Natural Gas and the Canadian Industrial Sector

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Executive Summary

The industrial sector uses roughly 37% of the total energy used in Canada. Natural gas (NG) is the fuel of choice in this sector and assumes about 51% of the total energy used by industry. NG is also a feedstock to numerous industrial processes; about 4% of the total supply of NG served this end. In recent years, a well-supplied North American market has continued to put downward pressure on NG prices making it an increasingly valuable energy source for industry, as well as the other sectors, in Canada.

The versatility of NG makes it an important fuel for all Canadian sectors – it is, by far, the primary supplier of heat in residential and commercial sectors and is also used in transportation – but about half of the available supply is used in the industrial sector. This report provides data on the relative use and importance of NG in industry. Industries described in more detail include Food and Beverage, Wood Products, Pulp and Paper, Chemical Products, Cement and Lime, and the Primary Metals industries.

Using a simulation model, estimates were obtained on where natural gas is used in Canada. The model could allocate over 2,000 PJ of energy to specific process tasks; the primary uses were steam and other thermal generation (36%), turbines for the production of electricity (24%), direct drive using turbines or internal combustion engines to move, compress, or liquefy NG (15%), and drive chemical reactions to produce cement, lime, alumina, and ammonia (12%).

The chemical products industry is the largest user of NG of the manufacturing industries. They are also the largest consumer of NG as a feedstock. The primary metals industry is the second largest user of NG as an energy carrier, primarily in the production of iron and steel, followed by petroleum refining, and pulp and paper industries. In the mining group industry (outside of oil and gas extraction), potash extraction uses the most natural gas. While these are the biggest users, all industry groups from construction to logging to metal mining use natural gas where it is available.

Two non-industry users of natural gas are also reviewed. Natural gas plays an increasingly important role in the production of electricity, both by utilities and by industry. The range of NG technologies allows it to be used to provide base load electricity as well as meet peak load demand, and it is the typical fuel for combined heat and power systems ( cogeneration).

The second non-industry user of considerable quantities of natural gas is the pipeline component of the transportation sector. About 99% of all NG used in the transport sector is to prepare the NG for shipment and run the compressors that move it down the pipeline. While the pipeline shipments of NG have doubled since 1990, the average distance travelled has declined by 40%. While there was a 32% improvement in intensity (energy per unit moved), the energy used to run pipelines in 2015 was 23% higher than what it was in 1990.

In 2016, the government of Canada established several paths to meet its climate change commitments. Amongst those paths, it defined a carbon price beginning at $10/tonne CO$_2$e for 2018 rising to $50/t by 2022. Users of NG will face the cost of simply releasing CO$_2$ (and CH$_4$) to the atmosphere, as well as the costs passed on by producers due to extraction, preparation,
transportation, venting, and flaring of NG. The manufacturing industry in Canada will face an additional cost of about $0.52/GJ in 2018 with a $10/tCO₂ carbon price, which had this tax been applied at 2015 NG prices, would have increased energy costs by 16%. A $50/tCO₂ carbon price would increase costs by $2.63/GJ, nearly 80% over the cost of the NG fuel. Some sectors can adjust their use of natural gas (and other fuels) relatively quickly in response to market changes and may be able to avoid some of these costs. A $30/tCO₂ price (currently applied in BC and in Alberta in 2018, but about 50% higher than current Québec auction price), would create an average 8.2% increase of total energy and water costs for Canadian manufacturing industries; however, several industry groups could face much higher and lower costs.¹ In particular, furniture manufacturing (NAICS 337), chemical manufacturing (NAICS 325), and petroleum and coal product manufacturing (NAICS 324) could each see double digit increases to fuel costs, unless carbon price exemptions are provided.

¹ Expenditures are only provided for the combined spending on energy and water. CANSIM Table 301-0008.
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Natural Gas and the Canadian Industrial Sector

1 Introduction: Natural Gas as an Energy Carrier and Feedstock Source

Energy is needed in all facets of society and industry is no exception, using roughly 37% of all energy consumed in Canada by the various sectors (residential, commercial, energy transformation, transportation and agriculture, Fig. 1.1).²,³

Figure 1.1: Energy use in Canadian economic sectors, 2015

- Total Energy Available = 11,924 PJ
- Industry 39%
- Mines 37%
- Manuf. 61%
- Other Ind. 2%
- Trans. 23%
- Elec. Prod. 11%
- Agric. 2%
- Res. 12%
- Com. 9%
- Other 6%

Note: Total Available = sum of all sectors; "Other" includes energy used to transform one energy carrier to another (e.g., generation of steam for sale) as well as statistical differences and other adjustments; "Other Ind." includes construction, forestry, and logging.
Source: Statistics Canada, CANSIM Table 128-0016

Energy is provided to industry though several different carriers – coal, electricity, various refined oil products, and biomass – but the largest direct carrier of energy in industry today is natural gas (NG). In manufacturing industries, it has increased its market share since 2005 and exceeded electricity as the primary driver of activity in 2011.⁴

Structurally the simplest of all fossil fuels, its chemical nature makes NG useful as a feedstock in the production of methanol, plastics, fertilizer (ammonia and ammonia products), hydrogen to refine crude oil products, gasoline additives, and many other commodities.⁵ When NG is

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² Industry includes mining, construction, fishing, logging and forestry, and the set of manufacturing industries. In this report, we address the use of natural gas in the food and beverage, wood products, pulp and paper, chemical products, cement and lime, and metals industries.
³ Energy transformation includes the production of electricity from other fuels, the production of steam for sale, the production of coke and coke oven gas from coal, and any other processes where energy carriers are converted from one form to another.
⁴ Fuels are typically defined as materials that release energy as a result of chemical reactions, i.e., combustion. More recently the concept has been expanded to include materials that generate nuclear energy. Electricity, while an energy carrier, is not considered a fuel.
⁵ Natural gas consists primarily of methane, CH₄, and has the highest hydrogen to carbon ratio of all fossil fuels.
extracted, it is often accompanied by other, more complex organic compounds such as ethane, propane, and butane that can be stripped out of the NG and used as fuels or as feedstocks to many other products, particularly polymers used in the formation of plastics.

### 1.1 Energy Carriers

Because of the high hydrogen to carbon ratio, NG releases more energy per unit weight than any other fossil fuel. As a gas, it is easily compressed and can be readily shipped via pipelines. It can also be converted to a liquid by refrigerating the gas to -162°C (-260°F) at near atmospheric pressure to produce liquefied natural gas (LNG), reducing its volume by 600 times. While it is cheaper and easier to transport NG by pipeline, transporting LNG can be economical if pipelines cannot be built or aren't available.

As noted, NG dominates as the fuel of choice in Canadian industry. Fig. 1.2 provides an indication of its prevalence, comparing it to other energy carriers like oil products, biomass such as wood and spent pulping liquor, coal and coal-based fuels.

**Figure 1.2: Use of natural gas compared to other energy carriers in Canadian industry, 2015**

![Pie chart showing energy use breakdown]

**Total Energy Use = 4,223 PJ**

- **NG 50%**
- **Biomass 12%**
- **RPP 19%**
- **Elec. 17%**
- **Coal Products 0%**
- **Gas Plant NGLs 1%**

Note: NG includes that used by the producer as well as industry for energy; see Fig. 1.3 for disaggregation. Non-energy use is NOT included. Coal products include coal, coke, and coke oven gas. RPP = refined petroleum products.

Source: Statistics Canada, CANSIM Table 128-0016

### 1.2 Non-energy Use of Natural Gas

Natural gas is used as a feedstock in numerous chemical processes. In many cases, the methane enters steam reformers where methane and water (steam) break down into their component elements: hydrogen, oxygen, and carbon. These can be recombined in a number of different

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6 Natural gas is lighter than air and dissipates in the event of a leak. While there are atmospheric impacts (methane is a powerful greenhouse gas, 25 times that of CO₂), there is little or no ground-based pollution.
ways to produce various products for use as fuels and fuel additives, processing crude oil, solvents, precursors to other products (e.g. formaldehyde and dimethyl ether), and ammonia for use in nitrogen fertilizers.

The use of NG as a feedstock has generally diminished from highs of around 8% of the net supply of NG between 1996 and 2000 to lows of 4%-5% since 2008. There is significant fluctuation over the period; for example, in 1999, we saw a peak use of 258 PJ of NG used as feedstock while three years later, it dropped to 147 PJ and has fluctuated over the period since that time. In 2015, the amount used was 14% lower than in 1990, about 136 PJ.

**Figure 1.3: Natural gas non-energy use in Canadian Industry, 2015**

The bulk of this report focuses on NG as an energy carrier.

### 1.3 Natural Gas Price

To understand industry use of NG, an appreciation of the prices associated with NG is valuable. Natural gas is sold based on unit energy ($/GJ) or unit volume ($/1000 m$^3$).

In recent years a well-supplied North American market has continued to put downward pressure on NG prices (see Table 1.1 for resource to production ratios). In addition, the emergence of significant U.S. exports into the major northeastern market has pushed NG back into Canada and further enhanced NG’s domestic cost advantage. This advantage has made NG an increasingly valuable energy source for industry in Canada and indeed North America. At the current rate of production, the identified Canadian resource base could supply NG for close to the next 190 years. In terms of its availability (i.e., for direct Canadian use), the resource could last nearly 300 years.

The National Energy Board records prices of exported NG at more than 7 Canada / US ports. See Fig. 1.4 for average commodity prices since 2000. These prices are illustrative of commodity prices faced by industry.
Table 1.1: Comparison of production and availability (2015) with the natural gas resource

<table>
<thead>
<tr>
<th>Quantity (Bcf/yr)</th>
<th>Resource (Tcf)</th>
<th>Years (Resource to Production ratio)</th>
<th>Years at 2% annual growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production</td>
<td>5.83</td>
<td>1,230</td>
<td>211</td>
</tr>
<tr>
<td>Availability</td>
<td>3.74</td>
<td>329</td>
<td>102</td>
</tr>
</tbody>
</table>

Availability = Production - exports + imports (with other minor adjustments)

Source: Statistics Canada, CANSIM Table 128-0016; NEB Canada’s Energy Future, 2016

Figure 1.4: Natural Gas Exports, Volumes, and Prices, Canada


1.4 Impact of a Carbon Price on Natural Gas Costs to Industry

In 2016, the government of Canada established several paths to meet its climate change commitments. Amongst those paths, it defined a carbon price beginning at $10/tonne CO\(_2\)e for 2018 rising to $50/t by 2022. As a carbon-based fossil fuel, the use of natural gas would incur costs associated with this carbon price.

There are two components to the cost of carbon that users of NG will face. The first is simply the cost of releasing CO\(_2\) (and CH\(_4\)) to the atmosphere. While there is some variation by region of the amount of CO\(_2\)e released upon combustion, the differences are small (we used 1.89 tCO\(_2\)/’000 m\(^3\)). The CO\(_2\)e value is increased slightly by using Environment and Climate Change Canada (ECCC) estimates of CH\(_4\) and N\(_2\)O from its National Inventory Report (2016).

The second is associated with CO\(_2\)e costs the NG producer faces in the extraction, preparation, and transportation of NG and the venting and flaring associated with NG production. The amount of carbon released per m\(^3\) varies year to year but details for any particular year are available from ECCC in the Common Report Format tables associated with their NIR as...
submitted to the United Nations Framework Convention on Climate Change. Using data related to 2015, Table 1.2 provides some information regarding this cost, given that NG producers pass their costs on to consumers.

### Table 1.2: Average Cost to Industry per $1/tCO₂ at 2015 NG prices

<table>
<thead>
<tr>
<th></th>
<th>CO₂ cost of combustion</th>
<th>CO₂ cost of production</th>
<th>Total CO₂ cost</th>
<th>Additional cost relative to price of NG</th>
</tr>
</thead>
<tbody>
<tr>
<td>$/’000 m³</td>
<td>$1.90</td>
<td>$0.136</td>
<td>$2.04</td>
<td>1.58%</td>
</tr>
<tr>
<td>$/GJ</td>
<td>$0.049</td>
<td>$0.004</td>
<td>$0.052</td>
<td>1.58%</td>
</tr>
</tbody>
</table>


Because the carbon content of NG is relatively uniform across the industrialized region of Canada, carbon costs associated with NG remain relatively consistent. Table 1.2 suggests that industry will face an additional cost of about $0.52/GJ in 2018 with a $10/tCO₂ carbon price. Had this tax been applied at 2015 NG prices, this would have increased energy costs by 16%. A $50/tCO₂ carbon price would increase costs by $2.63/GJ, nearly 80% over the cost of NG alone.

To have a sense of the carbon price impacts by manufacturing sector, we can look at the expenses for energy (and water), natural gas use combined with a carbon price, and percent increase to fuel/water expenditures. Given that some sectors are able to adjust their use of natural gas (and other fuels) relatively quickly in response to market changes, it makes sense to compare recent NG usage with a carbon price currently applied in at least some jurisdictions in Canada. Table 1.3 looks at the effects of a $30/tCO₂ price applied to the Canadian total for most of the major industry groups. $30/tCO₂ is the current price in BC and will be applied in Alberta in 2018. This is somewhat higher than the projected prices for Ontario and Quebec, which are estimated to be about $19.40/tCO₂ by 2020; however, given the price uncertainty of their cap-and-trade systems, a higher price is possible. While the average impact to manufacturing industries is an 8.2% increase in costs, several industry groups could face much higher and lower costs. In particular, furniture manufacturing (NAICS 337), chemical manufacturing (NAICS 325), and petroleum and coal product manufacturing (NAICS 324) could each see double digit increases to fuel costs, unless carbon price exemptions are provided.

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7 Figure 1.4 indicates that the average cost of NG in 2016 declined to $2.71 (about 18% less than 2015). In this case, a $10/tCO₂ carbon price would increase energy costs by nearly 20%.
8 Expenditures are now only provided for the combined spending on energy and water. CANSIM Table 301-0008.
Table 1.3: Cost to Industry Sectors at $30/tCO₂ based on 2015 energy and water costs and 2015/2013 natural gas usage

<table>
<thead>
<tr>
<th>Sector</th>
<th>Energy &amp; Water cost ($M)</th>
<th>Natural Gas usage (TJ)</th>
<th>Carbon price cost ($M)</th>
<th>Percent increase (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturing [31-33]</td>
<td>13,068</td>
<td>680,061</td>
<td>1,071</td>
<td>8.2%</td>
</tr>
<tr>
<td>Food manufacturing [311]</td>
<td>1,522</td>
<td>74,064</td>
<td>117</td>
<td>7.7%</td>
</tr>
<tr>
<td>Beverage and tobacco product manufacturing [312]</td>
<td>190</td>
<td>6,952</td>
<td>11</td>
<td>5.8%</td>
</tr>
<tr>
<td>Textile mills [313]</td>
<td>40</td>
<td>2,302</td>
<td>4</td>
<td>9.1%</td>
</tr>
<tr>
<td>Clothing manufacturing [315]</td>
<td>18</td>
<td>756</td>
<td>1</td>
<td>6.5%</td>
</tr>
<tr>
<td>Leather and allied product manufacturing [316]</td>
<td>6</td>
<td>112</td>
<td>0</td>
<td>3.0%</td>
</tr>
<tr>
<td>Wood product manufacturing [321]</td>
<td>774</td>
<td>26,829</td>
<td>42</td>
<td>5.5%</td>
</tr>
<tr>
<td>Paper manufacturing [322]</td>
<td>2,192</td>
<td>72,080</td>
<td>114</td>
<td>5.2%</td>
</tr>
<tr>
<td>Printing and related support activities [323]</td>
<td>143</td>
<td>2,375</td>
<td>4</td>
<td>2.6%</td>
</tr>
<tr>
<td>Petroleum and coal product manufacturing [324]</td>
<td>850</td>
<td>69,927</td>
<td>110</td>
<td>13.0%</td>
</tr>
<tr>
<td>Chemical manufacturing [325]</td>
<td>1,950</td>
<td>208,096</td>
<td>328</td>
<td>16.8%</td>
</tr>
<tr>
<td>Non-metallic mineral product manufacturing [327]</td>
<td>809</td>
<td>38,070</td>
<td>60</td>
<td>7.4%</td>
</tr>
<tr>
<td>Primary metal manufacturing [331]</td>
<td>1,917</td>
<td>111,364</td>
<td>175</td>
<td>9.2%</td>
</tr>
<tr>
<td>Fabricated metal product manufacturing [332]</td>
<td>497</td>
<td>23,672</td>
<td>37</td>
<td>7.5%</td>
</tr>
<tr>
<td>Machinery manufacturing [333]</td>
<td>297</td>
<td>11,015</td>
<td>17</td>
<td>5.8%</td>
</tr>
<tr>
<td>Computer and electronic product manufacturing [334]</td>
<td>100</td>
<td>1,753</td>
<td>3</td>
<td>2.8%</td>
</tr>
<tr>
<td>Electrical equipment, appliance and component manufacturing [335]</td>
<td>77</td>
<td>4,564</td>
<td>7</td>
<td>9.3%</td>
</tr>
<tr>
<td>Transportation equipment manufacturing [336]</td>
<td>778</td>
<td>2,811</td>
<td>4</td>
<td>0.6%</td>
</tr>
<tr>
<td>Furniture and related product manufacturing [337]</td>
<td>142</td>
<td>22,089</td>
<td>35</td>
<td>24.5%</td>
</tr>
<tr>
<td>Miscellaneous manufacturing [339]</td>
<td>97</td>
<td>11,102</td>
<td>17</td>
<td>18.0%</td>
</tr>
</tbody>
</table>

Note: Values shown in red are for 2013 since that is the most recent year that data are available for these sectors. Source: Statistics Canada, CANSIM Tables 301-0008, 128-0006, and 128-0016

2 Role of Natural Gas in Industry and Other Sectors

All economic sectors in Canada use NG and in the industrial sector, all the various sub-industry groups also use NG to provide energy.10 Regionally, this is not the case because there are parts of Canada where NG is less readily accessible (e.g., the Atlantic provinces, particularly Prince Edward Island and Newfoundland and Labrador).

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10 All industry groups show values for natural gas use except for Forestry and Logging; these data are listed as not available.
2.1 Comparison of Sectors

The versatility of NG makes it an important fuel for more than just the industrial sector. It is, by far, the primary supplier of heat in residential and commercial sectors. It is also used in the transportation sector, although demand there is modest. The largest growth is seen in the use of natural gas in the production of electricity by both utilities and industries (including cogeneration). Fig. 2.1 compares NG use by sector.

**Figure 2.1: Natural gas use by sector, 2015**

![Natural gas use by sector, 2015](chart)

Note: Highlighted sectors (Industry, Transportation, and Electricity production) are further explored in this report. "Other" includes production of steam and other uses not attributable to a sector.

Source: Statistics Canada, CANSIM Table 128-0016

2.2 What Industries are Included?

While all industries use NG in their respective activities, this report focuses on the primary users of the fuel which include mining activities (particularly potash) and manufacturing industries comprising the bulk of the industrial sector. Table 5.1 in the Appendix provides an indication of the relative use and importance of NG in the industry set. Industries described in more detail in this report include Food and Beverage, Wood Products, Pulp and Paper, Chemical Products, Cement and Lime, and the Primary Metals industries. This report also examines NG used by pipelines and electricity generation which, while not part of the industrial sector as such, consume large quantities of NG. Production, NG intensities, and employment in these industries are compared in Table 5.2 in the Appendix.

2.3 Typical Uses of Natural Gas as a Fuel

While industries vary in how the fuel is used, industrial use centres on the combustion of NG to provide heat to a process. Technologies to accomplish this are as simple as NG burners and steam boiler systems or as complex as infrared devices that transmit heat by electromagnetic radiation and gas turbines that convert rapidly expanding gases into usable forms of mechanical energy that run compressors or electricity generators.
Processes, of course, vary considerably. While most processes require heat in one way or another, the disaggregation in Fig. 2.2 provides some picture of how heat was used. Turbines, for example, use the heat to generate electricity.

**Figure 2.2: Natural gas use by process, 2010**

![Natural gas use by process, 2010](image)

Source: Analysis in CIMS model.\(^{11}\)

In many industries, NG provides both heat and electricity using combined heat and power technologies (CHP or cogeneration). Industries like cement, lime, aluminium, and chemicals use the heat to drive chemical reactions that will produce their end products (cement and lime, alumina, ammonia, for example). Heat in direct drive technologies uses turbines or internal combustion engines to move NG down pipelines or run compressors to chill NG to remove natural gas liquids or compress the gas. Often, the heat from combustion is simply used to drive off water as in the drying of paper products. In chemical and refining industries, the heat can be used to separate components of a mixture through distillation. The remainder of this report describes how each industry uses NG energy.

### 3 Primary Users and Uses of Natural Gas by Industry

As noted earlier, all industries can utilize NG to drive their activities. Variation in the importance of NG depends on the industry process and the region.\(^{12}\) In this section, we focus on the major users of NG (see Table 5.1 in the Appendix) and describe the relative importance of NG in their activity (in GDP and physical production, if the latter are available) including how the NG is used. Comparisons of the various industries in terms of their relative intensities, employment, and size are found in Table 5.2 in the Appendix.

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\(^{11}\) CIMS is an in-house simulation model that assesses technology evolution over time. Fuel use in this model can be disaggregated by industry, region, or process for a limited set of the industrial sector. It is not always simple to disaggregate the data in this way; these values should be considered as indicative.

\(^{12}\) In general, natural gas can be used in any industry where other fossil fuels are currently used; the 'region' restriction mentioned here reflects availability.
3.1 Mining, Potash Mines (NAICS 212396)

The Minerals Division of Natural Resources Canada gathers data through Statistics Canada surveys on all mining except upstream oil and gas. In this part of the mining sector, electricity is the primary energy carrier at around 37% of all energy used. The primary fossil fuel is diesel (30% share), used in the extraction and transport of ores and other mine output. The exception is potash mining: of the ±14 mining sub-groups (iron, salt, copper mining, etc.), potash mining accounted for 76% of the NG used in the industry in 2015 (recall that mining here does not including upstream oil and gas). About 70% - 75% of the energy used in potash mining comes from NG in any given year with most of the remainder coming from electricity (Fig. 3.1).

Canada has about 46% of global potash reserves, most of it in the Prairie Evaporite Deposit under Alberta, Saskatchewan, and Manitoba. The industry exports about $6.7 billion of potash per year. This is about 32% of global production; Canada is the world’s largest producer and exporter of potash. The industry employs about 5,000 people in Canada and generated $1.24 billion (2007$) in GDP in 2014.\(^{13,14}\)

Potash, a potassium salt mined primarily in southern Saskatchewan, is extracted by direct conventional mining (80%) or by solution mining (20%), a process unique to potash mining.\(^{15}\) To better dissolve the potassium salts, the water is heated using NG. While this process is about three times more energy intense than conventional mining, it involves lower capital expenditures, requires less labour, and has a higher extraction ratio than conventional mining.

Figure 3.1: Natural gas in the Potash Mining industry, 2015

Other = middle distillates and propane
Source: NRCan, Annual Census of Mines

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\(^{14}\) Statistics Canada, CANSIM Table 379-0031

\(^{15}\) There is potash potential in both Alberta and Manitoba. The potash mining facility near Sussex, NB, closed in 2015.
Like most minerals extracted from their ores, potash is isolated from the other components of the ore using flotation techniques to separate potash from the salt and clay. This leaves the potash in need of drying, another process requiring heat from NG. On average over the last few years, the industry consumed 2.3 GJ of NG for each tonne of potash. In terms of value added, they utilized 20.0 GJ/$1000 GDP.

### 3.2 Food (NAICS 311) and Beverage (NAICS 312)

More than 10% of all NG consumed by the Canadian manufacturing industry is used to prepare foods for distribution. Heat is required for many processes in the industry to ensure that food products and beverages are safe for consumption. This includes pasteurization, sterilization (reusable containers, ensuring processing facilities are clean, etc.), drying and curing, baking, canning, and pre-cooking. Prior to 2005, NG provided 65%-70% of the energy used in food and beverage processing. Since then it has dropped marginally, even though the amount of NG hasn't diminished; electricity market shares have increased, covering growth in the industry (Fig. 3.2).

One third of all food processing facilities are in Ontario and they account for over 41% of GDP contribution of food manufacturing to the Canada's GDP. Another quarter of the enterprises are found in Québec who collectively contribute another 24% of GDP. These two provinces, as well as BC (at 16% of firms and 8% of GDP) and Alberta (at 8% of firms and 10% of GDP), account for about 85% of the firms and GDP in the food processing industry. Overall, the industry employs about 260,000 people in over 8,800 operations.

**Figure 3.2: Energy carriers in the food and beverage industries, 2015**

![Energy carriers in the food and beverage industries, 2015](image)

Note: Contains estimates of data considered confidential by Statistics Canada. "Other" includes heavy fuel oil, middle distillates, propane, wood waste, and steam.

Source: Statistics Canada, CANSIM Table 128-0006

The Beverage industry is located primarily in Ontario (40% of firms and 47% of industry's GDP) and BC (30%, GDP contribution not available) with Québec claiming 14% of firms and over 30%
of GDP of the industry; the three provinces account for nearly 85% of the industry's activities. They employ over 30,000 people in Canada.

These two industry groups account for about 16% of manufacturing industry value added (GDP). They use about 2.7 GJ of natural gas to generate $1,000 of GDP.

### 3.3 Wood Products (NAICS 321)

Three provinces account for the bulk of wood products firms and production; Québec and Ontario each have about 28% of all firms and generate about 27% and 13% respectively of the total wood products GDP to Canada. BC accounts for another 23% of all firms and add another 37% to wood products GDP. In aggregate, this amounts to nearly 80% of all firms and total GDP. Industry employment has been dropping at over 5% per year since 2000 and, in 2015, was at about 96,000 people. The industry is working hard to broaden the scope of its products including bio-energy, bio-chemical and bio-material products that will be important to the chemical, energy, pharmaceutical, auto, aerospace and plastics industries.

Wood products industries account for about 5% of total manufacturing contribution to GDP. The industry uses about 2.9 GJ of natural gas to produce $1,000 GDP.

Before finished wood products are shipped to market, the product may need to be cured (e.g., setting glues in laminated beams or plywood) and/or have moisture removed. The primary energy source for the heat to cure and dry is wood waste, followed by electricity and NG (Fig. 3.3). The energy share of wood waste is increasing as wood burning technologies improve and as restrictions on waste disposal become more stringent. Electricity, the other primary energy carrier in the industry, is used to provide mechanical power to manufacture wood products from raw logs and generally does not compete for the services provided by wood waste and NG.

**Figure 3.3: Energy carriers in the wood products industries, 2015**
Note: This chart contains estimates of data considered confidential by Statistics Canada. "Other" includes heavy fuel oil, middle distillates, butane, propane, and steam.
Source: Statistics Canada, CANSIM Table 128-0006

Process technology using NG can be as simple as direct heat input to kilns using fans, or more complicated with the use of infrared drying technologies, which tend to be more efficient. Steam boilers can also provide heat, through heat exchangers, to dry the wood products or cure the value added wood products like laminated beams, plywood, strandboard, and particle board.

3.4 Pulp and Paper (NAICS 3221)

The pulp and paper industry uses more energy than any other industrial group in Canada with almost 60% of the energy coming from biomass sources (wood waste and spent pulping liquor, Fig. 3.4). In spite of this large proportion, it still uses over 10% of all NG used by manufacturing industries in Canada.

Pulp can be processed from wood in a number of ways, some of which demand a lot of input heat. For example, the generation of kraft pulp, used in the production of cardboard, tissue paper, writing paper, and coated paper (for magazines and catalogues), requires heat for the "digestion" of the wood pulp to remove lignin, the binding agent that holds the cellulose together in wood. The cellulose and lignin are separated; the cellulose goes on to form the paper and the lignin is trapped in the digestion liquid called "spent pulping liquor". This is burned to use the contained energy, recycle the digestion chemicals, and continue the process. The cellulose pulp can then be sold as market pulp or can be converted to the variety of paper products mentioned above; in every case, the pulp or paper product must be dried. Many pulp mills can actually derive all their energy needs from the bio-material that comes in the plants but, in many cases, this material is supplemented by alternative energy sources such as NG.

Figure 3.4: Energy carriers in the pulp and paper industries, 2015
The process to make pulp and paper is much more energy intense than to generate wood products (the other major forest sector manufacturing industry). As in wood products, biomass is the primary provider of heat energy in this sector; NG plays a distant second (Fig. 3.4). Even so, the amount of NG used per unit of GDP is about four times higher than that seen in the wood products sector at 10.3 GJ / $1,000 GDP. Pulp and paper's contribution to Manufacturing GDP is just over 4%.

Most of the industry firms are found in Ontario (46%) and Québec (30%); they generate about 35% and 39% of Pulp and Paper GDP respectively. BC accounts for another 11% of pulp and paper operations generating another 18% of the GDP. In 2015, about 54,000 people worked in the industry; like the wood products industry, the number employed has been dropping since 2004 at a rate of 2%-6% per year.

3.5 Petroleum Refining (NAICS 32411)

Converting crude oil into useful refined products requires a lot of energy. Processing and refining crude generates quite a number of different products, some of which are simply separated by distillation and some of which require further processing; coking, catalytic cracking, and alkylation help to convert less valuable products into more valuable ones. Even so, there are end products that are less useful or salable and are typically used to run the refinery (Fig. 3.5).\(^\text{16}\) NG supplements processes by providing direct heat (e.g., distillation of crude) or serving as a source of hydrogen to produce lighter carbon chains (like those in gasoline) out of longer, heavier carbon chains. NG is also used to ensure the proper disposal of off-gases, acting as a "pilot light" to ensure their proper ignition.

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\(^{16}\) When crude oil is distilled, light gases like methane and ethane are driven off and used to run the refinery; these are collectively called Refinery Fuel Gases (RFG). When heavier oil products like heavy fuel oil are broken up through the coking or catalytic cracking process, they also generate some RFG as well as very heavy end products like petroleum coke. These fuels have low market value and are used to run the refinery. Roughly about 7% of the incoming crude is used to run the refinery and is supplemented by natural gas and purchased electricity.
In Canada, refinery processing capacity is concentrated in Alberta and southern Ontario. In terms of number of facilities directly associated with this sector (i.e., includes more than just refineries, but excludes exploration and extraction industries including oil sand operations, which is considered part of the mining sector), 52% are found in Alberta, generating 20% of the GDP associated with petroleum refining, 14% are found in Ontario where another 29% of the GDP is generated, 12% in BC (no GDP value available), and 10% in Québec producing a further 16% of the GDP. The industry, overall, represents over 3% of the GDP generated in the Manufacturing Industry sector in Canada. It employs about 6,800 people.

### 3.6 Chemical Products (NAICS 325)

In Canada’s Chemistry Industry, NG is often used as a feedstock, providing natural gas liquids (NGLs; primarily ethane, propane, and butane) and a ready source of hydrogen by "reforming" methane. The NGLs are used as feedstocks in polymerization reactions to produce plastics like polyesters (fibers and textiles), polyethylene (plastic bottles, supermarket bags), polypropylene (bottle caps, yogurt containers, appliance parts), polystyrene (packaging foam, plastic tableware, CD cases), and polycarbonates (eyeglasses, security windows, traffic lights).

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17 Natural gas, when extracted, contains primarily methane but is often accompanied by a number of hydrocarbon gases like ethane, propane, butane, and pentane, usually in increasingly smaller amounts. While there is no real need to remove these gases from the natural gas stream, these other gases are often economically more valuable as a feedstock than as a fuel. Therefore, they are often "stripped" out of the natural gas stream to provide almost pure methane. Other gases, including CO$_2$ and H$_2$S (hydrogen sulfide, a very poisonous gas) are also stripped out of the natural gas stream.
Figure 3.6: Energy carriers in the chemical products industry, 2015

Notes: This chart contains estimates of data considered confidential by Statistics Canada. Feedstocks of natural gas or natural gas liquids are NOT included in this graph. Steam is purchased; the type or quantity of energy used to make it is not known. ”Other” includes heavy fuel oil, middle distillates, butane, propane, petroleum coke, coal, and wood waste.
Source: Statistics Canada, CANSIM Table 128-0006

Steam reformers subject methane in the presence of water vapour (steam) and a suitable catalyst to high temperatures to release hydrogen. The reactive by-products of this process can be used directly in fuel cells or used to make other compounds like methanol and ammonia. The process of steam reforming requires temperatures of 700 - 1,100°C; since NG is already available as a feedstock, it is also used to provide the heat to allow steam reforming to occur. Because NG serves a dual purpose for many of the industries in this group, it has the greatest share of all energy carriers; on average, 68% of energy needs in the industry are met by NG (Fig. 3.6). As a result, it has one of the highest NG intensities of all the manufacturing sectors; it used just over 15.1 GJ / $1,000 GDP

The chemical products industry accounts for nearly 7.5% of Manufacturing GDP in Canada and employ about 86,000 people. About 41% of all firms associated with the chemistry industry are in Ontario. They generated about 48% of the GDP of this industry. Québec also has a large representation in this sector, with nearly 27% of the industry's firms found there, producing about 24% of the industry's GDP. The bulk of the remaining firms are found in Alberta (11%) and BC (12%); their contributions to industry GDP are 16% and 4.5%, respectively.

Much of the energy data associated with the various industry groups found in the chemistry products sector, including data on NG use, are deemed confidential by Statistics Canada. But the importance of NG to this group of industries, and how it is used there, is further explored below.
3.6.1 Organic and Inorganic Chemical Products (NAICS 3251)
Outside of its use as a feedstock, NG provides energy to drive chemical reactions (e.g., cracking – splitting longer organic compounds into shorter ones), separate products from these reactions through distillation, and drying or crystallizing end products. The organic compounds produced tend to be short chain compounds that are often used in other parts of the industry to make more complex materials.

This group of industries also uses heat energy from NG to make alkali materials (caustic soda for pulp production, baking soda), hydrogen peroxide (bleaching agent and disinfectant), chlorine (bleach), many types of acids (sulfuric acid for fertilizers and car batteries, hydrochloric acid used in metal production, textiles, and dyes), and other inorganic compounds. While electrolytic processes generate these and many of the other inorganic chemical agents in this industry group, the medium in which the electrolytic reactions occur generally needs to be at a higher than ambient temperature, which requires a source of heat provided by NG.

This extremely diverse group of industries generates about 20% of the GDP in the Chemistry Industry sector, a contribution exceeded only by the pharmaceutical industry. About 37% of this is generated in Alberta where there are some very large organic chemical facilities. A further 30% is generated in Ontario and 23% in Québec.

3.6.2 Resin, Synthetic Rubber, Artificial and Synthetic Fibres and Filaments (NAICS 3252)
Many of the simpler compounds from the organic chemical products industries (NAICS 3251) are used in this group to generate the plastics, resins, and rubber products that we find commonly in our economy (foam rubber, styrofoam, melamine, many types of man-made fibres, yarns and clothing materials, and cellophane). Once again, the primary role of NG in the production of these goods is to provide a heated environment to form, cure, or set the materials into their final product.

Most of the firms associated with this industry are found in Ontario (43%) and Québec (34%). GDP data on this industry are, by and large, considered confidential. The largest firms in this group are located in Alberta which, while it has only around 11% of the facilities, generates 33% of the industry's GDP. Even though Québec has more facilities than Alberta, it generates less than 5% of the total GDP in NAICS 3252.

3.6.3 Pesticide, Fertilizer and Other Agricultural Chemicals (NAICS 3253)
The primary use of NG in this industry is for the production of ammonia used to make a number of different nitrogen-bearing fertilizers. The process involves the use of a steam reformer mentioned above to release methane's hydrogen. The hydrogen is then allowed to react with nitrogen to form ammonia (NH₃). The ammonia can be used directly as a fertilizer or, because it is a harmful gas that requires careful handling, can be altered to form other easier-to-handle fertilizers like urea, ammonium nitrate, ammonium phosphate, and others.

Even though Alberta has only 11% of firms associated with fertilizer and other agricultural chemical production, it accounts for 38% of the GDP in this group. We find some large establishments in this province that use the NG to generate ammonia and ammonia-based
compounds.\textsuperscript{18} The bulk of the firms are found in Québec (29\%) and Ontario (27\%); GDP data are not available.

### 3.7 Non-metallic Minerals, Cement and Lime (NAICS 32731, 32741)

In order to produce cement and lime, limestone (calcium carbonate, CaCO\textsubscript{3}) is crushed, ground, and heated to drive off CO\textsubscript{2} in a process called calcination. The result is an oxide of calcium (CaO) which, when exposed to CO\textsubscript{2} (non-hydraulic cement or lime) or water (hydraulic cement like Portland cement containing other compounds that bond with the calcium) reacts to form CaCO\textsubscript{3} again or some type of silicate in the case of hydraulic cement. The calcination process occurs in a large kiln where the raw materials (primarily ground limestone) to produce cement are subjected to intense heat of at least 1,450°C. NG can be combusted to provide this heat, although just about any energy carrier (coal, oil, old tires, municipal solid waste, wood, or other biomass) can be used and is often used in conjunction with the primary fuel.

Cement is the binding ingredient in concrete which is a mixture of sand, gravel, and cement mixed to a homogenous consistency in water. The water initiates a chemical reaction of the cement particles that solidifies the mixture. Cement comes in a number of varieties (energetically modified, geopolymer, slag lime, pozzolan lime) but the most common, by far, is Portland cement.

Lime is also used as a binding agent but has many other uses in steel production, sugar refining, waste water treatment, and as a soil conditioner. Its production is very similar to that of cement.

In the production of cement, any ash produced by the fuel when combusted is entrained in the cement, eliminating a problem faced by other processes that burn coal, tires, waste, or biomass. Most cement plants can introduce fuels or switch from one fuel to another fairly quickly; such flexibility in fuel type is often economically advantageous. Fig. 3.7 displays the current mix of fuels in the cement industry. Natural gas levels have been climbing recently, while coal and petroleum coke use have diminished (Fig. 3.8).

\textsuperscript{18} Industry Canada categorizes industry size by number of employees. A large facility employs more than 500 people, a medium one between 100 and 499. Only one large facility exits in Canada and is found in Alberta. Of the 12 medium facilities, five are found in Alberta.
Figure 3.7: Energy carriers in the cement industry, 2015

Total = 61 PJ

- Coal, Pet Coke: 62%
- Waste Fuel: 5%
- Electricity: 13%
- Other: 6%
- Natural Gas: 14%

Note: This chart contains estimates of data considered confidential by Statistics Canada. "Other" includes heavy fuel oil, middle distillates, propane, and wood waste. "Waste fuel" includes old tires, municipal solid waste, recycled oil, biomass other than wood waste, landfill gas and other miscellaneous fuels.
Source: Statistics Canada, CANSIM Table 128-0006

Figure 3.8: Energy carriers in the cement industry
It takes about 5.3 GJ of energy to generate a tonne of clinker, the precursor to cement.\textsuperscript{19} Since NG’s share as an energy carrier is currently about 14%, the Canada-wide intensity is about 0.8 GJ/t. In terms of GDP, about 9.1 GJ are consumed to generate $1,000.

The cement industry is scattered across Canada with plants in BC, Alberta, Ontario, Québec, and Nova Scotia. These plants can generate up to 16 Mt of clinker per year, but typically produce about 13 Mt annually. About 46% of this capacity is in southern Ontario with another 20% in Québec. BC accounts for 16% and Alberta another 15%. The industry employs about 2,200 people but, if one includes the production of concrete and concrete production materials, about 27,600 people are employed.

Like cement, lime production occurs primarily in Ontario with about half of all establishments, Québec with another quarter, with the remainder shared between Alberta and BC. The industry employs about 2,500 people.

3.8 Metals (NAICS 331)

There are many processes that are used to smelt metals. Nearly all of them involve heat in one way or another, either to prepare a precursor for final purification (see Aluminium below) or to liquefy the metal to form or shape it, as in the production of steel. Natural gas can serve as the primary source in this role or act as a supplemental source where more readily available alternatives exist. It can also serve as a reducing agent; that is, it can be used to remove oxygen from the incoming oxidized metal (e.g., iron oxide, FeO\textsubscript{3}) to a pure form (e.g., pig iron, Fe).

3.8.1 Iron and Steel (NAICS 3311)

In the iron and steel making process heat plays a dominant role. Two processes are commonly used to produce the desired steel. In an integrated mill, iron dense pellets are reduced to iron using carbon from coal coke to make pig iron, which is then purified to remove some of the carbon to make liquid steel. In a mini-mill, recycled steel is melted using electric arc furnaces to produce the liquid steel. In both cases, the molten steel is shaped or formed into sheets, rods, or billets. These primary forms are further shaped to form sheet metal of varying thickness, wire and other cylindrical forms, as well as beams and rails.

In integrated mills, coke is typically used as the reducing agent to strip off oxygen from the iron. Coal is fed into coke ovens where it is heated in the absence of oxygen to produce coke and a by-product called coke oven gas. This gas has qualities similar to NG and is used to run the coke ovens, preheat input materials, and reheat steel for further processing. In these integrated mills, NG is used to supplement coke oven gas where needed. In mini-mills, no off-gases from other processes are available and so NG is used to preheat and reheat materials in the production cycle.

Carbon, typically from the coke, is used to reduce iron oxide to pig iron in an integrated mill. In principle, the carbon from NG can also be used as a reducing agent but it requires a different

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\textsuperscript{19} Clinker is ground to a fine powder and mixed with 2% - 10% gypsum to form the finished product, cement. The gypsum is added to reduce the reaction rate when cement is mixed in slurry with sand and gravel. Increased levels of gypsum delays the setting or hardening time.
technology than currently exists at most integrated steel mills. For example, the DRI Midrex process generates pig iron without having to melt the incoming iron ore and uses NG as the reducing agent. This process is much less capital intensive and more efficient than coke-based integrated mills.

As noted above, the liquid steel is generally cast into a shape that reflects its final form - sheets, rods, and billets. These primary forms can undergo a number of subsequent processes, such as galvanization, annealing, and reshaping that require reheating before the final form is produced. In most cases, NG is used to reheat and otherwise treat the primary steel in its final transformation to the finished product.

Fig. 3.9 shows the relative importance of NG in the steel making process. Its share of the required energy is just over one-third; coke and coke oven gas account for under half. Capital investments in the industry make it very difficult to move from one fuel to another; it is unlikely that NG will take over as the primary energy supply in old facilities but it is a strong competitor for new ones.

The bulk of the steel making process occurs in Ontario with about 44% of all iron and steel firms there. The largest mills are also found in this province and they employ about 80% of the 15,000 people working in the industry. Québec firms, about 25% of the total, employ another 10% of steel workers in Canada. Most of the remaining firms can be found in BC (7%), Alberta (8%), and Saskatchewan (7%). The industry accounts for less than 2% of manufacturing GDP but more than 20% of the GDP generated by the primary metal industries. It uses about 5.8 GJ of natural gas to produce a tonne of steel and about 17.4 GJ to generate $1,000 of GDP.

**Figure 3.9: Energy carriers in the iron and steel industry, 2015**

![Energy carriers in the iron and steel industry, 2015](image)

Note: This graph contains estimates of data considered confidential by Statistics Canada. "Other" includes heavy fuel oil, middle distillates, propane, petroleum coke, coal, and wood waste.

Source: Statistics Canada, CANSIM Table 128-0006

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3.8.2 Aluminium (NAICS 3313)

The production of aluminium from its precursor, alumina (AlO$_3$), requires no NG; an electrolytic process (the Hall-Héroult process) splits the aluminium from the oxygen to provide a liquid metal ready for shaping or forming. In this industry, NG still plays an important role in the production of the alumina precursor from its ore, bauxite, in what is known as the Bayer process. In this process, temperatures must reach 980°C for the reaction to be completed. Overall, the greatest demand for energy in the process of smelting aluminium comes from electricity for the electrolytic process (Fig 3.10). Most of the remaining energy required is for heat and NG is the primary fuel for heat use.

Outside of one plant in Kitimat, BC, all Canadian aluminium is smelted in Québec and the only region where alumina is prepared is at Rio Tinto Alcan Vaudreuil (Jonquière) refinery in Québec. Thus, the bulk of the NG used by the industry is in Québec. The industry employs about 12,000 people of whom about 65% are in Québec. The remainder are employed at the BC plant or scattered in smaller facilities that recycle or reshape aluminium in the other provinces, primarily Ontario.

Figure 3.10: Energy carriers in the aluminium industry, 2015

Note: This chart contains estimates of data considered confidential by Statistics Canada. "Other" includes heavy fuel oil, middle distillates, and propane.
Source: Statistics Canada, CANSIM Table 128-0006

It takes about 61.3 GJ to produce a tonne of aluminium. Of that, NG provided nearly 6 GJ (10%). In terms of GDP, the industry used just over 5.3 GJ of NG for each $1,000 of value added.

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21 Only a small fraction of the alumina required to make aluminium in Canadian plants is manufactured in Canada. In most cases, the alumina is refined from bauxite near where the bauxite is extracted and is then imported to Canada. There are other uses for alumina; not all the alumina generated in Canada goes to making aluminium.
4 Other Major Non-Industry Users of Natural Gas

4.1 Electricity Production (NAICS 2211)

While electricity production is defined as a utility and not as an industry, it is included in this report because, since 1990, use of NG grew by a factor of seven (726%) by 2015. Characteristics of NG make it useful to meet base, shoulder, or peak loads, depending on the technology used.\(^{22}\) Fig. 4.1 indicates the changes that have occurred in electric utilities over time; since 1990, coal used by utilities has dropped more than 25% and light oils (e.g., diesel) by nearly 81%. Some provinces have more than doubled their use of NG (Ontario, likely to offset coal phase-out) while others have recently shown diminished use (BC). In the Atlantic Provinces, NG was not available at the beginning of this period; its use has grown in each Atlantic province except Prince Edward Island.

Natural gas can be used to fire steam turbines by heating water to high pressure vapour which then drives a turbine to generate electricity. Because start-up and cool-down take a long time, these sorts of systems are typically used to satisfy base loads where the system can be fired at a consistent level for a long time. Efficiency in such a system hovers around 33% but can go as high as 48% depending on how "waste heat" is captured.

Figure 4.1: Fossil Fuels used to generate electricity in utilities

![Fossil Fuels used to generate electricity in utilities](source)

The power generation sector also uses NG directly in gas turbines where the rapid expansion of gases caused when the NG is burned spins a turbine, much like what happens in a jet engine. This has the advantage of rapid start-up and shut-down (suitable to meet peak loads). It is marginally more efficient than simple steam turbines but, if one captures the heat of the

\(^{22}\) Demand for electricity varies from one hour to the next. Some portion of the demand exists at all times (i.e., each hour of the day) and is called the "base" load. For a couple of hours per day, the demand is much higher than this base load and is called peak load. Loads which occur for large portions of the day but not the whole day are called shoulder loads. Not all generation devices are useful in meeting peak loads because they are unable to start up or shut down quickly enough.
exhaust gases that leave the turbine to make steam for further generation (a "combined cycle gas turbine"), efficiencies can go as high as 60%.

Based on calculations of actual NG use and electricity generated by NG in Canadian electricity utilities, the generation of one megawatt hour (MWh) requires 10.8 GJ of NG, an efficiency of about 33%. Because electricity can be generated in several ways using a number of energy carriers, it is difficult to assess the importance of NG in terms of intensity of value added; all one can tell from the values (GJ/$'000 GDP) is that the importance of NG to the electricity utility reflects it growth as seen in Fig. 4.1. In the early 1990s, utilities used about 3.8 GJ of NG for each $1,000 generated where it exceeded 12 GJ per $1,000 in 2015.

### 4.2 Natural Gas Pipelines (NAICS 4862)

Natural gas is used in the transportation sector in several ways, but by far the largest (98.5% - 99.2%) is used to move NG through pipelines. While other transport methods are available (compressed NG or liquefied NG), pipelines are the primary method used to transport NG from well head to final user.

After extraction, the raw NG is typically stripped of sulphur compounds such as hydrogen sulfide (H\textsubscript{2}S, a very toxic gas), NGLs (ethane, propane, butane, etc.), CO\textsubscript{2}, and moisture by absorption and adsorption techniques, or condensing these compounds through compression and chilling. Natural gas can be used to drive the compressors/chillers to complete the stripping process but its primary use is in internal combustion motors or turbines to drive reciprocating or centrifugal compressors that moves the gas down the pipeline. It takes about 2% to 3% of the total flow of NG to run the pipeline system. While this is a huge amount of gas, comparatively speaking, this is half as much of the relative flow that it takes to move electricity in a wire where line losses can be 6% to 7%.

The amount of NG transported by pipeline in 2011 was nearly double that in 1990, but has been declining slowly since then (Pipeline Disposition in Fig. 4.2). However, the average distance travelled decreased by 40% over that time; the average distance traveled by a cubic metre of NG in the early 1990s was 1,500 km, while in last few years it was between 850 and 1,000 km. As a result, total m\textsuperscript{3}-km has decreased since 2005 (Pipeline Transport in Fig. 4.2) but is up 29% since 1990.

The energy required to complete this task dropped consistently from 1998 to 2012, thereafter rising to 23% above 1990 levels. The intensity of this action has closely followed the energy required to complete the task, decreasing to 2012, and then rising again (Fig. 4.3). Intensity per unit NG moved was 32% less in 2015 than in 1990.

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23 Recently, there have been proposals to utilize natural gas in truck freight vehicles. While some trucking firms have explored this as an energy carrier, the impact on market share has been very small (see www.cngva.org).

24 In "absorption", molecules fill the pores of the absorbent. In "adsorption", the molecules attach to the surface of the adsorbent. In both cases, the attached molecules can be removed and the absorbent/adsorbent reactivated and re-used.

25 Reciprocating compressors use a cylinder/piston approach much like a bicycle pump while centrifugal pumps use a rotating impeller like a ship’s propeller or a fan.
Figure 4.2: Natural gas disposition, transport, and energy use in pipelines

Note: Energy is in PJ, pipeline disposition is in billions of m$^3$, and pipeline transportation is in trillions m$^3$-km.
Source: Statistics Canada, CANSIM Tables 128-0018 and 129-0002.

Figure 4.3: Natural gas energy use and intensity in pipelines

Source: Statistics Canada, CANSIM Tables 128-0018 and 129-0002.
Appendix

5.1 Caveat on Natural Gas Data

All data used to compare NG use to other Canadian sectors, other fuels, and non-fuel uses come from the Report on Energy Supply and Demand (RESD, CANSIM Tables 128-0016, 128-0017). These data are adjusted to allow the RESD to report as an energy-balanced table (production and use of energy balance, including exports, imports, non-energy use of energy carriers, etc.). Data on specific industries are obtained directly from the Industrial Consumption of Energy (ICE) survey of those industries. As a result, ICE-based values may not be the same as those found in tables and graphs where the data source is the RESD.
### 5.2 Tables of Natural Gas Use in Industries and Other Sectors

**Table 5.1: Industrial sectors and natural gas use**

<table>
<thead>
<tr>
<th>Industrial Sector</th>
<th>NAICS</th>
<th>NG use (TJ, 2015)</th>
<th>% of NG Available</th>
<th>% of Mine or Manuf.</th>
<th>In Report</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mining (not Oil, Gas and Coal)</td>
<td>212</td>
<td>29,388</td>
<td>0.8%</td>
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<tr>
<td>Metal Ore Mining</td>
<td>2122</td>
<td>3,526</td>
<td>0.1%</td>
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<td>Non-metal Mining</td>
<td>2123</td>
<td>25,862</td>
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<td>Potash Mines</td>
<td>212396</td>
<td>22,467</td>
<td>0.6%</td>
<td>76.4%</td>
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<td>Electricity Generation*</td>
<td>221110</td>
<td>747,364</td>
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<tr>
<td>Construction</td>
<td>230</td>
<td>17,556</td>
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<tr>
<td>Manufacturing Industries (31 - 33)</td>
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<td>74,064</td>
<td>2.0%</td>
<td>10.9%</td>
<td>✓</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Textile Mills</td>
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<td>XX</td>
<td>N/A</td>
<td></td>
<td></td>
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<td>Clothing Manufacturing</td>
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<td>756</td>
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<td>0.1%</td>
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<td>Paper Manufacturing</td>
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<td>Pulp and Paper</td>
<td>3221</td>
<td>XX</td>
<td>N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pulp</td>
<td>32211</td>
<td>36,826</td>
<td>1.0%</td>
<td>5.4%</td>
<td></td>
</tr>
<tr>
<td>Printing and Related Support Activities</td>
<td>323</td>
<td>2,375</td>
<td>0.1%</td>
<td>0.3%</td>
<td></td>
</tr>
<tr>
<td>Petroleum and Coal Products Manufacturing</td>
<td>324</td>
<td>69,927</td>
<td>1.9%</td>
<td>10.3%</td>
<td></td>
</tr>
<tr>
<td>Chemical Manufacturing</td>
<td>325</td>
<td>208,096</td>
<td>5.5%</td>
<td>30.6%</td>
<td></td>
</tr>
<tr>
<td>Organic, Inorganic Chemical Manuf.</td>
<td>3251</td>
<td>113,896</td>
<td>3.0%</td>
<td>16.7%</td>
<td>✓</td>
</tr>
<tr>
<td>Resin, synthetic rubber, artificial/synthetic fibres &amp; filaments</td>
<td>3252</td>
<td>2,014</td>
<td>0.1%</td>
<td>0.3%</td>
<td>✓</td>
</tr>
<tr>
<td>Pesticide, fertilizer &amp; other agricultural chemicals</td>
<td>3253</td>
<td>XX</td>
<td>N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plastics and Rubber Products Manufacturing</td>
<td>326</td>
<td>XX</td>
<td>N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-Metallic Mineral Product Manufacturing</td>
<td>327</td>
<td>XX</td>
<td>N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glass &amp; Glass Product Manufacturing</td>
<td>3271</td>
<td>0</td>
<td>0.0%</td>
<td>0.0%</td>
<td></td>
</tr>
<tr>
<td>Cement Manuf.</td>
<td>32731</td>
<td>8,603</td>
<td>0.2%</td>
<td>1.3%</td>
<td>✓</td>
</tr>
<tr>
<td>Lime &amp; Gypsum Product Manuf.</td>
<td>3274</td>
<td>XX</td>
<td>N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lime Manuf.</td>
<td>32741</td>
<td>XX</td>
<td>N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary Metal Manuf.</td>
<td>331</td>
<td>111,364</td>
<td>3.0%</td>
<td>16.4%</td>
<td></td>
</tr>
<tr>
<td>Iron &amp; Steel Mills &amp; Ferro-Alloy Manufacturing</td>
<td>3311</td>
<td>70,644</td>
<td>1.9%</td>
<td>10.4%</td>
<td>✓</td>
</tr>
<tr>
<td>Primary Production of Alumina &amp; Aluminium</td>
<td>331313</td>
<td>16,748</td>
<td>0.4%</td>
<td>2.5%</td>
<td>✓</td>
</tr>
<tr>
<td>Non-Ferrous Metal (except Aluminium) Smelting &amp; Refining</td>
<td>331410</td>
<td>11,030</td>
<td>0.3%</td>
<td>1.6%</td>
<td></td>
</tr>
<tr>
<td>Fabricated Metal Product Manufacturing</td>
<td>332</td>
<td>XX</td>
<td>N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Machinery Manufacturing</td>
<td>333</td>
<td>XX</td>
<td>N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Computer and Electronic Product Manufacturing</td>
<td>334</td>
<td>XX</td>
<td>N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrical Equipment, Appliance and Components</td>
<td>335</td>
<td>XX</td>
<td>N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transportation Equipment Manufacturing</td>
<td>336</td>
<td>XX</td>
<td>N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transportation Equip. Manuf., Motor Vehicles</td>
<td>3361</td>
<td>XX</td>
<td>N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Furniture and Related Product Manufacturing</td>
<td>337</td>
<td>XX</td>
<td>N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Miscellaneous Manufacturing</td>
<td>339</td>
<td>XX</td>
<td>N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pipelines*</td>
<td>4862</td>
<td>113,537</td>
<td>3.0%</td>
<td>16.7%</td>
<td>✓</td>
</tr>
</tbody>
</table>

* These are not part of the Industry sector.

XX- Data are confidential. Data in **Red Bold** are confidential but estimated by CIEEDAC analysts.

Source: Statistics Canada, CANSIM Table 128-0006
Table 5.2: Comparison of Industrial sectors including intensities of natural gas use, 2015

<table>
<thead>
<tr>
<th>Industrial Sector</th>
<th>NAICS</th>
<th>GJ NG/Prod</th>
<th>GJ NG/$1000 GDP</th>
<th>Employment</th>
<th>Number of firms</th>
<th>Primary Regions (if of firms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mining (not Oil, Gas and Coal)</td>
<td>212</td>
<td></td>
<td></td>
<td></td>
<td>1,624</td>
<td>ON, QC, BC, AB</td>
</tr>
<tr>
<td>Potash Mines (tonne of Potash)</td>
<td>212396</td>
<td>2.04</td>
<td>17.28</td>
<td>5,000</td>
<td>17</td>
<td>SK</td>
</tr>
<tr>
<td>Electricity Generation*</td>
<td>221110</td>
<td>12.28</td>
<td></td>
<td></td>
<td>2,429</td>
<td>ON, AB</td>
</tr>
<tr>
<td>Manufacturing Industries (31 - 33)</td>
<td>(31 - 33)</td>
<td></td>
<td>1,550,100</td>
<td></td>
<td>89,885</td>
<td></td>
</tr>
<tr>
<td>Food and Beverage</td>
<td>311</td>
<td>2.75</td>
<td>225,600</td>
<td>8,949</td>
<td></td>
<td>ON, QC, BC</td>
</tr>
<tr>
<td>Wood Product</td>
<td>321</td>
<td>2.73</td>
<td>96,200</td>
<td>6,395</td>
<td></td>
<td>ON, QC, BC, AB</td>
</tr>
<tr>
<td>Pulp and Paper</td>
<td>322</td>
<td>10.45</td>
<td>54,100</td>
<td>811</td>
<td></td>
<td>ON, QC, BC</td>
</tr>
<tr>
<td>Petroleum and Coal Products</td>
<td>324</td>
<td></td>
<td>13,400</td>
<td>513</td>
<td></td>
<td>ON, AB</td>
</tr>
<tr>
<td>Petroleum Refineries (m³ of product)</td>
<td>32411</td>
<td>2.63</td>
<td>6,800</td>
<td>59</td>
<td></td>
<td>ON, AB</td>
</tr>
<tr>
<td>Chemistry Industry</td>
<td>325</td>
<td>16.29</td>
<td>86,400</td>
<td>3,205</td>
<td></td>
<td>ON, QC, AB</td>
</tr>
<tr>
<td>Organic, Inorganic Chemical</td>
<td>3251</td>
<td></td>
<td>12,900</td>
<td>433</td>
<td></td>
<td>ON, QC, AB</td>
</tr>
<tr>
<td>Resin, synthetic rubber, artificial/synthetic fibres &amp; filaments</td>
<td>3252</td>
<td></td>
<td>4,700</td>
<td>151</td>
<td></td>
<td>ON, QC, AB</td>
</tr>
<tr>
<td>Pesticide, fertilizer &amp; other agricultural chemicals</td>
<td>3253</td>
<td></td>
<td>5,300</td>
<td>318</td>
<td></td>
<td>ON, QC, AB</td>
</tr>
<tr>
<td>Cement</td>
<td>32731</td>
<td>0.80</td>
<td>8.97</td>
<td>2,200</td>
<td>79</td>
<td>ON, QC</td>
</tr>
<tr>
<td>Primary Metal</td>
<td>331</td>
<td></td>
<td>59,100</td>
<td>932</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iron &amp; Steel Mills &amp; Ferro-Alloy</td>
<td>3311</td>
<td>6.79</td>
<td>27.66</td>
<td>15,100</td>
<td>127</td>
<td>ON</td>
</tr>
<tr>
<td>Production of Alumina and Aluminium</td>
<td>331313</td>
<td>5.80</td>
<td>5.32</td>
<td>12,200**</td>
<td>138**</td>
<td>QC</td>
</tr>
<tr>
<td>Pipelines*</td>
<td>4862</td>
<td>0.81</td>
<td>0.05</td>
<td></td>
<td>114</td>
<td></td>
</tr>
</tbody>
</table>

* These are not part of the Industry sector.
** Values only available for Alumina and Aluminium Production and Processing (NAICS 33131).
Source: Statistics Canada, CANSIM Table 128-0006, Innovation, Science and Economic Development Canada.