A. A Rough Survey of the Marketing Possibilities for Sulfur Produced at Edmonton from Hydrogen Sulphide from Hydrogenation of Distillate from Bituminous Sand Oil. Private communication (August 1950).

8. Mullins, P.V. Helium Production Process, Chemical Engineering Process, <u>44</u>, 567 (1948)

industrial and commercial uses - as a "tracer gas" in gas and oil reservoir studies; as an inert protective atmosphere in certain welding and metallurgical operation on magnesium, aluminum and stainless steel; and as a replacement for nitrogen for certain synthetic breathing mixtures in medicinal applications. It has recently been suggested as a high temperature heat transfer medium for nuclear reactors.

The present price, covering the costs of production to civilian users, is $13/M cu. ft. at the plant in tank car lots. The American plants operate on a natural gas containing approximately 1% helium, and operation is probably not feasible on gas containing less than about ½% helium.

On that basis, the analyses of gases in Hume's Report [4] does not show any Alberta natural gases with a high enough helium content for commercial production. However, the analyses are by no means complete, and it is suggested that a more comprehensive survey of helium content in Alberta natural gases be made before any definite conclusions be drawn on this interesting phase of natural gas utilization.

B. Reactivity of components

Natural gas is primarily a mixture of the lower hydrocarbons and this non-homogeneity introduces many technical problems into its effective use as a chemical raw material. The reactivity increases with molecular weight. Thus methane, the most plentiful component, is also by far the most resistant to chemical change. For any specific reaction each individual hydrocarbon has a different set of optimum operating conditions (temperature, pressure, time of contact and etc.) for producing the best yields and quality of products. Thus, those conditions under which the methane would best react would be much too severe for the propane-butane fraction and likely to cause complete degradation of the latter. Ideally, then, from the chemical reaction standpoint, the natural gas should be separated into its individual components and the latter used as primary feeds. Indeed, this may be one of the long -range developments in natural gas utilization.

Processes using natural gas may be divided into two catagories (a) those in which methane is the main hydrocarbon to be used, and (b) those in which the propane-butane fraction (the so called LPG - liquefied petroleum gas) is the primary starting material. In the first group the natural gas may be used in the "whole" form, or the higher hydrocarbon fractions may be removed, depending upon economic considerations. The use of the LPG fraction as a primary feed stock offers several advantages because of its greater uniformity, greater reactivity, and greater ease of handling.

## C. Processes using "whole" natural gas

These processes involve the subjection of the natural gas to a severe thermal or electrical shock, which serves to break down the methane molecule into free radicals. The latter may be decomposed all the way to carbon and hydrogen (as in the carbon black processes) or under other conditions may recombine to form higher hydrocarbons (as in the pyrolytic processes).

### 1. Carbon Black

Interest in carbon black plants in Alberta has heightened in the last few years. This is due to several factors - the fact that the entire Canadian consumption, some 50,000,000 lbs. per year, is all imported, the availability of the raw material (natural gas), and the comparative simplicity of the processes for producing carbon black. It is estimated, based on present yields, that to supply the present Canadian consumption of carbon black would require the annual processing of 24 billion cu. ft. of natural gas.

Carbon black refers to a group of industrial carbons used chiefly as fillers for rubber and plastics and as pigments for paints and printing inks. It has special physical and chemical properties and consists of particles submicroscopic in size, ranging from 50 - 5000° A. The rubber industry uses approximately 90% of all the carbon black produced.

There arethree main processes for producing carbon black:

(a) The channel process produces over half of the total American carbon black consumption. Natural gas is burned in specially designed winged tip soapstone burners with an incomplete supply of air. The flame is allowed to impinge upon a cold metallic surface (8-12 inch channel irons) depositing the carbon black, which is then scraped off into hoppers. This process produces a high quality black, which is very fine in particle size, has high absorptivity, and makes an excellent filler and reinforcing agent in compounding natural rubber. The yield is low, averaging 1.3 - 1.5 lbs. of carbon black per M. cu. ft. of gas as compared to the theoretical yield of 31.8 lbs. per M. cu. ft.

(b) The thermatomic process operates on a cycle. The natural gas is decomposed in the absence of air in a special furnace filled with refractory brick, the heat capacity of the brick supplying the heat necessary for decomposition. The brick is preheated with a gas-air mixture to about 1400°C. The carbon black is collected in bag filters. Yields as high as 16 lbs. of black per M. cu. ft. have been reported but normal yields are closer to 8-10 lbs. per M. cu. ft. The black so produced is of large particle size, unsuitable for natural rubber compounding, but can be used in synthetic rubber. A better carbon black can be produced by diluting the natural gas feed with hydrogen, but this reduces the yield.

(c) The Furnace Process utilizes the incomplete combustion of natural gas and air (unlike the channel process, without impingement) to make the carbon black. Special burners introduce alternate layers of natural gas and air into an unobstructed furnace chamber. The diffusion flames at the gas-air boundaries produce enough heat to decompose the rest of the natural gas into carbon and hydrogen. Yields range from 3 to 16 lbs. per M. cu. ft. depending upon gas quality, furnace design, and carbon black quality.

There has been considerable objection to the use of the channel process because of its low efficiency, but it should be pointed out that the furnace processes are not the complete answer, since they produce blacks of a different character to be used for specialized purposes. A direct comparison between channel process and furnace process yields is therefore not valid - the channel blacks being markedly superior from the viewpoint of particle size, absorptivity and reinforcing power. The situation is analogous to that in the petroleum industry where, from a given feed stock, one does not expect the same yields of 100 octane gasoline as 60 octane gasoline. There have been numerous processes suggested (for example, the NRC Pidgeon Process) which attempt to combine high yields of carbon black with high quality. But it would be unduly optimistic to expect the early development of a "cure-all" process.

There are several factors which tend to militate against the immediate establishment of a carbon black industry in Alberta. In the first place, although the Canadian consumption is only 5% that of the United States, just as many grades of carbon black are required. Hence any one process can only capture a fraction of what is a small market to start with, and for many grades this market is too small to set up a separate plant. It appears hopeless to try and capture the foreign market. Secondly, the carbon black industry is in a very unsettled state at present because of the uncertainty of the outcome of the struggle between synthetic and natural rubber. Furthermore, newer developments in rubber compounding require the use of new specialized blacks, thus making the market for any type of carbon black uncertain. Thirdly, while the freight rate from Alberta to eastern Canadian consumers is substantially the same as from Texas, plant installations would be more expensive in Alberta because of the more severe climatic conditions.

Notwithstanding these factors, in the long run, it might be logical to assume that in the interests of the overall Canadian economy that a substantial portion of the Canadian consumption would be produced from Alberta natural gas.

2. Pyrolysis

There have been many attempts reported in the literature [9] to

9. Egloff, G. Reactions of Pure Hydrocarbons. Reinhold Publishing Corp., New York, (1937)

produce a marketable product from both the catalytic and non-catalytic pyrolysis of natural gas. The desired products are:

1) Unsaturated gases - either ethylene or acetylene, which may be used as the starting material for other synthetic organic chemicals.

2) Aromatics like benzene and napthalene.

Catalysts have failed to produce the desired effects, and the best operation seems to be at 800 - 1100° C. in the gas phase at atmospheric pressure. However, the yields have been discouragingly low, and unless new technical developments (more selective catalysts, better temperature control) are forthcoming, commercial exploitation of these processes seems unlikely.

3. Acetylene production by the Schoch Electric Arc Process

Up to now, no acetylene has been produced on an industrial scale from natural gas but indications are that several plants will be constructed in the near future using the Schoch process. This process has been worked out in detail by Schoch and co-workers[10] at the University of Texas, and consists essentially of the passage of a sulfur-free, low nitrogen (less than 2%) natural gas through an electric discharge between specially designed electrodes. The discharge converts a fraction of the natural gas to acetylene and hydrogen, together with some byproduct carbon black. The economics of a small plant have been partially worked out. Power consumption is 4.89 KWH per pound of acetylene, the cost of feed gas is 0.9 cents per lb. based on a purchase price of 15 cts. per M cu. ft. One of the more attractive features of the process is that small self-sufficient units (with production capacity as low as 60 lbs of

10 - Schoch, E.P. and Co-Workers - Acetylene from Hydrocarbons by the Schoch Electric Discharge Process, University of Texas Publication No. 5011, 1950

acetylene per hour) are entirely feasible. In 1949 there was produced from calcium carbide in Alberta 21,251,000 cu. ft. of acetylene.

4. Partial oxidation, chlorination, and nitration of natural gas

Attempts to use methane as the primary feed in partial oxidation (to produce organic acids, aldehydes, alcohols, and ketones), chlorination, and nitration reactions have met with little commercial success. In all three cases, the reaction is initiated, but then must be carefully controlled and stopped before complete degradation takes place. This is most difficult with a compound as unreactive as methane. Yields have been discouragingly low, and it would seem that at present the more fruitful approach involves using either butane or propane as the basic starting material for these reactions. However, this picture may change as scientists begin to understand more fully catalytic and high temperature gas reactions. For example, the use of fluidized beds may bring about better control of the reaction through more effective contact of the catalyst and the gas and better temperature control.

5. Production of synthesis gas and hydrogen

One of the major synthetic chemical developments of the past half century is the conversion of natural gas (and other carbonaceous raw materials) into synthetic liquid fuels by the well known Fischer-Tropsch Process. A plant is being built at Brownesville, Texas, operated jointly by Carthage Hydrol and Stanolind Oil and Gas Co., and with an estimated production of 7,000 barrels per day of gasoline and oil products. This represents a comparatively small production, but it is a portent of things to come. One of the more remarkable features about the process is the large quantities of organic chemicals which are byproducts of the main synthesis. Thus ten plants the size of the Brownesville installation could produce approximately 75% of the total American consumption of acetaldehyde, acetone, ethanol, acetic acid, propyl alcohol, butyl alcohol, and higher solvents[11]. The development of large scale Fischer-Tropsch production would of course disrupt the whole price structure of organic oxygenated compounds, and it is being watched with apprehension by the chemical industry.

The Fischer-Tropsch synthesis is a two-stage process. The natural gas is first partially oxidized with pure oxygen (two parts methane and one part of oxygen) to give the so-called "synthesis gas", which consists of two parts of hydrogen and one part of carbon monoxide. This synthesis gas is then passed over an iron catalyst in a fluidized bed at moderate temperatures and pressures to produce higher hydrocarbons (synthetic gasoline) and oxygenated water soluble organic compounds.

Prior to the discovery of oil at Leduc, Alberta, in February, 1947, the larger oil companies operating within the province were considering the possibilities of producing synthetic oil from natural gas in Alberta. It now seems unlikely, with present successes in oil exploration, that synthetic plants will be required in Alberta for many years to come, unless to meet a national emergency.

Of more immediate interest to Alberta is the production of synthesis gas from natural gas. With the almost revolutionary developments in the production of cheap tonnage oxygen, a method is available for readily converting a relatively inert gas (methane) into the comparatively

11 - Alden, R.C. and Clark, A. Liquid Fuels from Natural Gas - paper presented at the Petroleum-Mechanical Engineering Conference of the American Society of Mechanical Engineers (October 3-6-1948)

reactive carbon monoxide and hydrogen. By the proper choice of catalysts and operating conditions, organic chemicals, rather than higher hydrocarbons, can be made the primary product of the synthesis. Thus large scale synthetic methanol plants have been built in the United States using this principle. Synthesis gas will no doubt find other uses as a result of the continual research being carried out at the present time.

In many cases, pure hydrogen rather than synthesis gas is the desired product. In that case, steam rather than oxygen is the proper oxygenating agent in the first stage. This mixture of carbon monoxide and hydrogen is reacted with more steam under the proper conditions of temperature and catalyst such that practically all the carbon monoxide gas is converted into carbon dioxide. The latter is absorbed in an alkaline solution, leaving pure hydrogen. This source of pure hydrogen has formed the basis of numerous synthetic ammonia plants, the one in Calgary operated by the Alberta Nitrogen Co. being a prime example. There are, of course many other applications to which hydrogen could be put, e.g. in hydrogenating processes, and as a reducing agent in metallurgical operations.

D <u>Liquefied petroleum gas as a chemical raw material</u>

Because of its much greater reactivity as compared to methane and because of its availability and ease of recovery from wet natural gas, there has been a remarkable increase in the use of propane and butane as the following diagram (Figure 3.) indicates.

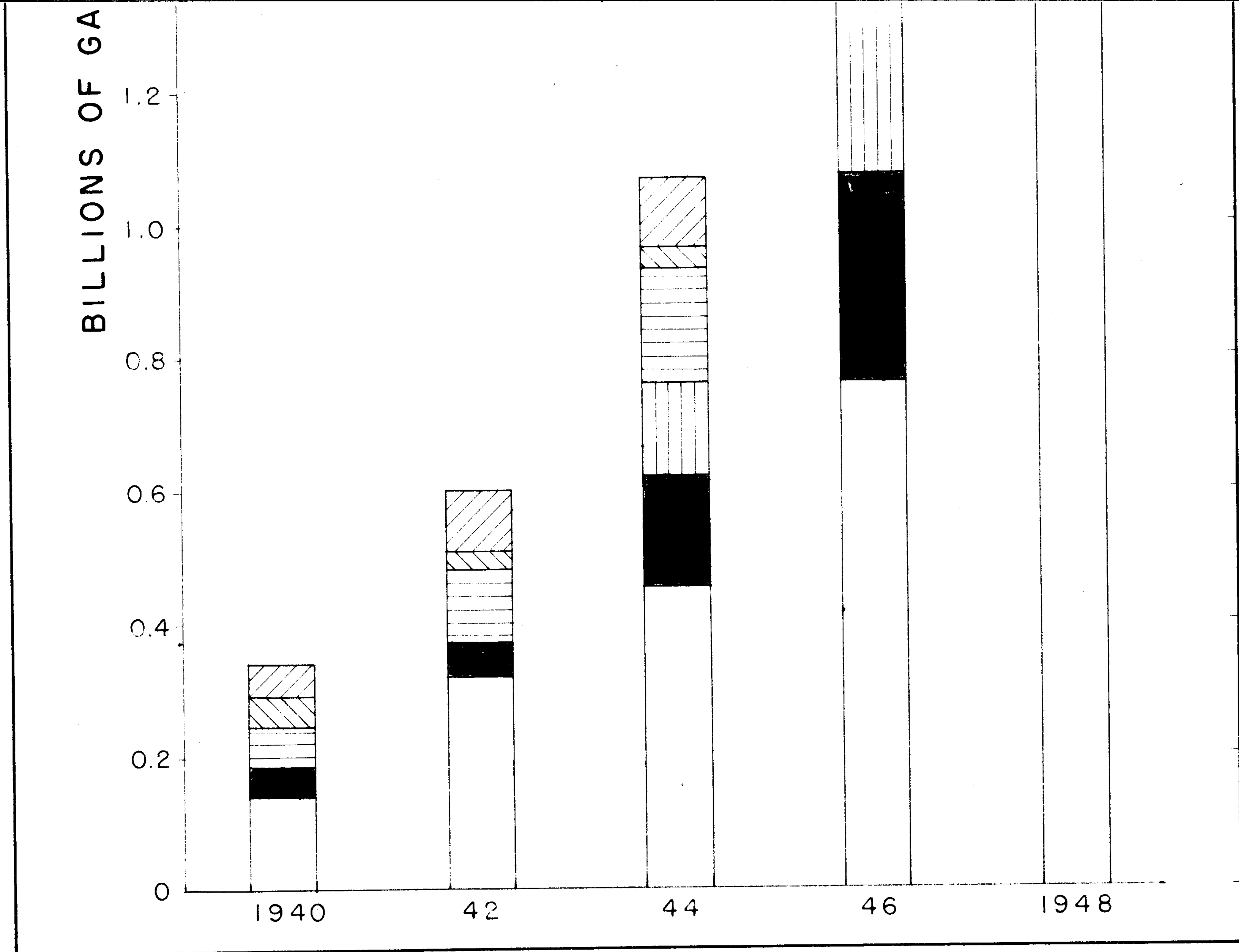
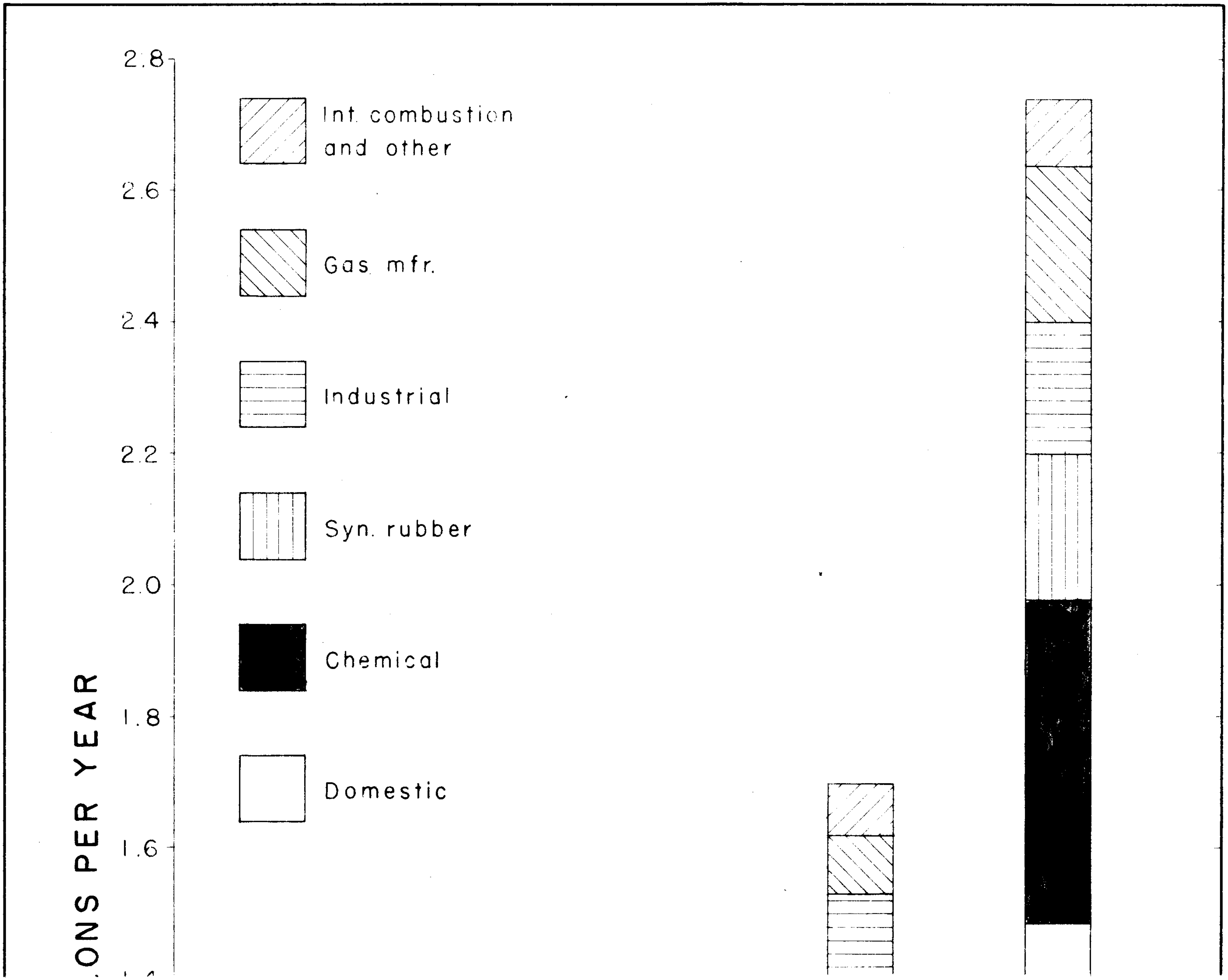



FIGURE 3

TRENDS IN SALES OF L.P.-GAS IN U.S.A., BY USES.



2.8
2.6
2.4
2.2
2.0
1.8
1.6
ONS PER YEAR
Int. combustion
and other
Gas mfr.
Industrial
Syn. rubber
Chemical
Domestic

Aside from its use as a fuel, which is considered in another section, liquefied petroleum gas has a very promising future as feed stock for production of butadiene for certain synthetic rubbers, of oxygenated organic compounds by partial oxidation, and of chlorinated and nitrated hydrocarbons.

1. Butadiene from butane

The critical wartime demands for synthetic rubber led to the development of the Houdry Dehydrogenation Process for the production of butadiene from a relatively pure butane feed stock[12]. The butane is subjected to dehydrogenating conditions in the reactors in two stages. The first stage yields butane, butylene and higher hydrocarbons. The butane and butylene portion is concentrated in a vapor recovery system and fed into a second reactor where butadiene is produced.

The heat required for the dehydrogenation steps is supplied by burning the carbon deposited on the catalyst during the dehydrogenation. This burning with air also serves to regenerate the catalyst. Yields of butadiene of up to 70% are reported. Operating details are not available.

Alberta thus possesses both the raw material and the technology for a synthetic rubber industry - butadiene from the butane fraction, carbon black from the natural gas.

2. Partial oxidation of L P G

Two companies - the Celanese Corp. at Bishop, Texas and the Cities Service Oil and Gas Co., Tallant, Oklahoma - have been producing oxygenated organic chemicals from a propane-butane feed for a number of years. Exact operating details are not revealed, but it is believed

12 - Thayer, C.H. - Liderer, E.R. and Lassiat, R.C.
Butadiene by the Houdry Dehydrogenation Process
Chemical and Metallurgical Engineering 49,
No. 11 116 (1942)

that the reaction takes place in the gas phase at a temperature of 400° C and a pressure of 300 psia, the reactants being a propane-butane mixture, steam, and oxygen (kept below 6%). The gas stream is recycled to increase the overall yield. One hundred lbs. of butane is reported to yield 15.2 lbs. formaldehyde, 19.6 lbs. acetaldehyde, 7.0 lbs acetone, 19.0 lbs. methanol, traces of propanol and butanol, and 11.4 lbs of higher solvents. The Tallant plant produces annually 280,000 tons of methanol and 350,000 tons of formaldehyde. The Canadian market is sufficiently large, especially for formaldehyde and methanol, to warrant serious consideration of the establishment of a small chemical plant using butane as the feed. Unfortunately, the market is in eastern Canada, and transportation costs are comparatively high. Nevertheless, this is one of the more promising processes for utilizing the L P G fraction, and long term prospects are good.

3. Nitration and chlorination of propane and butane

The main fundamental research on both the nitration and chlorination of paraffin hydrocarbons has been carried out over a number of years by Hass, McBee and co-workers at the Purdue Research Foundation. The nitration studies[13] have led to the establishment, by the Commercial Solvents Corporation, of an industrial process for nitrating propane in the gas phase at 400°C and 150 psia to give nitro methane, nitro ethane, 2-nitropropane, 1-nitropropane, and smaller amounts of nitro butane.

This process is of particular interest to Alberta because cheap nitric acid is available from the Alberta Nitrogen Co. ammonia plant in Calgary. However, it is believed that the Canadian market for nitro paraffins at the present time is too small for a practical sized plant.

13 - Hass, H.B. et al. Industrial and Engineering Chemistry, 39 817, (1937); 35, 1146, (1943) and 32 427, (1940).

McBee and Hass[14] have worked out a process for chlorinating the lower hydrocarbons which involves the introduction of gaseous chlorine into the hydrocarbon stream through jets suitably spaced along the reactor. By this arrangement, the momentary concentrations of chlorine are maintained below those which would yield explosive mixtures. The reaction is carried out at atmospheric pressure and around 450°C. Good control is claimed over the chlorine content of the resulting product. It is not known whether any industrial plants are using this process.

E <u>Future of the petrochemical industry, utilizing natural gas</u>

An attempt has been made to review the major present chemical processes which are most likely to use large quantities of natural gas in Alberta. Developments in the petrochemical industry have been so rapid in recent years, that it would be well nigh impossible to predict what new developments will be made in the next ten years let alone fifty. Two points must be kept in mind. First, in chemical technology, fifty years is a long time. Sustained research, resulting in technological improvements, will continue to turn laboratory curiosities into everyday products, and will continue to transform uneconomical and marginal processes into highly profitable ones. For example: one might reasonably expect technological advances in the use of fluidized beds in heterogeneous catalytic reactions; improvements in refrigeration techniques, which would facilitate the separation of natural gas into individual components; developments in electric discharge reactions; and an extension of our inadequate knowledge of high temperature catalytic gaseous reactions in

14 - McBee, E.T., Hass, H.B. et al, Industrial and Engineering Chemistry, 34, 296 (1942); 33, 176, (1941), and 28, 333, (1936).

general. The second point is that there can be no question about the direction of the trend -- that trend is to an ever-increasing use of natural gas as a chemical raw material. The two most promising processes for Alberta at present appear to be decomposition of dry natural gas to form carbon black, and partial oxidation of the butane fraction to form oxygenated organic chemicals.

In evaluating the chemical potentialities of natural gas in Alberta, it has seemed advisable to consider separately those processes which use the whole dry natural gas, and those which use the liquefied petroleum gas fraction. Dry natural gas is the main raw material for carbon black. It is also an ideal source of cheap acetylene, cheap synthesis gas, cheap hydrogen, and possibly cheap ethylene. These gases themselves represent the raw material, the building blocks for other synthetic chemicals, of which plastics are a notable example. The future market for these gases is closely linked to the degree of industrialization in future Alberta.

Because it will be used both as a fuel and as a raw material, it seems safe to assume a rate of increase of natural gas consumption higher than either the expected rate of population or of industrial growth in Alberta. Its use as a chemical raw material could represent immense quantities. One need only point out that the Alberta Nitrogen Co. Ammonia Plant uses approximately one quarter as much natural gas as the City of Calgary.

The other potential raw material for chemical use is the liquefied petroleum gas fraction. If natural gas is exported, then presumably large quantities of propane and butane would be available in Alberta. This could form the basis of a sizable chemical industry. Indeed, because of its potentialities, its greater versatility and reactivity (as compared to natural gas) for direct chemical synthesis, special efforts should be made to make certain that it be used constructively. Wastage of this valuable product would definitely not be in the best interests of the province.

## V Liquefied petroleum gas (L P G)

The more important hydrocarbon constituents of wet natural gas are methane, ethane, propane and butane. Of these propane and butane are considered as Liquefied Petroleum Gas (L P G), since as the name implies they can be liquefied under moderate pressures.

It is assumed that only dry natural gas would be exported by pipeline, and that some other disposal must therefore be found for the other constituents.

Some of the physical properties for methane, ethane, propane, and butane are given in Table I and the percentage of these components in the raw gas from a number of gas fields in Alberta can be found in Hume's Report[4]. It will be noted that the calorific value of the gas in B.t.u. per cu. ft. increases as you go up the hydrocarbon series and that the calorific value of a raw natural gas is dependent on the percentage of each of the hydrocarbons present in it and on the presence of diluents in the form of non-combustible gases.

In emphasizing the importance of Liquefied Petroleum Gas it should be pointed out that in addition to its use for domestic, commercial and industrial heating, constituents of the gas can be used for internal combustion engines, as raw materials for the manufacture or enriching of artificial gases, and for the production of synthetic rubber and chemicals. It is used also in components for high octane aviation gasoline, and in various processing operations such as solvent extraction of oils, waxes, and asphalts. In the United States over 20 percent of the marketed production of liquefied petroleum gas, (excluding butanes blended with heavier petroleum fractions for motor fuel purposes, and the hydrocarbons used in plants manufacturing synthetic rubber, aviation gasoline or their components) goes into the manufacture of a long list of organic chemicals. The importance of propane and butane in the organic chemical industry has been discussed already in Chapter IV. Even though it is considered that propane and butane are the most potentially valuable constituents of natural gas yet the Council does not anticipate that there will be any extensive market for these products in Alberta in the immediate future.

Propane is being extracted at two plants in Alberta, namely at Western Propane Ltd., Turner Valley, and Imperial Oil Absorption, Devon. The reported capacity of these plants is 40,000 to 45,000 gallons per day. The production of propane in Alberta rose from 297,001 gallons in 1948 to 1,895,544 gallons in 1949. A larger increase will occur this year since during the first 7 months of 1950 there was produced over 1,800,000 gallons whereas the amount for the similar period of 1949 was under 900,000 gallons.

The major part of the propane produced in Alberta has been sold as a domestic fuel in rural areas and in villages and towns not serviced by natural gas. A small amount has been used in motor vehicles. In this connection the experience of the City of Edmonton is particularly interesting.

The Edmonton Transit system converted toward the end of 1949 a Ford Transit Coach, powered with a Vee-Eight engine, to use propane. Results with the conversion proved so satisfactory that a modern, high performance, Twin Coach, converted at the factory to use propane, was purchased in July, 1950, and has been in operation since that time. A further order of ten Twin Coaches, with larger engines, is being built for delivery in the fall of 1950, and will all be converted at the factory to use liquefied petroleum gas as the fuel.

The experience of the Edmonton Transit System is that not only did the converted buses give better road and operating performance but that there was less fouling of the parts of the motor, allowing for longer periods between overhauls. This has been the experience elsewhere when using this fuel in motor vehicles.

An interim mimeographed report on the use of propane as the fuel in coaches of the Edmonton Transit System was prepared by D. L. MacDonald, Electrical Engineer and Assistant Superintendent, in September, 1950.

It is suggested that the use of propane and possibly butane for motor vehicles could be expanded to include fleets of transport trucks or buses, operating between specific points where supplies of liquefied petroleum gas would be available. The cost of engine conversions runs from $400. for a small fuel system to approximately $1,000. for a larger system. The latter figure includes the cost for an increase in compression pressures for a higher performance engine. Storage tanks and facilities cost from $1.50 to $2.00 per gallon on storage required.

Propane can also be used in internal combustion natural gas engines, which might serve for the production of electrical energy in rural communities or in town and village power plants. If at a later time natural gas were piped to these localities the same engine could be used for the cheaper fuel.

There is very little market for butane in Alberta at present other than for blending with gasoline. It has not proven satisfactory as a domestic fuel because its low vapor pressure does not insure vaporization in our climate, especially in winter, since the storage tanks and regulators require to be installed outside the dwelling.

The situation with respect to butane could be changed with the establishment of a synthetic rubber plant in Alberta. In this connection it was reported recently that the Polymer Corporation Ltd. of Sarnia were contemplating doubling the capacity of their plant. Not only would the decentralization of essential industries such as a synthetic rubber plant be desirable in case of war, but it would seem logical that such a plant should be established close to the source of the major raw materials. Alberta should be, therefore, a desirable location for a synthetic rubber plant because of the availability of butane for the production of butadiene, and of carbon black which is used in large quantities as a filler in the rubber. Carbon black is a bulky material and transportation charges form a large percentage of its ultimate cost. Canada imported in 1947 approximately 55 million pounds of carbon black valued at nearly three million dollars. Most of it was used in the synthetic rubber industry.

The selling price of propane in Alberta, of six to nine cents per gallon, f.o.b., the plant is considered too high for its use in general house heating or for industrial purposes. The overall cost is accentuated by transportation charges and costs of the necessary capital equipment.

The amount of liquefied petroleum gas, which may be available in Alberta in the future is dependent on the extent of oil and gas production, and of petroleum refining. Certain gas fields in Alberta, including those of Jumping Pound and Pincher Creek, are wet gas fields and when developed will produce large quantities of propane and butane. Unless an adequate market can be found for these materials, or steps are taken to curtail their dissipation, there may be criminal wastage of a raw material of great potential value to future industry.

The Council wishes to emphasize again the importance of liquid petroleum gas in the considerations of the Board with respect to the export of dry natural gas from Alberta. The experience of the United States is that the liquefied petroleum gas industry is developing very rapidly. It is prospering there because of density of population and of wider markets, but its development may be limited in Alberta until such time as our population has increased and wider markets are available here. However this does not in any way minimize its ultimate value.

## NATURAL GAS IN RELATION TO THE INDUSTRIAL GROWTH IN ALBERTA

In order to assess possible industrial growth in Alberta, with corresponding growth in heat and power requirements, the development to date will be reviewed and some comments ventured as to the future. The statistical data in this chapter have been taken largely from Alberta Facts and Figures, compiled and published by the Bureau of Statistics, Department of Industries and Labour of the Province of Alberta.

### A. Gross Production

The values for gross and net production for the Province of Alberta are shown in Table XI. Gross value represents the total value to the producer, as distinguished from net value which represents the gross value minus the value for raw materials.

Table XI

Value of Production, Alberta

| Year | Gross $ | Net $ |
|---|---|---|
| 1920 | 376,420,786 | 264,571,430 |
| 1921 | 223,648,964 | 154,376,861 |
| 1922 | 221,929,251 | 161,098,720 |
| 1923 | 301,105,188 | 241,241,457 |
| 1924 | 298,589,566 | 210,972,370 |
| 1925 | 356,165,710 | 257,040,994 |
| 1926 | 383,207,517 | 298,026,980 |
| 1927 | 462,347,821 | 378,578,571 |
| 1928 | 439,513,402 | 341,413,575 |
| 1929 | 409,642,138 | 237,493,962 |
| 1930 | 329,898,695 | 184,659,449 |
| 1931 | 255,519,947 | 164,947,717 |
| 1932 | 214,177,072 | 157,015,824 |
| 1933 | 206,997,231 | 144,210,672 |
| 1934 | 255,549,707 | 162,784,883 |
| 1935 | 246,617,139 | 153,271,341 |
| 1936 | 260,635,137 | 161,864,956 |
| 1937 | 311,106,844 | 206,987,784 |
| 1938 | 302,422,229 | 200,906,189 |
| 1939 | 298,090,640 | 199,771,754 |
| 1940 | 358,660,082 | 235,153,134 |

(cont.)

| Year | Gross $ | Net $ |
|---|---|---|
| 1941 | 384,712,429 | 230,681,177 |
| 1942 | 578,573,349 | 394,933,661 |
| 1943 | 531,634,131 | 328,198,886 |
| 1944 | 655,351,857 | 416,117,352 |
| 1945 | 596,276,054 | 340,703,182 |
| 1946 | 708,612,493 | 434,902,340 |
| 1947 | 815,624,396 | 493,641,826 |
| 1948 | 1,073,361,412 | 668,992,346 |

A breakdown of total production into various industries is shown in Table XII. It is to be noted that the percentage of total production contributed by the manufacturing industry has steadily increased.

## B. Manufacturing Industries

The following particulars give the origin of production, and also an outline of the principal manufacturing industries of the province:-

Vegetable Products - flour and feed mills, bakeries, breweries, cereal factories, vegetable canning factories, sugar refineries, stock and poultry foods, fruit and vegetable preparations, aerated and mineral waters, etc.

Animal Products - creameries and cheese factories, ice cream plants, milk condensery, tanneries, leather goods, footwear, fur goods, slaughtering and meat packing plants, etc.

Textiles and Textile Products - awnings, tents and sails, clothing, hats and caps, hosiery and knittod goods, woollen goods, etc.

Wood Products - sawmills, planing mills, sash and door factories, box factories, coffin and casket factories, boat building, carriages, wagons and sleighs, furniture, beekeepers' and poultrymen's supplies, wooden refrigerators, woodenware, wood preservation, veneer and plywood,

## Table XII

### Survey of Production, Alberta Gross

| Year | Agri- culture | Trap- ping | Total Agriculture and Trapping | Forestry | Fisheries | Mining | Electric Power | Con- struc- tion | Custom and Repair | Manu- factures | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | % | % | % | % | % | % | % | % | % | % | % |
| 1920 | 64.05 | .40 | 64.45 | 1.02 | .14 | 8.62 | .68 | 1.13 | 1.62 | 22.34 | 100% |
| 1921 | 53.76 | .47 | 54.23 | 1.44 | .18 | 13.15 | 1.30 | 2.50 | 2.59 | 24.61 | 100% |
| 1922 | 55.67 | .59 | 56.26 | 1.37 | .14 | 11.90 | 1.32 | 3.80 | 2.52 | 22.69 | 100% |
| 1923 | 65.79 | .58 | 66.37 | 1.17 | .14 | 9.95 | .98 | 2.25 | 1.87 | 17.27 | 100% |
| 1924 | 65.07 | .63 | 65.70 | 1.18 | .11 | 7.14 | 1.06 | 2.11 | 1.88 | 20.82 | 100% |
| 1925 | 67.48 | .54 | 68.02 | 1.03 | .12 | 6.83 | .95 | 1.05 | 1.72 | 20.28 | 100% |
| 1926 | 65.10 | .55 | 65.65 | 1.20 | .19 | 6.77 | .96 | 2.52 | 1.78 | 20.93 | 100% |
| 1927 | 70.13 | .46 | 70.59 | 1.33 | .15 | 6.14 | .83 | 1.57 | 1.60 | 17.79 | 100% |
| 1928 | 61.98 | .34 | 62.32 | 1.54 | .16 | 7.13 | 1.00 | 3.92 | 1.86 | 22.07 | 100% |
| 1929 | 53.38 | .54 | 53.92 | 2.12 | .17 | 8.11 | 1.20 | 6.81 | 2.53 | 25.14 | 100% |
| 1930 | 49.07 | .29 | 49.36 | 2.40 | .12 | 8.86 | 1.60 | 7.26 | 3.10 | 27.30 | 100% |
| 1931 | 52.94 | .35 | 53.29 | 2.16 | .06 | 8.77 | 2.07 | 5.33 | 2.89 | 25.43 | 100% |
| 1932 | 56.16 | .28 | 56.44 | 1.59 | .07 | 9.41 | 2.46 | 2.64 | 2.83 | 24.56 | 100% |
| 1933 | 58.16 | .36 | 58.52 | 1.50 | .07 | 9.03 | 2.05 | 1.30 | 2.48 | 25.05 | 100% |
| 1934 | 58.03 | .42 | 58.45 | 1.41 | .09 | 7.10 | 1.70 | 2.81 | 2.57 | 25.87 | 100% |
| 1935 | 54.31 | .42 | 54.73 | 1.68 | .09 | 8.48 | 1.87 | 3.99 | 2.55 | 26.61 | 100% |
| 1936 | 54.62 | .42 | 55.04 | 1.65 | .11 | 8.31 | 1.83 | 3.56 | 2.10 | 27.40 | 100% |
| 1937 | 56.18 | .46 | 56.64 | 1.52 | .13 | 7.38 | 1.60 | 3.47 | 2.54 | 26.72 | 100% |
| 1938 | 51.83 | .16 | 51.99 | 1.59 | .16 | 9.09 | 1.81 | 4.29 | 2.84 | 28.23 | 100% |
| 1939 | 48.66 | .24 | 48.90 | 1.61 | .14 | 9.77 | 1.92 | 5.90 | 2.84 | 28.92 | 100% |
| 1940 | 47.35 | .52 | 47.87 | 2.00 | .13 | 9.14 | 1.66 | 7.48 | 2.37 | 29.35 | 100% |
| 1941 | 37.37 | .50 | 37.87 | 2.37 | .11 | 10.11 | 1.71 | 8.97 | 2.63 | 36.23 | 100% |
| 1942 | 50.55 | .88 | 51.43 | 1.74 | .08 | 7.70 | 1.22 | 5.67 | 1.90 | 30.26 | 100% |
| 1943 | 41.37 | .65 | 42.02 | 2.00 | .15 | 8.63 | 1.52 | 4.64 | 2.10 | 38.94 | 100% |
| 1944 | 45.09 | .50 | 45.59 | 1.73 | .14 | 7.24 | 1.31 | 4.13 | 1.96 | 37.90 | 100% |
| 1945 | 39.70 | .34 | 40.04 | 2.22 | .12 | 8.06 | 1.48 | 5.23 | 2.33 | 40.52 | 100% |
| 1946 | 42.95 | .41 | 43.36 | 2.43 | .18 | 7.83 | 1.35 | 7.10 | 2.35 | 35.40 | 100% |
| Av.27 yrs. | 53.08 | .46 | 53.54 | 1.67 | .13 | 8.30 | 1.46 | 4.32 | 2.31 | 28.27 | 100% |

artificial limbs, charcoal, etc.

Paper Products - blue printing, engraving, stereotyping and electrotyping, printing and bookbinding, printing and publishing, paper boxes and bags, trade composition and miscellaneous paper goods.

Iron and Steel Products - machine shops, foundries, etc. - castings and forgings, bridge and structural steel, railway rolling stock, sheet metal products, machinery, farm implements, automobile supplies, cooking and heating apparatus, boilers, tanks and plate works, wire and wire goods, etc.

Non-Ferrous Metal Products - electrical apparatus and supplies, brass and copper manufacturers, jewellery and electro plated ware, etc.

Non-Metallic Mineral Products - salt, cement and cement products, clay products from domestic clay, lime, petroleum products, propane gas, coke, tar sands' products, glass and glass products, stone-monumental and ornamental, gypsum products, mineral wool for insulation, etc.

Chemicals and Chemical Products* - medicinal and pharmaceutical preparations, soaps, washing compounds, compressed gases, paints, pigments and varnishes, amonia anhydrous, ammonium nitrate, fertilizer compounds, hardwood distillation, plastics, etc.

Miscellaneous - signs (neon and other), rubber stamps and stencils, scientific and professional equipment, mattresses and springs, brooms, brushes and mops.

* The production of chemicals and chemical products from petroleum and natural gas is contained in a separate section of this report.

## Table XIII

### Value of Production - Manufacturing Industries of Alberta, By Groups of Industries

| Year | Vegetable Products $ | Animal Products $ | Textiles & Textile Products $ | Wood & Paper Products $ | Iron & Steel Products $ | Non-Ferrous Metal Products $ | Non-Metallic Mineral Products $ | Chemicals & Chemical Products $ | Misc. Products $ | TOTAL $ |
|---|---|---|---|---|---|---|---|---|---|---|
| 1930 | 27,128,776 | 22,911,477 | 2,839,780 | 12,105,899 | 7,525,510 | 430,295 | 16,000,905 | 549,651 | 170,619 | 89,662,912 |
| % of Total | 30.26 | 25.55 | 3.17 | 13.50 | 8.39 | .48 | 17.85 | .61 | .19 | 100% |
| 1931 | 18,975,269 | 16,405,767 | 2,307,185 | 7,936,484 | 5,607,498 | 255,507 | 11,642,445 | 466,384 | 96,015 | 63,692,554 |
| % of Total | 29.79 | 25.76 | 3.62 | 12.46 | 8.80 | .40 | 18.28 | .73 | .16 | 100% |
| 1932 | 16,461,444 | 13,077,159 | 2,070,081 | 6,810,597 | 4,117,982 | 245,400 | 7,328,792 | 428,372 | 72,981 | 50,612,808 |
| % of Total | 32.52 | 25.84 | 4.09 | 13.46 | 8.14 | .48 | 14.48 | .85 | .14 | 100% |
| 1933 | 16,142,838 | 14,994,019 | 1,945,994 | 6,124,779 | 3,185,864 | 212,922 | 7,071,766 | 438,259 | 60,339 | 50,176,780 |
| % of Total | 32.17 | 29.88 | 3.88 | 12.21 | 6.35 | .42 | 14.09 | .87 | .13 | 100% |
| 1934 | 20,201,578 | 20,265,175 | 2,048,874 | 6,831,623 | 3,821,606 | 216,731 | 10,917,027 | 432,908 | 86,397 | 64,821,919 |
| % of Total | 31.16 | 31.26 | 3.16 | 10.54 | 5.90 | .33 | 16.84 | .67 | .14 | 100% |
| 1935 | 21,642,982 | 22,730,949 | 1,520,780 | 7,059,210 | 3,992,170 | 245,017 | 9,937,291 | 562,736 | 139,783 | 67,830,918 |
| % of Total | 31.91 | 33.51 | 2.24 | 10.41 | 5.89 | .36 | 14.65 | .83 | .20 | 100% |
| 1936 | 24,474,660 | 25,444,407 | 1,453,668 | 7,759,026 | 4,283,106 | 333,493 | 9,516,834 | 604,924 | 181,892 | 74,052,010 |
| % of Total | 33.05 | 34.36 | 1.96 | 10.48 | 5.78 | .45 | 12.85 | .82 | .25 | 100% |
| 1937 | 27,162,663 | 31,602,145 | 1,840,366 | 8,442,457 | 4,916,371 | 369,507 | 10,867,020 | 658,064 | 366,476 | 86,225,069 |
| % of Total | 31.51 | 36.65 | 2.13 | 9.79 | 5.70 | .43 | 12.60 | .76 | .43 | 100% |
| 1938 | 25,894,974 | 31,713,345 | 1,727,226 | 8,638,605 | 5,282,198 | 299,492 | 11,973,190 | 641,964 | 504,506 | 86,675,500 |
| % of Total | 29.88 | 36.59 | 1.99 | 9.97 | 6.09 | .35 | 13.81 | .74 | .58 | 100% |
| 1939 | 24,732,783 | 32,428,072 | 1,780,639 | 8,352,904 | 5,095,424 | 338,048 | 13,541,250 | 629,456 | 575,504 | 87,474,080 |
| % of Total | 28.27 | 37.07 | 2.04 | 9.55 | 5.83 | .39 | 15.48 | .72 | .65 | 100% |
| 1940 | 28,723,362 | 42,213,358 | 2,121,840 | 10,877,872 | 5,813,965 | 301,077 | 15,948,792 | 627,183 | 686,515 | 107,313,964 |
| % of Total | 26.77 | 39.34 | 1.98 | 10.14 | 5.42 | .28 | 14.86 | .58 | .63 | 100% |
| 1941 | 33,809,992 | 62,791,413 | 2,790,515 | 13,981,714 | 7,568,862 | 493,834 | 19,213,240 | 1,072,222 | 929,701 | 142,651,493 |
| % of Total | 23.70 | 44.02 | 1.96 | 9.80 | 5.31 | .35 | 13.47 | .75 | .64 | 100% |
| 1942 | 37,241,445 | 83,400,676 | 3,726,114 | 16,298,377 | 9,164,743 | 785,565 | 23,947,774 | 2,613,581 | 924,736 | 178,103,011 |
| % of Total | 20.91 | 46.83 | 2.09 | 9.15 | 5.15 | .44 | 13.45 | 1.46 | .52 | 100% |
| 1943 | 44,697,465 | 101,377,205 | 3,880,610 | 16,404,706 | 14,955,614 | 703,610 | 24,626,450 | 3,301,024 | 1,212,458 | 211,159,142 |
| % of Total | 21.17 | 48.01 | 1.84 | 7.77 | 7.08 | .33 | 11.66 | 1.56 | .58 | 100% |
| 1944 | 56,278,917 | 125,506,481 | 3,864,726 | 18,502,895 | 16,038,988 | 596,938 | 26,089,057 | 5,190,555 | 881,337 | 252,949,894 |
| % of Total | 22.25 | 49.62 | 1.53 | 7.31 | 6.34 | .24 | 10.31 | 2.05 | .35 | 100% |
| 1945 | 61,674,533 | 114,710,920 | 3,439,686 | 22,884,055 | 13,524,096 | 573,185 | 25,133,911 | 5,356,245 | 990,873 | 248,287,504 |
| % of Total | 24.84 | 46.20 | 1.39 | 9.22 | 5.45 | .23 | 10.12 | 2.16 | .39 | 100% |
| 1946 | 75,033,065 | 98,594,171 | 4,434,880 | 30,276,895 | 13,059,146 | 596,214 | 28,470,159 | 5,424,071 | 1,143,266 | 257,031,867 |
| % of Total | 29.19 | 38.35 | 1.73 | 11.78 | 5.08 | .23 | 11.08 | 2.11 | .45 | 100% |
| 1947 | 94,312,246 | 98,125,197 | 4,943,153 | 39,221,355 | 16,439,328 | 763,057 | 36,097,604 | 5,662,761 | 489,428 | 296,054,129 |
| % of Total | 31.86 | 33.14 | 1.67 | 13.25 | 5.55 | .26 | 12.19 | 1.91 | .17 | 100% |
| 1948 | 92,338,433 | 136,662,931 | 6,528,335 | 49,249,173 | 21,363,361 | 1,082,799 | 49,249,173 | 8,882,123 | 557,862 | 366,090,082 |
| % of Total | 25.22 | 37.33 | 1.78 | 13.50 | 5.84 | .30 | 13.45 | 2.43 | .15 | 100% |

The value of production of the manufacturing industries of Alberta by groups of industries are shown in Table XIII.

## C. Principal Individual Industries

In addition to viewing the production figures for industry groups as shown above it is of interest to study the values of production of some of the individual industries which make up these groups.

Flour and Feed mills comprise the largest single industry in the Vegetable Products group and production values for this industry are shown in Table XIV.

Table XIV

Flour and Feed Mills

| Year | Total Value $ |
|---|---|
| 1922 | 12,677,672 |
| 1926 | 18,097,886 |
| 1931 | 9,348,399 |
| 1936 | 12,261,814 |
| 1941 | 13,438,890 |
| 1946 | 33,812,288 |
| 1947 | 46,699,799 |
| 1948 | 38,017,776 |

The slaughtering and meat packing industry accounts for the bulk of the production in the Animal Products group. The values of production are as in Table XV.

Table XV

Slaughtering and Meat Packing Industry

| Year | Value of Production, $ |
|---|---|
| 1910 | 4,029,635 |
| 1920 | 23,265,841 |
| 1926 | 15,069,972 |
| 1931 | 10,411,117 |
| 1936 | 17,681,494 |
| 1941 | 46,655,412 |
| 1946 | 77,190,577 |
| 1947 | 68,831,113 |
| 1948 | 98,981,476 |

The Wood Products group represented 13.50 % of the total value of manufacture in Alberta in 1948. This group is composed of a large number of small industries. The establishment of a pulp and paper industry now presently under consideration would place this group into one of major importance.

The Non-Metallic Mineral Products form a substantial share of the manufacturing industries in Alberta and are destined to play an even greater role. Petroleum products account for the largest proportion of this group and their production values are shown in Table XVI.

Table XVI

Petroleum Products

| Year | Value of Production, $ |
|---|---|
| 1924 | 5,934,678 |
| 1931 | 8,389,577 |
| 1936 | 7,410,882 |
| 1941 | 14,329,999 |
| 1946 | 19,941,937 |
| 1947 | 26,478,933 |
| 1948 | 35,390,373 |

The refining capacity in this province as portrayed by the last table will be markedly increased upon the completion of the two refineries now under construction and upon the realization of the proposed expansion program of the present refinery in Edmonton.

The production figures for Glass and Glass Products are shown in Table XVII. The method of compiling statistics for this industry was changed in recent years and consequently production values cannot be issued since 1946 without divulging confidential information regarding the largest producer of glass and glass products in Alberta.

Table XVII

Glass and Glass Products

| Year | Establishments | Value of Production, $ |
|---|---|---|
| 1945 | 3 | 2,594,208 |
| 1946 | 3 | 2,461,508 |

This industry consists essentially of a large glass factory at Redcliff manufacturing glass bottles, glass jars and sealers. This factory serves all Western Canada and its location is determined by the availability of cheap natural gas. All raw materials are imported. Recently sands suitable for glass making have been discovered in Alberta. Should these deposits prove of sufficient extent, the glass industry of this province will receive further impetus possibly with the installation of facilities for making window glass.

Salt production in Alberta is shown in Table XVIII.

Table XVIII

Salt Production

| Year | Tons |
|---|---|
| 1938 | 4,045 |
| 1939 | 3,319 |
| 1940 | 8,524 |
| 1941 | 16,610 |
| 1942 | 22,179 |
| 1943 | 17,408 |
| 1944 | 25,242 |
| 1945 | 29,362 |
| 1946 | 31,683 |
| 1947 | 29,552 |
| TOTAL | 187,924 |

The large established salt deposits are a potential source of such chemicals as caustic soda, chlorine, hydrochloric acid and soda ash. At present these chemicals are imported from Eastern Canada but with an increasing market for these products in the west the establishment of an alkali industry will no doubt take place in the near future.

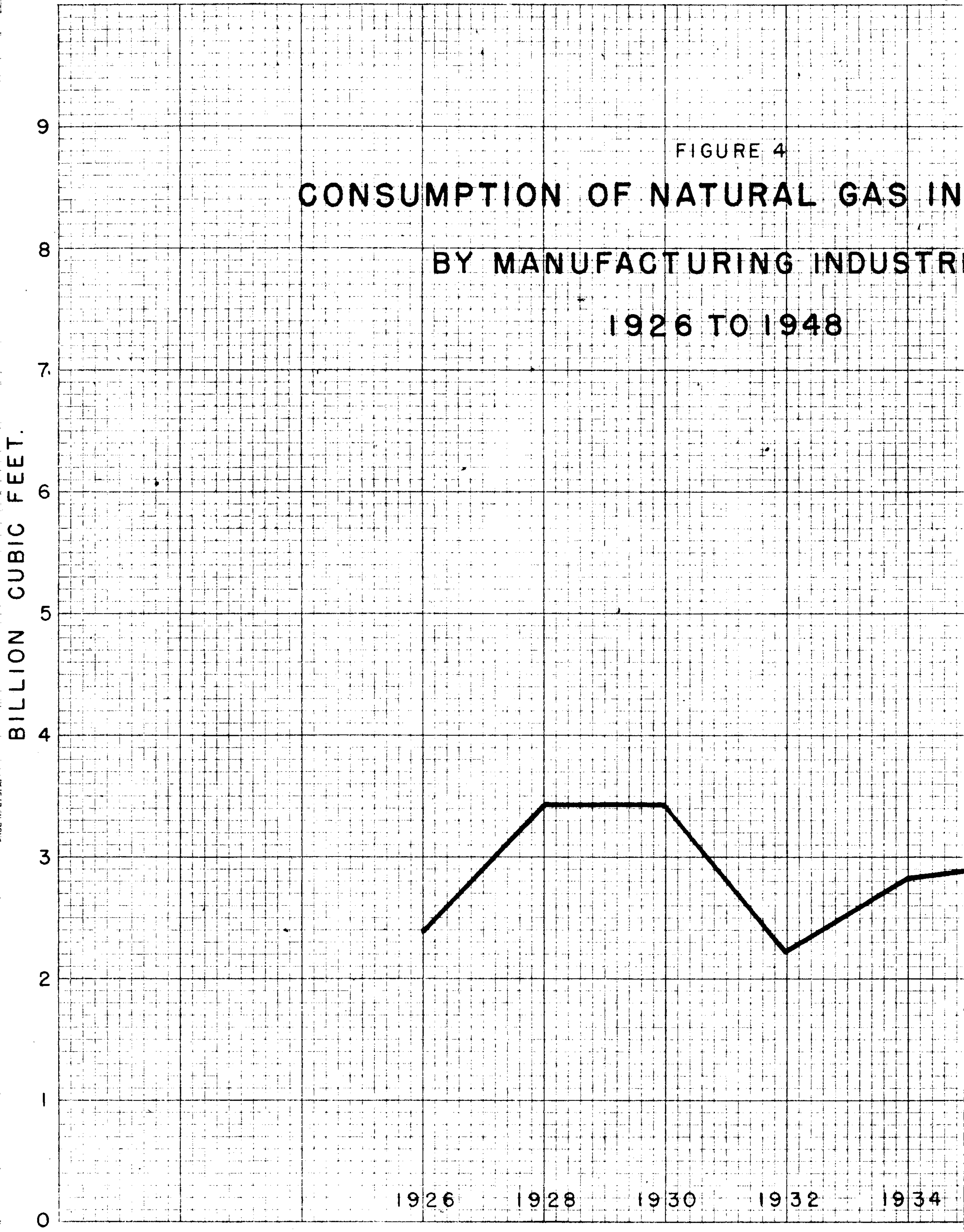
Alberta has large reserves of the non-metallic minerals necessary for the manufacture of cement, brick and tile, gypsum products, lime, mineral wool, etc. With the availability of a cheap fuel in the form of natural gas expansion in these industries in future should be substantial.

## D. The Use of Natural Gas in the Manufacturing Industries

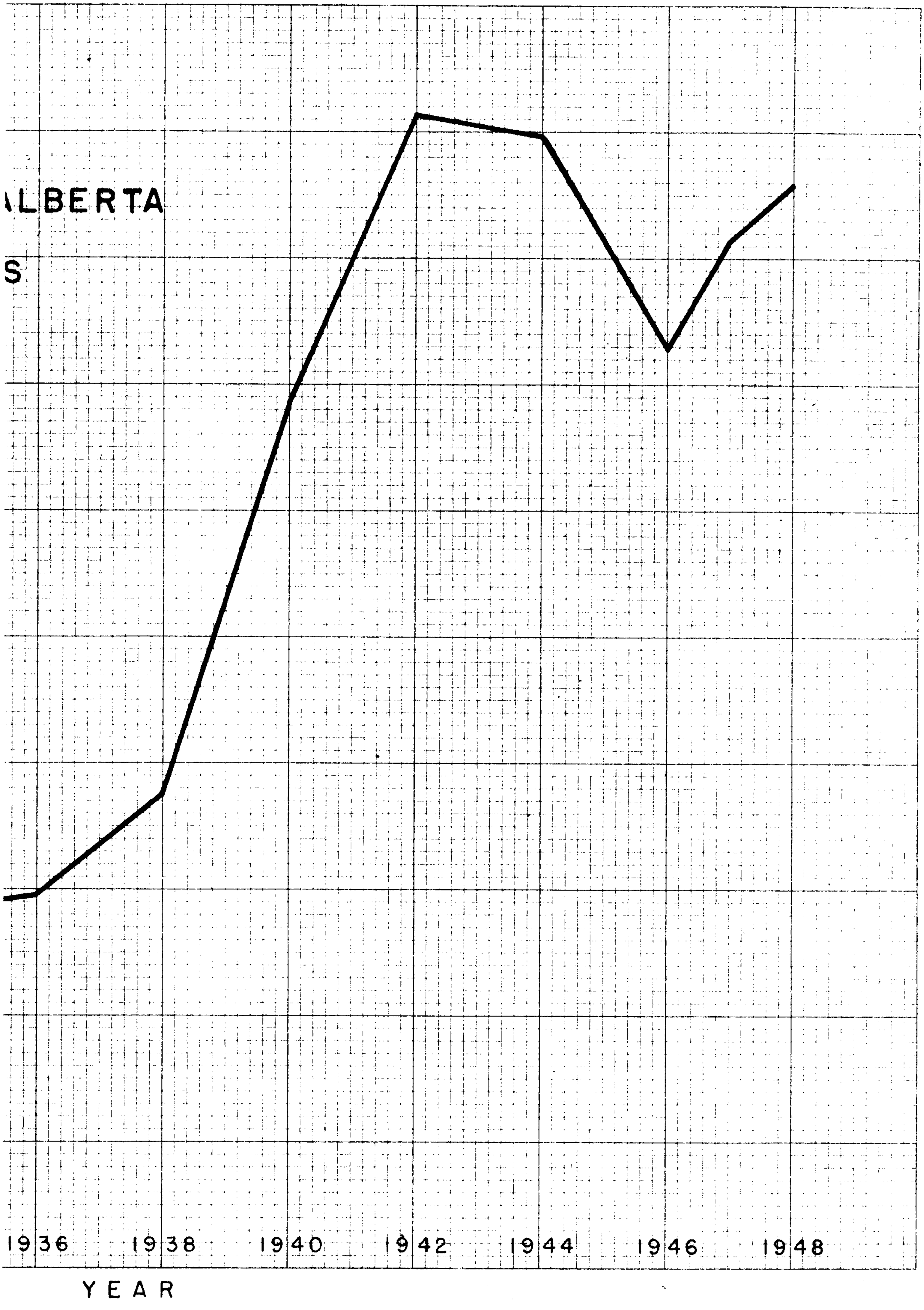
Data are available on the use of natural gas in the manufacturing industries in Alberta up to and including the year 1948.

Figure 4 shows the consumption of natural gas by all manufacturing industries to 1948 inclusive and Figure 5 gives the quantities by groups of industries.

From Figure 5 it is evident that the non-metallic mineral



KEUFFEL & ESSER CO. N. Y. NO. 359-5L
MADE IN U.S.A.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1948
YEAR

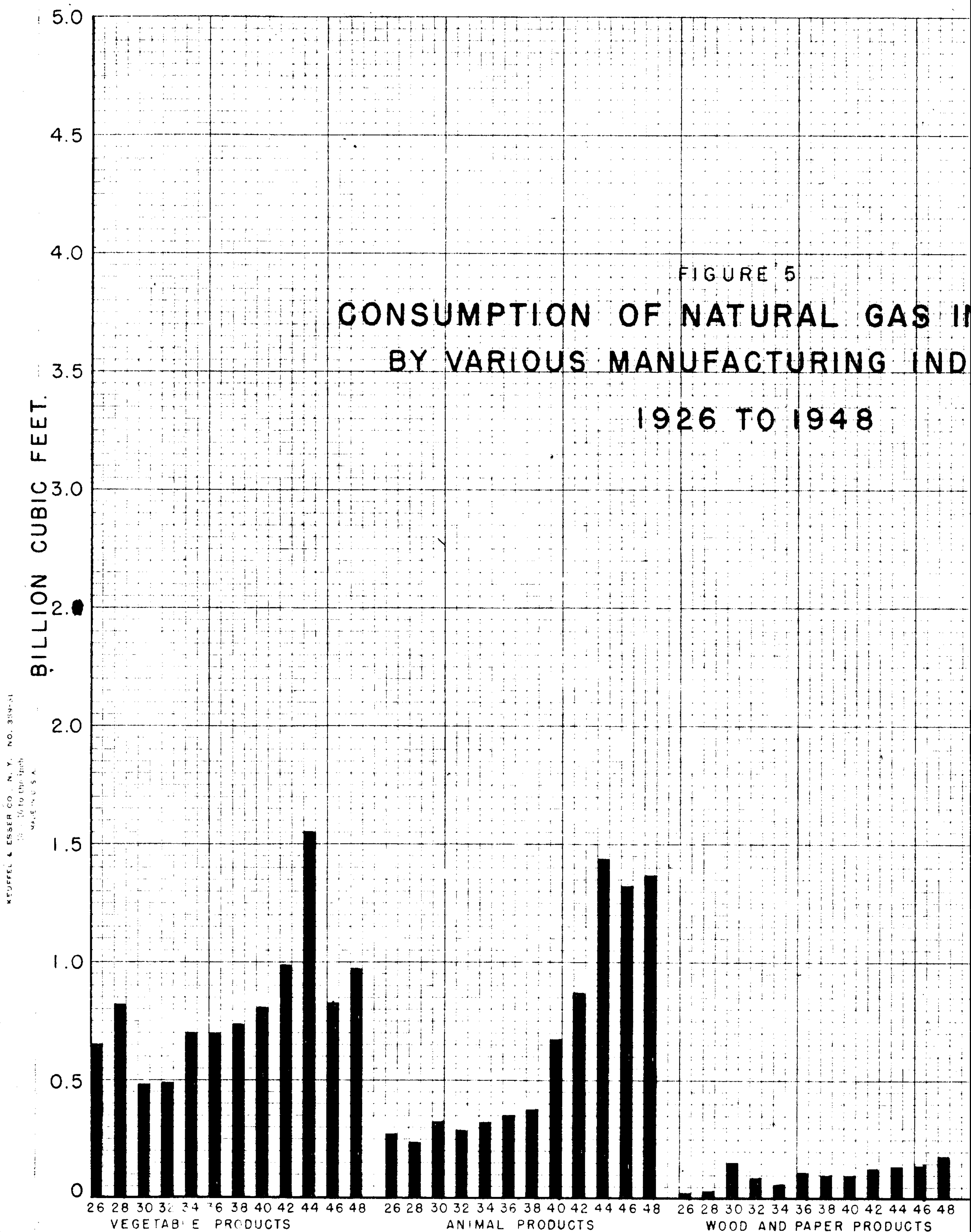
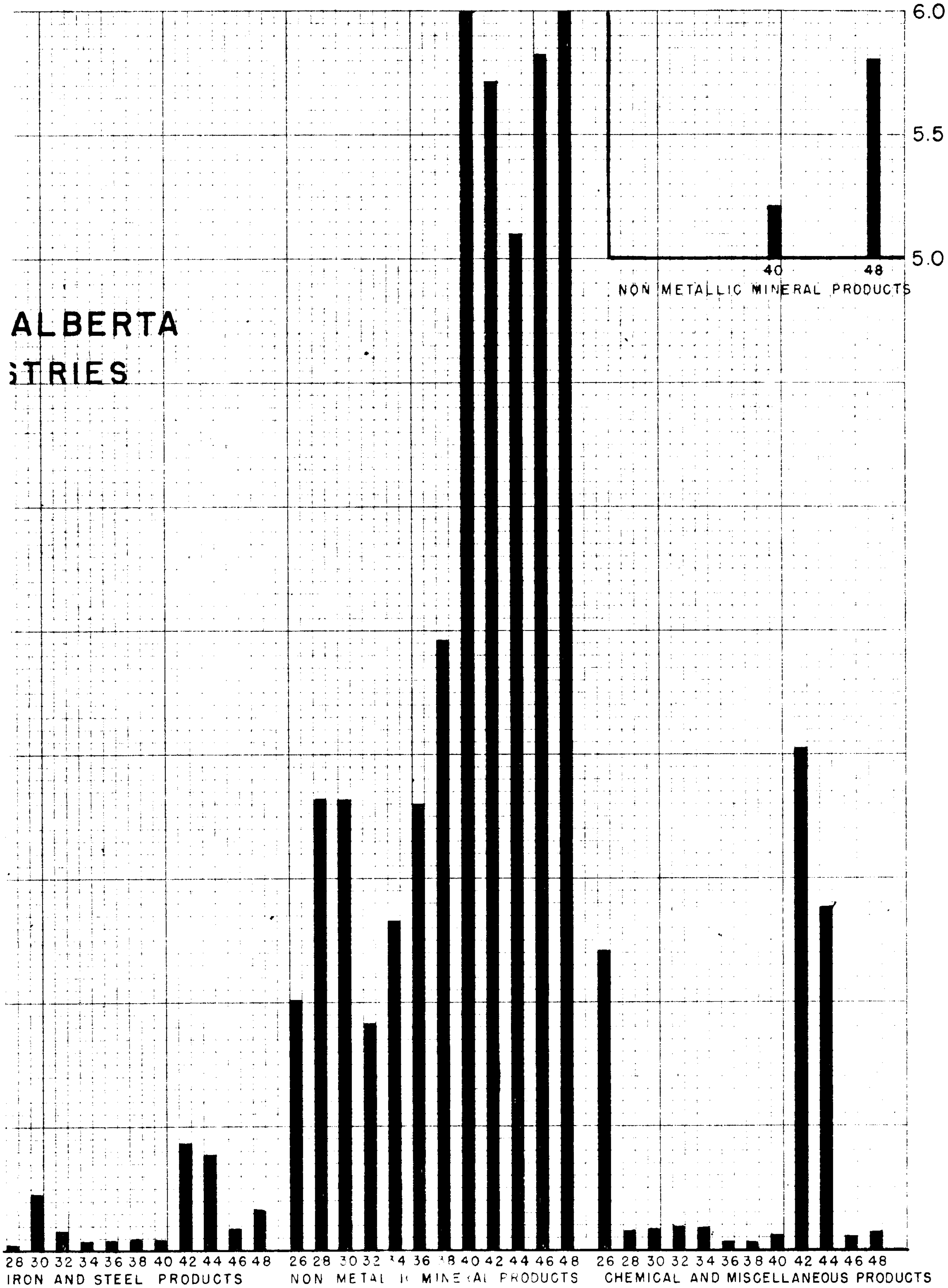


FIGURE 5
CONSUMPTION OF NATURAL GAS I
BY VARIOUS MANUFACTURING IND
1926 TO 1948
BILLION CUBIC FEET.
5.0
4.5
4.0
3.5
3.0
2.0
1.5
1.0
0.5
0
26 28 30 32 34 36 38 40 42 44 46 48
VEGETABLE PRODUCTS
26 28 30 32 34 36 38 40 42 44 46 48
ANIMAL PRODUCTS
26 28 30 32 34 36 38 40 42 44 46 48
WOOD AND PAPER PRODUCTS


ALBERTA
STRIES
6.0
5.5
5.0
40
48
NON METALLIC MINERAL PRODUCTS
28 30 32 34 36 38 40 42 44 46 48
IRON AND STEEL PRODUCTS
26 28 30 32
36
40 42 44 46 48
PRODUCTS
26 28 30 32 34 36 38 40 42 44 46 48
CHEMICAL AND MISCELLANEOUS PRODUCTS

industries are by far the largest users of natural gas. Vegetable and Animal products are in second place using roughly the same amount. With the exception of the ammonia plant of the Consolidated Mining and Smelting Company of Canada at Calgary, Alberta, which uses natural gas as a raw material, the rest of the manufacturing industries of the province use the natural gas as a fuel only. The utilization of natural gas for fuel purposes will be in keeping with the general increase in industrial expansion in future years. In addition, substantial quantities of natural gas are expected to be used as a raw material in the petrochemical industry.

## E. Natural Gas Requirements of Alberta In Relation to Industrial Growth

A study of the production figures of the various industries of the Province of Alberta shows a general increase, especially in the last decade, in virtually all fields of industrial activity. While it is impossible to predict quantitatively the status of industry in the province in future years, expansion in existing industries is expected to continue and, in addition large scale developments in the petrochemical field are certain to come. Elsewhere in this report it has been estimated that the population of this province may be doubled in the next fifty years. As a long term trend the increase in industrial activity should be of the same order as population growth as the two are closely related in that a population is necessary to operate industry and also serves as a major consumer for that industry. Actually, it is anticipated that the rate of industrial expansion in Alberta will exceed that of population growth for the following reasons:

(1) The ever increasing trend towards mechanization of industry will result in a greater output per individual employed.

(2) The province is rich in the raw materials of industry.

(3) As the province becomes more industrialized the ratio of exports to imports will increase.

(4) In the greater population of the Alberta of tomorrow the ratio of the population employed in industry to that engaged in agriculture will increase.

From the foregoing it is suggested that industrial activity in Alberta will be at least doubled and possibly tripled in the next fifty years. As the role of natural gas is intimately related to the future industrial growth of this province it might be reasoned that the consumption of that commodity would also increase in a like proportion. Actually, however, as a natural gas plays an increasingly important part in Alberta's industrialization by its greater use as a chemical raw material in years to come it is anticipated that the amount of natural gas used in this province in the next fifty years will be considerably more than two or three fold, possibly three to four times that used today.