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Market Study on Small Catalyst Converters

PREPARED FOR



BY OVG CONSULTING INC.

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4. CONTACT INFO

Client

[REDACTED]
[REDACTED]
[REDACTED]
[REDACTED]
[REDACTED]
[REDACTED]
[REDACTED]

Consultant

Olga Gorstenko
Principal Consultant
OVG Consulting Inc.
Tel.: 778-316-5515
info@ovgconsulting.com
<https://ovgconsulting.com/>

5. EXECUTIVE SUMMARY

This study investigates the current state of the market, its size, and penetration potential for the solution developed by [REDACTED] a new type of catalyst converter used to neutralize pollutants in exhaust gas from internal combustion engines. The developed solution addresses two major challenges that the industry faces: high cost of metals used as catalysts and high temperature required to activate the catalysts. [REDACTED]

[REDACTED] motors are typically used to operate lawn mowers, portable power generators and similar devices.

The study discovers that the demand in the solution is well supported by the multiple federal and regional “clean air” environmental regulations and promoted by the Greenhouse Gas (GHG) reduction initiatives introduced by local governments worldwide. Further strengthening of regulatory requirements currently anticipated in the industry, especially in California, will only solidify this demand.

Primary users of the small engine devices are Construction, Agriculture / Forestry and Household/ Gardening sectors. Since there is no industry directly covering the Household/Gardening sector under a government reporting structure, the study examines the residential sector of the Construction industry and Municipal services as proxies to this segment. COVID-19 has had a mild effect on these sectors in Canada and the U.S.A. but is not expected to have a lingering impact. Agriculture, being the essential service, is shielded from the economic downturn. Municipal services, funded by taxpayers, might see a decrease in financing; meanwhile those services that require the use of small engine equipment (gardening, cleaning, repairs, etc.) constitute the essential services and are unlikely to be affected. Construction activities will decline in the short-term; however, this trend is likely to be reversed in the long- and even mid- term.

Competition in the small motors market is limited. Large emission controls manufacturers do not position themselves in this niche. Instead, they focus on improving existing solutions by developing electrically heated catalysts, systems that activate the catalyst in low-temperature, durability of devices, as well as improving diesel exhaust systems. There is only a handful of manufacturers who position themselves as small engine emission controls makers; they are typically small and are focused on aggressive selling. They represent a modest competition to [REDACTED]

The future market projections are developed for the units of engines that meet the requirements for the product under study: four-stroke engines operating on gasoline. The resulting total estimated market is expected to reach the 10Mln and 23.5 Mln unit range in 2030. The North American segment is the largest one followed by Europe with the residential household and gardening sector dominating the market size. The market to be potentially captured by the client is estimated to range between 0.5 and 6 Mln units in 2030 globally and 0.25 and 2.8 Mln units in North America at the end of the forecast period.

For the solution to achieve the best results at market entry, its unique combination of features that are not offered by any other manufacturer should be promoted extensively to the market:

- Superior performance: earlier cold-start activation of the catalysts ensures an almost immediate commencement of emission reduction efforts resulting in advanced regulatory compliance;
- Lower cost: utilization of input components not containing expensive metals drives the production cost significantly lower leading to potentially lower prices;
- Abundancy of input components (metals) reduces operational and financial risks that are typically carried by the competition.

6. INTRODUCTION

This engagement was entered between Olga Gorstenko of OVG Consulting Inc. (the Consultant) and [REDACTED] (the Client). [REDACTED]

The Client is a developer of a low-cost, high-performance three-way catalyst to replace the costly precious metal-based catalysts used in automotive catalytic converters (the Solution or Product). These catalysts do not contain any platinum, palladium, or rhodium and can be processed using simple wash-coating methods that are scalable to high volume and low costs. There have been 3rd party tests performed to validate internal performance tests of catalysts.

The precious metals of rhodium, palladium and platinum typically used in catalytic converters are expensive and in a shortage. It has driven the industry to use the absolute minimum catalyst in the catalytic converter while still meeting emission requirements. In contrast, the Client's material costs a fraction of the typical precious metal incumbents, which allows much more flexibility in the quantity of material that can be used while still maintaining a [REDACTED] % cost reduction.

The key features of the Client's technology are

- Order of magnitude cost reduction in catalytic converter catalyst;
- Beginning of life performance is similar to costly incumbent catalytic converters;
- Responds to changing air-to-fuel ratios to adapt to any driving condition;
- Starts reducing toxic exhaust gases at low temperatures;
- Good exhaust gas conversion after aging at 900°C; and
- Convenient and cost-effective manufacturing.

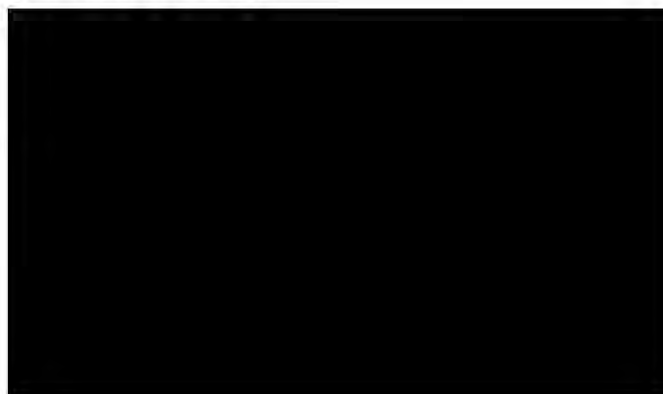


Figure 1: The Client's Technology Schematics

This Solution was originally intended for automobiles; however, the Client is now exploring the opportunity of entering the market of small-engine converters. The Client has engaged the Consultant to conduct market research on small motor catalyst converters.

7. STUDY SCOPE, APPROACH, ASSUMPTIONS

The Consultant followed the standard research project management approach. Below is the description of the scope, steps, assumptions, and data used for the development of the study.

Technology under study: catalytic converters for small spark ignition (SSI) motor equipment meeting the following conditions:

- i) 4-stroke engines;
- ii) engines run on gasoline.

Defining the Scope. Figure 2: Schematics of the Study Scope outlines the drivers that affect the demand for the Client's Solution. They can be tentatively divided into two groups: economic and regulatory drivers.

Regulatory drivers can be loosely defined as primary drivers. The usage of catalytic converters in small engines is driven not by an operational necessity (engines can operate very well without this part) but instead by regulations requiring the reduction of harmful emissions in the exhaust from engines working on fossil fuels. Because the catalytic converter is the core emission control part of the engine, its integration into the engine is driven by these current regulatory requirements. The status of these regulations and changes in allowable emission limits have a direct impact on demand for catalytic converters from the manufacturers/integrators of small engines. Regulatory drivers also include less stringent, from the point of mandatory compliance, requirements to reduce the GHG emission from the fossil-fueled equipment that are adopted by local authorities (municipalities) worldwide.

Economic drivers are the indirect impact and can be classified as secondary drivers. These are the drivers that impact the demand for small motor equipment and devices, which use catalytic converters. Small engines are installed in lawn and garden machines (hedge trimmers, brush cutters, lawn mowers, leaf blowers, garden tractors, snowblowers, etc.), in light-duty industrial machines (generator sets, welders, pressure washers), and in light-duty logging machines (chainsaws, log splitters, shredders, building, farming and material handling tools, mobile and portable power generators. These tools and devices are typical for Construction and Agriculture / Forestry industries. Gardening, repairing, and cleaning equipment, and backup generators are used by residential customers and municipalities. Hence, the analysis also covers drivers affecting the growth of residential sectors and public administration. Indirectly, a decrease in activities of these industries and sectors impact the usages of catalytic converters when being integrated in small engine devices.

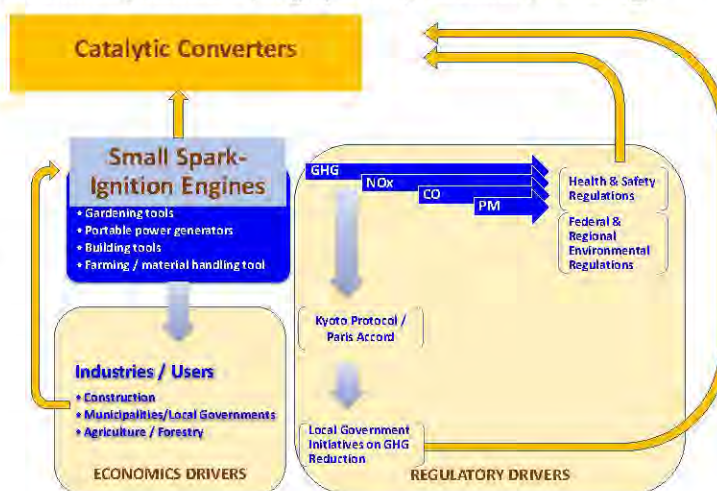


Figure 2: Schematics of the Study Scope

Geography: market and regulatory analysis of the U.S.A. and Canada markets; the market size forecast includes other regions.

Data. All data for the study is public and acquired via online research.

The Steps of the Study are summarized below.

1. Overview of the catalytic converters, their types, and applications (section Catalytic Converters Overview).
2. Summaries of small engines and small engine equipment manufacturers.
3. Summaries of the most prominent top manufacturers of catalytic converter providers and also those specialized in small engine emission controls, their marketing approaches and plans for strategic development (R&D) (section Catalytic Converter Manufacturers).
4. Overview of the regulations in the U.S.A. and Canada that set the stage and support the growth of small engine catalytic converters (section Emission Reduction Regulations for Exhaust from Engines).
5. Analysis of the GHG reduction targets and trends is in section GHG Emission Reduction Initiatives.
6. Examination of the historic state of Construction (emphasis on residential sector), Agriculture/Forestry and Municipal sectors, overall economy in the U.S.A. and Canada under the current (COVID-19 pandemic) conditions and projected recovery (section The State of the Economy and Industry, Impact on Demand).
7. Future projections of the total market size and that to be potentially captured by the Client (section Estimation of the Four-Stroke Gasoline SSI Engine Market Size).
8. Estimations of the air pollutants and GHG emissions from the engines calculated as the Client's target market in the previous section.
9. Section Marketing Strategy outlines recommendations on approaching the market entry.

Forecast approach.

The potential total market size is assumed to be equal to the number of the engines used in small power devices/tools/equipment. The number of engines is selected as a reference for that of catalytic converters because a) engine-related statistics are better reported and b) an engine, being the core component of any motor device, can be easily considered a proxy for this device.

Forecasts estimate the number of engine units that meet the requirements of being a) four-stroke, b) small size, and c) gasoline-fuelled. Forecasts are segregated by;

- Industry: Construction, Agriculture/Forestry, Household/Gardening (Municipalities);
- Sector: Commercial and Residential; and
- Region: North America, South America, Asia, Europe.

The forecast period starts in 2021; however, any delay in R&D, demo, or a marketing campaign will shift the timeframe for the estimated Client's potential market share. Forecasts have been developed until the year 2030.

Estimations of the potential current and future market size for Low Case and High Case and Average reflect possible options for market conditions, solution development and market capture.

Engine units' forecasts are accompanied by the estimates of air pollutants and GHG emissions volumes developed for the same market size and its composition.

Study Limitations. The study is limited in its scope and excludes any consideration given to the Client's internal capacity in operational, HR, and financial stance.

8. CATALYTIC CONVERTERS OVERVIEW

A catalytic converter is a device that catalyzes toxic gases and pollutants in exhaust gas from an internal combustion engine into less-toxic pollutants. Catalytic converters are usually used with internal combustion engines (ICE) fueled by fossil fuels such as gasoline, diesel, or gas. Catalytic converters were originally introduced to exhaust systems in automobiles in response to government regulations requiring cleaner exhaust with less pollutants in the 1970s. Those "two-way" converters combined oxygen with carbon monoxide (CO) and unburned hydrocarbons (C_nH_n) to produce carbon dioxide (CO_2) and water (H_2O). In the 1980s, two-way catalytic converters were upgraded with "three-way" converters that also reduce oxides of nitrogen (NO_x). As environmental and health and safety regulatory requirements get more stringent, technology becomes more advanced and the number of applications widens, catalytic converters are now not only used in automobiles, but also in motorcycles, electrical generators, forklifts, mining and construction equipment, kerosene heaters and stoves, among others.

Spark Ignition Engines

This section provides an overview of the internal combustion engine and catalytic converter processes.

ICE is the most common form of heat engines, as it is used in vehicles, boats, ships, airplanes, and trains.¹ ICE works on the principle of the ideal gas law: $pV=nRT$ $pV=nRT$. Raising the temperature of a gas increases the pressure that makes the gas expand. ICE has a chamber, which has fuel added to it that ignites to raise the temperature of the gas. When heat is added to the system, it forces gas inside to expand. With a piston engine, this causes the piston to rise, and with a gas turbine, the hot air is forced into the turbine chamber, turning the turbine. The piston or turbine attached to a camshaft, converts a portion of the energy into useful work. To compress the piston in an intermittent combustion engine, the engine exhausts the gas. Heat is used to keep the system running at a consistent temperature. A gas turbine, which uses continuous combustion, simply exhausts its gas continuously rather than in a cycle.

A spark-ignition engine (SI engine) is the combustion process of the air-fuel mixture ignited by a spark from a spark plug. This contrasts with compression-ignition engines, typically diesel engines, where the heat generated from compression, together with the injection of fuel, is enough to initiate the combustion process, without needing any external spark. SI engines are commonly run on gasoline, petroleum gas, methanol, ethanol, bioethanol, compressed natural gas, hydrogen, and (in drag racing) nitromethane.²

An engine that uses a piston is called an intermittent combustion engine, whereas one that uses a turbine is called a continuous combustion engine.

A piston engine is extremely responsive, in comparison to a turbine, as well as more fuel-efficient at low outputs. This makes them ideal for use in vehicles, as they also start up more quickly. Conversely, a turbine has superior power-to-weight ratio compared to a piston engine, and its design is more reliable for continuous high outputs. A turbine also works better than a naturally aspirated piston engine at high altitudes and cold temperatures. Its lightweight build, reliability, and high-altitude capability make turbines the engine of choice for airplanes. Turbines are also commonly used at power plants for electrical generation.³



The working cycle of both spark-ignition and compression-ignition engines may be either two-stroke or four-stroke.

A four-stroke spark-ignition engine is an Otto cycle engine. It consists of following four-strokes:

1. Suction or intake stroke: fuel is injected into the chamber;
2. Compression stroke or ignition: the fuel catches fire (this happens differently in a diesel engine than in a gasoline engine);
3. Expansion or power stroke: the fire pushes the piston which is the useful motion;
4. Exhaust stroke: the waste chemicals, water vapour and other pollutants get emitted. After the exhaust is expelled, the intake stage begins the engine cycle anew.



Figure 3: 4-stroke Internal Combustion Engine⁴

The main differentiating factor that allows the two-stroke engine to function with only two piston movements is that the exhaust and intake of gas occurs simultaneously. The piston itself is utilized as the valve of the system, along with the crankshaft, to direct the flow of the gases. In addition, due to its frequent contact with moving components, the fuel is mixed with oil to add lubrication, allowing smoother strokes. Overall, two-stroke engines contain two processes:

1. Compression stroke: the air-fuel mixture is added, and the piston moves upwards (compression). The inlet port is opened due to the position of the piston and the air-fuel mixture enters the holding chamber. A spark plug ignites the compressed fuel and begins the power stroke.
2. Power stroke: the heated gas exerts high pressure on the piston, the piston moves downward (expansion), waste heat is exhausted.

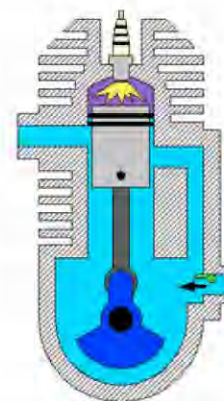


Figure 4: 2-stroke Internal Combustion Engine

Compared to four-stroke engines, two-strokes are lighter, more efficient, can use lower-grade fuel, and are more cost-efficient. The lighter engines result in a higher power-to-weight ratio (more power for less weight). However, they lack the maneuverability possible in four-stroke engines and require more lubrication. This makes two-stroke engines ideal for ships (need to carry a lot of cargo), or motorcycles. The four-stroke piston engine is one of the most common internal combustion engines. It is used in various automobiles (that specifically use gasoline as fuel) like cars, or trucks.

Four-stroke engines offer significant environmental benefits over two-stroke designs. These benefits include:

- reduced emissions;
- improved fuel economy; and
- less noise output.

Four-stroke motors burn 40% less fuel and release 90% fewer hydrocarbon emissions into the environment than the two-stroke motors they replace.⁵ Four-strokes are inherently much cleaner than two-strokes for three reasons:

1. they burn clean gasoline, not oil-based mixtures;
2. the fuel is burned more thoroughly and therefore with much greater efficiency than in a two-stroke;
3. four-stroke motors draw in the air/fuel mixture and expel exhaust gases on separate strokes of the piston, which means that large amounts of unburned fuel are not released from a four-stroke as they are in a two-stroke (a fact that also contributes substantially to a four-stroke's much greater inherent fuel efficiency).

Catalytic Converter Overview

The job of the catalytic converter is to convert harmful pollutants into less harmful emissions before they leave the exhaust system. In order to reduce emissions, modern engines carefully control the amount of fuel they burn.⁶ They try to keep the air-to-fuel ratio very close to the stoichiometric point, which is the ideal ratio of air to fuel. Theoretically, at this ratio, all the fuel will be burned using all the oxygen in the air. For gasoline, the stoichiometric ratio is about 14.7:1, meaning that for each pound of gasoline, 14.7 pounds of air will be burned. The fuel mixture varies from the ideal ratio quite a bit while driving. Sometimes the mixture can be lean (an air-to-fuel ratio higher than 14.7), and other times the mixture can be rich (an air-to-fuel ratio lower than 14.7), meanwhile, some emissions are emitted. Since the combustion process is never perfect, smaller amounts of more harmful emissions are produced in car engines as well.

The harm from ICE-generated pollutions should not be underestimated. Even small gasoline powered engines produce huge amounts of carbon monoxide, the most poisonous gas. Emitted gases can poison people in semi-enclosed spaces. Many people using power tools such as high-pressure washers, concrete cutting saws (walk-behind/hand-held), power trowels, floor buffers, welders, pumps, compressors, and generators in buildings or semi-enclosed spaces have been poisoned by carbon monoxide. CO can rapidly accumulate and build up to dangerous or fatal concentrations within minutes. Examples of such poisonings include the cases summarized below.⁷

- A farm owner died of CO poisoning while using an 11-horsepower, gasoline-powered pressure washer to clean his barn. He had worked about 30 minutes before he succumbed.
- A municipal employee at an indoor water treatment plant lost consciousness while trying to exit from a 59,000-cubic-foot room where he had been working with an 8-horsepower, gasoline-powered pump.
- Five workers were treated for CO poisoning after using two 8 horse-power, gasoline-powered, pressure washers in a poorly ventilated underground parking garage.

[REDACTED]

- A plumber was using a gasoline-powered concrete saw in a basement with open doors and windows and a cooling fan. He experienced a severe headache and dizziness and began to act in a paranoid manner.

Three-way catalytic converters are designed to directly reduce at least three air pollutants:

Carbon monoxide, a poisonous gas that is colorless and odorless;

Hydrocarbons or volatile organic compounds (VOCs), a major component of smog produced mostly from evaporated, unburned fuel;

Nitrogen oxides (NO and NO₂, together called NO_x), a contributor to smog and acid rain, which also causes irritation to human mucus membranes.

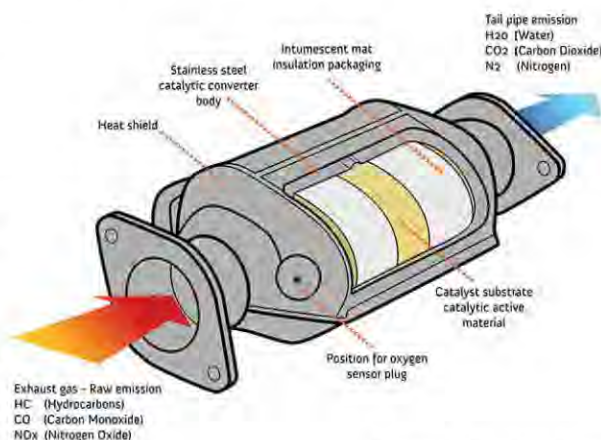


Figure 5: Catalyst Converter³

It should be noted that catalytic converters do not directly reduce the GHG emissions, to be more specific, its largest component CO₂. At the same time, their ability to curb the CO volume has a tremendous impact on the environment. Carbon monoxide is not only highly toxic and potentially lethal gas, but it also has important indirect effects on global warming. CO reacts with hydroxyl (OH) radicals in the atmosphere, reducing their abundance. As OH radicals help to reduce the lifetimes of strong GHG gases, like methane, CO indirectly increases the global warming potential of these gases. Carbon monoxide in the atmosphere can also lead to the formation of the tropospheric GHG gas 'ozone'.⁹ **BECAUSE OF THESE PROPERTIES, CATALYTIC CONVERTERS DO NOT ONLY CONTRIBUTE TO THE CLEANER AIR, BUT ALSO TO THE REDUCTION OF GHG EMISSIONS.**

In a typical catalytic converter, there are two different types of catalysts at work, a reduction catalyst, and an oxidation catalyst. Both types consist of a ceramic structure coated with a metal catalyst, usually platinum, rhodium and/or palladium. The idea is to create a structure that exposes the maximum surface area of catalyst to the exhaust stream, while also minimizing the amount of catalyst required when the catalyst consists of precious metals. There are two main types of structures used in catalytic converters – honeycomb, the most common, and ceramic beads.

There are three stages of the pollutant's conversion.

1. The reduction catalyst is the first stage of the catalytic converter. It uses typically platinum and rhodium to help reduce the NO_x emissions. When an NO or NO₂ molecules contact the catalyst, the catalyst rips the nitrogen atom out of the molecule and holds on to it, freeing the oxygen in the form of O₂. The nitrogen atoms bond with other nitrogen atoms that are also stuck to the catalyst, forming N₂. For example: $2\text{NO} \Rightarrow \text{N}_2 + \text{O}_2$ or $2\text{NO}_2 \Rightarrow \text{N}_2 + 2\text{O}_2$
2. The oxidation catalyst is the second stage of the catalytic converter. It reduces the unburned hydrocarbons and carbon monoxide by burning (oxidizing) them over a platinum and palladium catalyst. This catalyst aids the reaction of the CO and hydrocarbons with the remaining oxygen in the exhaust gas. For example: $2\text{CO} + \text{O}_2 \Rightarrow 2\text{CO}_2$

3. The third stage of conversion is a control system that monitors the exhaust stream and uses this information to control the fuel injection system. There is an oxygen sensor mounted upstream of the catalytic converter, meaning it is closer to the engine than the converter. This sensor tells the engine computer how much oxygen is in the exhaust. The engine computer can increase or decrease the amount of oxygen in the exhaust by adjusting the air-to-fuel ratio. This control scheme allows the engine computer to make sure that the engine is running at close to the stoichiometric point, and also to make sure that there is enough oxygen in the exhaust to allow the oxidization catalyst to burn the unburned hydrocarbons and CO.

The catalytic converter does a good job at reducing the pollution, but it has several challenging areas that manufacturers have been working on to improve:

1. The largest challenge is the cost and availability of precious metals used in a catalyst. It is typically mitigated by reducing the volume of these metals in the catalyst mixture.
2. Another shortcoming is that it only works at a fairly high temperature. One typical solution to this problem is to move the catalytic converter closer to the engine. This means that hotter exhaust gases reach the converter and it heats up faster, but this may also reduce the life of the converter by exposing it to extremely high temperatures. Most carmakers position the converter under the front passenger seat, far enough from the engine to keep the temperature down to levels that will not harm it. The easiest way to preheat the converter is to use electric resistance heaters. Unfortunately, the 12-volt electrical systems on most cars do not provide enough energy or power to heat the catalytic converter fast enough. Most people would not wait several minutes for the catalytic converter to heat up before starting their car.

Catalytic converters in diesel engines do not work as well in reducing NO_x. One reason is that diesel engines run cooler than standard engines, and the converters work better as they heat up. Some of the leading environmental auto experts have come up with a new system that helps to combat this. They inject a urea solution in the exhaust pipe, before it gets to the converter, to evaporate and mix with the exhaust and create a chemical reaction that will reduce NO_x. Urea reacts with NO_x to produce nitrogen and water vapor, disposing more than 90% of the nitrogen oxides in exhaust gases.

THE CLIENT'S SOLUTION ADDRESSES TWO MAJOR CHALLENGES THAT ARE FACED BY THE MANUFACTURING INDUSTRY: HIGH COST OF METALS USED AS CATALYSTS AND THE REQUIRED HIGH TEMPERATURE TO ACTIVATE THE CATALYST PERFORMANCE.

9. SMALL ENGINE AND EQUIPMENT MANUFACTURERS

The small engine market represents a highly competitive landscape with a number of small and large players comprised of different manufacturer types. Some of them are specialized in producing engines only; others manufacture the whole device / tool / equipment of which the engine is just a component; another group is engaged in the integration of parts that are produced by different manufactures. **THE CONSULTANT BELIEVES THAT IT IS IMPORTANT TO KNOW THE COMPOSITION OF EACH GROUP TO ACHIEVE DIFFERENT OBJECTIVES. UNDERSTANDING MAKERS OF ENGINES, WHETHER AS PART OF THE COMPLETE DEVICE OR AS A FINAL PRODUCT FOR FURTHER SALES IS IMPORTANT FOR DEVELOPING THE MARKET SIZE FORECAST. KNOWING THE MANUFACTURERS OF THE COMPLETE DEVICES AND INTEGRATORS IS IMPORTANT FOR THE CLIENT AS THESE ENTITIES ARE POTENTIAL BUYERS OF THE CLIENT'S SOLUTION.** The table below summarizes all types of engine manufacturers.

Unlike most other industries, some of these manufacturers are not in direct competition with one another and typically serve a specific niche: they supply engines to specific markets within the industry or specialize in the production of specific engine types. For example, Briggs & Stratton is the world's largest producer of small (less than 20 horsepower), air cooled gasoline engines for outdoor power equipment (such as those found in lawn and garden applications), while Yanmar or Jeemar Power are the world's largest diesel engine manufacturers, in terms of units, offering engines between 5 and 5000 horsepower. Such specialization decreases the likelihood that Briggs & Stratton and Yanmar or Jeemar Power will directly compete for market share.

Similarly, equipment manufacturers also service specific segments. Some specialize in the production of lawn and garden equipment (such as STIGA Group) while others produce constructional equipment (Koshin Ltd.).

The lower end of the relevant horsepower range is comprised of mostly lawn and garden equipment powered by air-cooled, four-stroke or two-stroke gasoline engines, while the higher end includes light construction, agricultural, or commercial/industrial equipment often powered by water-cooled diesels and four-stroke gasoline engines.

Equipment powered by alternative power sources is a separate niche. For example, electrically powered lawn and garden equipment present a viable alternative to some applications. Similarly, compressed natural gas (CNG) and liquefied petroleum gas (LPG) engines are common in some industrial equipment.

Below are the lists of four-stroke gasoline engine manufacturers grouped by their production arrangements and focus:

Engines and Equipment Manufacturer: make their own engines for their equipment; their engines are also sold to other manufacturers:

1. Briggs & Stratton
2. Honda
3. Kohler
4. Yamaha

Engines and Equipment Manufacturers: make their own engines for their equipment

1. STIGA
2. Andreas STIHL

3. Lifan
4. Makita
5. Suzhou ERMA Machinery
6. Weima Agricultural Machinery
7. Stanley Black & Decker
8. Kawasaki
9. Kubota (just 1 gasoline powered 4 stroke engines ~25HP is close to the desired range)
10. Brilliant Group
11. MTD/ Asian manufacturing company
12. ECHO Incorporated/Yamabiko Corporation

Engines and Equipment Manufacturers: use their own and other manufactures' engines for equipment

1. Koshin
2. John Deere

Engines Manufacturers only:

1. Changzhou Fuji Changchai Robin Gasoline Engine Co., Ltd was a joint venture invested by Fuji Heavy Industries Ltd of Japan and Changchai Co., Ltd of China.
2. Liquid Combustion Technology

Two engine manufacturers, Honda and Briggs & Stratton stand alone at the top in small engine sales. The rest of the market is served by smaller firms.

Briggs & Stratton

Briggs & Stratton located in Milwaukee, Wisconsin, is the world's largest producer of air-cooled gasoline engines for outdoor power equipment ranging from 2 to 18 horsepower. Unlike most other manufacturers of utility engines, Briggs & Stratton's engine sales account for more than 90% of the total sales. The technology level of most of its products is such that significant investment may be necessary to comply with strict emission certification standards.

Briggs is committed to maintaining its prominence in the lawn and garden industry. As a major focus of the company's marketing efforts, the lawn and garden market accounts for 86% while the remaining 14% - to generators, pumps, pressure washers, and light construction and agricultural equipment.

Its products are sold under its own brand as well as Victa, Simplicity, Ferris, Billy Goat, Vanguard, Branco and Allmand. It also sells engines to other manufacturers including Deere & Co., the Toro Co. and Viking.

As of July 20, the company filed for chapter 11 bankruptcy. On September 22, 2020, Briggs & Stratton announced completion of sale to KPS Capital Partners. Briggs & Stratton will operate as an independent company with the long-term support of KPS, a leading global private equity investor with a demonstrated track record of successfully transforming businesses and creating profitable, growing companies. The Consultant does not believe that this event will affect the market.

Honda

Honda, the largest company in the study, is in Tokyo, Japan. Honda is well-known throughout the world for its automobiles, but the company also manufactures a premium line of lawn and garden equipment and gasoline and diesel engines for sale to small engine equipment manufacturers. However, because of

Honda's success in the motorcycle and automobile industries, less than 10% of sales are derived from the sale of lawn and garden equipment and loose small engines.

Honda offers both diesel and gasoline engines for a wide range of small engine equipment. Their line of gasoline engines includes twelve models, rated mostly from 2.2 to 13 HP characterized by their modern design and predominantly overhead valve technology. Most of the equipment offered by Honda are lawnmowers, mostly rated from 2.4 to 5.5 HP. Honda offers few models of riding mowers that utilize engines with power ranges between 11 and 13 HP. Each model employs four-stroke engines.

Honda's diesel engines are commonly installed into light industrial equipment, as well as lawn and garden minitractors. Honda's line of multi-purpose minitractors includes four models powered by either 13 or 18 HP engines.

Market Players Excluded from the Forecast or Included Partially

The Consultant did not include some sound names into forecast or included them partially.

- Generac, Kubota, and John Deere are included in almost all small engine market forecasts published by credible agencies. However, these manufacturers are focused on tractors, power generators and diesel engines. Since these specifications do not meet the Client's requirements for the target market, they are only partially included.
- Stanley Black & Decker manufactures various types of lawn and garden equipment mostly targeted to the residential consumer: edgers, trimmers, lawnmowers, hedge trimmers, and blower vacuums. These products are almost exclusively powered by Stanley Black & Decker electric motors, although one edger model is powered by a gasoline engine.
- Yanmar, Jeemar Power Co., Ltd., and Motorenfabrik Hatz GmbH & Co. produce diesel engines hence they are excluded from the estimates.
- Subaru small engine division was shut down on October 2nd, 2017 and repurposed for the Subaru's automobile branch; hence it was excluded from the forecast.

Major engine producers are shown in Table 1: Global Small Engine Manufacturers.

	Name	Business	Contact Information	Revenue	Units	Market Coverage	Engines	Notes
1	Briggs & Stratton Corporation	Manufacturer of gasoline engines	Headquarters: Wauwatosa, Wisconsin, U.S. 1-800-661-6662	US\$1.786 Bln (2017) ¹⁰	10 Mln units per year as of April 2015	- Lawnmowers - Pressure washers - Power generators - Go-karts	Vertical shaft, 4-stroke side-valve units with ratings between 3.5 and 12.5 HP	Briggs & Stratton powers 8/10 US lawn mower brands.
2	Honda Motor Company, Ltd.	Global manufacturer of automobiles, motorcycles, and power equipment	Headquarters: Minato, Tokyo, Japan 1-888-946-6329	¥15.36 Trl (2018) ¹¹	2010-4.7 Mln units.	- Scooters - Electric generators - Water pumps - Lawn and garden equipment	Diesel and gasoline from 2.2 to 13 HP, 17 distinct models of lawnmowers, from 2.4 to 5.5 HP	Honda and Briggs & Stratton stand alone at the top at around \$1.4Bln in small engine sales

[REDACTED]

	Name	Business	Contact Information	Revenue	Units	Market Coverage	Engines	Notes
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'								
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	Name	Business	Contact Information	Revenue	Units	Market Coverage	Engines	Notes

	Name	Business	Contact Information	Revenue	Units	Market Coverage	Engines	Notes

[Redacted Content]

	Name	Business	Contact Information	Revenue	Units	Market Coverage	Engines	Notes
20	Brilliant Group Industry Inc.	Brilliant had three production lines. The first two lines were used for gasoline engines	Headquarters: Valley Stream, NY, US, 1-844-392-6242	~1 Mln US		-Engine parts -Engines -Generators -Pressure washers -Sprayers		

Table 1: Global Small Engine Manufacturers

10. CATALYTIC CONVERTER MANUFACTURERS

Catalytic converters are manufactured by companies that are specialized in emission control equipment. Large manufacturers usually offer several lines of products with emission controls being one of them. Their typical clients are automotive and other types of equipment makers; each manufacturer usually serves several makers. Larger players hold key technologies and patents with high-end customers; they have been forming the monopolistic position in the industry.

This section has two subsections. The first one, Top Catalyst Converter Manufacturers, covers the top producers of catalytic converters and emission controls; the second subsection summarizes information about specific manufacturers who are focused on servicing catalytic solutions for small engines.

Top Catalyst Converter Manufacturers

This part summarizes the information about the largest eleven manufacturers. Information on each company covers its revenue information, developed emission reduction technologies, and corporate strategy and focus. THE CONSULTANT BELIEVES THAT THIS INFORMATION CAN BE IMPORTANT FOR THE CLIENT TO DEVELOP AN UNDERSTANDING OF A GENERAL DIRECTION OF THE R&D EFFORTS AND STRATEGIC DEVELOPMENT OF THE INDUSTRY. THIS UNDERSTANDING CAN BE USEFUL FOR ALIGNING ITS OWN RESEARCH EFFORTS AND DEVELOPING MARKETING MESSAGING. ANOTHER POTENTIAL INTEREST CAN BE IN BUILDING A PARTNERSHIP OR A LICENSING AGREEMENT WITH A LARGE COMPANY THAT CAN BE INTERESTED IN EXPANDING ITS PRODUCT OFFERINGS WITH THE CLIENT'S SOLUTION.

Faurecia (France)

■ faurecia

<https://www.faurecia.com/en>

Sales in 2019: EUR 17.8B (US\$ 21B)

Overview

Faurecia is a French global automotive supplier headquartered in Nanterre, in the western suburbs of Paris. Faurecia designs and manufactures seats, exhaust systems, interior systems (dashboards, center consoles, door panels, acoustic modules) and decorative aspects of a vehicle (aluminum, wood). In 2018 it was the 9th largest international automotive parts manufacturer in the world and #1 for vehicle interiors and emission control technology. One in three automobiles is equipped by Faurecia.²⁷ It has 300 sites in 37 countries and 37 R&D centers with 115,500 employees in total. In 2019, the company filed 608 patents.

Emission reduction technologies

Faurecia provides emissions and noise reduction systems that contribute to meet future standards, as well as aftertreatment systems for internal combustion engines and hybrid powertrains to reduce their emissions, noise and recover waste energy. As a global leader for the last 15 years in air quality and energy efficiency solutions for passenger vehicles, Faurecia is expanding its passenger vehicle expertise to commercial vehicles & high horsepower engines.

Focus and Strategy

The company is focused on building cleaner technologies to reduce environmental impact. Faurecia aims to expand its initiatives for future zero emissions mobility focusing on emerging hydrogen fuel cells and battery packs. The acceleration of both battery and fuel cell electric vehicles is driving the need for lightweight battery housing and integrated battery thermal management and as well as efficient fuel cell systems and lightweight fuel cell tanks. In the area specific to catalysts, the company develops electrically heated catalysts, a cutting-edge system that activates the catalyst in low-temperature phases using electric energy to heat up exhaust gases. The system enhances the aftertreatment performance by heating the gases and the ceramic catalyst bricks.

²⁷ Wikipedia: Faurecia, <<https://en.wikipedia.org/wiki/Faurecia> - cite note-1>

Tenneco (U.S.A.)

[illegible]

[illegible]

Sango Automotive Parts (Japan)



[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

Futaba Industrial Co. Ltd (Japan)

FUTABA

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

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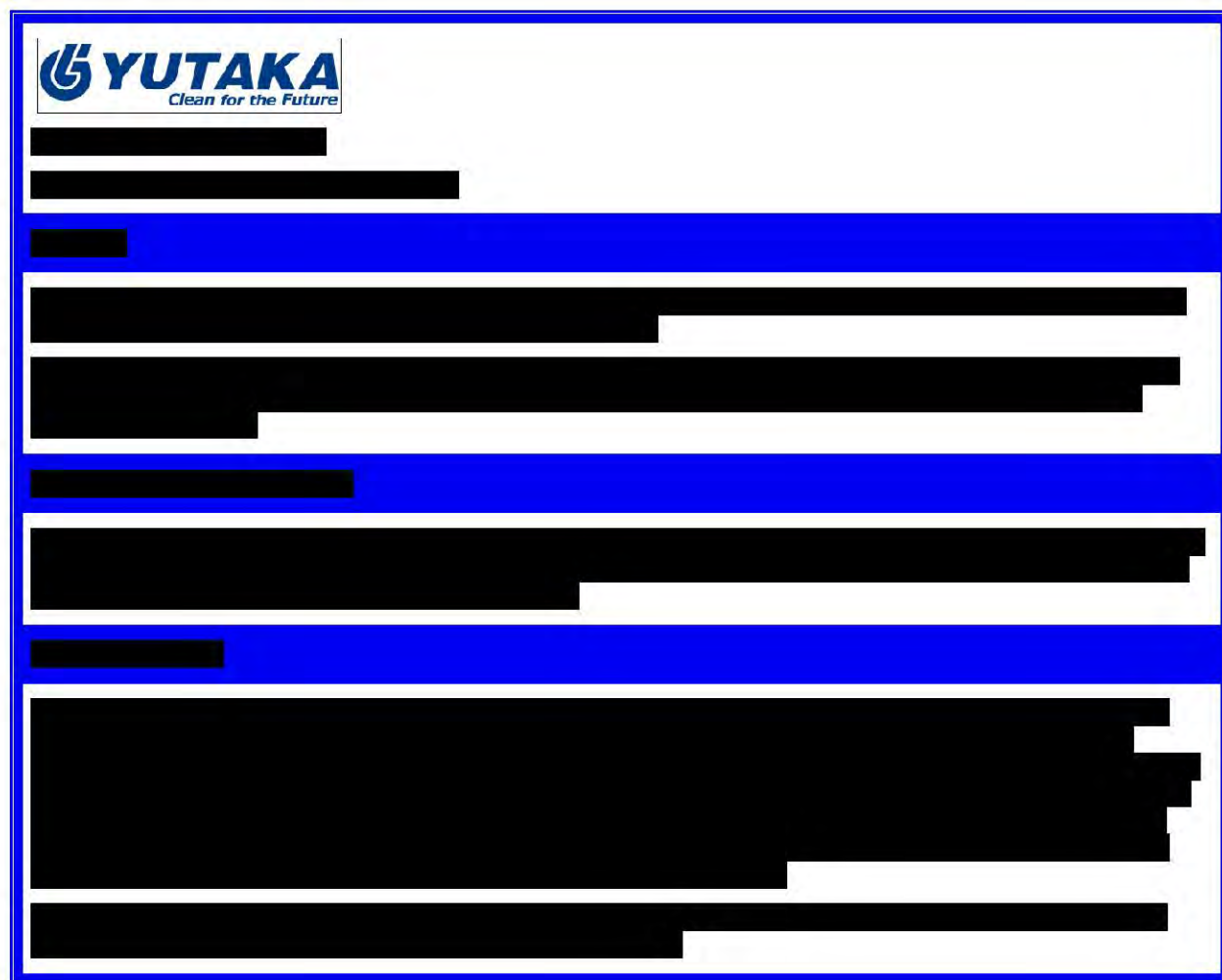
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Yutaka Giken (Japan)



MAJORITY OF THE LARGE EMISSION CONTROL MANUFACTURERS ADHERE TO SIMILAR STRATEGIC DIRECTIONS:

- DEVELOPING AN EXPERTISE ON ENTERING OTHER AREAS OF EMISSION CONTROL TECHNOLOGIES, SUCH AS FUEL CELL, HYBRIDS, ELECTRIC CARS.
- DEDICATING RESOURCES TO FOCUS ON IMPROVING THE OVERALL PERFORMANCE AND PRODUCTION PROCESSES TO ENSURE THE HIGHEST PRODUCT AND SERVICES QUALITY WITH ZERO DEFECTS. OTHER OVERALL IMPROVEMENTS ACROSS ALL PRODUCTS TARGET WEIGHT AND NOISE REDUCTION. COST CONTAINMENT IS ALSO ONE OF THE IMPORTANT DRIVERS.
- SPECIFIC TO CATALYTIC CONVERTERS AND EMISSION CONTROL DEVICES, MOST MANUFACTURERS FOCUS ON IMPROVING EXISTING SOLUTIONS BY DEVELOPING ELECTRICALLY HEATED CATALYSTS, SYSTEMS THAT ACTIVATE THE CATALYST IN LOW-TEMPERATURE PHASES USING ELECTRIC ENERGY TO HEAT UP EXHAUST GASES, DURABILITY OF DEVICES, AS WELL AS IMPROVING DIESEL EXHAUST SYSTEMS.

SOME MANUFACTURERS, SUCH AS SANGO, HIROTEC AND MARELLI, PROMOTE THE FACT THAT THEY EITHER DEVELOP THEIR OWN MATERIALS OR DELIVER THE COMPLETE TURN-KEY SOLUTIONS AND

WORK TOGETHER WITH RAW MATERIAL MANUFACTURERS TO DEVELOP LOW COST MATERIAL WITH HIGH QUALITY FUNCTIONS. SUCH STRATEGIES CAN BE OF AN INTEREST TO THE CLIENT FROM THE PERSPECTIVE OF BUILDING POTENTIAL PARTNERSHIPS. IT IS ALSO INTERESTING TO NOTE THAT MOST OF THE LARGE MANUFACTURERS' TAGLINES/MOTTOS TARGET QUALITY OF THE PRODUCTS AND SERVICES.

Small Motor Catalytic Converter Manufacturers

There are only a handful of manufacturers that specialize in technologies targeting specifically small engine catalytic converters. This part has a summary of those identified. The information on each manufacturer includes the contact data, summary about the manufacturer, description of product(s) that can be considered a direct competition to the Client's Solution, services, applications for technologies, engines compatible with their technology. There is a description on how each manufacturer positions the company and products in the marketplace, such as tagline, pricing, and marketing promotional techniques used to market its solutions online. **THIS INFORMATION CAN BE OF USE TO THE CLIENT IN DEVELOPING ITS OWN ONLINE MARKET POSITIONING.**

300 Technologies Inc. (U.S.A.)

<https://300technologies.com/>

4905 NE 12th Avenue, Oakland Park, FL 33334, US

[\(954\) 234-0018](tel:(954)234-0018)

About Company

N/a

Product Description

GenCat® is a bolt-on replacement catalytic muffler for all small gasoline powered engines designed to significantly reduce deadly carbon monoxide (CO). Carbon monoxide reduction is achieved through a thermal conversion process using proprietary technology without the use of a closed-loop lambda system. Carbureted engines inherently run "rich" by design. The GenCat acts like a secondary afterburner converting this fuel-rich CO laden exhaust to a much safer mix of carbon dioxide (CO₂), and water (H₂O). The result being near perfect combustion. Small gas engine exhaust contains CO levels up to 30,000 ppm, roughly equivalent to that of 300 idling cars! With the GENCAT installed, carbon monoxide is reduced to a mere 150-250 ppm, about as much as a 4-burner stove.

Tagline

99% filter REDUCTION OF CARBON MONOXIDE on all small engines

Applications

Designed for use in small engines, suitable for a wide variety of small gas engine muffler applications, including the following:

- Generators
- Concrete and construction tools
- Fire rescue tools

- Go Kart racing
- Positive Pressure Ventilators (PPVs)
- Jaws of Life
- Pressure Washers
- Any small gasoline engine

Emission Reduction

The focus is on reducing the CO emission: The Clean Air Muffler System (CAMS) technology is ideal for reducing carbon monoxide emissions and can help comply with OSHA's safety standards to keep safe when working with small gasoline engines. 300 Technologies collaborated with the Florida International University and Clean Air Mufflers. The EPA/CARB ISO-9001 Laboratory has verified that their CAMS mufflers achieve a 99.1% reduction of CO.

Compatible engines

Honda GX120, GX160, GX200, GX240, GX270, GX390

Price

CAMS160200

\$396.00

Honda GX120, GX160, GX200



CAMS24390

\$495.00

Honda GX240, GX270, GX390



CAMSO5500

\$495.00

ONAN5500: Emerald 4k - 7k



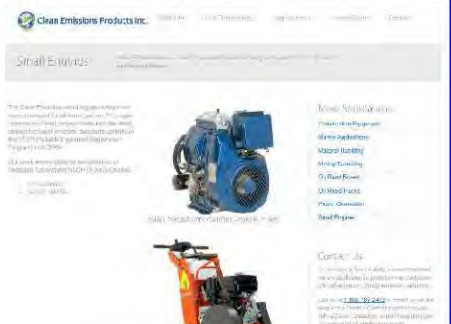
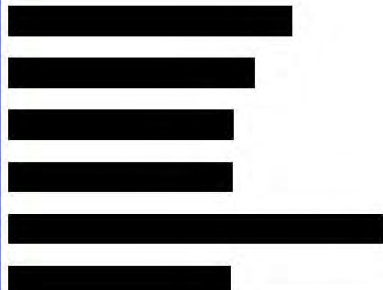
Marketing / Promotion

Quite simple, clear, and direct message focused on selling. A simple website with one scroll-down page and multiple selling calls. there are several video testimonials. There are three products listed at the bottom of the webpage with prices, images and equipment models that can be served by these products.



[illegible]

The screenshot shows the LinkedIn Learning homepage. At the top, there's a navigation bar with 'LinkedIn Learning' and 'My Learning' tabs. Below this is a search bar and a 'Browse by Skill' section. The main content area is titled 'Learn & Grow' and features a 'New Course' button. A list of courses is displayed, including 'Introduction to Project Management' and 'Introduction to Data Science'.



Nett Technologies



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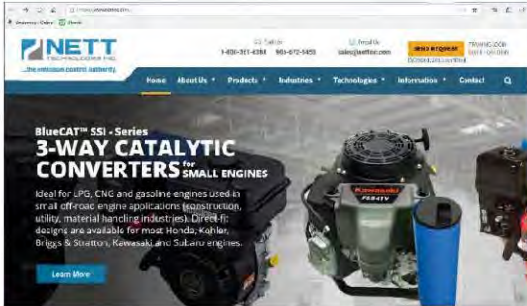
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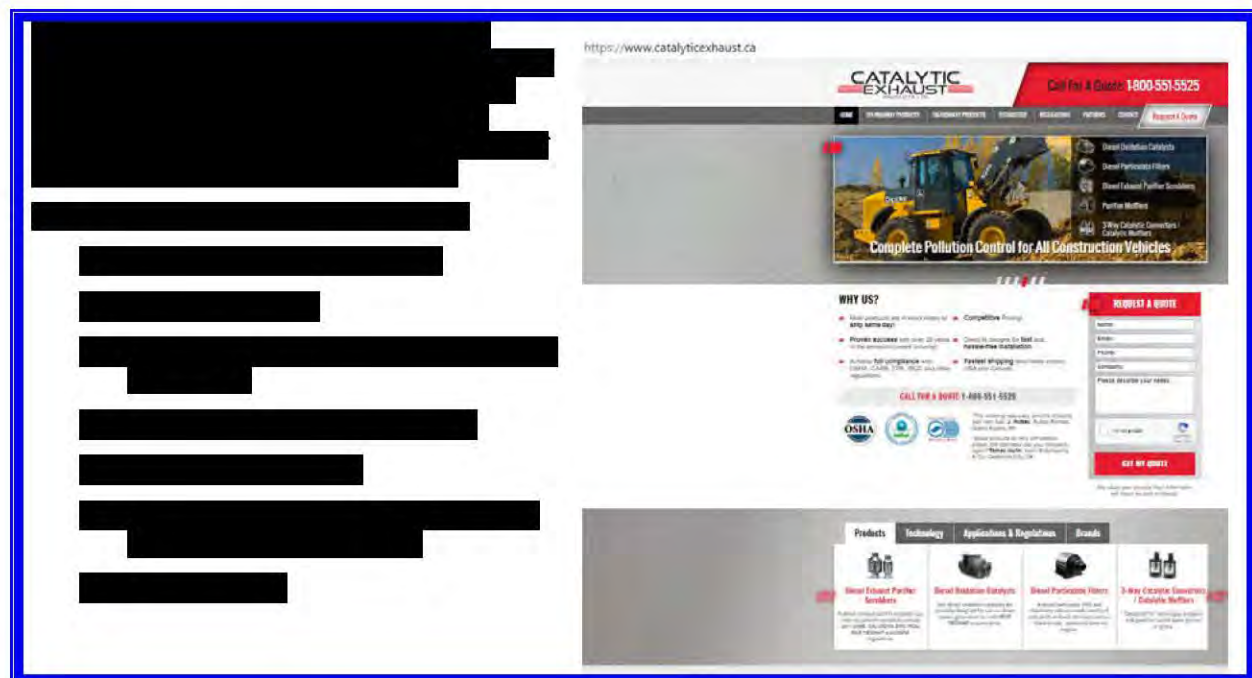
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MANUFACTURERS WHO POSITION THEMSELVES AS SMALL ENGINE EMISSION CONTROL MAKERS ARE TYPICALLY SMALL. OPPOSING THE LARGE MANUFACTURERS, THEY ARE MAINLY FOCUSED ON AGGRESSIVE SELLING.

ENVIRONMENTAL REGULATIONS ARE EXTENSIVELY FEATURED ON WEBSITES; THEY POSITION THEIR PRODUCTS AS ULTIMATE SOLUTIONS TO THE EXHAUST EMISSION REDUCTION, THEIR TAGLINES ADDRESS EMISSION REDUCTION AS THE KEY OBJECTIVE. ALSO, DETAILED INFORMATION IS PROVIDED ON COMPATIBLE ENGINES AND SERVICES THAT ACCOMPANY THE PRODUCTS. CUSTOMIZED DESIGN, EXPEDIENCY IN PRODUCING AND SHIPPING ARE HEAVILY PROMOTED. THIS APPROACH SEEMS REASONABLE SINCE SMALLER COMPANIES HAVE MORE FLEXIBILITY IN FASTER DESIGNING AND MANUFACTURING. DETAILED MARKETING MATERIALS ALSO DIFFERENTIATE THEM FROM LARGE PRODUCERS.

11. EMISSION REDUCTION REGULATIONS FOR EXHAUST FROM ENGINES

Typically, government support is the most effective force behind any new technology. In the case of engine exhaust emissions, this premise is taken to another level. In fact, regulation is the main driver for adoption of the new technology by the market.

Emissions from spark-ignition engines contribute to air pollution, which leads to adverse impacts on human health and the environment. These adverse impacts include increased risks of various cardiovascular and respiratory outcomes, as well as damage to forest ecosystems, crops and wildlife, impaired visibility, and the soiling of surfaces. Emitted substances are involved in a series of complex reactions activated by sunlight that result in the formation of ground-level ozone, a respiratory irritant and component of smog. Smog is a noxious mixture of air pollutants, primarily ground-level ozone, and particulate matter. It can often be seen as a haze in the air, especially over urban centers, and leads to numerous negative impacts relating to human health and the environment.²⁸

Motors operating on fossil fuels have been under strict regulations due to the harmful nature of emissions. Because of the complex nature of these emissions and the serious impact on human health and the environment, they have been under control by different regulatory authorities. These controls are established on federal, regional, and local levels and are constantly scrutinized with more and more restrictions added on an ongoing basis. They target different pollutants and industries, and frequently have their targets overlap.

Government regulatory limitations is not the only force that drives equipment manufacturers to incorporate advanced solutions to reduce exhaust emissions. Grassroot movements that have been pushing an agenda on curbing specifically GHG emissions have been gaining more momentum with the government. Now we are witnessing the trend of governments at all levels adopting and strengthening the GHG reduction targets.

This section discusses these regulations from two perspectives. The first one is the existing regulations on the federal level that target harmful pollutants in the U.S.A. and Canada from the SSI engines. There is also discussion of the California standards as they are stricter than those of the federal level; California emission regulations are frequently adopted by other states to supersede the federal mandate. Another perspective is the movement specifically targeting GHGs. They do not directly target emissions from engines but the drive for an elimination of the GHG emission can affect these engines.

UNDERSTANDING THESE POLICIES AND INITIATIVES IS VERY IMPORTANT. DEPENDING ON THE ANGLE AND FOCUS OF THE POLICY, THE CLIENT CAN FORMULATE AND ADJUST THE MARKETING MESSAGE TO TARGET THE AUDIENCE. ALSO, STAYING ABREAST OF THE CHANGES TO THE REGULATIONS AND MOVEMENTS WILL HELP THE CLIENT STAY AHEAD OF THE COMPETITION.

The Federal-level Regulations on Emissions from Engines

There is a multitude of emission-specific regulations issued on the federal level by different branches and departments. The Occupational Safety and Health Administration (OSHA), which sets and enforces protective workplace safety and health standards, has standards limiting emissions from equipment and



other chemical contaminants at the workplace. A division of the US Department of Labor; the Mine Safety and Health Administration also sets standards preventing death, disease, and injury from mining and to promote safe and healthful workplaces for the nation's miners including regulations for using diesel in mines²⁹.

Meanwhile, Environmental Protection Agency (EPA) leads in the scope and depth of regulations targeting emissions reduction.

Summary of Environmental Protection Agency's Standards for Engine-related Emissions

EPA's Office of Transportation and Air Quality³⁰ protects public health and the environment by regulating air pollution from motor vehicles, engines, and the fuels used to operate them. Some of its regulations that control the volume of emissions are listed below.

1. Forklifts, Generators, and Compressors (gasoline/propane/natural gas): nonroad spark-ignition (SI) engines over 19 kW (25 horsepower), including many kinds of equipment, such as forklifts, generators, and many other farm, industrial, and construction applications.³¹
2. Heavy Trucks, Buses and Engines: diesel engines, gasoline-fueled and other spark-ignition engines, engines installed in all vehicles with Gross Vehicle Weight Rating above 14,000 pounds, and to some engines installed in vehicles with Gross Vehicle Weight Rating between 8,500 and 14,000 pounds.³²
3. Small Spark-ignition Engines and Equipment (Lawn and Garden Small Gasoline Equipment): emission standards to control both exhaust and evaporative emissions from small spark-ignition engines. Phase 3 exhaust emissions standards took effect in 2011 or 2012, depending on the size of the engine. Evaporative emission standards address fuel permeation through fuel-system components in addition to fuel venting during engine operation.³³
4. Locomotives: a three-part program to reduce emissions from diesel locomotives of all types -- line-haul, switch, and passenger rail. The rule cuts PM emissions from these engines by as much as 90% and NOx emissions by as much as 80% when fully implemented.³⁴
5. Nonroad Diesel Engines: excavators and other construction equipment, farm tractors and other agricultural equipment, heavy forklifts, airport ground service equipment, and utility equipment such as generators, pumps, and compressors.³⁵
6. RICE NESHAP (Stationary Engines): National Emission Standards for Hazardous Air Pollutants (NESHAP) applies to existing, new, and reconstructed stationary Reciprocating Internal Combustion Engines (RICE). Covers stationary diesel-fueled/compression ignition (CI) RICE and stationary gas-fired engines/spark ignition RICE.³⁶



7. Clean School Bus: older diesel school buses.³⁷
8. Diesel Boats and Ships, from small recreational runabouts to large ocean-going vessels.³⁸
9. Gasoline Boats and Personal Watercraft: exhaust and evaporative emissions from marine spark-ignition engines and vessels.³⁹

The EPA's Standards Targeting Small SI Engines

The list of regulations in the previous section is very exhaustive and covers a wide array of equipment, engines, and vehicles. This section summarizes specifically the standard that applies to the Client's intended target market, small spark-ignition engines (it is listed as item 3 in the list above).

The EPA has adopted 40 CFR Part 1054, emission standards to control both exhaust and evaporative emissions from new small spark-ignition engines and equipment with maximum engine power at or below 19 kW. This section covers only those aspects of the regulation that address exhaust only emissions.⁴⁰

These engine standards reduce emissions of NO_x, CO, and selected air toxins.

Covered equipment: new, spark-ignition engines. This includes auxiliary marine spark-ignition engines of the following model years:

Engine type	Engine displacement	Model year
Handheld	all	2010
Nonhandheld	displacement <225 cc	2012
Nonhandheld	displacement ≥225 cc	2011

Responsible for compliance: manufacturers of engines and equipment.

Nonroad engines excluded: engines used in snowmobiles and all-terrain vehicles, propulsion marine engines, engines used in reduced-scale models of vehicles that are not capable of transporting a person.

Standard exceptions:

- Wintertime engines. Emission standards regulating HC and NO_x exhaust emissions are optional for wintertime engines. However, if you certify an emission family to such standards, those engines are subject to all the requirements of this part as if these optional standards were mandatory.

EPA Phase I non-handheld engine classes:

Class I—engines less than 225 cc in displacement; or

Class II—engines greater than or equal to 225 cc in displacement.

Engines powering equipment defined as handheld:

Class III—engines less than 20 cc in displacement; or

Class IV—engines equal to or greater than 20 cc and less than 50 cc in displacement; or

Class V—engines equal to or greater than 50 cc in displacement.

- Two-stroke snow thrower engines. Two-stroke snow thrower engines may meet exhaust emission standards that apply to handheld engines with the same engine displacement instead of the nonhandheld standards that would otherwise apply.

Exhaust emission standards for handheld engines: Exhaust emissions from handheld engines may not exceed the emission standards in the table below:

Engine displacement class	HC + NOX	CO
Class III	50	805
Class IV	50	805
Class V	72	603

Table 2: Phase 3 Emission Standards for Handheld Engines (g/kW-hr)

Exhaust emission standards for nonhandheld engines: Exhaust emissions from handheld engines may not exceed the emission standards in the table below:

Engine displacement class	HC + NOX	Primary CO standard	CO standard for marine generator engines
Class I	10.0	610	5.0
Class II	8.0	610	5.0

Table 3: Phase 3 Emission Standards for Nonhandheld Engines (g/kW-hr)

The useful life period for meeting exhaust emission standards, which is the period during which engines are required to comply with all emission standards that apply: five years or several hours of operation, whichever comes first. The useful life period for exhaust requirements is the number of engine operating hours that most closely matches the expected median in-use life of engines:

Nonhandheld			
	Residential	Extended life residential ¹	Commercial
Class I	125	250	500
Class II	250	500	1,000
Handheld			
	Light use	Medium use	Heavy use
Class III—V	50	125	300

Table 4: Nominal Useful Life Periods

One may select a longer useful life for nonhandheld engines than that specified, in 100-hour increments not to exceed 3,000 hours for Class I engines or 5,000 hours for Class II engines. For engine families generating emission credits, you may do this only with our approval. These are considered “Heavy Commercial” engines.

The minimum useful life period for engines with maximum engine power above 19 kW is 1,000 hours.

Canadian Emission Regulations for SSI Engines

In Canada, emissions from SSI engines are regulated by means of the Off-Road Small Spark-Ignition Engine Emission Regulations. These engines are defined as those off-road engines using a spark plug or other sparking device and producing no more than 19 kW of power.⁴¹

The regulation aligns Canadian standards for air pollutant emissions with the EPA emission standards for SSI engines.

It is estimated that around 1.5 to 2 million SSI engines enter the Canadian market on an annual basis, the largest share of which is coming from the U.S.A. engine production.

The alignment of emission standards in Canada with those of the United States creates a levelled Canada–U.S. market, allowing for incremental reductions in emissions by means of preventing the import of SSI engines into Canada that do not meet the EPA emission standards. If Canada adopted regulatory standards that were different from those introduced by the United States, product availability would potentially be reduced in the Canadian marketplace, and the average costs of engines designed to meet unique Canadian standards would likely be greater than the average costs of the analogous engines meeting the Phase 3 standards. Unique Canadian standards would require additional design and manufacturing costs and require extensive development of testing and certification procedures. The higher costs would be partly passed on to consumers. Adopting unique Canadian standards would conflict with Canada's policy of alignment with U.S. emission standards and the trend towards global harmonization of emission standards.

The EPA implemented Phase 1 Standards for Small Spark-Ignition Utility Engines in 1997. The Canadian Federal government established a voluntary agreement or a Memorandum of Understanding with manufacturers that reflect the EPA's Phase 1 regulations.

A transitory period between 2002 to 2007 saw the implementation of Phase 2. At this time Canada harmonized with the U.S.A.

In 2008, the EPA published Phase 3 emission standards for SSI engines. In 2017, Canada published Regulations Amending the Off-Road Small Spark-Ignition Engine Emission Regulations to decrease exhaust and evaporative emissions of air pollutants from off-road engines using a spark plug, or other sparking device, and producing no more than 19 kW of power. Amendments incorporated the U.S. EPA Phase 3 exhaust emission standards for machines powered by SSI engines and established more stringent standards in Canada for emissions of air pollutants of NO_x, hydrocarbons and CO from the exhaust systems of engines designed to be used in non-handheld machines.

According to the cost-benefit analysis, from 2018 to 2031, the amended standards would lead to reductions of air pollutant emissions from SSI engines in Canada, including approximately 20,000 fewer tonnes of NO_x and 58,000 fewer tonnes of VOCs. The health benefits of NO_x and VOC emissions avoided under the regulatory scenario are projected to be at least \$140 million. Further, pre-tax fuel (gasoline) savings and reductions in administrative costs in the order of \$ [REDACTED] million, respectively, would benefit consumers and importers of SSI engines. The total benefits were estimated to

According to the data from 2016, all SSI engines in Canada are imported, as there is no domestic manufacturing:

- Around 65% of the engines are imported from the United States;
- The next largest share of these engines in Canada comes from China and other Asian countries, excluding Japan (about 20%); and
- 15% (approximately) comes from Japan, Mexico, and the European Union.

be approximately \$ million and the net benefits of \$ million, with a benefit-to-cost ratio of more than 2 to 1.

U.S. State-Level Regulations Targeting Emission Reduction

State level regulators are mainly focused on restricting harmful emissions from power generation sources. Currently, there are 16 state programs in the U.S.A. where authorities require power distributor's disclosure of the emissions from power generation sources. The table below summarizes provides a current list and links to these regulatory policies as reported by the Database of State Incentives for Renewables & Efficiency (DSIRE)⁴².

State	Name of Policy	Policy/Incentive Type	Created	Last Updated
CT	Fuel Mix and Emissions Disclosure	Generation Disclosure	01/01/2001	08/28/2020
NV	Fuel Mix and Emissions Disclosure	Generation Disclosure	01/01/2000	07/20/2020
OK	Zero-Emission Facilities Production Tax Credit	Corporate Tax Credit	01/11/2002	06/10/2019
ME	Fuel Mix and Emissions Disclosure	Generation Disclosure	01/01/2000	03/16/2017
MA	Fuel Mix and Emissions Disclosure	Generation Disclosure	01/01/2000	10/28/2016
DC	Fuel Mix and Emissions Disclosure	Generation Disclosure	11/30/2001	08/18/2016
VA	Fuel Mix and Emissions Disclosure	Generation Disclosure	12/03/2001	03/29/2016
IA	Fuel Mix and Emissions Disclosure	Generation Disclosure	02/14/2005	02/10/2016
OH	Fuel Mix and Emissions Disclosure	Generation Disclosure	09/14/2001	12/02/2015
MI	Fuel Mix and Emissions Disclosure	Generation Disclosure	05/06/2001	07/20/2015
IL	Fuel Mix and Emissions Disclosure	Generation Disclosure	01/01/2000	07/09/2015
TX	Fuel Mix and Emissions Disclosure	Generation Disclosure	01/08/2001	06/24/2015
MN	Fuel Mix and Emissions Disclosure	Generation Disclosure	12/03/2001	05/15/2015
RI	Fuel Mix and Emissions Disclosure	Generation Disclosure	12/06/2005	12/05/2014
OR	Fuel Mix and Emissions Disclosure	Generation Disclosure	09/13/2001	10/20/2014
MD	Fuel Mix and Emissions Disclosure	Generation Disclosure	09/14/2001	10/17/2014

Table 5: U.S.A. State-Level Regulations Limiting Emissions from Power Generation

California Air Resources Board's Standards for SSI Emissions

CALIFORNIA HAS BEEN THE MOST PROGRESSIVE STATE AUTHORITY IN PROMOTING AND ESTABLISHING THE MOST ADVANCED CLEAN STANDARDS AND STRICTER THAN THOSE DEVELOPED ON A FEDERAL LEVEL THAT ARE ALSO FREQUENTLY ADOPTED BY OTHER STATES.

<https://www.arb.ca.gov/cc/ssi/ssi.htm>

In 1967, California's Legislature passed the Mulford-Carrell Act, which combined two Department of Health bureaus--the Bureau of Air Sanitation and the Motor Vehicle Pollution Control Board--to establish the Air Resources Board (CARB). Since its formation, the CARB has worked with the public, businesses, and local governments to find solutions to California's air pollution problem. The resulting state air quality standards set by the CARB continue to outpace the rest of the nation.

Summary of California's Standards for Engine-related Emissions

New motor vehicles and engines must be certified by the CARB for emission compliance before they are legal for sale, use, or registration in California. Certification is granted annually to individual engine families and is good for one model year. The following mobile sources are presently subject to the CARB's emission certification:

1. **In-Use Off-Road Diesel Vehicle Regulation:** on July 26, 2007, CARB adopted a regulation to reduce diesel particulate matter and NOx emissions from in-use (existing) off-road heavy-duty diesel vehicles in California. Such vehicles are used in construction, mining, and industrial operations.⁴³
2. **Stationary Diesel Engine ATCM (Airborne Toxic Control Measure):** this ATCM, which applies to stationary diesel engines used in both non-agricultural and agricultural operations is resulting in a reduction in the emissions of and exposure to diesel PM from stationary diesel engines throughout California.⁴⁴
3. **On-Road Heavy-Duty Vehicle Program:** emissions from on-road heavy-duty vehicles are major contributors to poor air quality in California. Diesel vehicles produce emissions in amounts highly disproportionate to the total population of these vehicles. The problem is complicated by the large number of heavy-duty vehicles, like line haul trucks, registered in other states that travel on California's highways and roads, while bringing goods and commerce into and out of the state.⁴⁵
4. **Cargo Handling Equipment (Diesel) at Ports:** regulations to reduce diesel particulate matter and NOx emissions from diesel-fueled cargo handling equipment at California's ports and intermodal rail yards. Cargo handling equipment is used to transfer goods or perform maintenance and repair activities and includes equipment such as yard trucks (hostlers), rubber-tired gantry cranes, top handlers, side handlers, forklifts, and loaders, just to name a few.⁴⁶
5. **Commercial Harbor Craft Regulatory Activities** to reduce diesel particulate matter, NOx, and reactive organic gases (ROG) from commercial harbor craft. There are several types of harbor craft in use in California, including crew and supply boats, charter fishing vessels, commercial fishing vessels, ferry/excursion vessels, pilot vessels, towboats or push boats, tugboats, and work boats.⁴⁷
6. **LSI - Large Spark-Ignition Engines:** off-road large spark-ignition equipment greater than 25 horsepower, including farm, construction, and industrial equipment, powered by gasoline, LPG, and other alternate fuels. Typical applications that use LSI engines include forklifts, specialty vehicles, airport service vehicles, large turf care equipment, portable generators, and a wide array of other agricultural, construction, and general industrial equipment.⁴⁸



7. SSI - Small Spark-Ignition Engines: off-road spark-ignition engines below 25 horsepower, including small utility equipment, lawn mowers and weed trimmers.⁴⁹
8. On-Road Heavy-Duty Diesel Vehicles (In-Use)
Regulation: the regulation requires diesel trucks and buses that operate in California to be upgraded to reduce emissions. Heavier trucks must be retrofitted with PM filters beginning January 1, 2012, and older trucks must be replaced starting January 1, 2015. By January 1, 2023, nearly all trucks and buses will need to have 2010 model year engines or equivalent.⁵⁰
9. Ground Support Equipment (GSE): new and in-use GSE used in airport operations for starting aircraft, aircraft maintenance, aircraft fueling, transporting cargo to and from aircraft, loading cargo, transporting passengers to and from aircraft, baggage handling, lavatory service, and food service. As a group, GSE largely comprise off-road types of equipment fueled by either gasoline or diesel.⁵¹
10. Commercial Marine Vessels: regulatory activities to reduce diesel particulate matter, NOx, and sulfur oxide emissions from commercial marine vessels, which includes both ocean-going ships and commercial harbor craft.⁵²
11. Recreational Marine: CARB's recreational marine engine program is an important element in CARB's efforts to improve air quality through reductions of hydrocarbon (HC) and NOx emissions. Regulations have been adopted for certain marine vessels and regulations have been proposed for other spark-ignition engines used in boats for propulsion.⁵³

The population of small engines in California (16.7 million) is greater than that of light-duty passenger cars (13.7 million) and is comprised of 77% residential lawn and garden equipment, 9% commercial lawn and garden equipment, 11% federally regulated construction/farming equipment, and 3% other equipment types (e.g., generators, utility carts).

According to the CARB analysis, operating the best-selling commercial lawn mower for one hour emits as much smog-forming pollution as driving the best-selling 2017 passenger car, a Toyota Camry, about 300 miles – approximately the distance from Los Angeles to Las Vegas. For the best-selling commercial leaf blower, one hour of operation emits smog-forming pollution comparable to driving a 2017 Toyota Camry about 1100 miles, or approximately the distance from Los Angeles to Denver.

CARB's Standards Targeting SSI Engines

There is a multitude of regulations listed in the previous section that cover a multitude of regulations for emissions from engines and vehicles. This section summarizes specifically the standard that applies to the Client's intended target market, small spark-ignition engines, and equipment (it is listed as item 7 in the list above).

According to California's standards, small engines in California; Small off-road engines (SORE) are spark-ignition engines rated at or below 25 HP or 19 kW, which is the same size as that defined by EPA for SSI. Engines in this category are primarily used for lawn, garden, and other outdoor power equipment.

The standard is defined in 13 CCR, §2401. According to the standard, any spark-ignited engine that produces gross horsepower <25HP (19kW) and is not used to propel an on-road vehicle, off-road motorcycle, all-terrain vehicle, sand car, or marine vessel (e.g., lawn mowers, weed trimmers, chainsaws,



generators, specialty vehicle), manufactured for sale, sold, or offered for sale in California, or that are introduced, delivered or imported into California for introduction into commerce, must not exceed:

Model Year	Displacement Category	Durability Periods (hours)	Hydrocarbon plus Oxides of Nitrogen ⁽¹⁾⁽³⁾	Carbon Monoxide	Particulate
2005 and subsequent	<50 cc	50/125/300	50	536	2.0 ⁽²⁾
	50-80 cc, inclusive	50/125/300	72	536	2.0 ⁽²⁾
2008 and subsequent	>80 cc - <225 cc	125/250/500	10.0	549	
	≥ 225 cc	125/250/500/1000	8.0	549	

Table 6: Exhaust Emission Standards for Spark-Ignition Engines (grams per kilowatt-hour)

Prospective Changes to the Emissions Standards for Small SI Engines

CARB adopted emissions standards for small engines in 1990 and was the first agency in the world to control emissions from these engines.⁵⁴ Due to the regulations put in place by CARB, small engines are 40-80% cleaner today than they were before the program began. In the early 2020s, however, total smog-forming emissions from small engines are projected to exceed those from passenger cars in the South Coast Air Basin because passenger car emissions will continue to decrease. By 2031, small engine emissions will be more than twice those from passenger cars. New lawn mower engines contribute 93 times more smog-forming emissions than new cars.

It is no wonder that the EPA and the state regulators of California are trying to get catalytic converters into lawn mowers and other small engines. However, the lawmakers are met with a powerful lobby. Briggs & Stratton, the leading manufacturer of small engines, state that these regulations would make for an unsafe product that emits too much heat. Briggs & Stratton also contend that the overheating could cause brush fires if the mowers are left running and sitting still. The Californian government and the EPA think it has more to do with the bottom line. Pending regulations proposed in California could reduce emissions by the equivalent of [REDACTED] cars per day.⁵⁵

DESPITE A STRONG OPPOSITION AND BECAUSE OF CALIFORNIA'S ONGOING AIR QUALITY CHALLENGES, ADDITIONAL EMISSIONS REDUCTIONS ARE EXPECTED. IN 2020, CARB WILL CONSIDER NEW STANDARDS FOR SMALL ENGINES TO HELP CALIFORNIA MEET ITS GOAL OF REDUCING SMOG-FORMING POLLUTANT EMISSIONS FROM MOBILE SOURCES BY [REDACTED] % IN 2031.⁵⁶ Significant emission reductions will be achieved through a combination of regulatory and incentive approaches, and a major shift to zero-emission equipment.

12. GHG EMISSION REDUCTION INITIATIVES

Kyoto Protocol and Paris Accord – Major Force in GHG Emission Reduction Movements

The main driving force of most policies on sustainability is the intention to reduce the impact from human activities on the environment. The paramount one is Kyoto Protocol, an international treaty among 192 parties, which extends the 1992 United Nations Framework Convention on Climate Change (UNFCCC) and commits state parties to reduce GHG emissions (CO₂, CH₄, N₂O, HFCs, PFCs, SF₆). The Kyoto Protocol was adopted in Kyoto, Japan, on 11 December 1997 and entered into force on 16 February 2005.⁵⁷ Its goals for each nation were extended until 2020.

Built on Kyoto Protocol, the Paris Agreement, an agreement within the UNFCCC, was signed in 2016. The agreement was negotiated by representatives of 196 state parties at the 21st Conference of the Parties of the UNFCCC in Le Bourget, near Paris, France. As of February 2020, all UNFCCC members have signed the agreement, 189 have become party to it⁵⁸ and the only significant emitters which are not parties are Iran and Turkey. The Paris Agreement's long-term temperature goal is to keep the increase in global average temperature to well below 2 °C (3.6 °F) above pre-industrial levels; and to pursue efforts to limit the increase to 1.5 °C (2.7 °F).

The Paris deal is the world's first comprehensive climate agreement: its strategy involves energy and climate policy including the so-called 20/20/20 targets, namely the reduction of CO₂ emissions by 20%, the increase of renewable energy market share to 20%, and a 20% increase in energy efficiency. The agreement has been described as an incentive for and driver of fossil fuel divestment.

THE CONSULTANT BELIEVES THAT THE PARIS AGREEMENT IS THE MAIN DRIVING FORCE FOR A MULTITUDE OF GHG REDUCTION STANDARDS THAT HAVE BEEN AND WILL CONTINUE EMERGING.

Local Governmental Response to the International Initiatives on GHG

LOCAL GOVERNMENTS, SUCH AS MUNICIPALITIES, TYPICALLY LED BY ELECTED OFFICIALS, HAVE BEEN FOLLOWING THEIR OWN PATH IN ATTEMPTING TO ACHIEVE MORE SUSTAINABLE AND CLEANER OPERATIONS. THEIR VISION AND OBJECTIVES DO NOT NECESSARILY OVERLAP WITH THOSE OF THE FEDERAL AUTHORITIES; LOCAL AUTHORITIES ARE FREQUENTLY MORE AGGRESSIVE AND SET THEIR OWN EMISSION REDUCTION TARGETS TO COMBAT EMISSIONS.

Building on the Paris Agreement, cities have been on an accelerated journey to limit global warming. There are at least two major initiatives adopted by most municipalities globally, the Global Covenant of Mayors for Climate and Energy and the Climate Mobilization Movement.



The Global Covenant of Mayors for Climate and Energy

The Global Covenant of Mayors (GCoM) for Climate & Energy was established in 2016 by bringing together the Compact of Mayors and the European Union's Covenant of Mayors. It is a global coalition of city leaders addressing climate change by pledging to cut GHG emissions and prepare for the impacts of climate change.

GCoM estimated that cities are responsible for more than 70% of global energy-related CO₂ emissions, and hence represent the greatest opportunity for tackling climate change.⁵⁹ With annual emissions reduction expected to reach 4.2 billion tons CO₂e in 2050, GCoM cities can progress towards Paris Agreement goals – simultaneously safeguarding the health and prosperity of their citizens.

World Resources Institute, C40 Cities Climate Leadership Group, and ICLEI – Local Governments for Sustainability have partnered to create a GHG Protocol standard for cities known as *Global Protocol for Community-Scale GHG Gas Emission Inventories* (GPC). GPC provides a framework for accounting and reporting city-wide GHG gas emissions. It seeks to:

- Help cities develop a comprehensive GHG inventory to support climate action planning;
- Help cities establish a base year inventory, set reduction targets, and track their performance;
- Ensure consistent measurement and reporting of GHG emissions between cities, following internationally recognized GHG accounting and reporting principles;
- Enable city inventories to be aggregated at subnational and national levels; and
- Facilitate insight through benchmarking – and aggregation – of comparable data.

GPC identifies basic requirements and rules for accounting the several gases covered by the Kyoto Protocol.⁶⁰ **EACH PARTICIPANT HAS TO ESTABLISH THE REDUCTION TARGETS AND MONITOR THEIR STATUS ALONG THESE SIX MAIN SECTORS:**

1. **STATIONARY ENERGY.** Stationary energy sources are one of the largest contributors to a city's GHG emissions. These emissions come from the combustion of fuel in residential, commercial, and institutional buildings and facilities and manufacturing industries and construction, agriculture, forestry, and fishing activities, as well as power plants to generate grid-supplied energy. This sector also includes fugitive emissions, which typically occur during extraction, transformation, and transportation of primary fossil fuels.
2. **TRANSPORTATION.** Transportation covers all journeys by road, rail, water, and air, including inter-city and international travel.
3. **WASTE.** Waste disposal and treatment produces GHG emissions through aerobic or anaerobic decomposition, or incineration. GHG emissions from solid waste shall be calculated by disposal route, namely landfill, biological treatment and incineration and open burning, wastewater treatment and discharge.
4. **INDUSTRIAL PROCESSES AND PRODUCT USE.** The main emission sources are releases from industrial processes that chemically or physically transform materials (e.g., the blast furnace in the iron and steel industry, and ammonia and other chemical products manufactured from fossil fuels and used as chemical feedstock). In addition, certain products used by industry and end-consumers, such as refrigerants, foams, or aerosol cans, also contain GHGs which can be released during use and disposal.

5. **AGRICULTURE, FORESTRY, AND LAND USE.** Emissions are produced through a variety of pathways, including livestock (enteric fermentation and manure management), land use and land use change (e.g., forested land being cleared for cropland or settlements), and aggregate sources and non-CO₂ emission sources on land (e.g., fertilizer application and rice cultivation).
6. **OTHER SCOPE.**

Activities taking place within a city can generate GHG emissions that occur inside the city boundary as well as outside the city boundary. To distinguish among them, the GPC groups emissions into three categories based on where they occur: scope 1, scope 2 or scope 3 emissions. The scopes framework helps to differentiate emissions occurring physically within the city (scope 1), from those occurring outside the city (scope 3) and from the use of electricity, steam, and/or heating/cooling supplied by grids which may or may not cross city boundaries (scope 2).

The figure below illustrates the schematics of emission to be established for the inventory and tracked by each participating city.

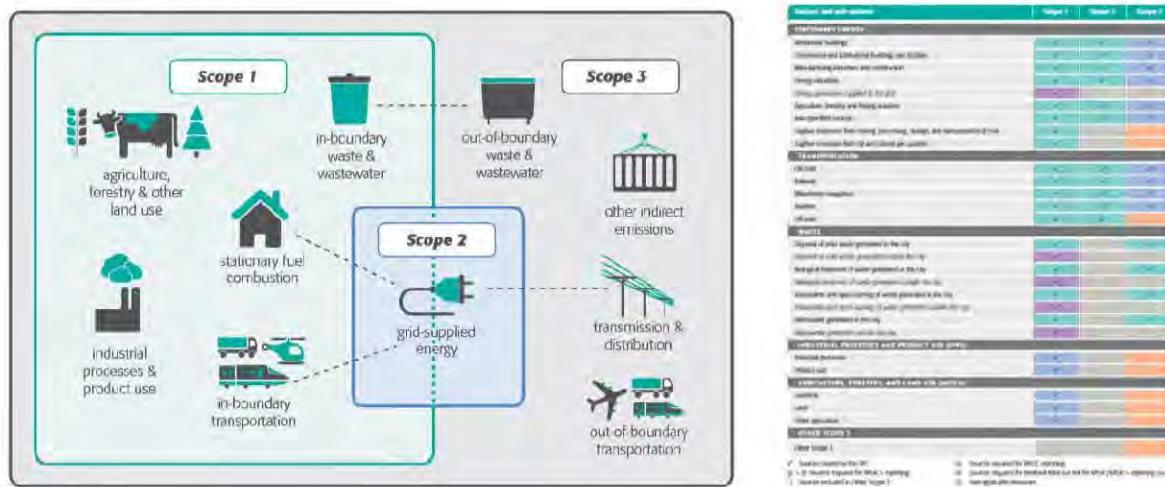


Figure 6: Source and Boundary of GHG Emissions

EACH CITY PARTICIPATING IN THE INITIATIVE HAS TO DEVELOP PROGRAMS TO MITIGATE THE EMISSIONS WITHIN THE SIX SECTORS DESCRIBED ABOVE. IT IS IMPORTANT FOR THE CLIENT TO UNDERSTAND THE SCOPE OF EACH SECTOR TO HAVE A CLEAR VISION WHERE ITS SOLUTION FITS WITHIN THE FRAMEWORK OF A SPECIFIC CITY MANDATE ON REDUCING EMISSIONS TO DIRECT THE PROMOTIONAL EFFORTS. IT LOOKS LIKE THE CLIENT'S SOLUTION FITS WITHIN THE INDUSTRIAL PROCESSES AND PRODUCT USE SECTOR APPLICATIONS.

As of September 15, 2020, there were 10,471 cities committed to the GCoM for Climate and Energy initiative. In North America, there are 226 total committed cities of which 49 are in Canada. GCoM website has a dashboard page of each participating city, which provides a snapshot of the city's status on emission reduction, links to the relevant programs and other data that ensures a transparent and comparable reporting on the progress.



Figure 7: North American Cities Signed to the Climate and Energy Initiative

Appendix A: Global Covenant Cities and Communities in Canada lists Canadian committed cities. Note that each city name is hyperlinked to the city's GCoM dashboard that contains all information on the city's commitments to the initiative.

According to the 2019 GCoM report, 77% of GCoM cities have set targets to reduce their emissions by 2030. On a regional basis, GCoM cities in the EU and Western Europe are most likely to have set either 2020 or 2030 targets. However, only 2.6% of all GCoM cities (261 cities) have so far adopted city targets through to 2050. By setting a target for 2050, these 261 cities alone have increased the potential 2050 emissions savings of GCoM cities by 6% compared with the baseline scenario, or 10% compared with the “enhanced ambition” scenario if those cities had not set 2050 targets.⁶¹

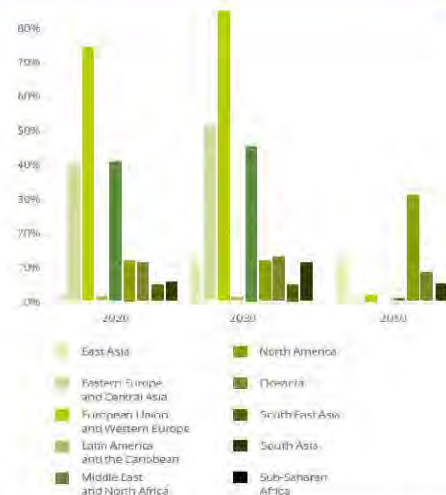


Figure 8: %age of GCoM cities in region with reported emission target

GCoM Vancouver Example

Vancouver in British Columbia is an example of a Canadian city with some of the most ambitious goals and objectives. Its GHG emission inventory, as stated on its GCoM page, is dominated by emissions from buildings (53%) closely followed by Transportation (43%).⁶² This city's dashboard also contains the links to the currently active city program aiming at achieving the intended objectives in the GHG reduction.



Figure 9: City of Vancouver GCoM page

According to the City of Vancouver, in July 2011, Vancouver City Council adopted the targets and actions in the Greenest City 2020 Action Plan. Over 35,000 people were consulted in developing the plan which highlights actions and strategies to make Vancouver the greenest city in the world by 2020. There are 10 goal areas within the plan, each with specific targets, totalling 15 targets in all. Each goal area has at least one measurable 2020 target. Many actions support multiple, interconnected goals across the entire plan. For example, increasing composting and gardening will support the Green Economy, Zero Waste, Access to Nature and Local Food targets, while improving transit services supports the Climate Leadership, Green Transportation and Clean Air targets⁶³.



Figure 10: City of Vancouver Greenest City Action Plan webpage

The Vancouver Greenest City Action Plan's 10 goal areas:



1. **Climate and Renewables.** Eliminate Vancouver's dependence on fossil fuels. Reduce community based GHG emissions by 33% from 2007 levels by 2020.
2. **Green Buildings.** Lead the world in green building design and construction. Require all buildings constructed from 2020 onward to be carbon neutral in operations. Reduce energy use and GHG emissions in existing buildings by 20% over 2007 levels.
3. **Green Transportation.** Make walking, cycling, and public transit preferred transportation options. Make most trips (over 50%) by foot, bicycle, and public transit. Reduce average distance driven per resident by 20% from 2007 levels.
4. **Zero Waste.** Reduce total solid waste going to the landfill or incinerator by 50% from 2008 levels.
5. **Access to Nature.** Vancouver residents enjoy incomparable access to green spaces, including the world's most spectacular urban forest. Ensure that every person lives within a five-minute walk of a park, greenway, or other green space. Plant 150,000 additional trees. Restore or enhance 25 hectares of natural areas. Increase canopy cover to 22% by 2050.
6. **Clean Water.** Vancouver will have the best drinking water of any city in the world. Reduce per-capita potable water consumption by 33% from 2006 levels.

GOAL AND TARGETS	INDICATOR	BASELINE	2019	CHANGE FROM BASELINE	IMPROVED OVER BASELINE	2020 TARGET
CLIMATE AND RENEWABLES						
Target 1: Reduce greenhouse gas emissions from the city's operations by 33% from 2007 levels by 2020	Large format of community (ClimateActionVancouver.org)	1,162,000 tonnes (2007)	1,162,000 tonnes (2019)	-100%	100%	1,162,000 tonnes (2020)
GREEN BUILDINGS						
Target 1: Require all new buildings constructed from 2020 onward to be carbon neutral in operations	Percentage of new buildings constructed from 2020 onward that are carbon neutral	0%	100%	100%	100%	100%
Target 2: Reduce energy use and GHG emissions in existing buildings by 20% over 2007 levels	Total energy use (kWh) and GHG emissions (tonnes) in existing buildings	1,162,000 kWh (2007)	1,162,000 kWh (2019)	-100%	100%	1,162,000 kWh (2020)
GREEN TRANSPORTATION						
Target 1: Make the majority of trips by foot, bicycle, and public transit	Percentage of trips by foot, bicycle, and public transit	45%	54%	+9%	100%	50%
Target 2: Reduce the average distance driven per resident by 20% from 2007 levels	Total distance driven per resident (km)	1,162 km (2007)	1,162 km (2019)	-100%	100%	1,162 km (2020)
CLEAN WATER						
Target 1: Reduce per-capita potable water consumption by 33% from 2006 levels	Per-capita potable water consumption (litres per day)	1,162 litres (2006)	1,162 litres (2019)	-100%	100%	1,162 litres (2020)
ACCESS TO NATURE						
Target 1: Ensure that every person lives within a five-minute walk of a park, greenway, or other green space	Percentage of population living within a five-minute walk of a park, greenway, or other green space	45%	54%	+9%	100%	50%
Target 2: Plant 150,000 additional trees	Total number of trees planted	0	150,000	+150,000	100%	150,000
Target 3: Restore or enhance 25 hectares of natural areas	Total area of natural areas restored or enhanced (hectares)	0	25	+25	100%	25
Target 4: Increase canopy cover to 22% by 2050	Canopy cover (%)	10%	22%	+12%	100%	22%
CLEAN WASTE						
Target 1: Reduce the total solid waste going to the landfill or incinerator by 50% from 2008 levels	Total solid waste going to the landfill or incinerator (tonnes)	1,162 tonnes (2008)	1,162 tonnes (2019)	-100%	100%	1,162 tonnes (2020)
Target 2: Recycle 50% of the waste generated in the city	Percentage of waste recycled	45%	54%	+9%	100%	50%
LOCAL FOOD						
Target 1: Increase the number of local food producers in the city	Number of local food producers	0	150	+150	100%	150
Target 2: Increase the number of local food products available in the city	Number of local food products available	0	150	+150	100%	150
GREEN ECONOMY						
Target 1: Increase the number of green jobs in the city	Number of green jobs	0	150	+150	100%	150
Target 2: Increase the number of green businesses in the city	Number of green businesses	0	150	+150	100%	150
GREEN LEADERSHIP						
Target 1: Increase the number of companies that are actively engaged in greening their operations	Number of companies actively engaged in greening their operations	0	150	+150	100%	150

7. **Local Food.** Vancouver will become a global leader in urban food systems. Increase city-wide and neighbourhood food assets by a minimum of 50% over 2010 levels.
8. **Clean Air.** Breathe the cleanest air of any major city in the world. Meet or beat the most stringent air quality guidelines from Metro Vancouver, BC, Canada, and the WHO.
9. **Green Economy.** Secure Vancouver's reputation as a mecca of green enterprise. Make most trips (over 50%) by foot, bicycle, and public transit. Reduce average distance driven per resident by 20% from 2007 levels.
10. **Green Leadership.** Double the number of companies that are actively engaged in greening their operations over 2011 levels.

Figure 11: City of Vancouver Greenest City 2020 ACTION PLAN Progress Dashboard, 2020⁶⁴

IN 2020, THE CITY PUBLISHED ITS LAST MEASURABLE UPDATE THAT REPORTED THAT THE CITY HAD ACHIEVED ALL TARGETS. NOW, THE CITY IS WORKING ON THE NEXT STAGE, DEVELOPING A PLAN FOR THE YEAR 2050. This process is expected to take over the next two + years and to present the Plan to City Council for a decision in the Summer of 2022^{65 66}.

The project timeline is summarized below.

1. **Fall 2019 – September 2020. Listen + Recovery.** To understand what matters most to our communities. It will identify the values we hold and the aspirations we have for our future and will help guide the decisions that will shape our city as we recover from the COVID-19 pandemic and look beyond.

2. October 2020 - May 2021. Envision the Future. Explore trends and forecasts together that may impact the outcome of our future city. Discuss the benefits and trade-offs on a range of possible options for the Vancouver Plan, select a preferred path to guide the remaining work ahead.
3. June 2021 - November 2021. Develop Key Directions. Begin translating this into an actionable plan. This will include multiple levels of analyses into policy options and choices.
4. January 2021 - May 2022. From Plan to Actions. Finalize the plan and ensure the right tools and partnerships are in place. Before reporting to Council in Summer 2022, report back to the community.
5. 2022+. Move Forward Together. With a Council approved Vancouver Plan, begin to make the changes and investments needed to intentionally achieve our collective vision. Continue to monitor, report out and adjust our actions.

From November 2019 to March 2020 the city ran its planning process by asking questions to understand the challenges and priorities of the residents. They collected responses from about 10,000 residents, employees, business owners and visitors. ACCORDING TO THE COLLECTED FEEDBACK, THE MAJORITY OF RESIDENTS BELIEVE THAT LIFE IN VANCOUVER IS GETTING WORSE (55%) COMPARED TO 15% WHO ARE HAPPY WITH THE LIVING CONDITIONS. THE MAJORITY ALSO THINK THAT CLIMATE CHANGE, AS WELL AS COST OF LIVING AND HOUSING AFFORDABILITY ARE THE KEY FEARS FOR THE FUTURE; THE SAME HOPES FOR FUTURE CHANGES ARE EXPECTED. IN SUMMARY, THE RESIDENTS OF VANCOUVER ARE LOOKING FORWARD TO LIVING IN AN AFFORDABLE PLACE WITH BEAUTIFUL NATURE AND REDUCED IMPACT ON THE CLIMATE. THE CONSULTANT BELIEVES THAT UNDERSTANDING THE KEY CONCERNS OF VANCOUVER RESIDENTS IS IMPORTANT WHEN TARGETING VANCOUVER AS A CITY. BECAUSE COST AND ENVIRONMENT ARE TWO KEY ISSUES, THE CLIENT'S PRODUCT PRESENTS A VIABLE SOLUTION TO THE CHALLENGE. WHEN DEVELOPING THE MARKETING MESSAGE, THESE TWO FACTORS HAVE TO BE EMPHASIZED, WITH THE REFERENCE TO THE CONCERNS VOICED BY THE RESIDENTS OF VANCOUVER. AS THE NEXT STAGE OF THE PROGRAM IS CURRENTLY IN THE WORKS, THE CLIENT SHOULD CONSIDER PUTTING FORWARD ACTIONS TO JOIN THE CAUSE. NOTE THAT THE NEXT STAGE, FROM PLAN TO VISION, STARTS IN JANUARY 2021; THIS STAGE INCLUDES BUILDING PARTNERSHIPS AND RELATIONSHIPS TO ENSURE COMPLETION OF THE PLAN. NOW IS A CRITICAL TIME TO ENTER THE POOL OF AVAILABLE RESOURCES AND BECOME A LEADER IN HELPING THE CITY OF VANCOUVER MEET ITS AGGRESSIVE GOALS OF BECOMING THE GREENEST CITY IN THE WORLD.



Figure 12: Select slides from the City of Vancouver Initial Results Feedback presentation on Plan 2050⁶⁷

The Climate Mobilization Movement

The Climate Mobilization Movement, originally a grassroots movement, started in 2014 as a non-profit and volunteering organization. Over time, its support by governments and other authorities has been growing.^{68 69} As of September 15, 2020, 1,773 local governments of 30 countries representing 830+ people have joined the movement.

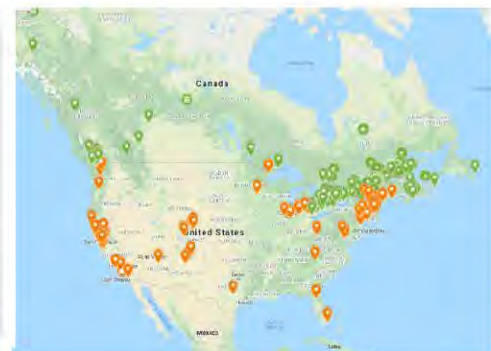
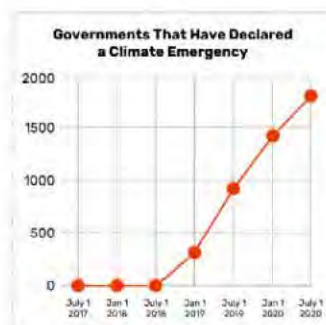


Figure 13: Climate Mobilization Movement Growth

There are 99 Canadian cities that have announced this mobilization (their list is in Appendix B:). British Columbian cities are represented by Victoria, Vancouver, North Vancouver, and West Vancouver among many others. Climate Emergency is usually proclaimed by the City Councils, followed by the release of Press Release and minutes of the City Council meeting where this proclamation took place. The Press

Release contains the description of the actions and programs currently in action and is to be introduced by the municipality in their efforts to join the movement.

There is also a petition to the U.S. Congress co-sponsored by B. Sanders (D-VT), K. Harris (D-CA) requesting to declare a climate emergency and mobilize all available resources to protect humanity.

The Climate Mobilization founding documents refer to its climate defense efforts as “a WWII-scale climate mobilization to protect civilization and the natural world”. The organizers envision the mobilization to be executed along two fronts.

FRONT ONE: Restore a Safe & Stable Climate. To restore a climate that is safe, stable, and supportive of human civilization, humanity must:

- Drive the economy to net zero GHG gas emissions as rapidly as possible using emergency economic measures; the U.S. must reach net zero GHG gas emissions by no later than 2025, and the entire world community must reach net zero GHG gas emissions by no later than 2030;
- Drastically slash annual global GHG gas emissions immediately with explicitly non-violent strategies, including international financial and technology transfers, and possible economic sanctions;
- Mount a large-scale carbon dioxide or GHG gas drawdown (or sequestration) effort immediately to restore pre-industrial GHG gas concentrations and cool the planet back to safe levels;
- Calmly consider whether a near-term cooling of the planet is required to combat positive feedbacks such as thawing permafrost and dying tropical rainforests that could take global warming out of humanity’s control. If needed, figure out if and how such a near-term cooling can be safely and humanely accomplished.

FRONT TWO: Reverse Overshoot. To reverse overshoot and stop the 6th mass extinction of species, humanity must:

- Phase out consumerism and planned obsolescence;
- Considerably shrink the physical resource consumption levels of the global economy, and drastically increase efficiencies of production;
- Set aside at least half the Earth’s land surface and oceans for preservation;
- Halt the further expansion of agricultural land and restore degraded lands.

The organizers announced some specific actions to kick-start the mobilization, as summarized below.

1. Declare a National Climate Change & Ecological Overshoot Emergency.
2. Set Pre-Industrial GHG Air Quality Standards. The standards should target safe, pre-industrial (1,750) tropospheric concentrations for all GHGs. Once established, every state in the country must submit zero emissions plans covering all GHG-emitting sectors to the EPA showing how the state plans to move to a net zero GHG gas emissions economy by 2025. Additionally, every state should submit GHG removal plans showing how it will contribute its fair share toward a global GHG gas removal effort.
3. Order Zero Emissions Plans from Large & Middle-Market Firms. Mandatory plans from businesses and organizations with total annual revenue greater than \$10 million showing how each entity will end the growth of their firm’s lifecycle GHG emissions within one year and cut them to net zero by 2025. In sectors where individual firms cannot develop zero emissions plans — such as aviation and steel — all relevant firms to develop whole-of-sector zero emissions plans.
4. State of the Union Championing the Four Freedoms of the 21st Century. The President should give a State of the Union address to reaffirm the validity and unfulfilled promise of the Four Freedoms of the

20th Century and to champion the Four Freedoms of the 21st: I. Right to a healthy and stable global environment II. Right to healthy food, clean air, and clean drinking water III. Right to life-affirming work at a living wage IV. Right to full democratic participation in government and at the workplace

The Movement calls to establish new federal government agencies:

1. Presidential Task Force on Economic Conversion to conduct a comprehensive assessment of the production goals required to deliver a safe climate and examine the capacity of America's industries to convert production to meet those goals. This Task Force will deliver its report to the Climate Mobilization Board, which will decide whether to impose stop-production orders, managed shutdowns, and other production controls to convert existing capacity to mission-critical production.
2. Climate Mobilization Board (CMB): Staffed by America's leading environmental analysts, engineers, scientists, economists, environmental justice leaders, labor leaders, the CMB will coordinate all agency-level mobilization activities, conduct technical assessments, issue stop-production and scheduled production phase-out orders, and cut through red tape.
3. Transition Compensation & Adjustment Authority (TCAA): During the mobilization, a wide range of capital assets, such as fossil fuel-based steam-electric power stations, internal combustion engine vehicles, jet aircraft, pipelines, and concentrated animal feeding operations, will be retired or decommissioned well before their scheduled expiration date as a result of new government policies. The owners of these scrapped capital assets will be given the opportunity to file compensation claims with the TCAA. Mobilization Labor Board will guarantee re-employment of all workers who lose jobs because of the mobilization.
4. Mobilization Oversight Agency
5. Mobilization Labor Board
6. Mobilization Finance Corporation
7. Office of Price Administration
8. Environmental Impact Accounting Service
9. Material & Technology Substitution Board
10. Industrial Transformation Agency
11. Climate & Environmental Science Information Bureau
12. Mobilization Research & Development Agency

DESPITE ITS SOMEWHAT UNREALISTIC OBJECTIVES AND ACTIONS EXPECTED TO ACHIEVE THE DESIRED OUTCOME, THE MOVEMENT HAS A WIDE FOLLOWING INCLUDING MANY MUNICIPALITIES. SINCE THE OBJECTIVES OF THIS MOVEMENT ARE THE MOST AGGRESSIVE OF ALL; THIS FACT CAN BE USED WHEN APPROACHING THESE SPECIFIC MUNICIPALITIES WITH PROMOTING THE CLIENT'S SOLUTION TO THEM.

13. THE STATE OF THE ECONOMY AND INDUSTRY, IMPACT ON DEMAND

Devices and tools equipped with SSI engines are common for applications related to gardening, yard work, construction, and agriculture. Any developments and events, global, political, or internal, that affect the growth of these industries, inadvertently have an impact on demand for small engines. This section discusses the historical state, current events and future expectations for Construction, Agriculture / Forestry, and local governments (municipalities). It should be noted that the analysis includes examination of municipalities. The Consultant believes that understanding municipalities' development is important for analyzing the small engine equipment because: a) municipalities themselves are prominent users of small engine tools ; b) increase/decrease in locational population has a direct impact on demand in residential construction, which also identifies the demand in small engine devices.

The U.S.A.

At 9.8 million square kilometers, the U.S.A. is the world's third-largest country by total area. With a population of over 328 million, it is the third most populous country in the world. The U.S. has retained its position of being the world's largest economy since 1871. The U.S. is often dubbed as an economic superpower and that is because the economy constitutes almost a quarter of the global economy, backed by advanced infrastructure, technology, and an abundance of natural resources. The United States is the largest importer of goods and the second-largest exporter with GDP \$21.7 Trillion in 2019.

The U.S. economy features a highly developed and technologically advanced services sector, which accounts for about 80% of its output. The U.S. economy is dominated by services-oriented companies in areas such as technology, financial services, healthcare, and retail. Large U.S. corporations also play a major role on the global stage, with more than a fifth of companies on the Fortune Global 500 coming from the United States.

Even though the services sector is the main engine of the economy, the U.S. also has an important manufacturing base, which represents roughly 15% of output. The U.S. is the second largest manufacturer in the world and a leader in higher-value industries such as automobiles, aerospace, machinery, telecommunications, and chemicals. ⁷⁰

Industries' Historical analysis, Current Status and Future Trends

The U.S.A. economy is the largest in the world from the point of the nominal GDP and the second by purchasing parity power. According to the data reported by the U.S. Bureau of Economic Analysis,⁷¹ GDP has consistently retained a stable level increasing from \$18.5 Trillion to \$21 Trillion by 2020 before sliding in the first quarter of 2020 (see more discussion about COVID-19 impact on economy below), as illustrated in Figure 14: U.S.A. GDP, 2016 – Q1 2020. Industries under study have not been impacted by the lockdown in the same degree as the overall economy.



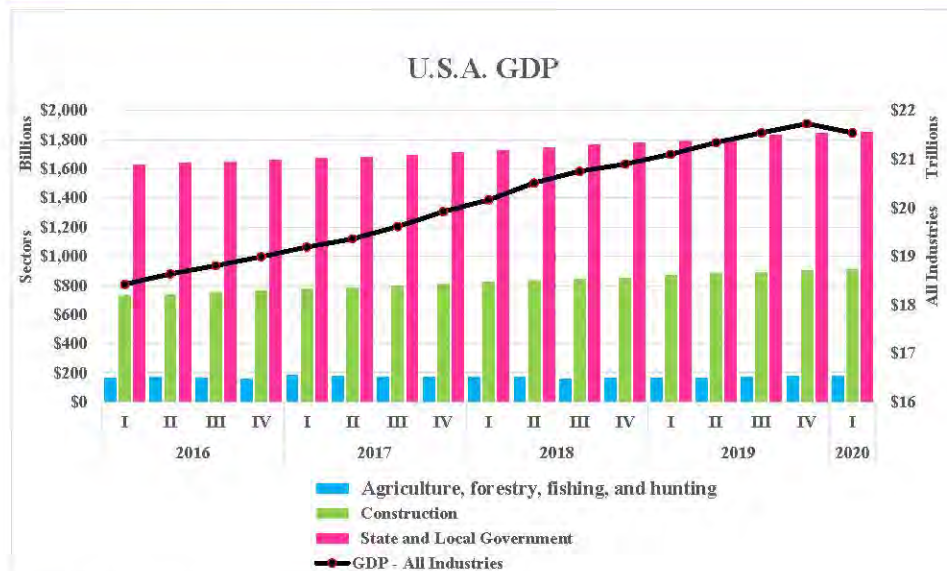


Figure 14: U.S.A. GDP, 2016 – Q1 2020

Municipalities

According to the most recent report prepared by the US Census Bureau of 2013,⁷² nearly two-thirds of Americans live in incorporated places, commonly referred to as cities or municipalities. As most of the nation's population lives in cities, patterns of population change among cities and the social and economic conditions affecting them often represent national trends.

Over 198.2 million people lived in incorporated places in 2013, constituting 62.7% of the U.S. population. Between 2000 and 2013, the population inside incorporated places increased by 24.1 million, or about 13.9%. Like the total population, **THE INCORPORATED PLACE POPULATION INCREASED IN EVERY REGION FROM 2000 TO 2013 AND DID SO AT FASTER RATES IN THE SOUTH AND WEST THAN IN THE NORTHEAST AND MIDWEST. THE NORTHEAST WAS THE ONLY REGION IN WHICH THE POPULATION INSIDE CITIES INCREASED AT A SLOWER RATE THAN THE TOTAL POPULATION between 2000 and 2013.**



There were 19,508 incorporated places in 2013. The Midwest had the largest number of incorporated places of any region (8,502), followed by the South (6,576), the West (2,310), and the Northeast (2,120).

Figure 15: %age of Population in Incorporated Places by Region: 2013

New York City remained the nation's most populous incorporated place with 8.4 million people, followed by Los Angeles (3.9 million), Chicago (2.7 million), Houston (2.2 million), and Philadelphia (1.6 million).

THE FASTEST-GROWING LARGE CITIES—THOSE WITH POPULATIONS OF 100,000 OR MORE—TEND TO BE IN THE SOUTH AND WEST AS WELL. Between 2000 and 2010, the fastest-growing large city was Gilbert, AZ (near Phoenix), with an increase of 90.0%; followed by North Las Vegas, NV, which grew by

87.9%; Fayetteville, NC, which grew by 65.7%. Large cities that lost population over the same period were found in every region, with a noticeable concentration in the states bordering the Great Lakes. Of the 52 large cities that lost population between 2000 and 2010, seven were in the Northeast, 21 were in the Midwest, 13 were in the South, and 11 were in the West. Nine were in California- more than any other state.

Four of the five fastest-growing large cities between 2010 and 2013 were in Texas. Frisco, TX, topped the list of fastest-growing large cities (16.9%); followed by McKinney, TX (13.3%); Austin, TX (12.0%). Of the ten fastest-growing large cities over this period, seven were in the South and three were in the West.

THE U.S. POPULATION REMAINS INCREASINGLY CONCENTRATED IN INCORPORATED PLACES, MORE SO IN THE WEST THAN IN ANY OTHER REGION. Incorporated places grew faster than the United States from 2000 to 2010, and from 2010 to 2013. CITIES IN THE SOUTH AND WEST GREW FASTER THAN THOSE IN THE MIDWEST AND NORTHEAST. Larger cities (of 100,000 or more population) grew faster than smaller ones between 2000 and 2013, with cities of 500,000 to 999,999 growing the fastest. Cities among the ten fastest growing across all size categories tended to be in metro areas. Cities with larger populations tended to be more dense than smaller cities. Several large cities with stable boundaries (e.g., New York, Washington, San Francisco) experienced population growth between 2010 and 2013, resulting in increased density levels. More cities incorporated in the South between 2010 and 2013 than in any other region. Three new cities incorporated in Texas, more than any other state. While more than one-third of the U.S. population lives outside incorporated places, America continues to be mainly a nation of cities.

A CRITICAL OBSERVATION FROM THIS SECTION IS THAT THE HIGHEST CONCENTRATION AND GROWTH OF MUNICIPALITIES IN THE U.S.A. IS IN THE SOUTH AND WEST LIKELY OFFERING MORE OPPORTUNITIES FOR THE SOLUTION SINCE HIGHER GROWTH CITIES RESULT IN HIGH DEMAND FOR RESIDENTIAL CONSTRUCTION, HENCE INCREASING DEMAND FOR GARDENING AND CONSTRUCTION EQUIPMENT.

Agriculture

Farms contribute 0.7% to the U.S. total GDP. However, large amounts of arable land, advanced farming technology and generous government subsidies make the U.S.A. a net exporter of food and the largest agricultural exporting country in the world.

According to the 2017 Census of Agriculture, the value of agricultural production declined slightly between 2012 (the previous census) and 2017 but remains concentrated by farm size, location, and industry. The number of large and small farms increased as the number of mid-size farms declined. The largest operations and a small number of the largest states accounted for most of the agricultural production and sales. Five commodities accounted for two thirds of value.^{73, 74}



In 2017, U.S. farms and ranches produced \$388.5 billion, down from \$394.6 billion in 2012. Crop and livestock commodities each account for half of the total. In 2012, only the second time in census history, the value of crop sales exceeded livestock sales; 2017 is a return to longer-term trends. The total value of crops in 2017 was \$194 billion, down 9% from 2012. For livestock, the value was \$195 billion, up 7%.

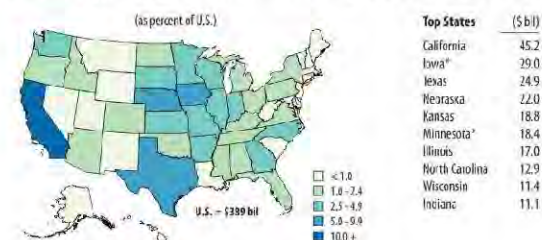
Figure 16: Value of US Farms Production, 1997-2017 (\$ billions)

The total number of farms declined between 2012 and 2017, from 2.11 to 2.04 million. The largest farms (sales of \$5 million or more) accounted for fewer than 1% of all farms but 35% of all sales. Small farms (sales of \$50,000 or less) accounted for 76% of the farms and 3% of the sales. The number of mid-sized farms declined between 2012 and 2017. Only small farms (annual sales of \$2,500 or less) and large farms (sales of \$5 million or more) increased in number. The 76,865 farms in the top two categories (sales of \$1 million or more) are fewer than 4% of U.S. farms; they sold more than two thirds of all agricultural production.



Figure 17: Number of Farms, by Size of Farm, 2012 and 2017 (thousands)

Although agricultural activity occurs in every state, it is particularly concentrated in the top ten states accounting for 54% of sales in 2017. California remained the largest provider of agricultural products, with sales of \$45.2 billion, 12% of the U.S. total. The top seven U.S. counties are in California, and the top county, Fresno, had larger agriculture sales than 25 states.



Agriculture Sales by State (% of U.S.A.)

Cattle and calves were the top ranked commodity, with \$77.2 billion in sales. Texas was the top state in cattle and calves' sales, accounting for 16% of the U.S. total. The top five commodities accounted for \$255 billion in sales, 66% of U.S. total agriculture sales.

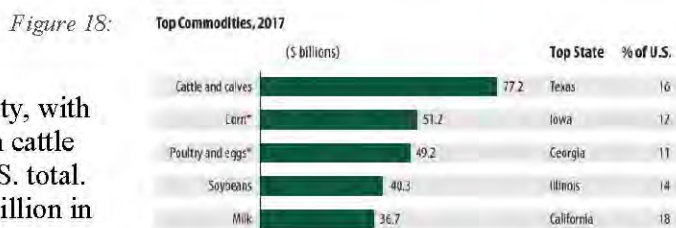


Figure 19: Top Agriculture Commodities, 2017 (\$ billions)

THE MAIN OBSERVATION FROM THIS SECTION IS THAT THE KEY AGRICULTURAL AREAS IN THE U.S.A. ARE THE MIDWEST AND SOUTH WITH A GROWING NUMBER OF SMALL AND LARGE FARMS. THIS TREND CLOSELY MIRRORS THAT OF THE U.S.A. MUNICIPALITIES, WHICH MAKES THE CASE FOR THE SOLUTION EVEN STRONGER FOR THESE LOCATIONS.

Construction

Construction is a major contributor to the U.S. economy. The industry has more than 680,000 employers with over 7 million employees and creates nearly \$1.3 trillion worth of structures each year contributing 4% to the nation's GDP.⁷⁵

Construction in all areas is a growing industry. This includes residential and nonresidential builders; contractors that install or service mechanical systems like electricity, water, elevators, and heating and cooling; and civil engineering construction. According to the Bureau of Labor Statistics, construction and extraction occupations were projected to grow by 11% from 2016 to 2026, which is a rate faster than the average for all occupations and are expected to add nearly 750,000 new jobs. The growth stems from overall economic and population growth, which is increasing demand for new buildings, roads, and other structures.

Historically, the number of building permits have been closely following the state of the economy in general. Figure 20: Building Permits in the U.S.A., 1986-2019 illustrates how the NUMBER AND VALUE OF BUILDING PERMITS EXPERIENCED A MAJOR DROP FOLLOWING THE FINANCIAL CRISIS OF 2008 FOLLOWED BY A CONSISTENT RECOVERY, WHICH IS YET TO REACH THE PRE-CRISIS LEVELS. NOTE THAT 1-UNIT BUILDINGS DOMINATE THE SCAPE OVERWHELMINGLY, COMPRISING ABOUT █% OF THE TOTAL.

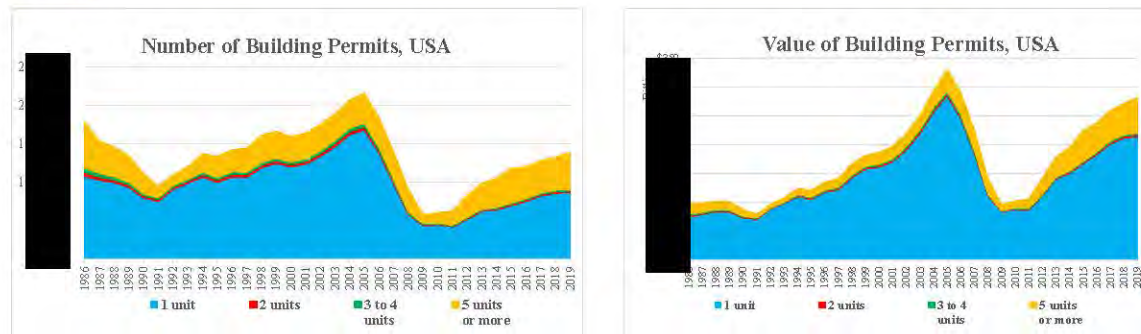


Figure 20: Building Permits in the U.S.A., 1986-2019

REGIONALLY, THE SOUTH OUTWEIGHS THE OTHER THREE REGIONS REPRESENTING OVER █% OF THE TOTAL NATION'S BUILDING STOCK (see Figure 21: Building Permits in the U.S.A., by Region, 1986-2019).

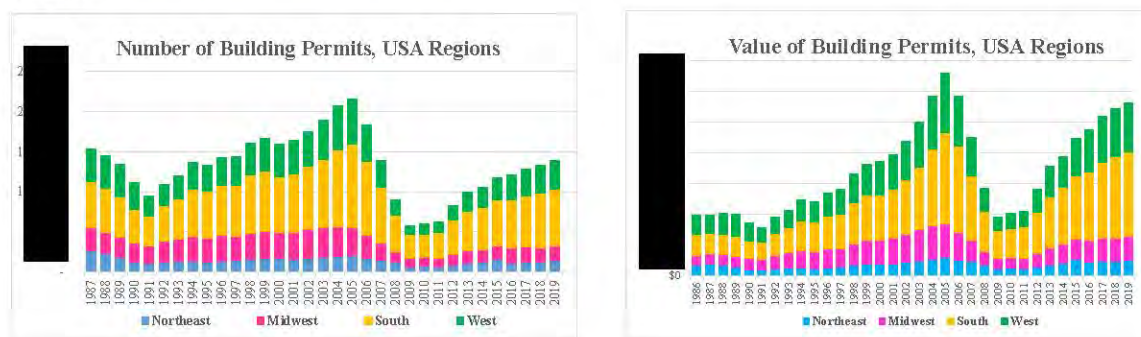


Figure 21: Building Permits in the U.S.A., by Region, 1986-2019

According to the US census Bureau⁷⁶, in 2019, top State and Metropolitan Core-Based Statistical Area (CBSA) with the highest growth in the number of units were NJ (30% increase compared to the previous year) and the city of Charleston, WV █% increase). THE REGIONS AND CBSA WITH THE HIGHEST GROWTH WERE ON THE EAST COAST AND IN THE SOUTH, as shown in Figure 22: Top U.S. Regions and CBSAs with the Highest Increase in the Residential Sector.

SIMILAR TO THE DATA ON MUNICIPALITIES AND AGRICULTURE, CONSTRUCTION TRENDS DEMONSTRATE THAT THE U.S. SOUTH IS THE MOST ATTRACTIVE REGION FOR THE CLIENT'S SOLUTION ADOPTION.

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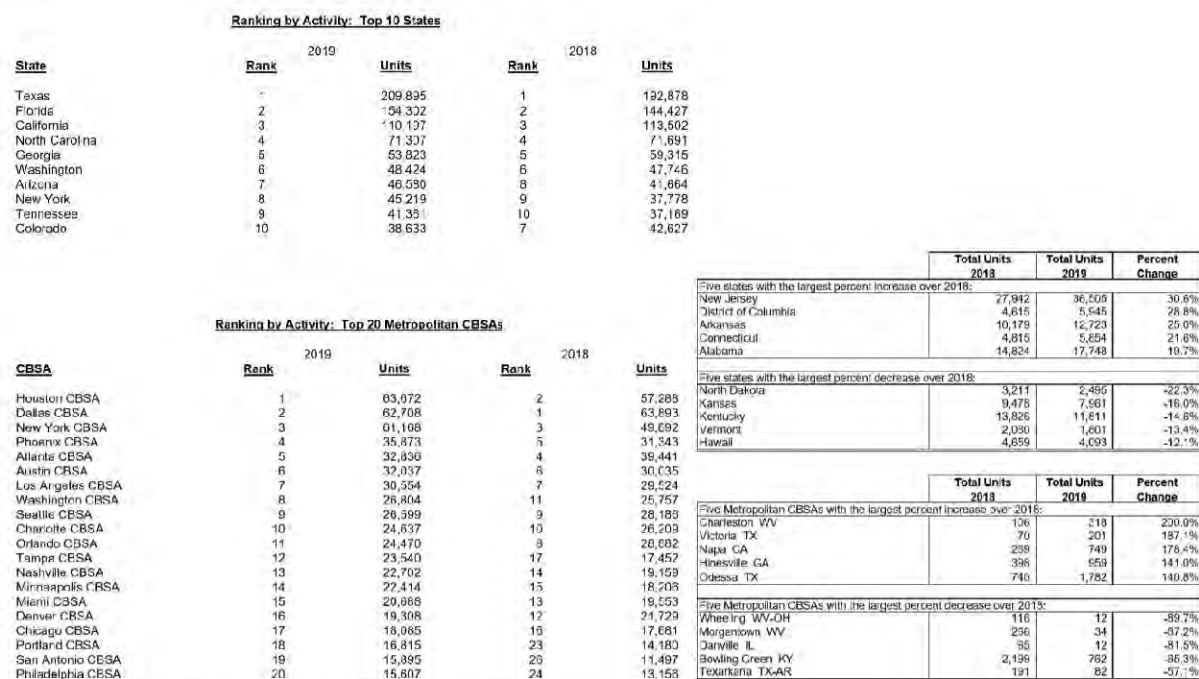


Figure 22: Top U.S. Regions and CBSAs with the Highest Increase in the Residential Sector

COVID-19 Impact in the U.S.A.

The General U.S. Economy

The coronavirus outbreak has been causing tremendous human and economic hardship across the United States. The virus and the measures taken to protect public health have induced sharp declines in economic activity and a surge in job losses.

On August 27, 2020, the U.S. Bureau of Economic Analysis reported the 2020 second quarter economic indicators. According to this report, GDP decreased at an annual rate of 31.7% in the second quarter of 2020. In the first quarter, real GDP decreased 5.0%, as shown in Figure 23: U.S. Real GDP, 2019 – Q2 2020.⁷⁷

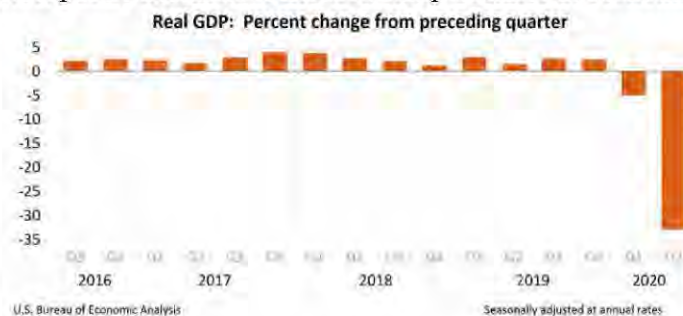


Figure 23: U.S. Real GDP, 2019 – Q2 2020

The decrease of GDP reflects decreases in personal consumption expenditures (PCE), exports, private inventory investment, non-residential fixed investment, residential fixed investment, and state and local

⁷⁷ BEA 20—37; “Gross Domestic Product, 2nd Quarter 2020 and Annual Update”, August 27, 2020, <<https://www.bea.gov/index.php/news/2020/gross-domestic-product-2nd-quarter-2020-second-estimate-corporate-profits-2nd-quarter>>

government spending that were partly offset by an increase in federal government spending. Imports, which are a subtraction in the calculation of GDP, decreased.

The **price index for gross domestic purchases** decreased 1.5% in the second quarter, in contrast to an increase of 1.4% in the first quarter. The PCE price index decreased 1.8%, in contrast to an increase of 1.3%. Excluding food and energy prices, the PCE price index decreased 1.0%, in contrast to an increase of 1.6%.

Disposable personal income increased \$1.53 trillion, or 42.1%, in the second quarter, compared with an increase of \$157.8 billion, or 3.9%, in the first quarter. **Real disposable personal income** increased 44.9%, compared with an increase of 2.6%.

Personal saving was \$4.69 trillion in the second quarter, compared with \$1.59 trillion in the first quarter. The **personal saving rate**—personal saving as a %age of disposable personal income—was 25.7% in the second quarter, compared with 9.5% in the first quarter.

According to the Federal Reserve's second statement since the outbreak of the pandemic crisis, done on July 29, 2020⁷⁸, the coronavirus outbreak is causing tremendous human and economic hardship across the United States. Following sharp declines, economic activity and employment have picked up somewhat in recent months but remained well below their levels at the beginning of the year. Weaker demand and significantly lower oil prices are holding down consumer price inflation. Overall financial conditions have improved in recent months, in part reflecting policy measures to support the economy and the flow of credit to U.S. households and businesses.

According to the Federal Reserve, the path of the economy will depend significantly on the course of the virus. The ongoing public health crisis will weigh heavily on economic activity, employment, and inflation in the near term, and poses considerable risks to the economic outlook over the medium term. Considering these developments, the Committee decided to maintain the target range for the federal funds rate at 0 to 1/4%. The Federal Reserve Committee expects to maintain this target range until it is confident that the economy has weathered recent events and is on track to achieve its maximum employment and price stability goals.

The key economic indicators' future projections are summarized in Figure 24: Economic Projections of Federal Reserve, June 2020. In these projections, Fed officials indicate that they expect the unemployment rate to end 2020 at 9.3% and remain elevated for some time, coming in at 5.5% in 2022. That would be well above the level they expect to prevail over the longer run in a healthy economy and far above the historically low jobless rates that preceded the virus.

THE FED IS PROJECTING A PARTICULARLY SHARP ECONOMIC HIT IN 2020, WITH OUTPUT TO CONTRACT BY 6.5% AT THE END OF THIS YEAR COMPARED TO THE FINAL QUARTER OF 2019, BEFORE REBOUNDBY BY 5% IN 2021.

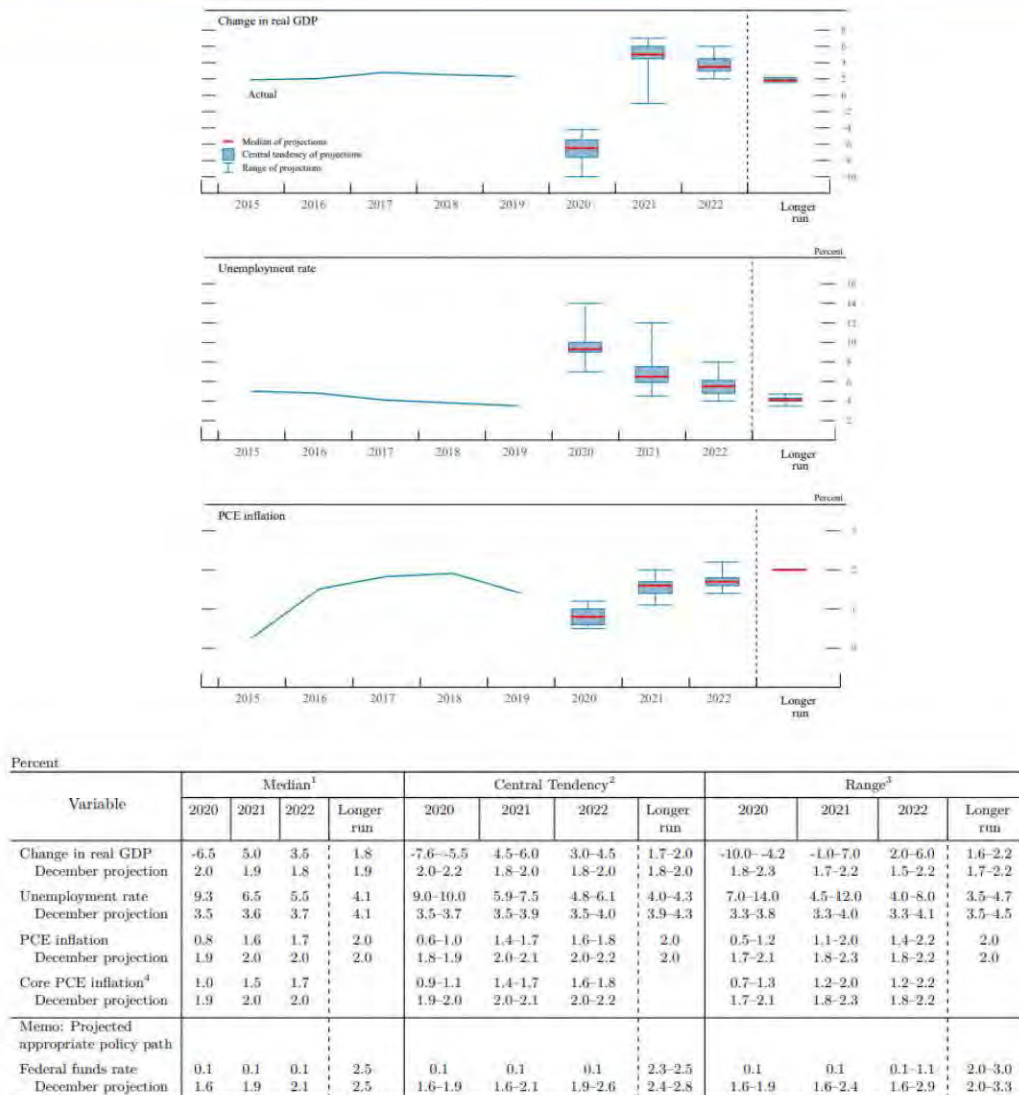


Figure 24: Economic Projections of Federal Reserve, June 2020⁷⁹

The U.S. Industries Under Study

ACCORDING TO THE BUREAU OF ECONOMIC ANALYSIS, DESPITE THE OVERALL ECONOMIC DOWNTURN, NOT ALL SECTORS ARE AFFECTED AT THE SAME RATE:

- The decrease in PCE reflects decreases in services (led by health care) and goods (led by clothing and footwear);
- The decrease in exports primarily reflected a decrease in goods (led by capital goods);
- The decrease in nonresidential fixed investment primarily reflected a decrease in equipment (led by transportation equipment);
- The decrease in private inventory investment primarily reflected a decrease in retail (led by motor vehicle dealers);

- The decrease in residential investment primarily reflected a decrease in new single-family housing.

OF THE SECTORS UNDER STUDY, AGRICULTURE- BEING THE INDUSTRY THAT PROVIDES ESSENTIAL NEEDS- IS UNLIKELY TO DEMONSTRATE ANY SIGNIFICANT DECLINE. THE OPERATIONAL SCOPE OF MUNICIPALITIES, LIKE ANY OTHER GOVERNMENT SERVICE, TYPICALLY REMAINS UNCHANGED. MEANWHILE, THEIR FUNDING IS DEPENDENT ON THE TAX COLLECTION, WHICH IN ITS TURN IS SUPPORTED BY THE HEALTH OF THE LOCAL ECONOMY. HENCE, THE IMPACT ON MUNICIPALITIES IS LIKELY TO BE DELAYED; THIS DELAY IS UNLIKELY TO AFFECT SERVICE LEVEL OR DEMAND FOR ENGINE-POWERED EQUIPMENT. CONSTRUCTION ON THE OTHER HAND, IS THE SECTOR WHICH HAS THE HIGHEST INHERITED VOLATILITY AS ITS DEMAND MIGHT BE AFFECTED IN THE LONGER TERM BY THE OVERALL HEALTH OF THE ECONOMY.

Because the construction industry is subject to the highest level of fluctuation, this section discusses this sector; its short-term and mid-term projections.

On August 18, 2020, the U.S. Census Bureau and the U.S. Department of Housing and Urban Development jointly announced the following new residential construction statistics for July 2020⁸⁰:

- Building Permits for Privately-owned housing units: 1,495,000. This is 18.8% above the revised June rate of 1,258,000 and is 9.45% above the July 2019 rate of 1,366,000. Single-family authorizations in July were at a rate of 983,000; this is 17.0% above the revised June figure of 840,000.
- Housing Starts of Privately-owned housing: 1,496,000. This is 22.6% above the revised June estimate of 1,220,000 and is 23.4% above the July 2019 rate of 1,212,000. Single-family housing starts in July were at a rate of 940,000; this is 8.2% above the revised June figure of 869,000. The July rate for units in buildings with five units or more was 547,000.
- Housing Completions of Privately-owned housing: 1,280,000. This is 3.6% above the revised June estimate of 1,236,000 and is 1.7% above the July 2019 rate of 1,258,000. Single-family housing completions in July were at a rate of 909,000; this is 1.8% below the revised June rate of 926,000. The July rate for units in buildings with five units or more was 364,000.

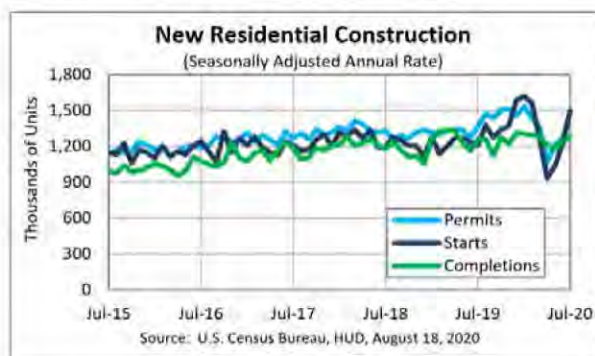


Figure 25: New Building Permits in U.S.A., July 2020

DESPITE THE REPORTED, CONSISTENT RATE OF PROJECT COMPLETION AND RECOVERY OF STARTS, THE CONSTRUCTION INDUSTRY FACES CONCERNS IN THE LONGER TERM; THIS TREND IS RECOGNIZED BY INDUSTRY INSIDERS.

On September 2, 2020, Associated General Contractors of America reported⁸¹ that the coronavirus has harmed the construction industry notably, prompting project delays, cancellations, and layoffs. Some observations from the survey conducted by the association are summarized below.

- 60% of responding firms report having at least one future project postponed or canceled because of the coronavirus. The share of firms reporting canceled projects has nearly doubled since the survey AGC conducted in June, when 32% of respondents reported cancellations.
- 33% report having projects that were already underway halted because of the pandemic.
- 44% of responding firms report that it has taken longer to complete projects.
- 32% say it has cost more to complete ongoing projects because of the coronavirus.
- 42% of firms report their volume of business has returned to year-ago levels or is expected to do so in the next six months, compared to 52% who held this view in AGC's June survey.
- 37% expect returning to normal levels of business will take more than six months, while the remainder do not know.
- Small firms were less likely to have experienced cancellations of upcoming projects. 55% of firms with revenues of \$50 million or less report a project has been postponed or canceled, versus 71% of mid-sized firms (revenue between \$50.1 million and \$500 million) and 69% of large firms (revenue exceeding \$500 million).
- Roughly a third of responding firms furloughed or terminated employees.



- In addition to turning to diverse technologies to alleviate labor shortages, 38% report having increased base pay rates to attract and retain workers. In contrast, only 3% have reduced pay- despite the downturn in business.

The USG Corporation + U.S. Chamber of Commerce Commercial Construction Index (CCI) is a quarterly economic index designed to gauge the outlook and resulting confidence in the commercial construction industry. Each quarter, contractors across the country are surveyed to better understand their levels of confidence in the industry and top-of-mind concerns.

The impact of COVID-19 has caused the first major drop in the index since its launch in 2017, lowering 18 points to 56. This is the largest quarterly decline in index history.⁸²

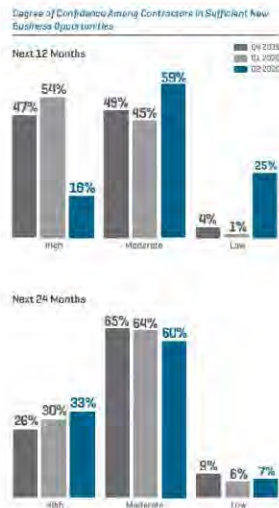
Figure 26: Pandemic Measures Introduced by US Construction Firms

Nearly all (■%) contractors have made changes to how they operate their businesses in response to COVID-19. The majority (■%) have already changed work procedures to increase social distancing.



However, very few (■) have adopted more automation to enhance social distancing, with large companies (■%) and GCs (■%) more likely to do so than small companies (■%) and trade contractors (■%). About one-third of contractors (■%) report they have adjusted employee salaries, furloughed, or laid off employees, with midsize (■%) and large (4■%) companies more frequently doing so than small companies (■%). A portion (■%) mentioned other types of changes, including remote working; supplying hand washing stations and extra PPE; and keeping workers on payroll regardless of the amount of work to preserve their workforce.

CONFIDENCE IN THE CONSTRUCTION MARKET DECREASES NOTABLY FOR THE NEXT 12 MONTHS BUT IS MORE OPTIMISTIC IN THE 24-MONTH OUTLOOK.



NEXT 12 MONTHS. Very few contractors (16%) report high levels of confidence in the ability of the market to provide sufficient new business opportunities in the next 12 months, and those with low expectations increased dramatically from previous quarters. However, the majority (59%) of contractors still fall in the moderate range. This suggests that most are expecting activity to continue at a level that will at least support their businesses.

NEXT 24 MONTHS. More contractors are overly optimistic about the market's ability to provide sufficient new business opportunities in two years than in the last quarter. This may suggest an expectation of pent-up demand in some sectors as the economy recovers.

VARIATION BY COMPANY SIZE. Large companies have a more optimistic outlook than smaller companies, with 29% of large companies reporting high confidence levels for the next 12 months and 56% for the next 24 months.

Figure 27: Confidence in the US Construction Market

SOME CONTRACTORS EXPECT REVENUE DECREASES IN THE NEXT YEAR, BUT THE MAJORITY BELIEVE REVENUE WILL REMAIN THE SAME.

Compared with the last two quarters, revenue expectations for the next year are far more pessimistic, with a spike from ■% in those expecting their revenues to decrease and an even steeper 30-point adjustment downward in those expecting revenues to increase. However, it is notable that the highest %age of contractors (■%) expect their revenues to remain about the same. Large companies (annual revenues of \$100M or more) express the most stable profit outlook.

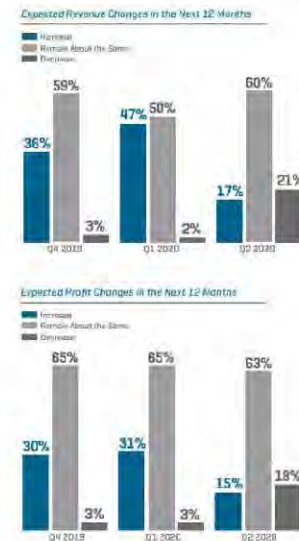


Figure 28: Revenue-Related Expectation in US Construction

OVERALL, ALL THREE SECTORS UNDER STUDY ARE NOT LIKELY TO SUFFER ANY SERIOUS DAMAGE CAUSED BY THE PANDEMIC LOCKDOWN AND ASSOCIATED DECLINE IN ECONOMIC ACTIVITIES. SOME DECLINE IS MOST LIKELY TO BE FACED BY THE CONSTRUCTION INDUSTRY, WHICH WILL BE RECOVERED IN THE MID-TERM.

Canada

Canada, the second largest country in the world in area (after Russia), occupies roughly the northern two-fifths of the continent of North America. Despite Canada's great size, it is one of the world's most sparsely populated countries with an extremely low population density.

The Canadian economy is a highly developed market economy dominated by the private sector, though some enterprises (e.g., postal services, some electric utilities, and some transportation services) are publicly owned.⁸³ It is the 10th largest GDP in the world⁸⁴ constituting around \$1.8 Billion.

Canada is the third country in the world by natural resources. It has an estimated \$33.2 trillion worth of commodities and has the third-largest oil deposits after Venezuela and Saudi Arabia. Canada is the leading supplier of natural gas and phosphate and is the third-largest exporter of timber.⁸⁵

Figure 29: Canadian GDP, 2018-2020: All Industries, Construction, Agriculture and Public shows the total country GDP and sectors under study. From this graph, Public Administration, which is the proxy for municipalities, and Construction sectors are at a relatively similar level from the point of their contribution to the nation's economy. Another observation that can be drawn from this graph is that THE ECONOMIC DOWNTURN CAUSED BY THE COVID-19 EPIDEMY HAS A VERY LIMITED (IF ANY) IMPACT ON AGRICULTURE AND THE PUBLIC SECTOR. CONSTRUCTION ON THE OTHER HAND, SUFFERED THE HIGHEST IMPACT IN MARCH-APRIL 2020; HOWEVER, ITS RECOVERY HAS BEEN VERY RAPID.

The construction industry experienced a decline in March and April 2020 (decrease) followed by a period of a % growth in May 2020, as shown in Figure 29: Canadian GDP, 2018-2020: All Industries, Construction, Agriculture and Public Administration. The total nation GDP during the same period experienced a harder decline and more modest recovery: total GDP declined % in March and % in April followed by % recovery in May 2020.

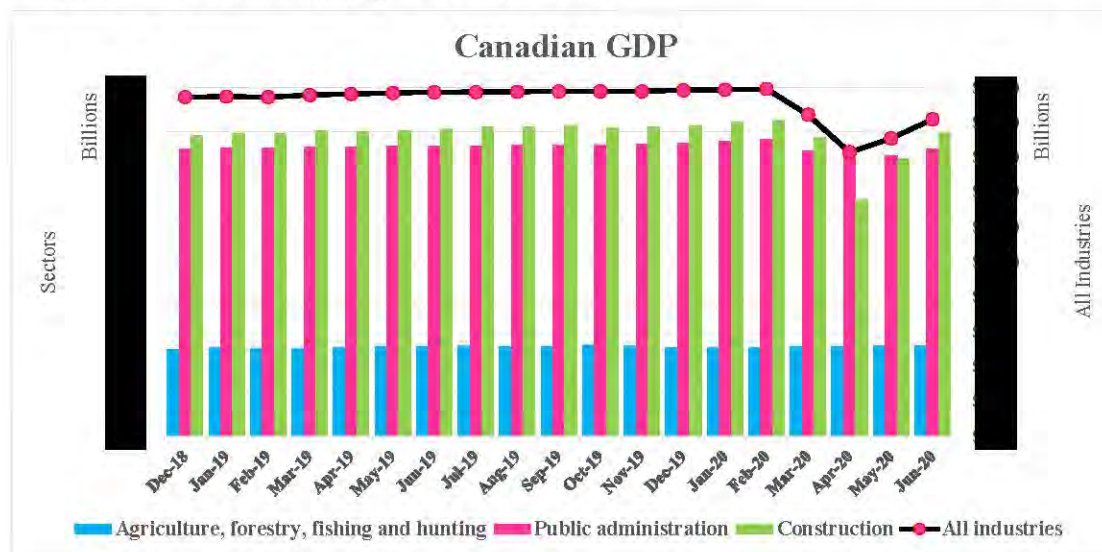


Figure 29: Canadian GDP, 2018-2020: All Industries, Construction, Agriculture and Public Administration⁸⁶



Agriculture in Canada

Although agriculture employs less than 4% of the Canadian labour force, it is vital to the national economy, producing large volumes of food for both the domestic and export in British Columbia and southern Ontario.⁸⁷

CANADIAN AGRICULTURE IS FIRMLY PRIVATE, BUT IT HAS COME TO DEPEND ON GOVERNMENT SUBSIDIES.

There has been a significant trend away from the family farm (more than one-fourth of Canadians lived on farms in the 1940s) toward larger farm units, mechanized farm operations, specialization in fewer products, and the use of improved varieties, breeds, and farming methods.

There are distinctive types of farming in different areas of the country.

- The Prairies are known for grain (particularly wheat), oilseeds (especially canola), and cattle grazing. About four-fifths of this cropland is in the Prairie Provinces, where long sunny days in summer and adequate precipitation combine to provide excellent grain yields.
- Central and eastern Canada have a wider variety of crops and livestock, and farmers tend to specialize in either a cash crop or a livestock type.
- Southwestern Ontario produces large amounts of grain corn (maize), soybeans, and white beans.

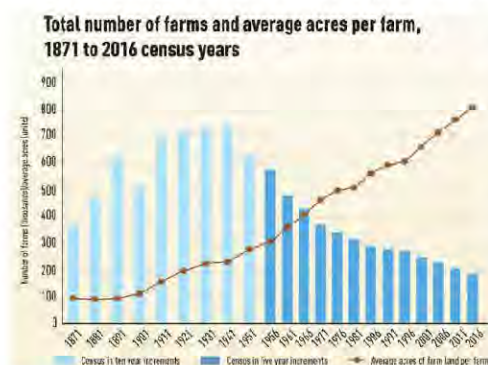


Figure 30: Total Number of Farms and Average Acres per Farm, 1871 to 2016 Census

In 2016, there were 271,935 farm operators and 193,492 farms, a 5.9% decrease from the previous census in 2011, with a total area of 158.7 million acres across Canada. Ontario is leading in the number of farms (50 K) followed by Alberta (40 K) and Saskatchewan (35 K). As farm numbers have declined, the average area per farm has increased, growing from 779 acres in 2011 to an average of 820 acres in 2016.

- Both southern Ontario and southwestern British Columbia produce a wide variety of fruits and vegetables.

According to the most recent census data on agriculture in Canada, in 2016^{88 89}, since Confederation (1867), the number of agricultural operations in Canada has shrunk. **WHILE THERE ARE FEWER FARMS, AGRICULTURAL OPERATIONS ARE GETTING LARGER AND USING MORE OF CANADA'S AVAILABLE AGRICULTURAL LAND TO GROW CROPS.** The area of cropland increased by 6.9% from 2011 to 93.4 million acres in 2016.

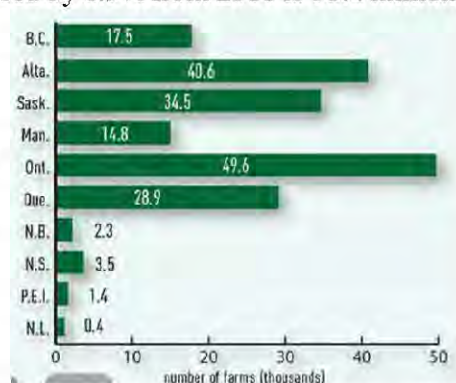
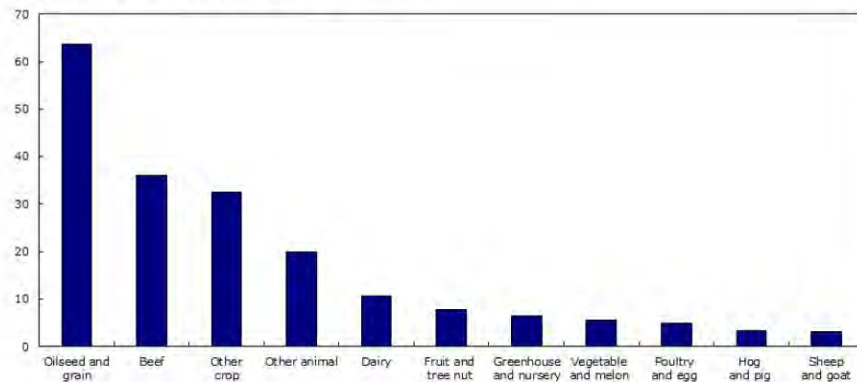


Figure 31: Canadian Number of Farms by Province, 2016

Oilseed and grain type farms account for the highest proportion of Canadian agricultural operations, in part due to the amount of arable land available on the Prairies (Chart 6). In 2016, the number of oilseed

and grain type operations increased from 61,692 to 63,628, accounting for 32.9% of all agricultural operations in Canada. This was up from 2011 when they accounted for 30.0% of all agricultural operations. Beef and feedlot type operations rank second (18.6%) with 36,013 agricultural operations—despite a 3.7% decline from 2011.⁹⁰

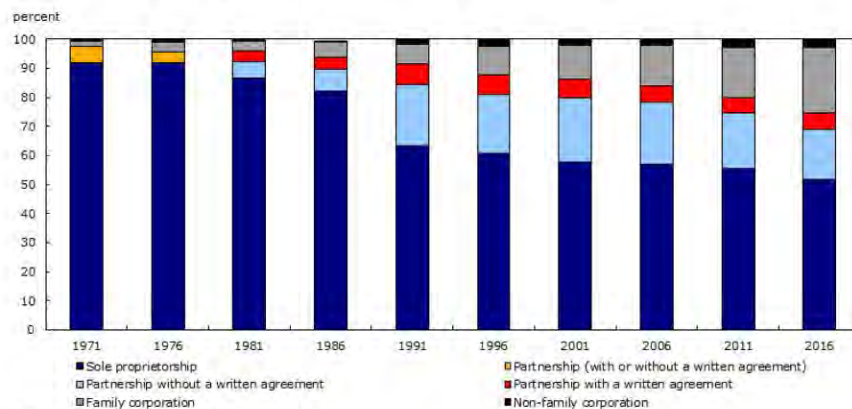


Source: CANSIM table 004-0200.

Figure 32: Number of Canadian Agricultural Operations (thousands), by type, 2016

The operating arrangements of agricultural operations has evolved over the years. In 1971, 97.6% of agricultural operations were reported as sole proprietorships or partnerships. Corporations (family or non-family) represented 2.2% of agricultural operations. By 2016, sole proprietorships and partnerships (with or without a written agreement) accounted for 74.6% of all agricultural operations, while the % of agricultural operations that were incorporated increased to 25.1%.

FARM OPERATORS HAVE BEEN MOVING AWAY FROM SOLE PROPRIETORSHIPS AND PARTNERSHIPS IN FAVOR OF CORPORATIONS, WHICH OFFER BUSINESS AND LEGAL ADVANTAGES PARTICULARLY AS THE SIZE AND COMPLEXITY OF OPERATIONS INCREASE. Many of these agricultural operations are still operated by families, with 22.5% of agricultural operations reporting as family corporations compared with 2.7% reporting as non-family corporations in 2016.



Note: Totals may not equal 100% due to rounding.
Source: Census of Agriculture (3438).

Figure 33: Canadian Agricultural Operations by Organizational Type (% age), 1971-2016

Multiple federal and provincial government programs⁹¹ are available to support farmers and food processors to start, grow and innovate their business, as well as provide Business Risk Management insurance & income protection. A summary of the existing programs that provide financial assistance on



federal and provincial (British Columbia) levels is in Appendix C: The List of Federal and Provincial Programs Supporting .⁹² AGRICULTURE IN CANADA HAS BEEN ENJOYING SUBSTANTIAL AND SUSTAINED GOVERNMENT SUPPORT; THE GOAL IS TO ENSURE A STABLE FOOD SUPPLY. COUPLED WITH THE CONTINUED GROWTH, AGRICULTURE OFFERS GOOD POTENTIAL FOR SMALL MOTORS' EQUIPMENT.

Forestry in Canada

The forestry industry is one of Canada's most important manufacturing sectors. The forestry industry represents a smaller %age of Canada's economy than other resource sectors, but it creates more jobs and contributes more to the balance of trade for every dollar of value added than other major sectors do. The forestry industry contributed \$25.8 billion (1.2%) to Canada's nominal GDP in 2018, employed about 210,600 people across the country, and accounted for about 7% of Canada's total exports.^{93 94}

Almost half of Canada's land area is covered with forest, the accessible portions of which provide abundant resources for lumber, pulp, and paper. The most valuable forest region for timber production is the West Coast, where the climate is conducive to the growth of giant trees with excellent lumber. Forest products form a larger part of Canada's export trade than do the combined exports of farm, fish, and mineral products. Canada is the world leader in the export of pulp and paper and exports large amounts of softwood lumber, mostly to the United States.⁹⁵

Forests are a major source of wealth for Canadians, providing a wide range of economic, social, and environmental benefits. The heart of the Canadian forest sector is traditional forest products, including lumber, other solid wood products, pulp and paper, and activities such as forest management and logging.

In a global context, Canada has the world's largest forest product trade balance. While other countries may produce more of one product or another, no nation derives more net benefit from trade in forest products than Canada, and the gap between Canada and the second largest net trader (Sweden) has been expanding continuously since 2009.⁹⁶



Figure 34: Forest Product Trade Balance

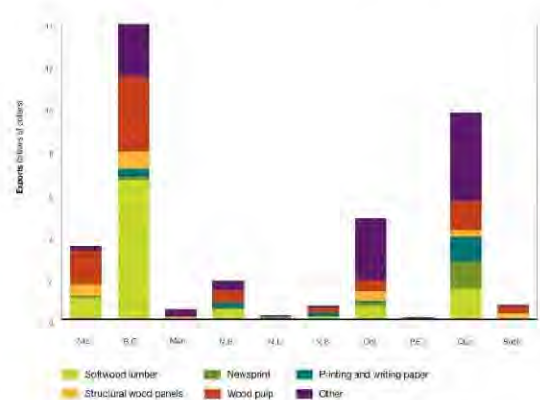


Figure 35: Exports of Canadian Forest Products by Province, 2017

Almost █% of forest industry employment is concentrated in three provinces: Quebec (█%), British Columbia (█%) and Ontario (█%). The two provinces for which the forest sector is the most important are New Brunswick and British Columbia:

- In New Brunswick, the forest sector accounted for around █ of the provincial GDP;
- In British Columbia, the forest sector accounted for around █ of the provincial GDP. British Columbia is Canada's leading exporter of softwood lumber, structural wood panels, and wood pulp.

Pulp produced in the eastern provinces is mostly used directly in the domestic manufacturing of paper products, while wood pulp produced by western provinces is mostly destined for export.⁹⁷

Quebec represents the bulk of Canada's remaining newsprint exports. The United States remains Quebec's largest export market.

In recent years, Canada's forest industry has undergone an especially deep cyclical decline, coupled with structural changes in world markets. The rise of electronic media has resulted in a decrease of paper-based communications products—including several products (such as newsprint) that have traditionally been critical to the Canadian pulp and paper subsector. In response to this challenge, the forest industry has begun to transform itself with new product development. These include new building materials, biofuels that can substitute for fossil fuels, and biochemicals that can be used to produce bio-based pharmaceuticals, biodegradable plastics, personal care products and industrial chemicals.

CANADA'S COMMITMENT TO CLEAN TECHNOLOGY AND THE TRANSITION TO A LOW-CARBON ECONOMY HAS ALSO AFFECTED FORESTRY. NATIONAL RESOURCES CANADA HAS GOALS AND OBJECTIVES FOR THE INDUSTRY IN RELATION TO THE GHG REDUCTION.

Some reported GHG-related data for the forestry sector were⁹⁸:

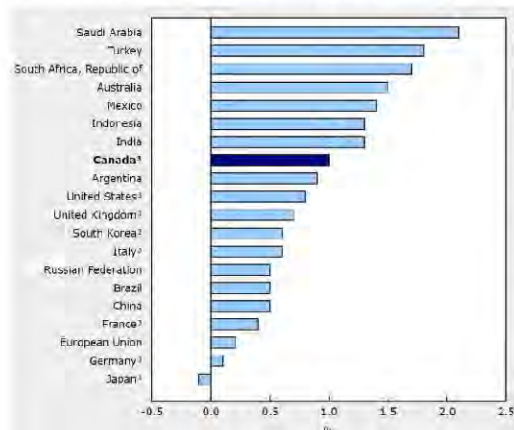
- Between 2006 and 2016, the forest industry reduced energy use by █% and total fossil GHG emissions (direct emissions plus indirect emissions from purchased electricity) by █%;
- The forest industry's ability to generate its own electricity, largely from bioenergy, has reduced its reliance on fossil fuels. The bioenergy share of the total energy use in the industry has been stable, accounting for █% of energy use in the forest industry in 2016, slightly down from the █% average observed over the 2005-2015 period.

OVERALL, THE CANADIAN FORESTRY INDUSTRY SHOULD GROW IN THE LONG-TERM. STRONGER DEMAND FOR CANADIAN LUMBER, STIMULATED BY INCREASED UNITED STATES HOUSING STARTS, AND FOR PULP SHOULD SUPPORT THAT GROWTH. THE GROWTH IS EXPECTED TO OVERCOME THE NEGATIVE IMPACT OF LONG-TERM THREATS TO THE FIBRE SUPPLY, SUCH AS PESTS AND WILDFIRE.

Canadian Municipalities, Status and Trends



According to the most recent census on Canadian municipalities of 2016, Canada was the eighth highest among G20 countries in population growth from 2011 to 2016, rising on average 1.0% per year, a ranking also recorded over the two previous intercensal periods (2001 to 2006 and 2006 to 2011)⁹⁹.

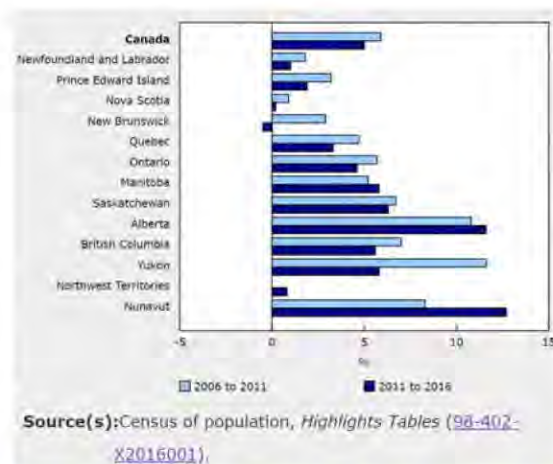


Canada has a small population living in a large land area (close to 9 million square kilometers), leading to a low population density compared with other countries. Canada had 3.9 people per square kilometer in 2016, compared with 35.3 people per square kilometer in the United States.

The Canadian population is highly concentrated geographically. In 2016, two out of three people (66%) lived within 100 kilometers of the southern Canada –United States border, an area that represents about 4% of Canada's territory. Many census metropolitan areas (CMAs) are located near the border, including Toronto, Montréal, and Vancouver.

Figure 36: Average Annual Population Growth Rate Among G20 and G7 Countries, 2011 to 2016

Provincial trends



	Population size in 2016	2006 to 2011 growth rate	2011 to 2016 growth rate
	number	%	%
Canada			
Newfoundland and Labrador			
Prince Edward Island			
Nova Scotia			
New Brunswick			
Quebec			

	Population size in 2016	2006 to 2011 growth rate	2011 to 2016 growth rate
Ontario			
Manitoba			
Saskatchewan			
Alberta			
British Columbia			
Yukon			
Northwest Territories			
Nunavut			

Figure 37: Population Size and Growth Rate, Canadian Provinces and Territories, 2006 to 2011 and 2011 to 2016¹⁰⁰

The national growth rate hides major regional differences.

- Atlantic provinces: LOW POPULATION GROWTH.** FROM 2011 TO 2016, THE POPULATION GREW MORE SLOWLY IN THE ATLANTIC PROVINCES THAN ELSEWHERE IN CANADA DUE TO INTERPROVINCIAL MIGRATION LOSSES, LOWER IMMIGRATION LEVELS AND LOWER NATURAL INCREASES. Prince Edward Island (+1.9%) recorded the fastest increase in Atlantic Canada, followed by Newfoundland and Labrador (+1.0%) and Nova Scotia (+0.2%). The population declined 0.5% in New Brunswick, the only province or territory to record a decrease from 2011 to 2016. In 2016, 6.6% of Canadians lived in the Atlantic provinces, with Nova Scotia (2.6%) accounting for the largest share, followed by New Brunswick (2.1%), Newfoundland and Labrador (1.5%) and Prince Edward Island (0.4%). In contrast, 10% of Canadians were living in the Atlantic provinces in 1966.
- Central Canada: HIGH POPULATION, LOW GROWTH.** In 2016, Ontario and Quebec accounted for 61.5% of the Canadian population. Ontario remained, by far, the most populous province in Canada with 13.4 million people representing 38.3% of the Canadian population. The number of people in the province rose 4.6% from 2011 to 2016, following a 5.7% gain in the previous five-year period. ONTARIO'S RATE OF POPULATION GROWTH WAS BELOW THE NATIONAL AVERAGE FOR TWO CONSECUTIVE INTERCENSAL PERIODS DUE TO LOWER IMMIGRATION LEVELS AND INTERPROVINCIAL MIGRATION LOSSES ACCOUNTING FOR MOST OF THE RECENT SLOWDOWN. In Quebec, the population surpassed the 8-million mark. The rate of growth was 3.3% from 2011 to 2016, below the national average of 5.0%. Because Quebec's population growth rate has remained below the national growth rate for the past 40 years, its share of the total Canadian population has fallen from 28.9% in 1966 to 23.2% in 2016.
- Western provinces: highest growth.** THE FOUR WESTERN PROVINCES WERE THE ONLY PROVINCES TO RECORD POPULATION GROWTH RATES HIGHER THAN THE NATIONAL AVERAGE. Alberta (+11.6%) had the fastest growth rate among the provinces, more than double the national average. Manitoba's population increased 5.8% from 2011 to 2016, posting a higher growth rate than the national average for the first time in 80 years. Most of the gain was due to stronger international migration. In Saskatchewan, the population rose 6.3% from 2011 and 2016, also above the national average for the second consecutive intercensal period. The number of people living in British Columbia also increased more rapidly than the national average, up 5.6% from 2011 to 2016. As a result of this growth, almost one-third (31.6%) of Canadians lived in the

West in 2016, the largest share on record. British Columbia accounted for the largest proportion (13.2%), followed by Alberta (11.6%), Manitoba (3.6%) and Saskatchewan (3.1%).

- **The territories:** Stable growth. Combined, the three territories were home to just over 113,600 people in 2016, representing 0.3% of the total Canadian population. This share has changed little since 1911.
- **Nunavut** RECORDED THE HIGHEST RATE OF GROWTH (+12.7%) AMONG THE PROVINCES AND TERRITORIES. Fertility levels in Nunavut are the highest in Canada, with women giving birth to 2.9 children on average in Nunavut, compared with the national average of 1.6 children. For the first time since Nunavut was founded in 1999, its population surpassed that of Yukon.
- The population of Yukon grew 5.8% from 2011 to 2016. While this rate was above the national average, it was nonetheless down from the rate of 11.6% recorded from 2006 to 2011. THE SLOWER RATE WAS MAINLY DUE TO INTERPROVINCIAL MIGRATION LOSSES.
- In the Northwest Territories, the population continued to increase slowly, up 0.8% from 2011 to 2016.

Municipal Trends

According to the 2016 Census, there are 5,162 municipalities and 35 CMAs in Canada, up from 33 the previous census. The three largest CMAs in 2016—Toronto, Montréal, and Vancouver—were home to more than one-third of all Canadians (35.5%), with a combined population of 12.5 million. Toronto (5,928,040 inhabitants) had the largest population, followed by Montréal, which surpassed 4 million inhabitants for the first time in census history (4,098,927), and Vancouver (2,463,431). Information on each CMA is in Appendix D: Population Size and Growth Rate of Metropolitan Areas in Canada.

FROM 2011 TO 2016, THE POPULATION GREW THE FASTEST IN FIVE CMAS LOCATED IN THE PRAIRIE PROVINCES: Calgary (+14.6%), Edmonton (+13.9%), Saskatoon (+12.5%), Regina (+11.8%) and Lethbridge (+10.8%).

As a result of strong growth over the last 15 years, Calgary (1,392,609) became the fourth largest CMA in the country in 2016, replacing Ottawa–Gatineau (1,323,783), which fell to fifth place. Edmonton was a close sixth at 1,321,426 inhabitants.

THE POPULATION GREW AT A SLOWER PACE IN MANY EASTERN AND SOME CENTRAL CMAS COMPARED WITH THE PREVIOUS INTERCENSAL PERIOD.

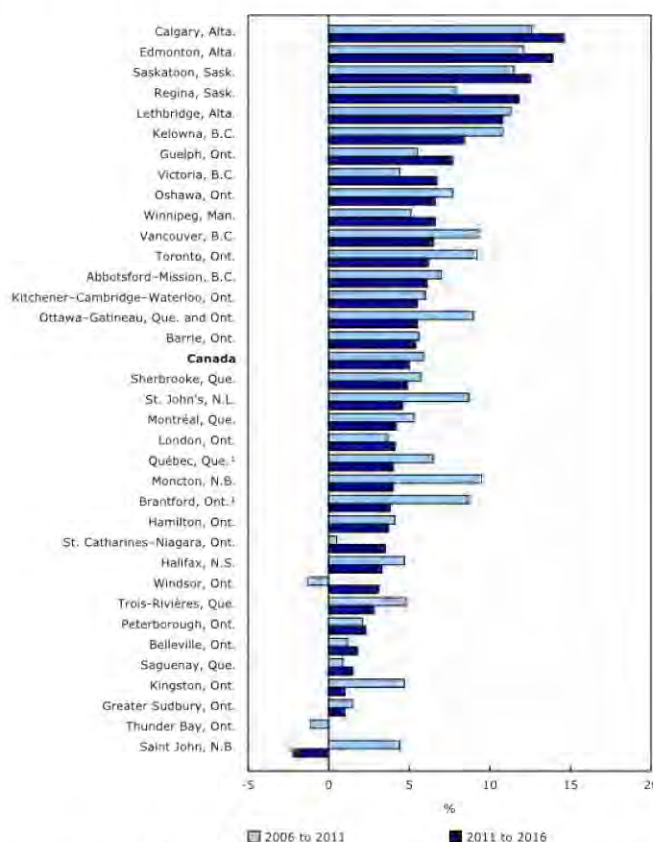


Figure 38: Population Growth Rate Among CMAs in Canada, 2006 to 2011 and 2011 to 2016, Ranked by %age Growth in 2016

From 2011 to 2016, the number of people living in the country's three largest CMAs also grew at a slower pace. In Toronto, the population grew 6.2% following a 9.2% gain from 2006 to 2011, while in Montréal, the population rose 4.2% following a 5.3% increase. In Vancouver, the number of people was up 6.5% from 2011 to 2016, after growing 9.3% during the previous intercensal period.

IN THE COMING YEARS, POPULATION GROWTH IN CANADA IS PROJECTED TO BE INCREASINGLY LINKED TO MIGRATORY INCREASE RATHER THAN NATURAL INCREASE, MAINLY BECAUSE OF LOW FERTILITY AND AN AGING POPULATION.



Figure 39: Annual Average Growth Rate, by Driver, Canada, 1851 to 2056

Construction History and Current Status

CONSTRUCTION IS ONE OF CANADA'S LARGEST AND MOST IMPORTANT INDUSTRIES CONTRIBUTING ABOUT 8% TO THE NATION'S GDP. From houses to skyscrapers, schools, hospitals, factories and shopping centres, construction also involves a wide variety of engineering projects including highways, nuclear power stations, dams, dredging, petrochemical plants, and pipelines. Members of the construction industry put in place most of the capital investment of all other industries, governments, business, and individual citizens. As a result, construction is both a production industry, providing the physical means for shelter and industrial development, and a service industry, with most work being carried out in response to orders and investment decisions of others.¹⁰¹

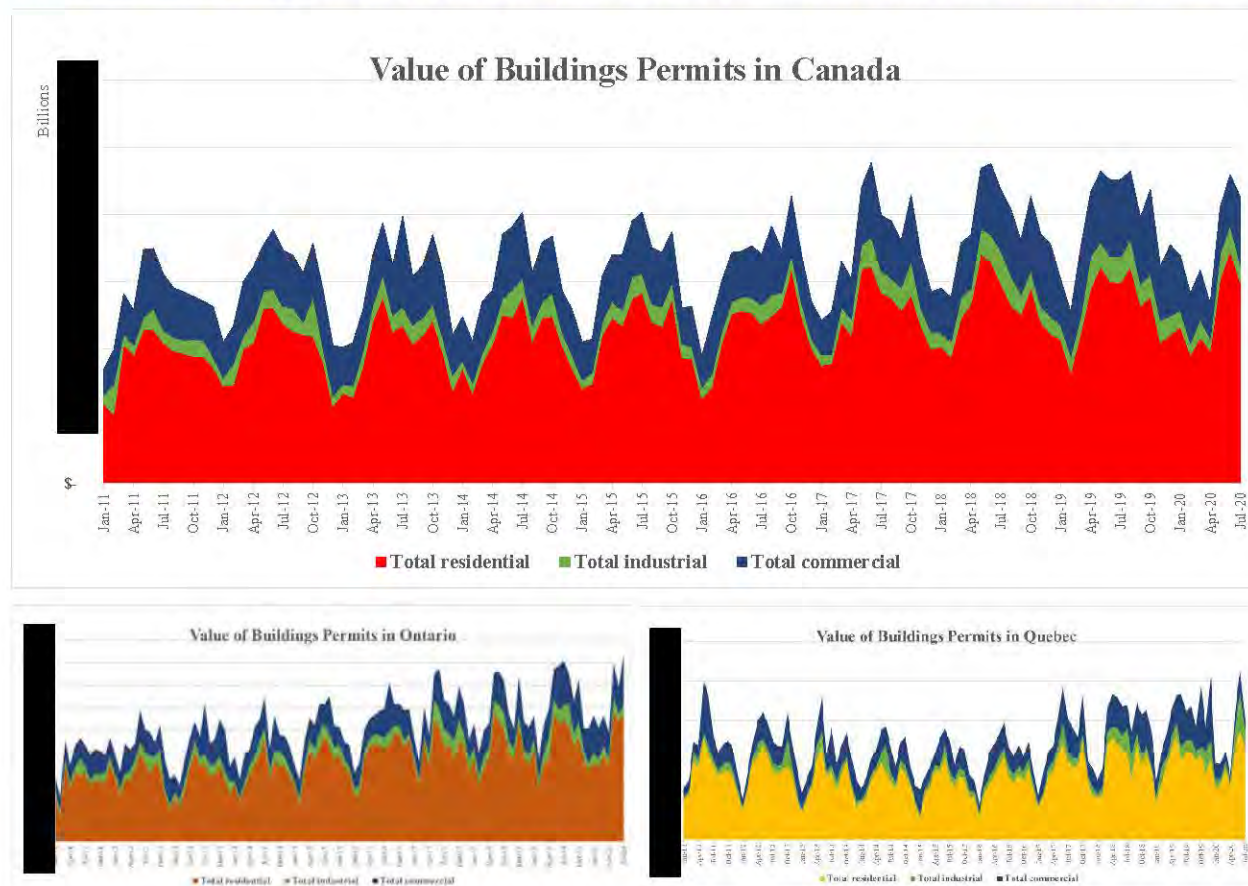
The construction industry boomed during the 1990s, with a total construction activity valued at an unprecedented \$100 billion in 1990. Due to a prolonged recession, this value was not matched again until 1996.

By the end of the 20th century, due to nation-wide public sector cutbacks only one-fifth of the country's construction was directly financed by government departments or agencies at the federal, provincial, or municipal level. As a result, in addition to the domestic market, Canadian developers, designers and contractors have developed a substantial export market, especially in the US.

The 21st century started out strong for the sector, with a high demand for both residential and commercial building projects. While major centres such as Toronto continued to grow, Alberta's oil and gas industry greatly increased the construction of both commercial and non-commercial buildings in Edmonton and Calgary. The number of residential building permits in the province grew 116% between

1994 and 2004, from 18,000 to just under 39,000. The construction industry continued to grow until 2008, when the recession prompted a significant decline.

Statistics Canada reports the value of building permits by province on Monthly basis¹⁰². As illustrated in Figure 40: Value of Building Permits, in Canada, BC, ON, QC, and AB, 2011-July, the value of building permits has been growing consistently since 2011 with residential share constituting a healthy nearly █% throughout the period. Commercial sector has been representing around █% throughout the period while industrial has been around █%. The Consultant also built graphs for four key provinces, BC, Alberta, Quebec, and Ontario, for comparative purposes. **AS IT CAN BE VIEWED IN GRAPHS BELOW, ONTARIO HAS ALMOST DOUBLED ITS VALUE OF BUILDING PERMITS BETWEEN 2011 AND 2020, FROM AROUND █ MONTHLY, ALSO HEAVILY DOMINATED BY THE RESIDENTIAL SECTOR. QUEBEC, WHILE FLUCTUATING SEASONALLY, HAS RETAINED THE CONSISTENT VALUE OF MAXIMUM █. BRITISH COLUMBIA HAS SHOWN A REMARKABLE GROWTH FROM █ IN 2018. BETWEEN 2018 AND NOW, VALUE HAS BEEN FLUCTUATING REMARKABLY BETWEEN █. ALBERTA HAS SEEN SUBSTANDARD GROWTH: EXCEPT FOR TWO RESIDENTIAL PEAKS IN FALL 2015 AND FALL 2016, IT HAS BEEN DECLINING ACROSS ALL SECTORS.**



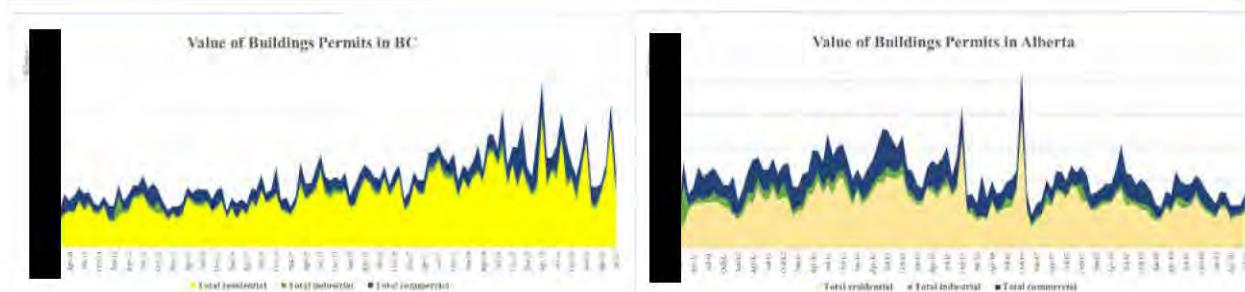


Figure 40: Value of Building Permits, in Canada, BC, ON, QC, and AB, 2011-July

According to Statistics Canada and as illustrated in Figure 41: Canadian Housing Starts and Completions, April 2018 – August 2020, residential subsector has grown marginally over the last two years. Apartment buildings have been dominating the space (■%).

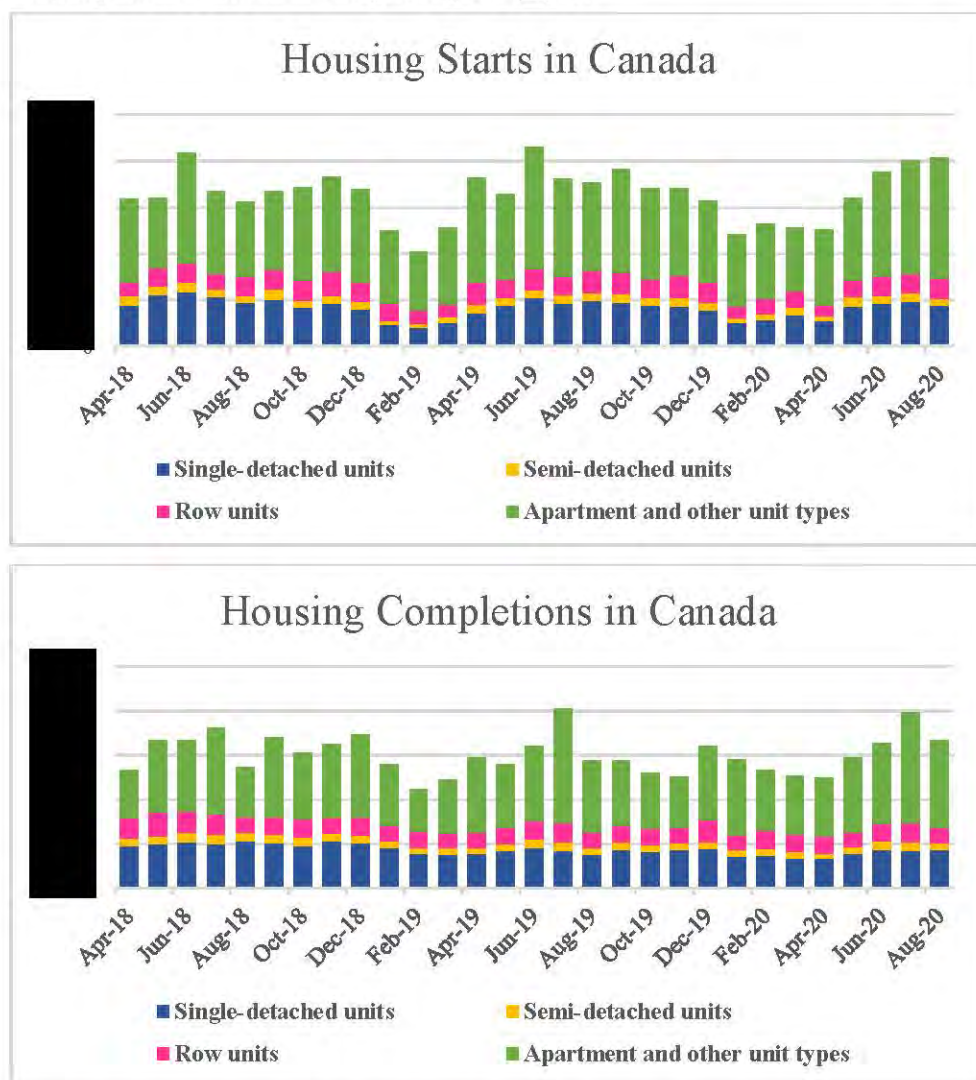


Figure 41: Canadian Housing Starts and Completions, April 2018 – August 2020

ON A PROVINCIAL LEVEL, ONTARIO DOMINATES THE RESIDENTIAL SECTOR, FOLLOWED BY QUEBEC AND THEN BRITISH COLUMBIA (Figure 42: Canadian Housing Starts by Province, April 2018 – August 2020).

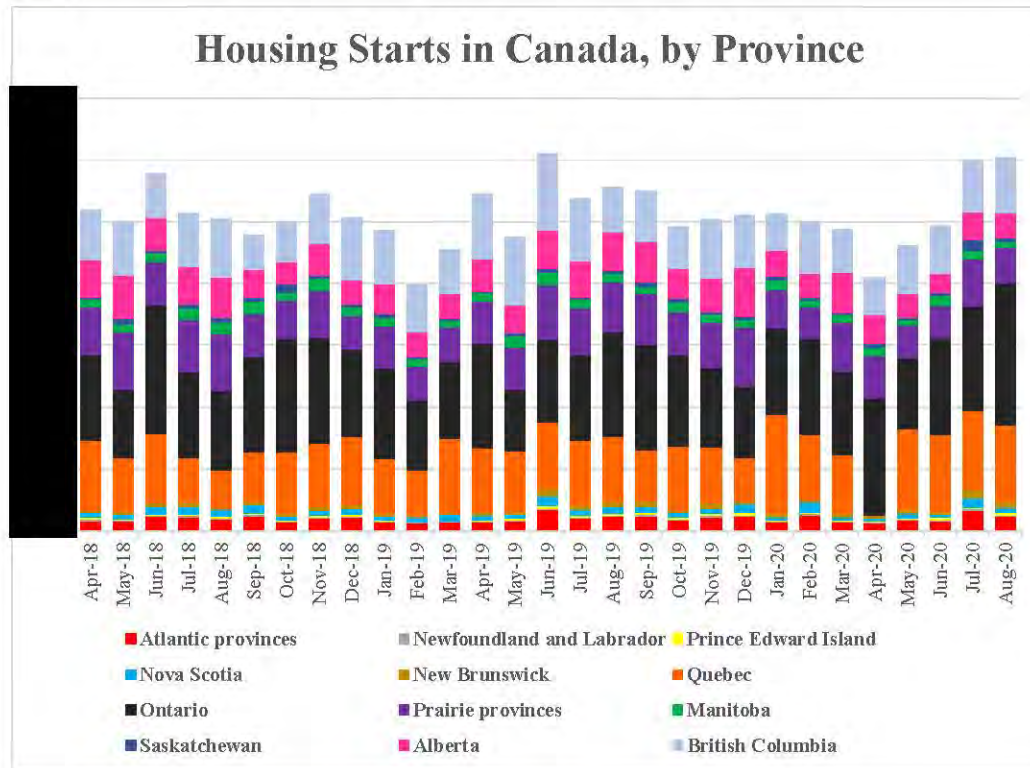


Figure 42: Canadian Housing Starts by Province, April 2018 – August 2020¹⁰⁴

CANADIAN CONSTRUCTION INDUSTRY HAS BEEN ON A SUSTAINED GROWTH PATH, ESPECIALLY IN BRITISH COLUMBIA AND ONTARIO. THIS TREND IS ALSO SUPPORTED BY THE DATA ON MUNICIPALITIES DESCRIBED IN SECTION CANADIAN MUNICIPALITIES, STATUS AND TRENDS POSITIONING THESE REGIONS AS ATTRACTIVE TARGETS FOR SMALL ENGINE EQUIPMENT.

COVID-19 Impact on Canadian Economy

The General Canadian Economy

The outbreak of COVID-19 followed by the economy shut down impacted economic activity in Canada. The lockdown that started in March pummelled Canada's economy; yet by May, the nation witnessed the signs of slow recovery. According to Statistics Canada, real GDP contracted 8.2% annualized in Q1 as domestic demand collapsed amid declines in business investment, residential investment, and consumption. In May, it had a 4.5% growth.

According to its release of August 7, 2020¹⁰⁵, the economy has ceased its decline.

- After increasing by nearly one million in June, employment rose by 419,000 in July as businesses and workplaces affected by COVID-19-related restrictions continued to reopen. After advancing

Canadian Economic Dashboard and COVID-19 of July 3, 2020. <https://www150.statcan.gc.ca/n1/pub/71-607-x/71-607-x2020009-eng.htm>

steadily from May to July, overall employment remains 1.3 million below pre-COVID levels, reflecting large cumulative losses in accommodation and food services, wholesale and retail trade, construction, transportation and warehousing, and manufacturing.

- The unemployment rate was 10.9% in July, after reaching a record high of 13.7% in May. Despite this decrease, almost 2.2 million Canadians were unemployed, nearly twice as many as in February. The number of people who wanted a job but did not search for work, likely for reasons related to COVID-19, continued to fall in July. If these people were included as unemployed, the adjusted unemployment rate would be 13.8%.



Figure 43: Canadian GDP January 2019 – May 2020

- Following a 5.6% gain in May, merchandise exports rose 17.1% in June, led by higher shipments of motor vehicles and parts. Production at Canadian assembly plants continued throughout June after activity resumed in mid-May. Overall, 85% of the growth in merchandise exports in June reflected higher shipments to the United States.
- After declining by 4.6% in May as COVID-19 continued to disrupt supply chains, merchandise imports rebounded sharply in June, advancing 21.8% on widespread gains across commodities. Higher imports of motor vehicles and parts accounted for almost one-half of the overall increase, as auto-related shipments climbed to \$5.2 billion after falling to \$1.7 billion in May. Excluding motor vehicles and parts, merchandise imports rose by 12.2%, supported by an increase in aircraft and other transportation equipment.

As a trading nation, much of Canada's annual private-sector investment in the economy is carried out in support of trade, often spurring construction activity. Canada's key trading partners have been similarly affected by COVID-19 and many of their economies, including that of the United States, and are expected to fall into recessions this year.

In addition to the government's fiscal stimulus now at work, the Bank of Canada's quantitative easing program has played a crucial role in improving financial conditions.

According to the National Bank of Canada, while a rebound is likely in the second half of 2020 as more of the economy reopens and firms rebuild inventories, that won't make up for the first half collapse in economic activity, leaving Canada with the worst annual GDP contraction on record- despite unprecedented fiscal and monetary policy stimulus. The 2020 Canada's GDP is forecast at -7.1% and them recovery at 4.9% in 2021.¹⁰⁶ RESIDENTIAL CONSTRUCTION IN CANADA WILL BE AFFECTED VERY MILDLY WITH 1.2% DECLINE IN 2020 FOLLOWED BY A VERY HEALTHY RECOVERY IN 2021. Canadian key economic indicators, as projected by National Bank of Canada, are summarized in the figure below.

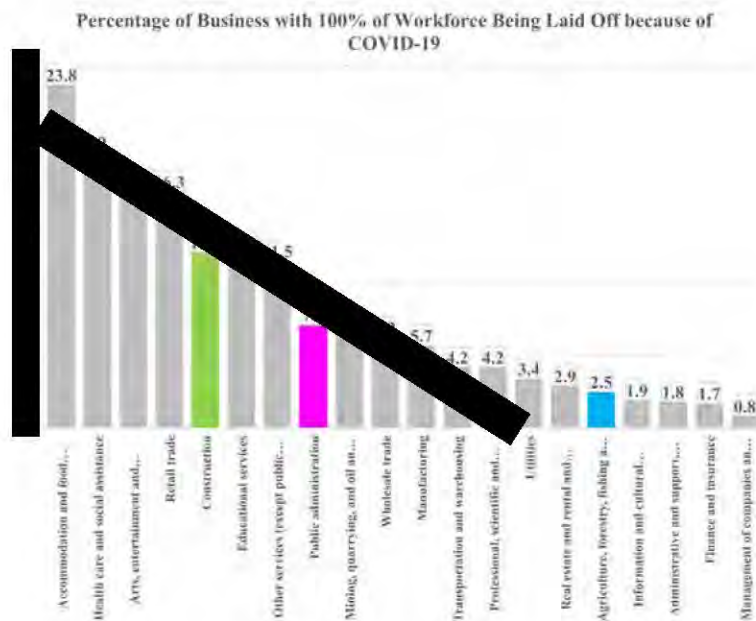
Canada Economic Forecast								
(Annual % change)*	2017	2018	2019	2020	2021	2019	Q4/Q4 2020	2021
Gross domestic product (2012 \$)	3.2	2.0	1.7	(7.1)	4.9	1.5	(5.4)	4.0
Consumption	3.7	2.2	1.6	(7.5)	4.4	1.7	(5.9)	2.7
Residential construction	2.2	(1.6)	(0.6)	(1.2)	3.5	4.3	(2.4)	4.0
Business investment	3.9	1.4	0.4	(28.8)	7.3	2.4	(29.2)	15.0
Government expenditures	2.9	3.4	1.7	0.5	1.3	1.8	0.8	1.0
Exports	1.4	3.1	1.3	(14.3)	3.3	0.2	(13.8)	5.0
Imports	4.2	2.6	0.6	(16.0)	2.4	0.5	(15.8)	5.0
Change in inventories (millions \$)	17,951	13,025	15,077	(499)	1,000	9,362	(4,000)	4,000
Domestic demand	3.3	2.1	1.3	(7.1)	4.5	1.8	(5.7)	3.6
Real disposable income	4.0	2.0	2.8	(2.2)	1.4	3.1	(3.0)	1.8
Employment	1.9	1.3	2.1	(5.8)	3.4	1.8	(4.0)	1.6
Unemployment rate	6.3	5.8	5.7	9.5	8.8	5.7	9.0	8.6
Inflation	1.6	2.3	1.9	0.7	2.0	2.1	0.8	2.0
Before-tax profits	19.9	2.5	(0.1)	(25.7)	12.5	5.5	(23.8)	13.8
Current account (bil. \$)	(60.2)	(55.5)	(47.0)	(60.1)	(55.0)			

* or as noted

Figure 44: Canada Economic Indicators Forecast for 2020 – 2021

Impact on Canadian Industries Under Study

Statistics Canada examined how COVID-19 impacted different industries. The results demonstrating the amount of laid off workforce is shown in Figure 45: %age of Canadian Businesses Laid off 100% of the Workforce in Q1 2020 vs. Q1 2019 because of COVID-19 . [ACCORDING TO THE REPORTED DATA, CONSTRUCTION REMAINS THE LARGEST CASUALTY COMPARED TO TWO OTHER SECTORS WITH ABOUT █% OF BUSINESSES LOSING 100% OF THE WORKFORCE.](#) Agriculture was affected the least with █% of businesses losing their entire staff.



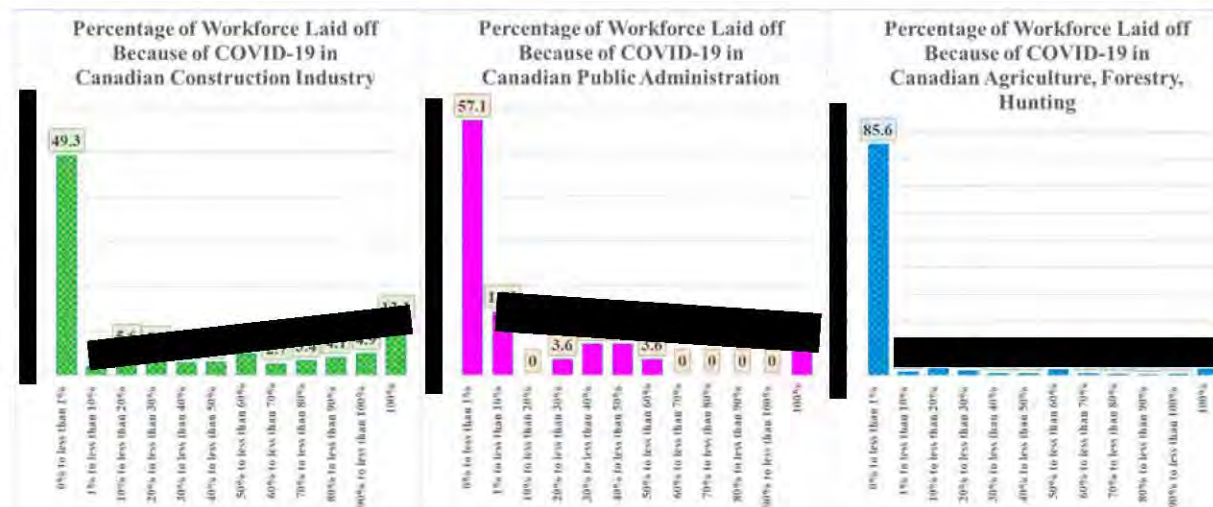
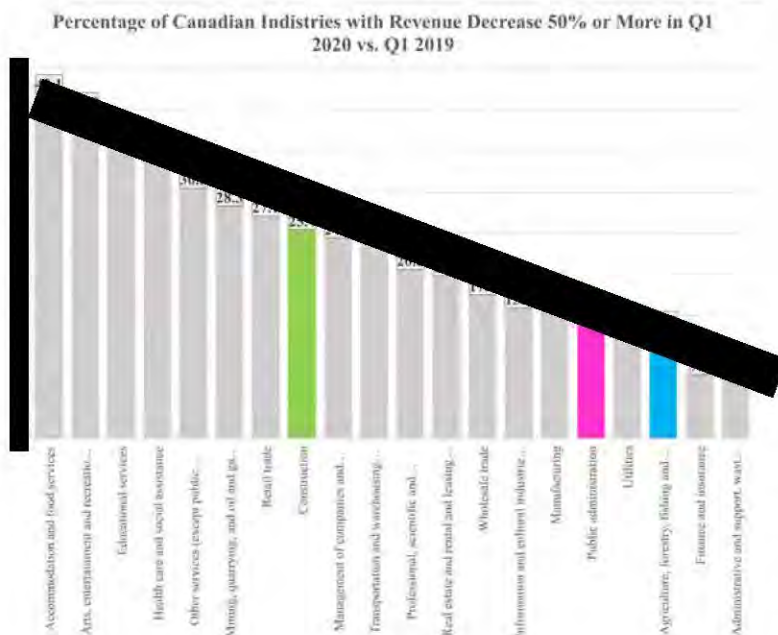


Figure 45: %age of Canadian Businesses Laid off 100% of the Workforce in Q1 2020 vs. Q1 2019 because of COVID-19

Construction also remained in the middle among all other industries with about █% of construction businesses losing over 50% of revenue. At the same time, about █% of construction businesses either retained the same financials or have even improved their financial position, as shown in Figure 46: %age of Canadian Businesses Losing over 50% of Revenue in Q1 2020 vs. Q1 2019 because of COVID-19. Most agriculture firms have retained the same financial position (a similar trend in public service █%).



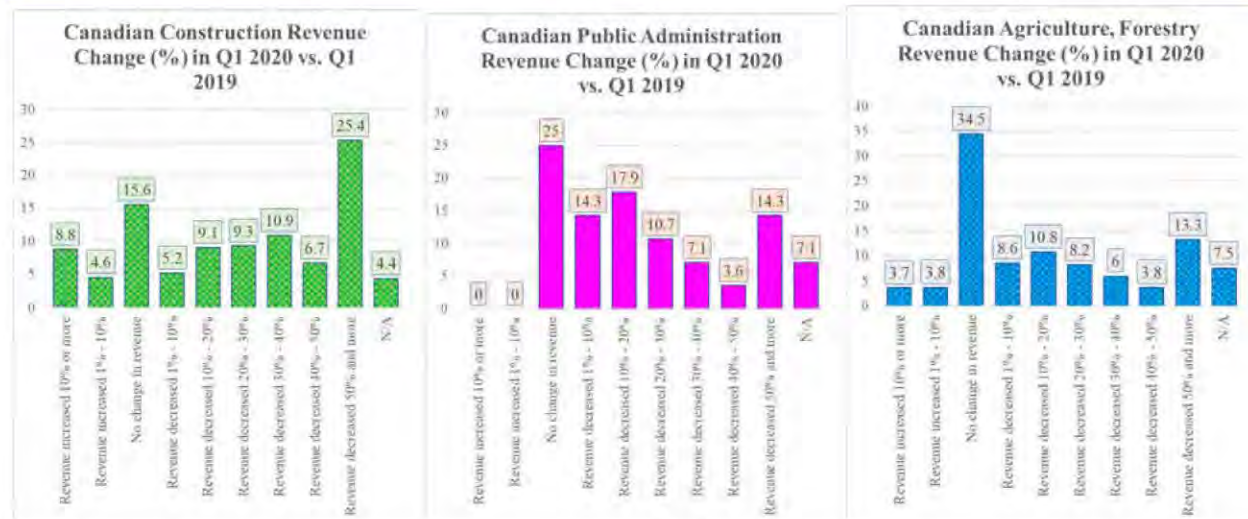


Figure 46: %age of Canadian Businesses Losing over 50% of Revenue in Q1 2020 vs. Q1 2019 because of COVID-19 108

Examination of the degree of the impact from COVID-19 to the decrease in demand in products and services showed that **CONSTRUCTION EXPERIENCED SOME OF THE HIGHEST IMPACTS FROM COVID-19 COMPARED TO ALL OTHER CANADIAN INDUSTRIES** (68% of businesses), as shown in Figure 47: Decrease in Demand for Products or Services in Canadian Businesses due to COVID-19 preceded by six other sectors. Agriculture and Public services had fewer businesses that experienced a heavy demand decline (38% and 28% respectively).

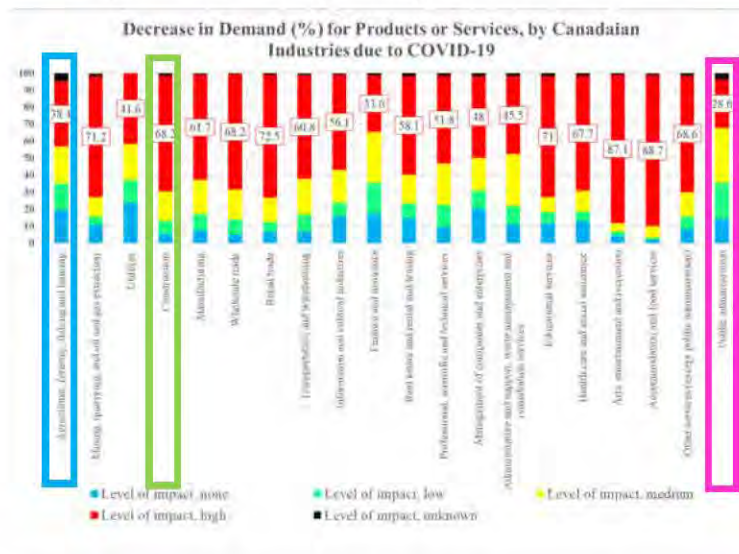


Figure 47: Decrease in Demand for Products or Services in Canadian Businesses due to COVID-19

Similar to the decrease in demand, Construction was the seventh among all other industries which suffered the highest degree of cancellation of services (46% of construction firms had a highest level of cancellation), as shown in Figure 48: Cancellation of Services by Canadian Businesses due to COVID-19. Agriculture had the lowest level of cancellation among all industries (only financial services did better).



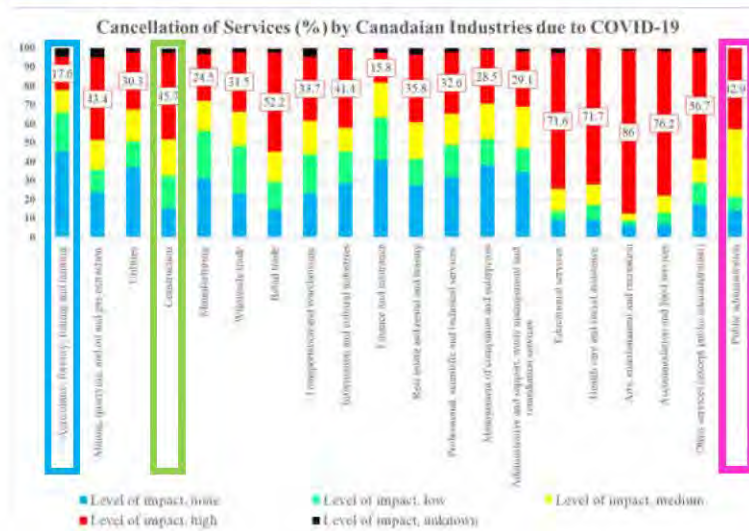


Figure 48: Cancellation of Services by Canadian Businesses due to COVID-19

Government Canada analyzed how different industries adapted to the changed operational environment¹⁰⁹. It surveyed to what degree the following businesses practices were introduced:

- working from home
- e-commerce
- maintaining business connections virtually
- introducing new services and products

According to the results of the survey, also summarized in Figure 49: Business Practices Used while Social Distancing Measures were in Place, by Business Characteristics, PUBLIC SERVICES CLOSELY FOLLOWED BY FINANCE & INSURANCE SECTORS PROVED TO BE THE HIGHEST ADOPTERS OF NEW BUSINESS PRACTICES ENSURING THEIR HIGH SURVIVAL RATE IN THE NEW ENVIRONMENT. ON THE OPPOSING SIDE, CONSTRUCTION RANKED AS ONE OF THE LOWEST AMONG ALL SECTORS IN ADOPTING SOCIAL DISTANCING MEASURES, WHICH IS WARRANTED BY THE OPERATIONAL NATURE OF THE BUSINESS. IT LIKELY MEANS THAT CONSTRUCTION MIGHT STILL BE HIT HARDER IN CASE THE COVID-19 SECOND AND THIRD WAVES PROVE TO BE SIGNIFICANT.

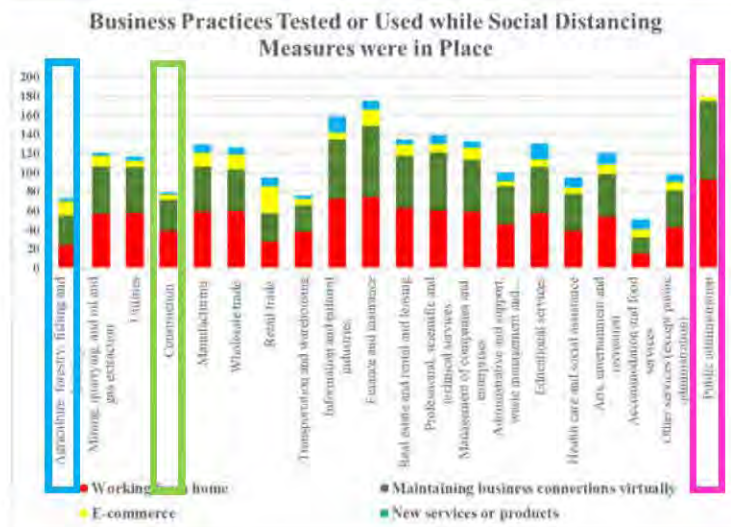


Figure 49: Business Practices Used while Social Distancing Measures were in Place, by Business Characteristics

SIMILAR TO THE U.S.A., WHEN COMPARED TO OTHER INDUSTRIES UNDER STUDY, CANADIAN CONSTRUCTION HAS SUFFERED THE HIGHEST IMPACT FROM THE PANDEMIC LOCKDOWN. AGRICULTURE AND PUBLIC SECTOR ARE BETTER PROTECTED FROM THE RECESSION DEMONSTRATING THE LOWEST DECREASES WHEN COMPARED TO CONSTRUCTION. CANADIAN AGRICULTURE HAS AN EXTRA PROTECTIVE LAYER IN THE SHAPE OF A WIDE RANGE OF FINANCIAL SUPPORT INCENTIVES PROVIDED BY FEDERAL AND PROVINCIAL AUTHORITIES.

Housing starts have experienced mixed results across the provinces for the first half of 2020, with half the provinces showing growth in the number of starts. While all construction businesses were affected, Quebec was impacted most by mandatory closures, as the province halted all non-essential construction. (see Figure 42: Canadian Housing Starts by Province, April 2018 – August 2020).

According to BuildForce, Residential investment in Canada is projected to fall 7.7% in 2020 as housing starts and renovation expenditures are reduced by a similar rate.¹¹⁰ Although numbers are expected to increase toward the end of the year, levels are projected to be significantly lower over the short term, leading to a slower recovery.

Housing starts are expected to see lower numbers in most provinces for the year, with roughly 187,000 units projected nationally this year, as compared to 208,700 in 2019.



Figure 50: Canadian Residential Construction Forecast, 2010-2022.

- Non-residential markets will remain slower and uncertain over the short term. Non-residential investment in Canada is projected to fall by 6.9% in 2020.
- Heavy-industrial construction is expected to be muted in line with demand for commodities. The investment outlook in Alberta and Newfoundland and Labrador has been diminished, as the decline in oil and gas prices has deferred or cancelled plans for some new oil sector investments.
- Industrial construction, largely driven by exports, will depend on global economic recovery. Major energy-and industrial-sector projects are expected to proceed, although project schedules may shift some activity scheduled for 2020 into 2021, causing a potential stacking of project demands. Infrastructure stimulus projects are expected to play a significant role in construction demand over the next year.
- Commercial construction levels will also depend on economic recovery and a resumption in consumer spending. Commercial investment is likely to soften in the mid-term as cash-challenged companies defer expansion plans. The extent of that growth, however, will depend on the capacity of governments to continue to fund projects announced prior to the onset of COVID-19.
- Civil-sector construction was expected to be robust prior to the pandemic and is likely to increase as governments accelerate investments in public infrastructure. The one caution currently is the capacity of municipalities to continue to participate in the infrastructure renewal process. With many experiencing significant revenue shortfalls related to the pandemic, their capacity to remain active partners may be diminished.



Figure 51: Canadian Non-Residential Construction Forecast, 2010-2022.

14. ESTIMATION OF THE FOUR-STROKE GASOLINE SSI ENGINE MARKET SIZE

Market Size Forecast Approach

The market size for gasoline powered four-stroke small engines is estimated based on the data available in the public domain. For calculations, the Consultant used the data reported by government agencies and forecasts developed by credible researchers.

Estimation of the market size for the Client's Solution follows the algorithm described below.

1. Evaluate the market composition by equipment type.
2. Estimate the total small engine market size.
3. Establish the share of four-stroke and gasoline-fuelled engine in the total market.
4. Establish the market composition by geography and user type.
5. Establish the market growth rate and adjust it to the COVID 19 epidemic.
6. Calculate the total market size for Low Case and High Case and the Client's potential market share.

Small Engine Market Composition by Equipment Type

The small engine equipment market is characterized by a diverse spectrum of machinery / tools / devices that serve many functions and applications within several industries. Common types sorted out by industries are listed below in Table 7: Types of Small Engine Equipment Grouped by Industry. Note that the list is divided into two groups to reflect their relevance to the forecast: a) **THE EQUIPMENT THAT MEETS THE BASIC CONDITIONS QUALIFYING IT FOR THE CLIENT'S SOLUTION (FOUR-STROKE SMALL ENGINES RUN ON GASOLINE) AND ACCORDINGLY TO BE INCLUDED INTO THE FORECAST CALCULATIONS** and b) tools that do not meet all conditions and accordingly do not qualify for the Client's Solution are listed as those excluded from the forecast estimates.

	Equipment included into the market size forecast	Equipment not included into the market size forecast
	HOUSEHOLD AND GARDENING	
1.	Lawn mowers are either two-stroke or four-stroke gasoline-engine powered, having a power output between 0.5 and 5kW. Mowers for professional use are typically diesel or four-stroke gasoline-engine powered.	Hobby chainsaws are mainly equipped with two-stroke gasoline engines.
2.	Snow mobiles/skidoos are generally equipped with two- or four-stroke gasoline engines with a power output of 10 to 50kW.	Trimmers/ trimmers / edgers / brush cutters are mainly two-stroke gasoline engine equipped and have about 0.25 kW to 1.4kW power output.
3.	Tiller Go Kart , are generally equipped with two- or four-stroke gasoline engine.	
4.	Small Power Generators are generally equipped with two- or four-stroke gasoline engine.	
5.	Pump Brush Cutters are generally equipped with two- or four-stroke gasoline engine.	

	Equipment included into the market size forecast	Equipment not included into the market size forecast
6.	Snowblowers are generally equipped with two- or four-stroke gasoline engine.	
7.	Chipper / Shredder Go-Kart are generally equipped with two- or four-stroke gasoline engine.	
8.	Set Stump Beater are generally equipped with two- or four-stroke gasoline engine.	
9.	Compressor Pressure Washer are generally equipped with two- or four-stroke gasoline engine.	
CONSTRUCTION		
10.	Generator Sets Small units have an output of 0.5 to 5kW and are powered by four-stroke engines. Diesel generators use less fuel than their gasoline-powered counterparts	Pilers originally included in the agriculture sector only, mobile piler units are now used on many building sites. They are nearly diesel engine and can be variable or constant speed, with a rated power greater than 56kW.
11.	Small mobile welders (<10kW) incorporate a gasoline, diesel, or propane fueled. Small mobile welders are typically equipped with four-stroke gasoline engines.	Asphalt pavers/concrete pavers. They are equipped with three- to six-cylinder diesel engines with a power output between 15 and 160kW.
12.	Cement Mixer, Pump Pressure Washer Generator Set can be equipped with two-and four-stroke gasoline engines.	Tampers and rammers are tools for surface treatment generally operated by two-stroke gasoline engines of about 1–3kW power output. These machines (e.g. smooth drum rollers, single drum rollers, tandem rollers, pad foot rollers), are used for earth compaction, are all diesel engine equipped.
13.		Trenchers/mini excavators (crawler or wheel-type machines) can be considered as a special type of a mini-excavator used for digging trenches. Some are equipped with special tools, e.g. cable plows. They are mostly diesel engines equipped with a power output of 10 to 40kW.
14.		Cranes (e.g. crawler mobile cranes, carry cranes, tower cranes) have an output of about 100 to 250kW, mostly diesel or electrical engines. Models with a special design can have a significantly higher power output.
15.		Graders (e.g. articulated steered or wheel-steered) are used to level surfaces. They have a power output of about 50 to 190kW, mostly diesel engine powered.
16.		Scrapers (e.g. wheel-steered tractor scrapers, articulated steered tractor scrapers) are used for earthwork. They have a power output of about 130–700kW and are nearly all diesel-engine powered.
17.		Bulldozers. This category includes wheel dozers, articulated-steered dozers, crawler dozers, crawler loaders, etc. They are mainly used for demolishing and earthmoving work and are almost all diesel engine equipped with a power output of about 30 to 250kW.
18.		Crawler loaders are nearly all diesel engine equipped.
19.		Dumpers/tenders. Most of them run with diesel engines with a power output of about 5 to 50kW.
20.		Backhoes are combinations of a wheel loader and a hydraulic excavator. They mostly run on diesel engines with a power output of about 10 to 130kW.

	Equipment included into the market size forecast	Equipment not included into the market size forecast
21.		Skid steer loaders are generally run on diesel engines having a power output between 15 to 60kW.
22.		Aerial lifts (<2 kW) run mainly on electric engines, while only some on small (mainly two-stroke) gasoline engines with a power output of 3 to 10kW.
23.		Forklifts are equipped with electric or internal combustion engines. The internal combustion engines are mostly diesel or CNG engines; have a power output between 20 and 100kW.
24.		Air/gas compressors. Nearly all the small compressors used for handicraft purposes run with electric engines. Nearly all large compressors used for construction works are equipped with diesel engines with a power output between 10 and 120kW.
25.		Welders (>10KW) are diesel-fueled going up to about 40kW.
26.		Refrigerating units usually have diesel engines.
27.		Conveyors, tunnel locomotives, snow clearing machines, industrial tractors, pushing tractors: diesel engines are primarily used, and power output is out of desired range.
28.		Paving and surfacing equipment, bore/drill rigs, crushing equipment, peat cutting and processing machines, concrete breakers/saws, pipe layers, etc.: mainly diesel and two-stroke gasoline engines are used and power output is out of looked-for range.
AGRICULTURE & FORESTRY		
29.	Two-Wheel Minitractors. Very small, single axle/two-wheel minitractors only have a few kW power output (about 5 to 15kW) are equipped with four-stroke diesel or gasoline engines (Minitractor Commercial Turf Walk-Behind Lawnmower, Minitractor Commercial Turf Riding Mower)	Commercial Chainsaws are mainly two-stroke gasoline-engine driven with a power output of about 2 to 6kW.
30.	Pumps. Many of the small pumps in use are operated with electric engines. Above 10kW and 20 kW power output for two and four-stroke respectively, diesel engines predominate.	Articulated-wheel and crawler-type tractors are nearly all exclusively diesel-engine powered and have a wide range of power output, between 20 and about 250kW.
31.	Sprayers are mainly diesel engines, but two-and four-stroke gasoline engines are also used in these machines.	Harvesters/combiners are generally diesel engine equipped.
32.	Manure distributors are mainly diesel engines, but two-and four-stroke gasoline engines are also used in these machines.	Forest tractors/harvesters/skidders are almost all diesel engine equipment with a power output of about 25 to 75kW.
33.	Mowers are mainly diesel engines, but two-and four-stroke gasoline engines are also used in these machines.	Lawn and garden tractors are mainly diesel engines.
34.	Balers are mainly diesel engines, but two-and four-stroke gasoline engines are also used in these machines.	Wood splitters are mainly diesel engines.
35.	Tillers are mainly diesel engines, but two-and four-stroke gasoline engines are also used in these machines.	Log cultivators are mainly diesel engine equipment; some use two-stroke engines.
36.		Tree processors are mainly diesel engine equipment; some use two-stroke engines.

	Equipment included into the market size forecast	Equipment not included into the market size forecast
37.		Haulers are mainly diesel engine equipment; some use two-stroke engines.
38.		Forestry cultivators are mainly diesel engine equipment; some use two-stroke engines.
39.		Fellers are mainly diesel engine equipment; some use two-stroke engines.
40.		Shredders are mainly diesel engine equipment; some use two-stroke engines.

Table 7: Types of Small Engine Equipment Grouped by Industry and Relevance to the Forecast

The Total SSI Engine Market Size

To estimate the size of the SSI engine market, the Consultant collected a multitude of available market forecasts developed by various research companies and extracted the most common trends also adjusted to the input parameters specific to each estimate. The Consultant identified 17 such forecasts developed in recent years that provide estimates of the current and future size of the global small engine market. Table 8: Small Engine Market Expected Growth Comparative Estimates summarizes data from these forecasts arranged in the order of their release. The compiled forecast data indicates that different researchers arrive at slightly different assessments of the global small engine market, which can be explained by a dispersed market dominated by private companies with inconsistent reporting and surveying practices. This increases the level of uncertainty in projecting the actual market size.

Data sets include information on technology, geography, and served industries, as well as CAGR and other forecasting parameters. The data from this table is used to develop assumptions and input parameters into future projections as summarized in section Assumptions and Input Data for the Four-stroke Small Gasoline Engine Market Size Forecast.

	Report Provider	Market	Published	Base Year	End of Forecast Period	Market Size	Units (Base Year)	Units (End of Forecast Period)	CARG	Small Engine Market Segment			Regions	Small Engine Market by Engine Type		
										Household and Gardening	Construction	Agriculture and Forestry		Gasoline/Diesel	Electric	Robotics
1	Persistence Market Research	Global Small Engine Market ¹¹¹	Jan-19	2018	2026	US\$ 4.127.2 Bln by 2018: US\$ 5.628.2 Bln by 2026	15.5131 Mln	21.4469 Mln	4.0%	5.4% - CARG 41.7%	17 %	17%	North America - 40.2%			

[REDACTED CONTENT]

	Report Provider	Market	Published	Base Year	End of Forecast Period	Market Size	Units (Base Year)	Units (End of Forecast Period)	CAGR	Small Engine Market Segment			Regions	Small Engine Market by Engine Type		
										Household and Gardening	Construction	Agriculture and Forestry		Gasoline/Diesel	Electric	Robotics

[REDACTED]

	Report Provider	Market	Published	Base Year	End of Forecast Period	Market Size	Units (Base Year)	Units (End of Forecast Period)	CAGR	Small Engine Market Segment			Regions	Small Engine Market by Engine Type		
										Household and Gardening	Construction	Agriculture and Forestry		Gasoline/Diesel	Electric	Robotics

[REDACTED]

	Report Provider	Market	Published	Base Year	End of Forecast Period	Market Size	Units (Base Year)	Units (End of Forecast Period)	CAGR	Small Engine Market Segment			Regions	Small Engine Market by Engine Type		
										Household and Gardening	Construction	Agriculture and Forestry		Gasoline/Diesel	Electric	Robotics
17	The Daily Chronicle	Ride on Mower Market ¹²⁶	2020	2019	2027								North America - 54.5% Europe - 13.5% Asia-Pacific -22.8% Middle East & Africa - 6.1% South America -3.1%			

Table 8: Small Engine Market Expected Growth Comparative Estimates

[REDACTED]

The Share of Gasoline-run Engines and Four-Stroke Engines in the Total Market Size

TO ARRIVE AT THE MARKET SHARE OF THE ENGINES THAT MEET THE REQUIREMENTS FOR THE CLIENT'S SOLUTION, THE CONSULTANT ESTIMATED THE SHARES OF DIFFERENT FUEL SOURCES AND ENGINE TYPE (2 STROKE VS. 4 STROKE). KNOWING THESE SHARES, THE CONSULTANT ESTIMATED THE MARKET SHARE FOR THE CLIENT'S SOLUTION. FOR EACH TYPE OF ANALYSIS, THE CONSULTANT APPROXIMATED THE DATA AS A WEIGHTED AVERAGE OF FORECASTS PROVIDED BY DIFFERENT AGENCIES AND SUMMARIZED IN TABLE 1: GLOBAL SMALL ENGINE MANUFACTURERS. THE WEIGHT FOR EACH FORECAST IS ASSIGNED ACCORDING TO THE DATE OF FORECAST AND RELEVANCE TO THE CLIENT.

Market Share by Fuel Source

Fuel sources analysis is consistent across all forecasts reported by market researchers. All of them except Market Research and OPE Business report on gasoline and diesel fuelled equipment: Market Research projections include only gasoline powered segment; OPE Business report includes only electric segment. There are 3 major sources to power engine devices: gasoline, diesel and electric.

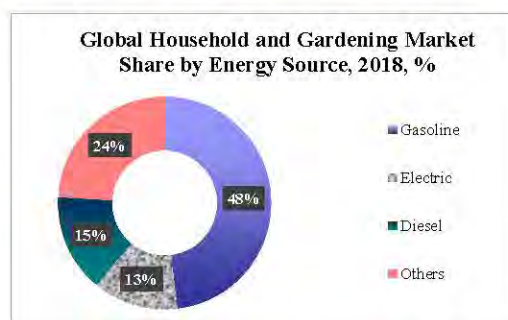


Figure 52: Global Household and Gardening Market share by Energy Source¹²⁷

Global Household and Gardening Markets share by power source is shown in Figure 52. While diesel fuels a significant part of devices, gasoline dominates the market (48% of the total). It should be noted that electricity as a source of energy is gaining a larger share reaching 13%, almost as much as diesel (15%).

It should be noted that the trend of replacing conventional sources of energy powering internal combustion engines with electrical and robotic sources has been emerging in Asia. As shown in Figure 53, the prevalence of substituting conventional power sources is the most evident in the lawn and garden equipment market where electrical and robotics have been common for many years. The number of robotic devices is expected to more than double between 2016 and 2027.

A more detailed breakdown of fuel-powered engines by energy source is shown in Figure 54: Small Engine Equipment Sales Trend by Energy Source. The data for this analysis is taken from the EPA reporting system on engine equipment.

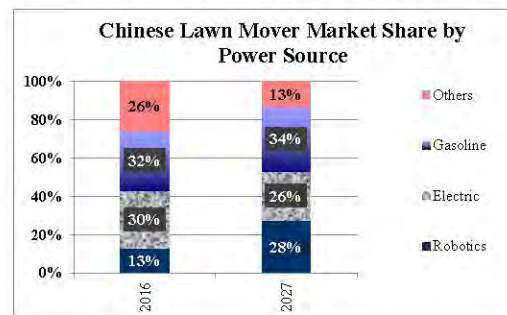


Figure 53: China Lawn Mower Market Share by Power Source¹²⁸

FROM THIS DATA, DIESEL DOMINATES IN CONSTRUCTION APPLICATIONS WHILE OTHERS HAVE GASOLINE AS A MAJOR TYPE OF FUEL.

Sector	Equipment	Diesel	Gasoline
Commercial and Industrial	Chain Saws	■	■
	Chipper/Grinder	■	■
	Comm. Turf	■	■
	Front Mowers	■	■
	Leaf Blowers	■	■
	Lawn Mowers	■	■
	Minitractors	■	■
	Others	■	■
	Shredders	■	■
	Snowblowers	■	■
	Hedge/ Cutters	■	■
	Total	■	■
Construction	Bore/Drill Rigs	■	■
	Mixers	■	■
	Concrete Saws	■	■
	Cranes	■	■
	Crush Equip	■	■
	Crawler Mini dozers	■	■
	Dumpers	■	■
	Graders	■	■
	Signal Bds	■	■
	Pavers	■	■
	Total	■	■
	Agriculture and Forestry	2 Wheel Minitractors	■
AG Mowers		■	■
AG Minitractors		■	■
Hydro Power Units		■	■
Sprayers		■	■
Tillers		■	■
Others		■	■

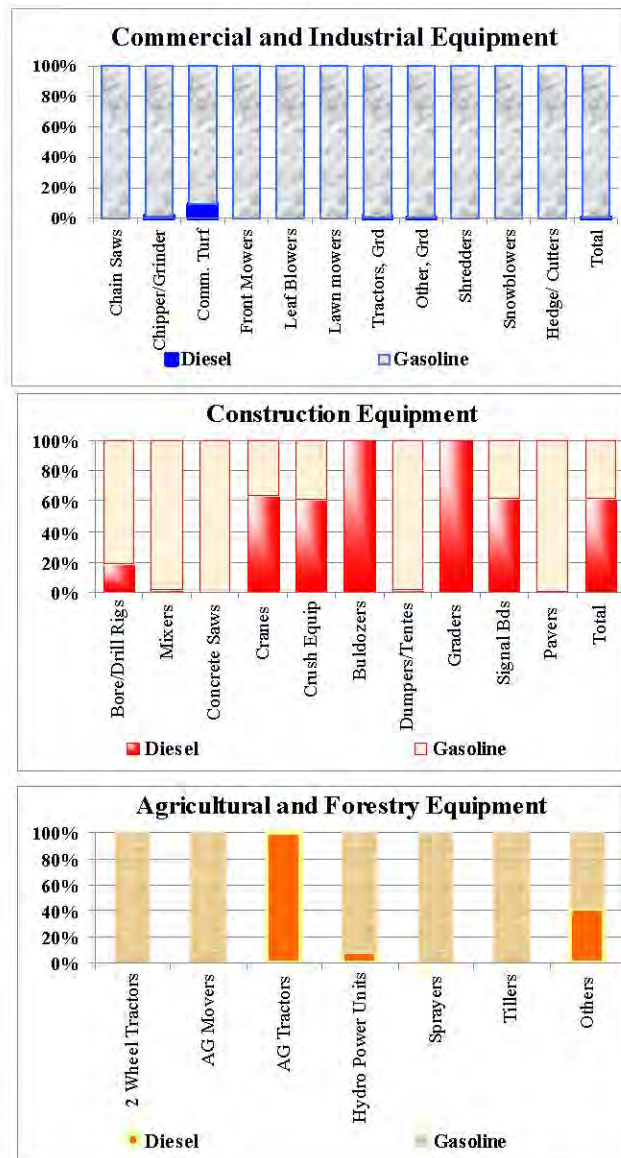


Figure 54: Small Engine Equipment Sales Trend by Energy Source¹²⁹

Market share of small engines <25 HP is substantial, █% between diesel and gasoline engines <50 HP, as shown in Table 9: Small Fuel-Powered, <50 HP Engine Segments.

	Categories, HP	%
Gasoline	0-25 HP	
	25-50 HP	
Diesel	0-25 HP	
	25-50 HP	

Table 9: Small Fuel-Powered, <50 HP Engine Segments

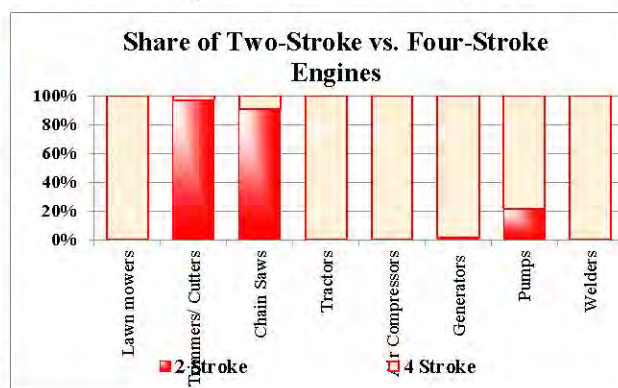
Market Share by Engine Type

To arrive at the share of the four-stroke engine in the total number of small engines, the Consultant analyzed the data provided by the EPA.

The resulting distribution of different types of petroleum-fed engines is demonstrated in Figure 55: The Share of Two-Stroke vs. Four-Stroke Engine. This distribution is applied when calculating the market size for the Client's Solution.

Equipment	2 Stroke	4 Stroke
Lawn mowers		
Trimmers/ Cutters		
Chain Saws		
Tractors		
Air Compressors		
Generators		
Pumps		
Welders		

Figure 55: The Share of Two-Stroke vs. Four-Stroke Engines



BASED ON THE COMBINED AND AVERAGED ESTIMATES DESCRIBED IN THE SECTION, THE FOUR-STROKE GASOLINE SMALL ENGINE MARKET SHARE IS AROUND 42% OF THE TOTAL SMALL ENGINE MARKET.

Market Distribution by Geography and Consumer Type

TO ARRIVE AT THE MARKET DISTRIBUTION OF THE ENGINES BY GEOGRAPHY AND CONSUMER TYPE THAT MEET THE REQUIREMENTS FOR THE CLIENT'S SOLUTION, THE CONSULTANT APPROXIMATES THE RELEVANT DATA AS A WEIGHTED AVERAGE OF FORECASTS PROVIDED BY DIFFERENT AGENCIES AND SUMMARIZED IN TABLE 1: GLOBAL SMALL ENGINE MANUFACTURERS. THE WEIGHT FOR EACH FORECAST IS ASSIGNED ACCORDING TO THE DATE OF FORECAST AND RELEVANCE TO THE CLIENT.

Regional Market Shares

Breakdown by geography is relatively consistent across all estimates by the market researchers and as summarized in Table 8: Small Engine Market Expected Growth Comparative Estimates. Many report forecasts for Europe, North America, and Asia – Pacific. Some reports also include South America and Middle Eastern & African regions. Relative shares are according to these market forecasts.

Based on the data estimated, the approximate shares of the intended market are likely to constitute the breakdown shown in Figure 56: Four-stroke Gasoline Small Engine Market by Region. **NORTH AMERICA LEADS AMONG ALL REGIONS COMPRISING ALMOST HALF OF THE MARKET FOLLOWED BY EUROPE (25% OF THE WORLD). THE GROWTH RATE SLIGHTLY DIFFERS AMONG REGIONS AVERAGING █% OF THE TOTAL.**

Region	Share	Growth Rate
Europe	█	█
North America	█	█
South America	█	█
Asia Pacific	█	█
Rest of the World	█	█

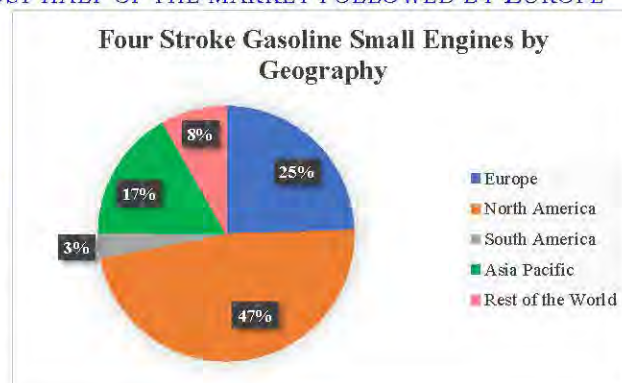


Figure 56: Four-stroke Gasoline Small Engine Market by Region

Market Shares by Consumer Type

Distribution by Industry

End users of the small engine devices reside in the following sectors:

- Household and gardening
- Construction
- Agriculture and forestry
- Other

Market shares by end users are estimated on the basis of the data retrieved from the forecasts developed by market researchers and summarized in section The Total SSI Engine Market Size, the results are shown in

Figure 57: Small Engine Sales by End Users. Household and gardening lead the demand in small engine devices (55%) remotely followed by construction (20%).

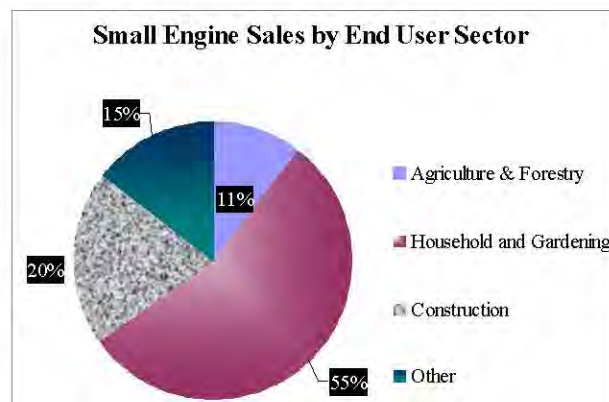


Figure 57: Small Engine Sales by End Users¹³⁰

It should be noted that the demand for household and gardening tools and devices is not evenly distributed across different regions. Warmer climates typically provide a more welcoming ground for gardening activities in general. For example, in California, residential and commercial lawn gardening equipment constitute an overwhelming majority of small devices utilization (██████████% respectively), as shown in Figure 58: California Engine Population by End Users. IT IS EXPECTED THAT COLDER CLIMATE PLACES PRODUCE MUCH LOWER DEMAND FOR GARDENING EQUIPMENT.

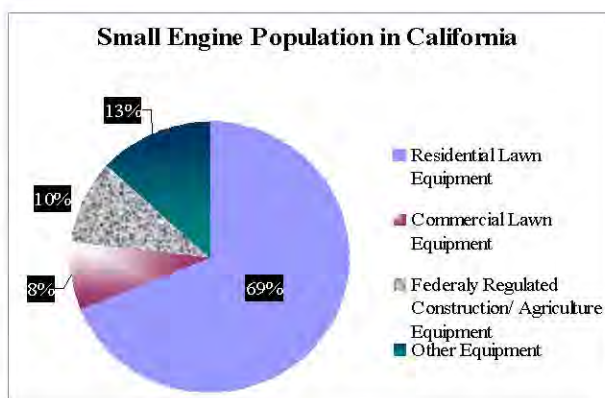


Figure 58: California Engine Population by End Users¹³¹

Residential vs. Commercial Users

IT IS IMPORTANT TO KNOW THE DIFFERENCE BETWEEN THE USAGE BY RESIDENTIAL (PRIVATE) VS. COMMERCIAL CUSTOMERS OF THE SMALL ENGINE EQUIPMENT BECAUSE IT CAN BE USEFUL FOR THE CLIENT WITH A MARKETING ACTIVITIES FOCUS.

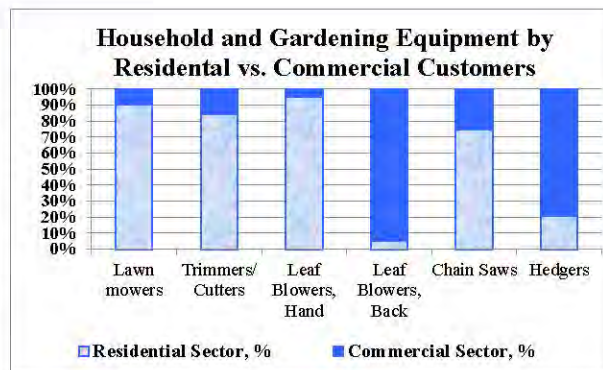
The Household and Gardening market caters to two types of consumers: residential users and commercial or professional users.

For lawn and garden equipment, residential consumers include homeowners or renters who maintain their own lawns. Commercial consumers generally include lawn and garden contractors who provide lawn maintenance services to difference customers including homeowners or renters, apartment or office complexes, municipalities, and commercial businesses. Lawn and garden equipment are also purchased directly by federal, state, and local government agencies (e.g., municipalities, parks, recreation) that maintain public space, airports, golf course maintenance crews, and other public utility users.

The types of equipment that are utilized by residential users include "conventional" rotary mowers, riding mowers, lawn minitractors, rotary tillers, snowblowers, and all types of portable hand-held equipment. Unlike residential end-users, commercial users depend on the labor-saving characteristics. The results of the data collected from the EPA sources are shown in Figure 59 and Figure 60. They demonstrate that the demand from residential (private) users is significantly higher than that from the commercial consumers. Within each consumer group, smaller devices are more popular with the private sector while commercial consumers are interested predominately in tools that are over 3 HP.

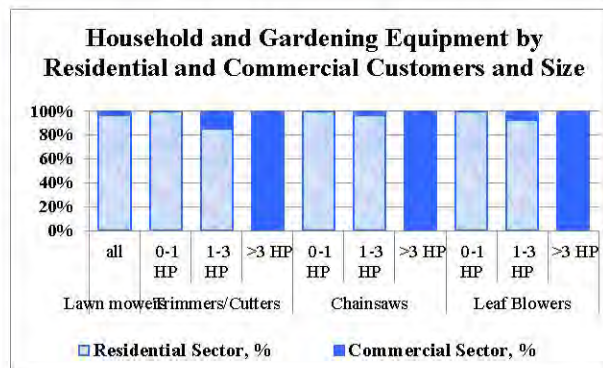
Equipment	Residential, %	Commercial, %
Lawn Mowers		
Trimmers/ Cutters		
Leaf Blowers, Hand		
Leaf Blowers, Back		
Chain Saws		
Hedgers		

Figure 59: Household and Gardening Equipment by Residential vs. Commercial Users¹³²



Equipment	Output, HP	Residential, %	Commercial, %
Lawn Mowers	all		
Trimmers / Cutters	0-1 HP		
	1-3 HP		
	>3 HP		
Chainsaws	0-1 HP		
	1-3 HP		
	>3 HP		
	>3 HP		
Leaf Blowers	0-1 HP		
	1-3 HP		
	>3 HP		
	>3 HP		

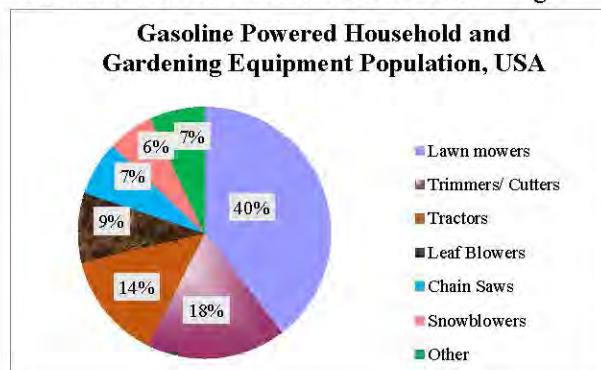
Figure 60: Household and Gardening Equipment by Residential vs. Commercial Users and Size¹³³



Within the household and gardening equipment group, lawn mowers represent the largest group of █% followed by trimmers (█%), as shown in Figure 61: Gasoline Powered Household and Gardening Equipment Population, US.

Equipment	Share	2 Stroke	4 Stroke
Lawn mowers			
Trimmers/ Cutters			
Tractors			
Leaf Blowers			
Chain Saws			
Snowblowers			
Other			

Figure 61: Gasoline Powered Household and Gardening Equipment Population, USA



Equipment originally designed for commercial and industrial applications that constitute construction, agriculture and forestry sectors is used not only by commercial customers, its intended users, but also by private parties (residents). As displayed in Figure 62, only a small amount of such devices is typically used for residential needs.

Equipment	Residential, %	Commercial, %
Air Compressors		
Pres Washers		
Pumps		
Welders		
Lifts		
Snowblowers		
Others		
Totals		

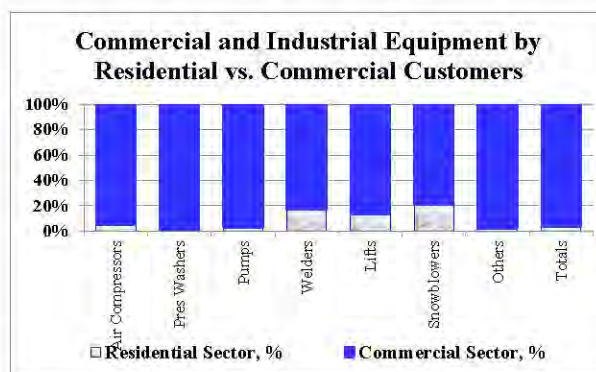


Figure 62: Light Commercial and Industrial Equipment by Residential vs. Commercial Users ¹³⁴

Assumptions and Input Data for the Four-stroke Small Gasoline Engine Market Size Forecast

To develop estimates of the future size of the market that is the potential target for the Client, the Consultant uses the assumption and input parameters described below.

The total market size for small engine equipment is estimated based on 17 synopses of forecasts provided by credible agencies and reports from the largest engine manufacturers.

- According to the data on the share of gasoline four-stroke engines discussed in section The Share of Gasoline-run Engines and Four-Stroke Engines in the Total Market Size, the Consultant estimates that four-stroke gasoline engines constitutes approximately █% of the total market size.
- According to the forecast data summarized in Table 8: Small Engine Market Expected Growth Comparative Estimates, the total market size ranges from around █ Mln units in year 2019. Adjusted to the estimate share of the four-stroke small gasoline engines, the adjusted number of units ranges between █ year 2019. The Consultant assigns █ units to the LOW CASE of the market forecast.
- Another source of data on the market size are reports of engine manufacturers as summarized in Table 1: Global Small Engine Manufacturers. According to this data, Briggs & Stratton and Honda are the largest manufacturers comprising most of global sales. Approximately █ of small engines are produced by Briggs & Stratton and █ of small engines produced by Honda. When adjusted to the production of the whole market and adjusted to the rate of the gasoline four-stroke engines' share, the Consultant estimates that there are █ units that get produced per year. The Consultant assigns this amount to the HIGH CASE. This amount is

█

consistent with some other available data. For example, it is consistent with the estimates of the Government of Canada, [REDACTED] according to which there [REDACTED] lawn mowers in North America of typical small engine lifespan between 500 and 1,000 hours at full load [REDACTED] (lawn mowers share [REDACTED] % of Household and Gardening equipment and Household and Gardening equipment shares [REDACTED] % in small engine's equipment park).

- The average market growth is expected to range between [REDACTED] which is applied to the future market estimates.
- As projected by the collective market opinion, COVID-19 pandemic will have a negative impact on the market in 2020 ([REDACTED] % decrease) followed by market recovery in 2021 with a continued growth; this assessment is consistent with the Government agencies' assessment of the economy recovery expectation.. These assumptions are applied to the forecast.
- The Consultant assumes that the Client's market share will constitute [REDACTED] % of the market at the end of the forecast period in the LOW CASE scenario and [REDACTED] % in the HIGH CASE scenario:
 - The limited number of similar products in the market and unique technology features (less expensive catalysts producing results that are superior to those of the competition) provide the opportunity for the Client to take an advantage of a larger market share (up to [REDACTED] %) at the end of the forecast period. This is the HIGH CASE.
 - The Client enters a niche of a mature market with the established market players. Currently, large market players do not position themselves in this niche. Instead, they focus on improving the existing solutions and entering other niches (e, g., hybrid). However, large market players can easily and quickly expand their reach to cover the Client's segment. For this case, the Consultant assumes that the Client's market share will constitute [REDACTED] % of the market at the end of the forecast period. This is the LOW CASE.
 - The Client's market share is assumed to grow gradually, from the minimum in 2020 to the fully assumed shares in 2030;

[REDACTED]

Resulting Market Size Estimates

The future market size is estimated to remain within the [REDACTED] range in 2030, as shown in Figure 63: Four-Stroke Gasoline Powered Small Engine Market, Mln Units, 2021-2030.

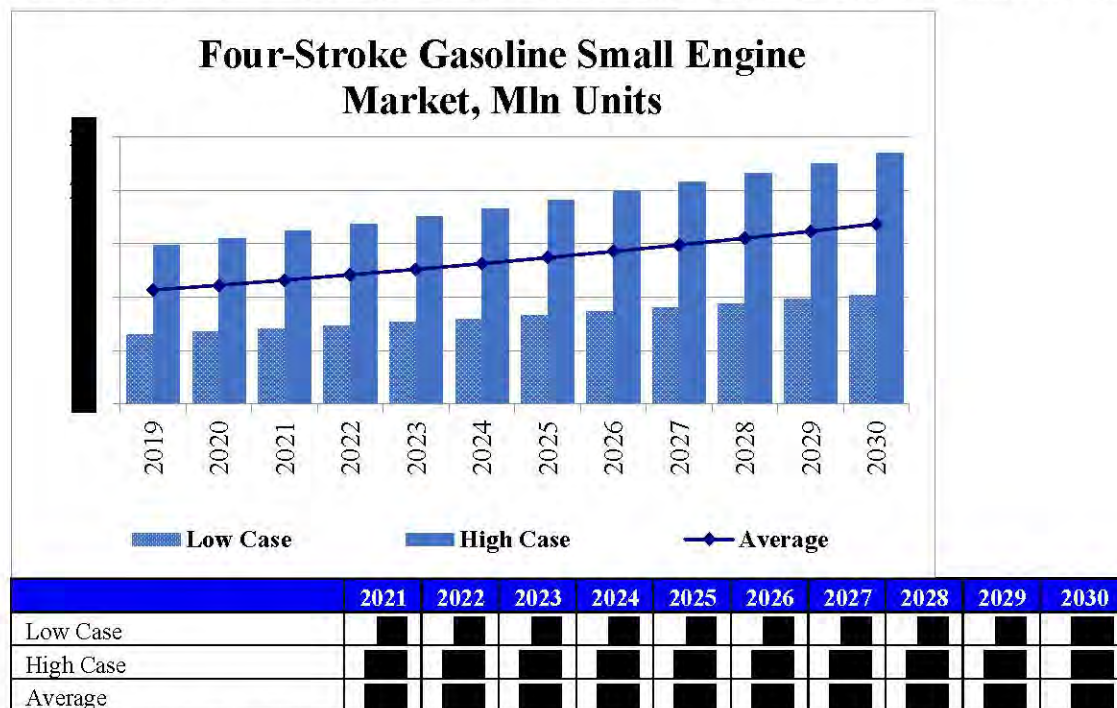
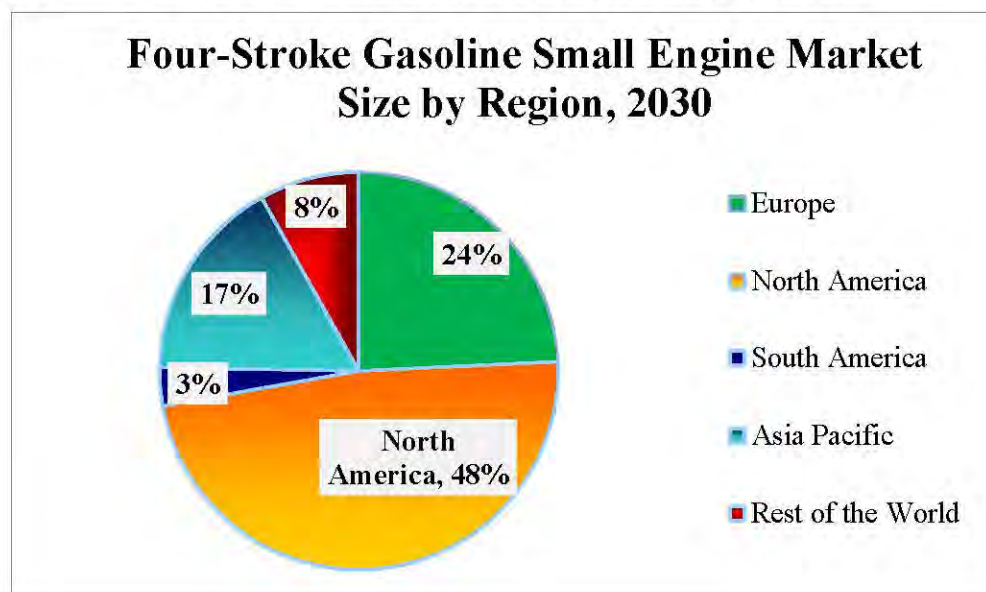


Figure 63: Four-Stroke Gasoline Powered Small Engine Market, Mln Units, 2021-2030

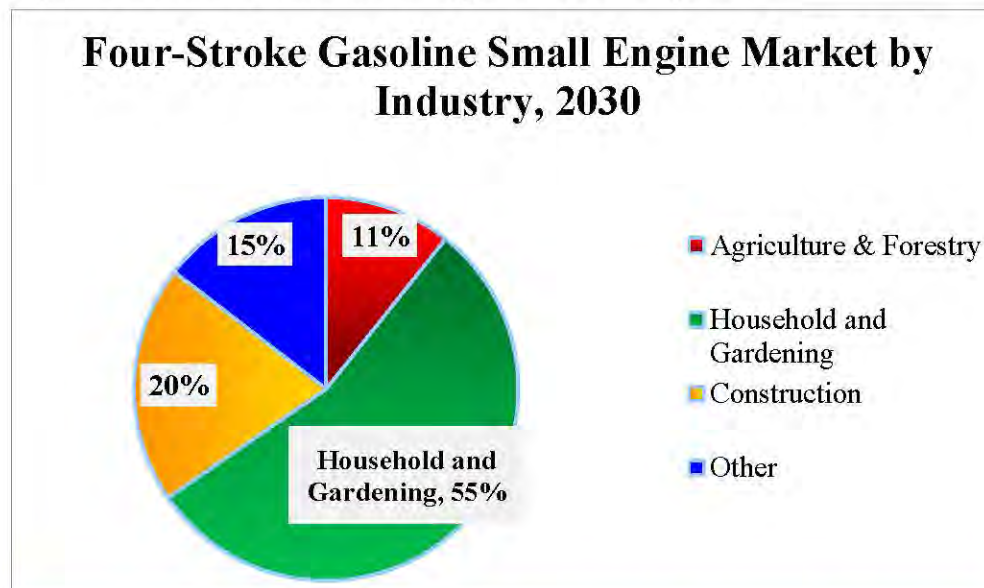
The four-stroke gasoline powered small engine's market share by region is shown in Figure 64: Four-Stroke Gasoline Small Engine Market Size by Region (Mln Units). North America is the largest market to [REDACTED]% in 2030. It is followed by Europe to constitute [REDACTED]% in 2030.



	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Low Case										
Europe										
North America										
South America										
Asia Pacific										
Middle East& Rest of World										
High Case										
Europe										
North America										
South America										
Asia Pacific										
Middle East& Rest of World										

Figure 64: Four-Stroke Gasoline Small Engine Market Size by Region (Mln Units)

The four-stroke gasoline powered small engine market forecast by industry is shown in Figure 65: Four-Stroke Gasoline Powered Small Engine Market Size by Industry (Mln Units). Household and gardening is expected to retain its dominance throughout the forecast period.



	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Low Case										
Agriculture & Forestry										
Household and Gardening										
Construction										
Other										
High Case										
Agriculture & Forestry										
Household and Gardening										
Construction										
Other										

Figure 65: Four-Stroke Gasoline Powered Small Engine Market Size by Industry (Mln Units)

Four-stroke gasoline powered small engine market size by consumer is shown in Figure 66: Four-Stroke Gasoline Powered Small Engine Market Size by Consumers (Mln Units). Residential household and gardening overwhelmingly outweigh all other customer groups (■%).

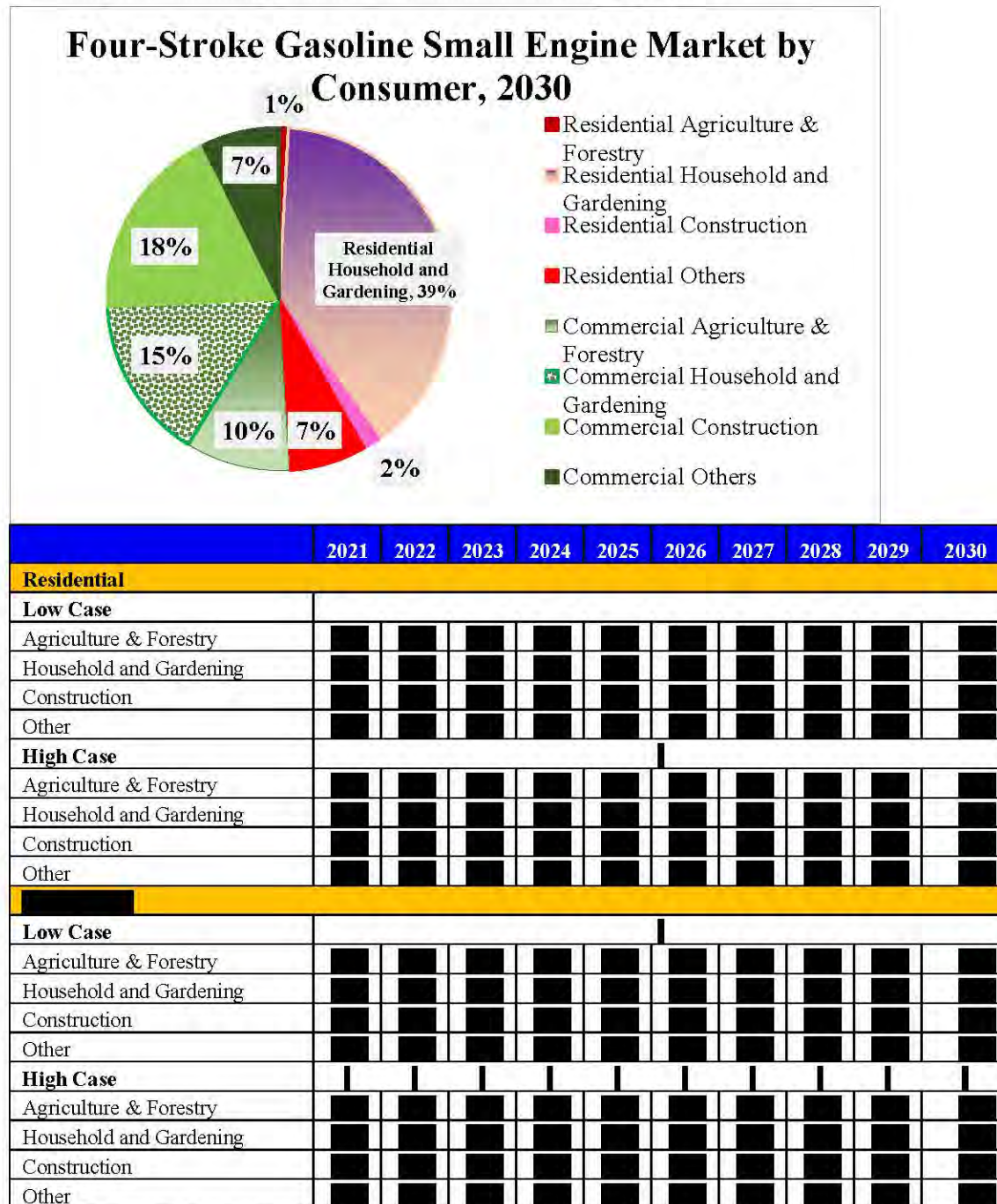


Figure 66: Four-Stroke Gasoline Powered Small Engine Market Size by Consumers (Mln Units)

Client's Market Share Forecast

The resulting forecast for the Client's share is demonstrated in Figure 67: Client's Global Market Share Forecast 2021 – 2030 and Figure 68: Client's North American Market Share Forecast 2021 – 2030. The market to be potentially captured by the client globally can achieve between [REDACTED] units in 2030. In North America, it is likely to range between [REDACTED] units at the end of the forecast period.

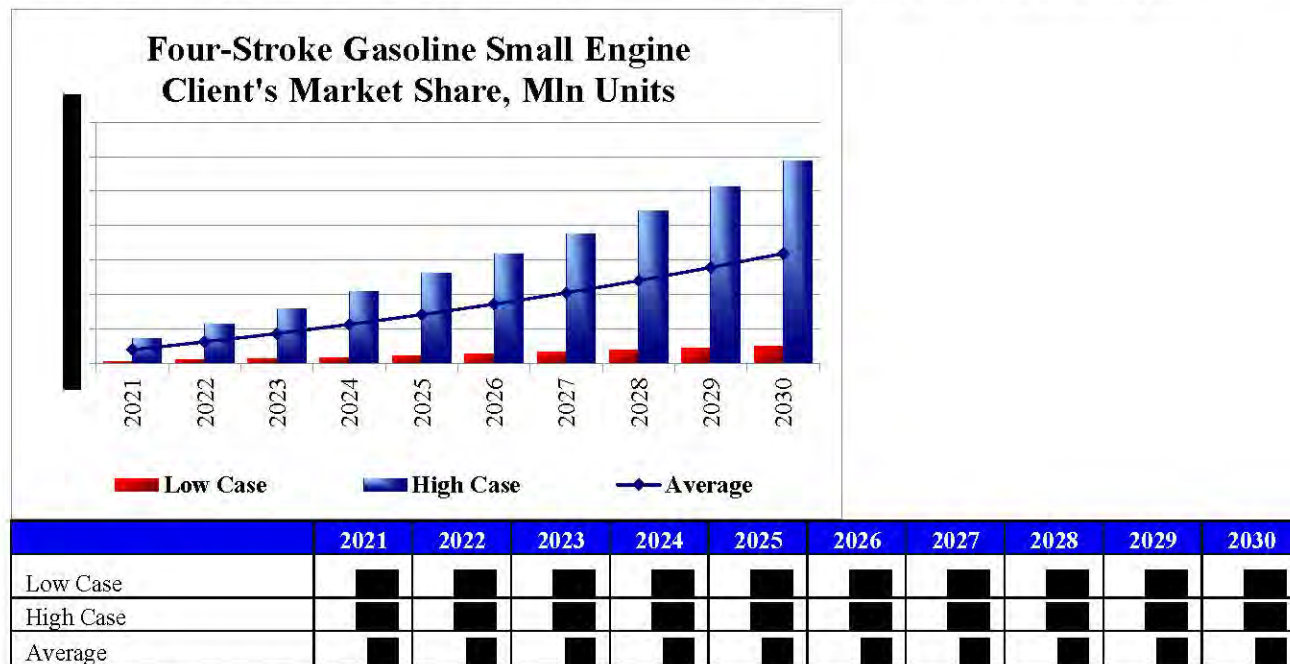


Figure 67: Client's Global Market Share Forecast 2021 – 2030

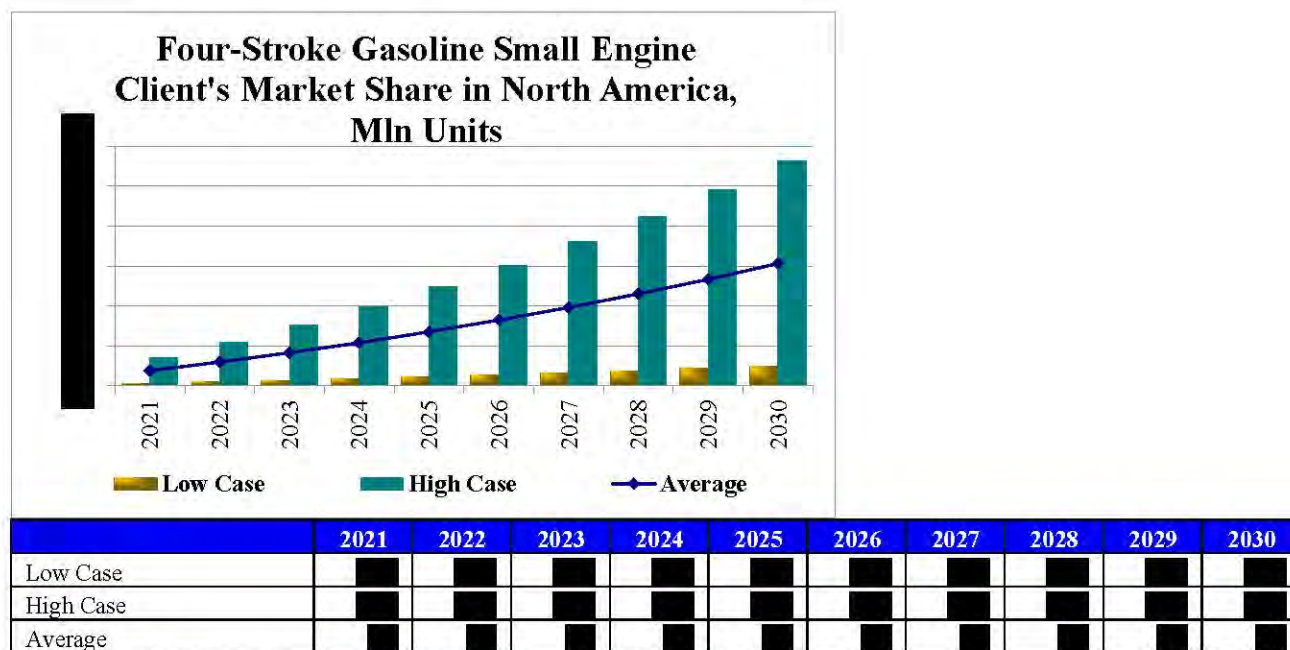


Figure 68: Client's North American Market Share Forecast 2021 – 2030

15. POLLUTIONS FROM FOUR-STROKE GASOLINE SSI ENGINES

Overview of Emission Volumes

Any gasoline-run engine is a producer of several types of pollutants, such as noise, ground contamination and air pollutants.

Noise pollution is a contamination of the quality of the sound in the air (gasoline powered leaf blowers, construction sites).

Ground pollution is typically the fuel spilled during refueling. According to some researchers, lawn, and garden equipment users in California alone spill 17 million gallons of fuel each year while refilling their outdoor power equipment. If each gasoline-powered lawn mower spills one liter of fuel per season, that would be 56 million liters of fuel spilled and leaked into our groundwater. This is the amount carried by about 2,800 tanker trucks¹³⁷. That's more than all the oil spilled by the Exxon Valdez, in the Gulf of Alaska. In addition to groundwater contamination, spilled fuel that evaporates into the air and volatile organic compounds spit out by small engines make smog-forming ozone when cooked by heat and sunlight¹³⁸.

Meanwhile, air pollution is the largest offender. According to the EPA, small engines contribute an estimated 5% to the volatile organic compound and carbon monoxide emission inventories of the total U.S.A., one gas mower spews 88 lbs of CO₂, and 34 lbs of other pollutants into the air every year.¹³⁹ According to the Government of Canada:

- A gasoline powered lawn mower emits about 48 kilograms (106 lbs) of GHG in one season. Gas-powered lawn mowers are very inefficient, which means that despite their small size they produce a lot of air pollution. In fact, running an older gasoline-powered lawn mower for one hour can produce as much air pollution as driving a new car 550 kilometers.
- A gasoline-powered lawn mower run for an hour puts out about the same amount of smog-forming emissions as 40 new automobiles running for an hour¹⁴⁰.
- A typical 3.5 horsepower gas mower, for instance, can emit the same amount of VOCs, NO_x, CO – key precursors to smog – in an hour as a new car driven (550 km) or 40 new cars run for an hour, according to industry experts.
- Each weekend, about 56 million North Americans mow their lawns, using 800 million gallons of gas per year and producing tons of air pollutants. Garden equipment engines, (mowers, trimmers, edger's, blowers) which have had unregulated emissions until very recently, emit high levels of carbon monoxide, volatile organic compounds and nitrogen oxides, producing up to 5% of the nation's air pollution and a good deal more in metropolitan areas.
- The conventional lawn mower pollutes as much in an hour as 40 late model cars do in an hour. Source: EPA statistics for Replacing Gas Power Lawn Mowers Assuming that a typical car travels 18,000 km per year, 33 gasoline lawn mowers would produce as much pollution a car

produces all year. The 56 million gasoline-powered lawn mowers generate as much pollution as [REDACTED] cars. Traditional landscaping gasoline engines create Ozone, O₃, a colourless, odourless gas at ambient concentrations which is a major component of smog¹⁴¹.

Calculation of Air Emissions from Four-stroke Gasoline Powered SSI Engines

The Consultant calculates the emissions volume (air pollutants and GHG and CO₂) for the market calculated in section Estimation of the Four-Stroke Gasoline SSI Engine Market Size.

Air Pollutants Emissions

Because the data for four-stroke engines is not directly available, in order to calculate the emissions from four-stroke gasoline powered small engines, the Consultant used the data released by Briggs & Stratton that reports the results of emission tests conducted on their four-stroke lawnmower engines, as summarized in Table 11.¹⁴²

Just for comparative purposes, the Consultant reviewed the emission data reported by EPA for two-stroke gasoline powered small engines¹⁴³ shown in Table 10: Impact of Regulation on Gasoline Two-stroke Small Engines. Comparison of emission data for two-stroke with that of four-stroke engines clearly shows that four-stroke engines emit low level of emissions.

Engine Type	HC, g/HP-hr	CO, g/HP-hr	NOx, g/HP-hr	PM, g/HP-hr	BSFC, lbs/HP-hr
Base Line	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
Phase I	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
Phase II with Catalyst	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]

Table 10: Impact of Regulation on Gasoline Two-stroke Small Engines

[REDACTED]

Engine	Age and Time in Use (Years)	Displacement cc	Rated Power	Fuel	# Replications	NMOG g/kW-h	NOx g/kW-h	CO g/kW-h
Briggs & Stratton, 12G702	New, 60 hours	190	5 HP	RFA	1	1	1	1
Briggs & Stratton, 12G702	New, 60 hours	190	5 HP	CaRFG	1	1	1	1
Briggs & Stratton, 12G702	New, 8 hours	190	5 HP	RFA	1	1	1	1
Briggs & Stratton, 12G702	New, 8 hours	190	5 HP	CaRFG	1	1	1	1
Briggs & Stratton, 12G702	2 years, in use 1 year	190	5 HP	RFA	1	1	1	1
Briggs & Stratton, 12G702	2 years, in use 1 year	190	5 HP	CaRFG	1	1	1	1
Briggs & Stratton, 1295502	11 years, in use 10 years	148	3 HP	RFA	1	1	1	1
Briggs & Stratton, 1295502	11 years, in use 10 years	148	3 HP	CaRFG	1	1	1	1
Briggs & Stratton, 20203D	7 years, in use 5 years	148	3.5 HP	RFA	1	1	1	1
Briggs & Stratton, 20203D	7 years, in use 5 years	148	3.5 HP	CaRFG	1	1	1	1
Briggs & Stratton, 93502	16 years, in use 10 years	148	3.5 HP	RFA	1	1	1	1
Briggs & Stratton, 93502	16 years, in use 10 years	148	3.5 HP	CaRFG	1	1	1	1
Briggs & Stratton, 93502	9 years, in use 2 years	148	3.5 HP	RFA	1	1	1	1
Briggs & Stratton, 93502	9 years, in use 2 years	148	3.5 HP	CaRFG	1	1	1	1
Briggs & Stratton, FC150V	New, 5 hours	150	5.5 HP	RFA	1	1	1	1
Briggs & Stratton, FC150V	New, 5 hours	150	5.5 HP	CaRFG	1	1	1	1
Briggs & Stratton, 92982	12 years, in use 10 years	148	3.5 HP	RFA	1	1	1	1
Briggs & Stratton, 92982	12 years, in use 10 years	148	3.5 HP	CaRFG	1	1	1	1
Briggs & Stratton, 124702	4 years, in use 4 years	190	5 HP	RFA	1	1	1	1
Briggs & Stratton, 124702	4 years, in use 4 years	190	6 HP	CaRFG	1	1	1	1

Table 11: Exhaust Emissions from Four-Stroke Lawnmower Engines Reported by Briggs & Stratton

Briggs & Stratton emission test results are compiled for the lawnmowers of different release dates. Since the emission levels have been consistently reduced by the manufacturer with each production year, the Consultant applies the emission change factors from lawn and garden equipment between 2011 and 2018 to arrive at the emissions from the modern SSI engines, as shown in Table 12: Emission Change from Lawn and Garden Equipment between 2011 and 2018. By 2018, the annual tonnage of VOCs and NO_x, emitted by lawn and garden equipment decrease substantially from 2011 as more of the in-use fleet becomes represented by equipment built to meet EPA small engine emission standards. CO emissions remained comparable to 2011 levels, while CO₂ and fine PM emissions increased modestly.

Emissions	% Change
VOCs	
NO _x	
CO	
CO ₂	
PM 10	
PM 2.5	

Table 12: Emission Change from Lawn and Garden Equipment between 2011 and 2018

In order to arrive at the actual emission levels from the lawn mowers, the Consultant uses the EPA-estimated activity levels and load factors for small engine equipment shown in Table 13: Activity Levels and Load Factors for Small Engine Equipment.

Equipment Type	Sector	Activity Level (Annual hours)	Load Factor
Lawn Mowers	Residential		
	Commercial		
Trimmers /Edgers/ Cutters	Residential		
	Commercial		
Leaf Blowers/ Vacuums	Residential		
	Commercial		
Chainsaws	Residential		
	Commercial		

Table 13: Activity Levels and Load Factors for Small Engine Equipment

The Consultant collected the data on how much power an engine produces for each equipment's activity type and load factors. These estimates are shown in Table 14: Average Power an Engine Produces by Equipment Type and Use.

Equipment Type	Sector	HP	KW
Lawn mowers	Residential		
	Commercial		
Trimmers/Edgers/Cutters	Residential		
	Commercial		
Leaf Blowers/ Vacuums	Residential		
	Commercial		
Chainsaws	Residential		
	Commercial		

Table 14: Average Power an Engine Produces by Equipment Type and Use 144



Based on all estimates above, the Consultant calculates the weighted average annual full load for small four-stroke gasoline engine usage per year to be [REDACTED] kW-hr. Following these estimates and based on the by number of units estimated are the actual air pollutant emissions from the market estimated for the Clients.

GHG Emissions

According to the Canadian government, a gasoline powered lawnmower emits about 48 kilograms (106 lbs) of greenhouse gas in one season¹⁴⁵.

Based on data from Figure 55: The Share of Two-Stroke vs. Four-Stroke Engines and

Figure 57: Small Engine Sales by End Users, the estimated share of lawnmowers is [REDACTED] %.

Adjusted on the basis of data from Table 14: Average Power an Engine Produces by Equipment Type and Use, the share of lawnmower engines is [REDACTED] %. If a lawnmower emits [REDACTED] kg in one season, the average engine emits [REDACTED] GHG in one season. It leads to [REDACTED] of GHG annually for all equipment engines in High Case according to the forecast and [REDACTED] kg GHG annually in Low Case.

According to the EPA, one gasoline powered lawnmower spews 88 lbs of CO₂. Based on aforementioned logic, the average engine emits [REDACTED] CO₂ in one season. It leads to [REDACTED] CO₂ annually in High cases and [REDACTED] kg CO₂ annually in Low Cases.

Resulting Air Pollutants, GHG Emissions and Ground Contamination

Table 15: Emissions Volumes from Four-Stroke Gasoline SSI Engines, High and Low Cases summarizes all emissions from the estimated power engines market:

	NMOG	NOx	CO	GHG	CO ₂
High Case, Tons, Mln	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
Low Case, Tons, Mln	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]

Table 15: Emissions Volumes from Four-Stroke Gasoline SSI Engines, High and Low Cases

The Consultant assumes that each gasoline-powered device spills at least half a liter of fuel per season. This leads to a minimum [REDACTED] liters and maximum of [REDACTED] of fuel spilled onto the ground and likely leaked into the groundwater annually.

16. MARKETING STRATEGY

Marketing strategy is shaped by business objectives, market, and company's available resources. Analysis of the Client's Strengths and Weaknesses, as well as market Opportunities and Threats (SWOT), provides the baseline for identifying the differentiators that separate the Client's Solution and delivering it to the marketplace.

This information is then used to develop the proper marketing mix. The marketing mix is a crucial tool to help understand what the Product and the Company can offer to potential customers and how to plan for a successful product offering. The marketing mix is most executed through the 4 Ps of Marketing: Price, Product, Promotion, and Place. The 4 Ps of the marketing mix establish the Product's position within its target markets. It is designed to meet the company's marketing objectives by providing its customers with the value.

Unique Value Proposition is built based on SWOT and 4 Ps. UVP, in its turn, helps to draft the marketing message. The main marketing message must be simple and straightforward to be easily absorbed by the target market. It also should be generic enough to be easily transferred to all market segments.

Once the marketing strategy is finalized, the Client should draw up a detailed marketing plan that sets out the specific actions to put that strategy into practice. A marketing plan should set out the goals, actions, dates, costs, resources and selling programmes. The plan should be constantly reviewed so it can respond quickly to changes in customer needs and attitudes in market, and in the broader economic climate. Note that marketing message and marketing plan are not part of this engagement.

This section outlines the process of developing the marketing strategy and tactics and some recommendations for positioning in the market. The Client might consider some of the ideas outlined by the Consultant below and build on them to refine the vision for the Company.

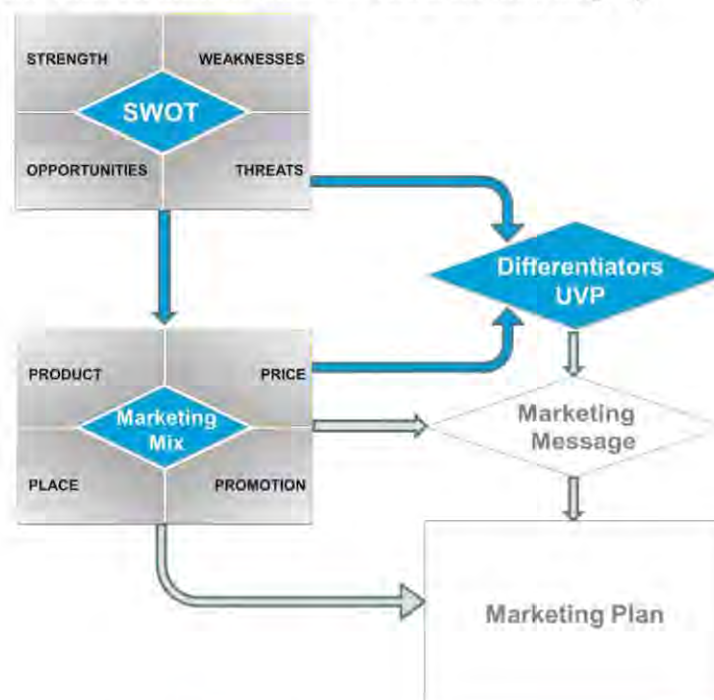


Figure 69: Schematics of Marketing Strategy and Tactics

The Client enters a niche of a mature market with the established market players. According to the Business Dictionary, entering the niche market means “concentrating all marketing efforts on a small but specific and well-defined segment of the population.”¹⁴⁶ In short, a niche market has several advantages:

- **Less competition.** The more specialized the products or services, the less competition there is, which provides the opportunity to take advantage of a larger market share and less price competition. Targeting a narrower audience also allows focused efforts on catering to specific customer needs.
- **Focused efforts.** The benefit of niche marketing is that it allows the Client to differentiate as a unique authority and resonate deeply with customers. Concentrated efforts allow the Client to become the specialist in the topic drawing more potential customers for advice and ultimately solutions.
- **Establishing brand loyalty.** Rather than blend in with the many other brands that offer the same type of product or service, a brand can use niche marketing to stand out, appear more knowledgeable and valuable, and build a stronger connection with its audience.

SWOT Analysis

With the understanding of business' internal strengths and weaknesses and the external opportunities and threats, the Client can develop a strategy that plays to strengths and matches them to the emerging opportunities. The Client should also identify weaknesses and try to minimise them. It is recommended that the Client play “a devil’s advocate” by preparing questions and situations that point at company vulnerabilities in its product/services and come up with the ways on how to address them. Tables below are an example of how it can be executed. In addition, they contain some information that can be applied by the Client for diving deep into the issues.



Understanding Strengths

Strengths	Resulting Benefits to the Client
Competence in the sector supported by an experience in a	

¹⁴⁶ Business Dictionary: Niche marketing, <<http://www.businessdictionary.com/definition/niche-marketing.html>>

Strengths	Resulting Benefits to the Client
lateral sector (automotive).	[REDACTED]
Limited number of similar products in the market.	[REDACTED]
Unique technology features (less expensive catalysts producing results that are superior to those of the competition).	The Solution is characterized by unique features that separate it from the rest of the market. It gives the Client an edge over competitors because when a product or service is niche, it stands out a lot more with unique features. Hence, the main objective is to communicate its UVP to the market in the most effective manner.
Small business.	[REDACTED]
A clearly defined target market	[REDACTED]

Mitigating Weaknesses

Weaknesses	Actions to Mitigate Weaknesses
Dependence on one product makes you vulnerable to the market changes or failures.	Given the Client's focus on more than one niche, a failure in the small motor market will not result in the company's downfall; instead, the Client has a cushion to provide a necessary recovery if everything else fails in the small motor sector.
Lack of the established reputation in the market segment.	[REDACTED]

Weaknesses	Actions to Mitigate Weaknesses
	[REDACTED]
Limited financial and manufacturing capacity.	[REDACTED]

Market Opportunities

Opportunities	Resulting Benefits to the Client
Well established target markets with stable structure and market players.	[REDACTED]
Lower cost of production.	[REDACTED]
Regulatory requirements favoring the Client's technology.	Current regulatory trends supporting all environmentally friendly technologies provide a vast and stable base for the Client's Solution. Build a market entry plan in accordance with the "clean air" and "GHG reduction" regulations that would help to maintain a sustained demand in the products.
Generic features of the product.	[REDACTED]

Mitigating Business Risks / Threats

Threats	Client's Mitigation Actions
Established long-term procurement contracts preventing potential customers from considering Client's Solution.	[REDACTED]

Threats	Client's Mitigation Actions
Smaller market = limited growth	[REDACTED]
New technology, untested by the market.	[REDACTED]
Economic downturn caused by the pandemic quarantine.	[REDACTED]
Limited capacity in achieving the intended market reach.	Subject business capacity and capability to a rigorous analysis; test various options and scenarios in a financial proforma model; find the best suited combination of pricing, marketing spending, etc., based on the results projected on a one-to ten-year scope that will illustrate amortization and ROI, among other key measures. Build strategic partnerships with the influencers (dealers, businesses), attend industry events to accelerate the learning curve.

Marketing Mix

The marketing mix can be divided into four groups of variables commonly known as the four Ps:

Product: the products and/or services offered to customers;

Price: the amount of money paid by customers to purchase the product/service;

Place: activities that make the product available to consumers, distribution channels'

Promotion: activities that communicate the Solution's benefits and persuade customers to purchase it.



All four marketing mix's variables are interrelated and affect each other. For example, increasing the price might negatively affect demand and as a result lesser distribution efforts (place) might be needed. On the other hand, the UVP can be so high that maximum concentration should be on creating brand awareness thus increasing need of higher pricing and more promotions. The Client should remember that the combination of marketing mix' variables is not set and should be analyzed and adjusted with the clientele response to the marketing mix and as the market and company conditions and objectives change (SWOT). The initial setting for the Client's efforts is discussed below.

Product



Product decisions are the first ones to make when preparing a marketing plan. This information will then affect other variables of the mix.

The Client's technology is introduced into the market at the early stage of the product cycle. Hence, the first objective is to create awareness followed by market penetration. The ultimate objective is to gain market adoption. Below is the summary of the product description and market positioning that can be applied by the Client at the initial market entry stage.

#	Factor	Product's Strategy Summary
1.	What is the Solution?	
2.	How and where will the customers use it?	
3.	Which Solution's features are different from the competing offerings?	The customer expectations from the Solution are centered around the following: • Lower cost due to the replacement of platinum, palladium, and rhodium with less expensive and more affordable metals; • Performance like other solutions in the market in its ability to neutralize air pollutants in exhaust gasses; • Better performance than similar solutions in the market in its ability to operate at low temperatures; • Good exhaust gas conversion after aging at 900°C.

#	Factor	Product's Strategy Summary
4.	How is it branded?	

Price, Packaging



Pricing reflects every other aspect of go-to-market strategy, from customer to the market to how one uses strategies like PR, marketing, and sales, thus, it needs to be a purposeful and deliberate choice. Price depends on different variables and hence it is updated periodically. Major factors (each one can change independently), which affect pricing, are:

- Cost of production;
- Advertising and marketing expenses, sales promotions in the form of trade discounts;
- Price fluctuations in the market, competition offerings;
- Distribution costs, etc.

The price must be set in a manner that would bear the effect of changes of these factors for a certain period. However, if these factors change, then the price must be adjusted.

Pricing affects positioning (unique features at high prices), and vice versa. There are different pricing strategies, which are influenced by the factors listed below.

#	Factor	Price Strategy Summary
1.	What is the value of the Solution to the buyers?	
2.	Are there established price	

#	Factor	Price Strategy Summary
	points for the Product?	
3.	Will the price differ for different distribution channels?	It is likely that the preferred sales mode is B2B or direct sales, leading to larger size orders. When compared to B2C, direct sales usually require higher sales and administrative expenses but carry lower inventory cost as manufacturing is executed to order.
4.	Are there other options of selling the Solution?	

Place



Place refers to distribution channels of the product. Distribution can have a big impact on profitability especially when the product must be shipped long distances.

#	Factor	Place Strategy Summary
1.	Who are the likely buyers?	The two major groups of prospective customers are manufacturers of the small engine equipment/devices and technology integrators/distributors. Some retail sales are possible.
2.	Where do buyers look for the product?	
3.	What are the costs associated with each channel?	

#	Factor	Place Strategy Summary
4.	Does the Client need to use a sales force?	

Promotion



Promotions in the marketing mix are comprised of sales promotions and integrated marketing communications, which include advertising and educating the market base of the product. Promotions are dependent on the product, place, and pricing decisions. In their turn, promotions affect all the other three variables – the product, price, and place. If the promotions are effective, you might have to increase distribution points and price. However, the budget required for extensive promotions is also high. Promotions are considered marketing expense; these costs must be taken into consideration while deciding on the price.

#	Factor	Promo Strategy Summary
1.	Where can the marketing messages get across to the target market?	
2.	When is the best time to promote?	
3.	What is the focus for promotional activities?	Generally, marketing activities should be directed at meeting three main objectives: 1) Build brand awareness; 2) Educate potential customers; 3) Create sales.

#	Factor	Promo Strategy Summary
		[REDACTED]
5.	What is the best digital strategy to be applied by the Client?	[REDACTED] [REDACTED] [REDACTED] The Client can benefit from examples of its competitors and their marketing materials as discussed in section Catalytic Converter Manufacturers.
6.	Can the Solution be promoted to the environmental organizations?	There are multiple environmental organizations the Client can get engaged with to promote its Solution as one of the green solutions. Also, in case of governmental and legal organizations, lobbying efforts can be put forward to ensure that more stringent environmental controls are applied to all small engine devices. • British Columbia Sustainable Energy Association – BCSEA.org • Ontario Environment Industry Association – ONEIA.ca [REDACTED] [REDACTED] [REDACTED] [REDACTED] [REDACTED] [REDACTED] [REDACTED]

#	Factor	Promo Strategy Summary

For better access to the target market, the Client should use an integrated marketing approach. It means the utilization of several different channels to communicate the same message in the same content piece. Such approach increases the reach and reduces the cost of marketing efforts. An example of an integrated marketing approach can be a product demo video. It can be available on the company's website, streamed through YouTube, Vimeo, and any other similar services, or be periodically mentioned in LinkedIn posts. A link to the website can be part of the e-mail signature or static closure paragraph communicating the UVP.

Product awareness is an ongoing process. Some of the communication pieces and channels to distribute the message are:

- Press Releases distributed via Associations and PR distribution services;
- Direct e-mail campaigns. For a better visual impact, infographics to be utilized as part of e-mail campaigns (can also be uploaded to the website and used as handbills at conferences);
- SEO. SEO is important for reaching out to the target market via online search results. SEO rules get periodically updated so the Client must remain informed on the current trends. Meanwhile, to develop the website with the most searchable content, the Client has to determine if other people are interested in it. The website content should be developed and refined to make it more market attractive. A great way to do this is by evaluating the internet and social media traffic around keywords related to your niche market. There are several tools the Client can use to evaluate search volume for specific keywords:

- Google AdWords Keyword Tool

- Articles and advertising



- Participation in industry conferences:
 - Walk the floor, pitch the Product
 - Sit on panels

Figure 70: Integrated Marketing Diagram demonstrates what communication channels can be employed for promoting the Product's benefits in various content pieces.

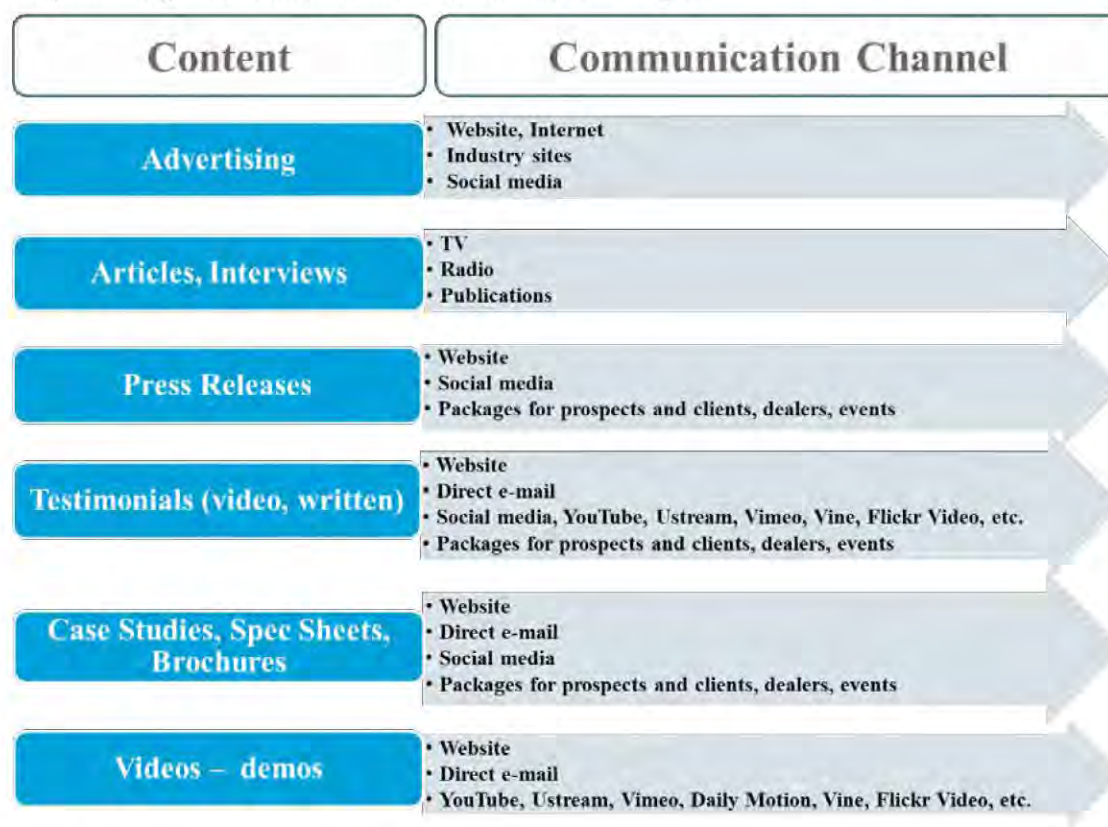


Figure 70: Integrated Marketing Diagram

Differentiators, UVP

There are several ways to differentiate the Client's Solution from the competition.

Product Differentiation. Product differentiation includes actual physical or perceived differences; it can take the form of features, performance, efficacy, meeting specifications, other criteria. Product

differentiation results from added features which give customers benefits that rivals cannot and find difficult to match.

THE CLIENT'S SOLUTION'S DIFFERENTIATION IS IN ITS UNIQUE COMBINATION OF FEATURES THAT DO NOT GET OFFERED BY ANY OTHER MANUFACTURER. THESE FEATURES CAN BE GROUPED AS FOLLOWS:

- **BETTER PERFORMANCE.** SUPERIOR PERFORMANCE ALLOWS FOR THE EARLY COLD-START ACTIVATION OF THE CATALYSTS. EARLIER ACTIVATION OF CATALYSTS RESULTS IN EARLIER COMMENCEMENT OF POLLUTANTS REDUCTION IN THE EXHAUST GASES. SUCH SIGNIFICANT IMPROVEMENT OF PERFORMANCE ENSURES SUPERIOR ENVIRONMENTAL COMPLIANCE. THIS IS THE OPERATIONAL OUTCOME THAT ALL MANUFACTURERS HAVE BEEN STRIVING TO ACHIEVE WITH LARGE R&D INVESTMENTS DEDICATED TO SOLVING THE DRAWBACK OF DELAYED ACTIVATION OF CATALYSTS COMPRISED OF PRECIOUS METALS. THIS MESSAGE HAS TO BE COMMUNICATED ACROSS THE BOARD IN ALL MARKETING MESSAGES.
- **LOWER COST.** UTILIZATION OF INPUT COMPONENTS NOT CONTAINING EXPENSIVE METALS DRIVES THE SOLUTION COST SIGNIFICANTLY LOWER. THIS FEATURE HAS TO BE COMMUNICATED TO THE MARKET ONLY IF THE SOLUTION IS PRICED BELOW THE COMPETITION.
- **LOWER OPERATIONAL AND FINANCIAL RISKS.** SIMPLICITY AND ABUNDANCY OF INPUT COMPONENTS REDUCES THE RISKS THAT ARE CARRIED BY THE COMPETITION: ACQUISITION OF METALS OF HIGH AND FLUCTUATING PRICE AND NECESSITY TO CARRY HIGHER INVENTORIES. THIS FEATURE HAS TO BE COMMUNICATED TO THE MARKET ESPECIALLY IF THE MAIN ACTUAL OR PERCEIVED CUSTOMERS ARE LARGE MANUFACTURERS. REMOVAL OF THESE OPERATIONAL AND FINANCIAL RISKS IS ESPECIALLY BENEFICIAL TO A SMALL BUSINESS WHEN PLACING COMPETITIVE BIDS, DESIGNING AND DEVELOPING CUSTOMIZED SOLUTIONS OR JUST FULFILLING LARGE AND REPEATED ORDERS.

Service Differentiation includes not only delivery and customer service, but all other supporting elements of a business such as installation, and ease of ordering. The Client should strive to match at least some of the services offered in the marketplace. NOTE THAT MOST OF THE COMPETITORS ARE FOCUSED ON CUSTOMIZATION, EXPEDIENCY OF DESIGNING AND MANUFACTURING AND DELIVERY.

Reputation Differentiation can be created by high levels of service, superior product quality, or performance. While the Client's Solution already can communicate the differentiation by performance, an image or reputation can be an obstacle for a new entrant such as the Client. The brand will not automatically differentiate a company from its competitors. The brand must stand for something, be recognized by the target audience, and communicate something unique and different from the competition. This exercise is a long-term game and requires consistency and customer loyalty also ensured by the repeated and predictable results.

17. CONCLUSIONS AND RECOMMENDATIONS

The Client is planning on entering a relatively new market niche of catalytic converters for SSI motors at a highly beneficial time. The Client's technology features characteristics that not only meet the market expectations but also solve several industry challenges. The demand for the Client's solution is predominantly defined by the environmental and health & safety regulations. The current drive to impose more stringent limitations on exhaust pollution from the SSI motor devices creates even more support for the Client's product.

[REDACTED]

[REDACTED]

[REDACTED]

Superior Technology Solves Several Industry Challenges and Reduces Costs

It will be safe to conclude that no other technology currently featured by other catalyst manufacturers offers the same benefits as the one developed by the Client. Even more, it effectively solves several challenges that top manufacturers have been attempting to solve by dedicating their R&D resources and setting at the top of their strategic objectives, as described in section Catalytic Converter Manufacturers. These priorities are the cost reduction and improvement of performance of solving the issue of delayed catalysts activation in cold environments.

The core differentiator of the Client's technology is the replacement of precious metals used as catalyst compounds with alternatives, which are not in the family of precious metals. These alternative metal compounds create unique positioning for the Solution.

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

Another challenge that the industry has been striving to solve is the delayed activation of catalysts in cold start. This challenge is described in section Catalytic Converter Overview.

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

THUS, THE CLIENT'S SOLUTION NOT ONLY REDUCES THE COST, BUT ALSO BRINGS IN SUPERIOR ENVIRONMENTAL PERFORMANCE VERSUS THE COMPETITION. IT IS RECOMMENDED THAT THE CLIENT PREPARE ESTIMATES FOR HOW MUCH FASTER THE SOLUTION STARTS PERFORMING IN COMPARISON TO ITS COMPETITORS. MATERIAL ESTIMATES CAN BE PREPARED EITHER IN TIME INCREMENTS (SECONDS) OR IN RELATIVE TERMS (PERCENTAGE) AND CLEARLY COMMUNICATED TO THE MARKET.

Competition is Limited and Can be Capitalized on

The Consultant believes that the market competition poses limited concern to the Client. Large manufacturers do not focus on small engines markets or at least do not position themselves as providers to this segment. Meanwhile, the Client should study their competitors marketing tactics and how they can be utilized for the Client's benefit. There is a significant difference in how large and small manufacturers position themselves in the marketplace. The Client can capitalize on the ideas from both groups when developing its market positioning.

[REDACTED]

[REDACTED]

[REDACTED]

Most large manufacturers adhere to a similar strategic approach: they either develop solutions that serve a new market of hybrid vehicles and fuel cells or improve production processes and existing technologies to ensure a better quality of their products. Many of them dedicate their efforts to solve the issue of slow cold-start catalyst activation. Large emission control manufacturers provide little to no details about their products and solutions.

[REDACTED]

[REDACTED]

Constantly Strengthening Environmental Agenda is the Client's Best Friend

The importance of environmental regulations in the Client's success cannot be overstated. In fact, the severity of their limitations and expansion to a wider set of applications and types of equipment will be the key to the Client's success. The more types of ICE's that fall under regulatory control, the bigger the Client's potential target base. Thus, the pending strengthening of the CARB's requirements for the SSI engine emissions will be of great benefit to the Client as it will expand the number of tools and devices to be required for compliance. **THE CLIENT SHOULD REMAIN VIGILANT OF THESE ENVIRONMENTAL REGULATIONS, PENDING CHANGES AND UPDATES, TO INTEGRATE THEM IN THE MARKETING MATERIALS AND MESSAGES TO THE MARKET.**

It also can be of great value for the Client to be aware of the GHG reduction initiatives introduced and promoted by regional governments, some of which are described in section GHG Emission Reduction Initiatives. Understanding these programs and their compliance options can be potentially of great value. **THE CLIENT MIGHT DECIDE TO ENGAGE IN DIRECT CAMPAIGNING TO THESE CITIES / MUNICIPALITIES AND PROMOTE ITS SOLUTION AS A MEANS OF REDUCING THE GHG EMISSIONS FROM THE ACTIVITIES TAKING PLACE WITHIN MUNICIPAL BORDERS.** Note that the most prominent and widespread global initiative is the one run within the GCoM framework. It has a global coverage and well-organized structure. According to its postulates

. To achieve the best results, the client might consider the following steps to identify the best targets and develop targeted messages and campaigns:

1. Review the analysis of municipalities, their growth and development trends, described in sections Municipalit and Canadian Municipalities, Status and Trends, as well as relevant sections on construction in the U.S.A. and Canada. Identify those cities of a larger size and with the stable growth rate: this ensures that they are likely to be financially sound and with the likely growing residential sector, which is the primary consumer of the SSI engine equipment. Make sure that construction in the area is also on the rise and agriculture/forestry are stable: health and stability of these sectors ensure stable demand in the small engine equipment.

Study the GCoM programs developed by these selected municipalities and identify which ones contain premises and conditions

“You are a large growing city with an increasing residential base and construction activities, which are the two largest groups of emitters of unmitigated GHG emissions from small engine equipment

18. APPENDIX A: GLOBAL COVENANT CITIES AND COMMUNITIES IN CANADA

1. [Baie-Saint-Paul](#)
2. [Beaconsfield](#)
3. [Brampton](#)
4. [Burlington](#)
5. [Bridgewater](#)
6. [Caledon](#)
7. [Candiac](#)
8. [Canmore](#)
9. [Chatham Kent](#)
10. [Commission de Services Régionaux Nord-Ouest](#)
11. [Courtenay](#)
12. [District of Saanich](#)
13. [Durham](#)
14. [Edmonton](#)
15. [Fredericton](#)
16. [Gatineau](#)
17. [Guelph](#)
18. [Halifax](#)
19. [Halton Hills](#)
20. [Hamilton](#)
21. [Kingston](#)
22. [Kitchener](#)
23. [Laval](#)
24. [London](#)
25. [Mississauga](#)
26. [Montreal](#)
27. [Moncton](#)
- ...
49. [Windsor](#)

19. APPENDIX B: LIST OF CANADIAN CITIES THAT HAVE DECLARED CLIMATE EMERGENCY¹⁴⁷

1. Amherstburg Town Council, Ontario, Canada
2. Annapolis County Council, Nova Scotia, Canada
3. Barrie City Council, Ontario, Canada
4. Bathurst City Council, New Brunswick, Canada
5. Berwick Town Council, Nova Scotia, Canada
6. Bowen Island Municipal Council, British Columbia, Canada
7. Brampton City Council, Ontario, Canada
8. Brant County Council, Ontario, Canada
9. Brantford City Council, Ontario, Canada
10. Burlington City Council, Ontario, Canada
11. Burnaby City Council, British Columbia, Canada
12. Caledon Town Council, Ontario, Canada
13. Canmore Town Council, Alberta, Canada
14. Cape Breton Regional Municipality, Nova Scotia, Canada
15. Capital Regional District (CRD), British Columbia, Canada
16. Central Elgin Municipal Council, Ontario, Canada
17. Central Kootenay, British Columbia, Canada
18. Central Saanich Municipal Council, British Columbia, Canada
19. Chatham-Kent Municipal Council, Ontario, Canada
20. City of Edmundston, New Brunswick, Canada
21. Clarington Council, Ontario, Canada
22. Cobourg Town Council, Ontario, Canada
23. Colwood City Council, British Columbia, Canada
24. Cowichan Valley Regional District Council, British Columbia,
25. District of Highlands Council, British Columbia, Canada
26. Duncan City Council, British Columbia, Canada
27. Durham Regional Council, Ontario, Canada
28. Edmonton City Council, Alberta, Canada
- ...
99. Yukon Legislative Assembly, Canada

20. APPENDIX C: THE LIST OF FEDERAL AND PROVINCIAL PROGRAMS SUPPORTING AGRICULTURE

[illegible]

Table 16: Canadian Federal Programs Providing Financial Assistance to Agriculture

[illegible]

Table 17: Provincial Programs Providing Financial Assistance to Agriculture

IN CANADA¹⁴⁸[illegible]

22. APPENDIX E: U.S. POPULATION IN INCORPORATED PLACES

Total Population and Population in Incorporated Places by Region: 2000 to 2013

Area	April 1, 2000, Census	April 1, 2010, Census	July 1, 2013, estimate	Change, 2000 to 2013		Change, 2000 to 2010		Change, 2010 to 2013	
				Number	Per- cent	Number	Per- cent	Number	Per- cent
TOTAL POPULATION									
United States	281,421,906	308,745,538	316,128,839	34,706,933	12.3	27,323,632	9.7	7,383,301	2.4
Northeast	53,594,378	55,317,240	55,943,073	2,348,695	4.4	1,722,862	3.2	625,833	1.1
Midwest	64,392,776	66,927,001	67,547,890	3,155,114	4.9	2,534,225	3.9	620,889	0.9
South	100,236,820	114,555,744	118,383,453	18,146,633	18.1	14,318,924	14.3	3,827,709	3.3
West	63,197,932	71,945,553	74,254,423	11,056,491	17.5	8,747,621	13.8	2,308,870	3.2
POPULATION IN INCORPORATED PLACES									
United States	174,073,290	192,326,392	198,207,340	24,134,050	13.9	18,253,102	10.5	5,880,948	3.1
Northeast	27,754,296	28,261,471	28,673,356	919,060	3.3	507,175	1.8	411,885	1.5
Midwest	45,461,284	47,471,807	48,074,818	2,613,534	5.7	2,010,523	4.4	603,011	1.3
South	53,859,905	62,089,090	64,749,890	10,889,985	20.2	8,229,185	15.3	2,660,800	4.3
West	46,997,805	54,504,024	56,709,276	9,711,471	20.7	7,506,219	16.0	2,205,252	4.0

Source: U.S. Census Bureau, Census 2000, 2010 Census, and 2013 Population Estimates.

Number of Incorporated Places, Population, and Percent of United States Population by Size of Incorporated Place: 2000 to 2013

Population size category	Number of incorporated places ¹			Population			Percent of United States total population		
	2000	2010	2013	April 1, 2000, Census	April 1, 2010, Census	July 1, 2013, estimate	2000	2010	2013
All incorporated places ..	19,454	19,541	19,508	174,073,290	192,326,392	198,207,340	61.9	62.3	62.7
1,000,000 or more	9	9	9	22,947,966	23,567,066	24,293,963	8.2	7.6	7.7
500,000 to 999,999	20	24	25	12,905,864	16,109,233	17,308,113	4.6	5.2	5.5
250,000 to 499,999	38	41	43	13,702,659	14,289,341	15,019,117	4.9	4.6	4.8
100,000 to 249,999	173	200	216	25,725,127	30,167,988	32,377,424	9.1	9.8	10.2
50,000 to 99,999	363	432	450	24,876,466	30,143,643	31,148,753	8.8	9.8	9.9
25,000 to 49,999	644	723	718	22,607,919	25,167,442	24,933,757	8.0	8.2	7.9
10,000 to 24,999	1,435	1,542	1,553	22,570,012	24,179,643	24,482,834	8.0	7.8	7.7
Less than 10,000	16,772	16,570	16,494	28,737,277	28,702,036	28,643,379	10.2	9.3	9.1

¹ The number of incorporated places is as of January 1 of the calendar year. The numbers of incorporated places for the census years 2000 and 2010 include places with inactive governments that are not included in the population estimates for 2013. There were 24 inactive incorporated places in 2010. These 24 places had a combined 2010 census population of 2,984.

Source: U.S. Census Bureau, Census 2000, 2010 Census, and 2013 Population Estimates.

23. APPENDIX E: MOST POPULOUS AND FASTEST GROWING INCORPORATED PLACES IN 2013

Population and Population Change for the 25 Most Populous Incorporated Places in 2013: 2010 to 2013

Population rank	Incorporated place	Population		Change, 2010 to 2013	
		April 1, 2010, Census	July 1, 2013, estimate	Number	Percent
2010	2013				
1	1 New York city, New York	8,175,133	8,405,837	230,704	2.8
2	2 Los Angeles city, California	3,792,621	3,884,307	91,686	2.4
3	3 Chicago city, Illinois	2,695,598	2,718,782	23,184	0.9
4	4 Houston city, Texas	2,099,451	2,195,914	96,463	4.6
5	5 Philadelphia city, Pennsylvania	1,526,006	1,553,165	27,159	1.8
6	6 Phoenix city, Arizona	1,445,632	1,513,367	67,735	4.7
7	7 San Antonio city, Texas	1,327,407	1,409,019	81,612	6.1
8	8 San Diego city, California	1,307,402	1,355,896	48,494	3.7
9	9 Dallas city, Texas	1,197,816	1,257,676	59,860	5.0
10	10 San Jose city, California	945,942	998,537	52,595	5.6
14	11 Austin city, Texas	790,390	885,400	95,010	12.0
12	12 Indianapolis city (balance), Indiana	820,445	843,393	22,948	2.8
11	13 Jacksonville city, Florida	821,784	842,583	20,799	2.5
13	14 San Francisco city, California	805,235	837,442	32,207	4.0
15	15 Columbus city, Ohio	787,033	822,553	35,520	4.5
17	16 Charlotte city, North Carolina	731,424	792,862	61,438	8.4
16	17 Fort Worth city, Texas	741,206	792,727	51,521	7.0
18	18 Detroit city, Michigan	713,777	688,701	-25,076	-3.5
19	19 El Paso city, Texas	649,121	674,433	25,312	3.9
20	20 Memphis city, Tennessee	646,889	653,450	6,561	1.0
23	21 Seattle city, Washington	608,660	652,405	43,745	7.2
26	22 Denver city, Colorado	600,158	649,495	49,337	8.2
24	23 Washington city, District of Columbia	601,723	646,449	44,726	7.4
22	24 Boston city, Massachusetts	617,594	645,966	28,372	4.6
25	25 Nashville-Davidson metropolitan government (balance), Tennessee	601,222	634,464	33,242	5.5

Source: U.S. Census Bureau, 2010 Census and 2013 Population Estimates.

Fastest Growing Incorporated Places of 100,000 or More Population: 2000 to 2010

Incorporated place	Population		Change, 2000 to 2010	
	April 1, 2000, Census	April 1, 2010, Census	Number	Percent
Gilbert town, Arizona	109,697	208,453	98,756	90.0
North Las Vegas city, Nevada	115,488	216,961	101,473	87.9
Fayetteville city, North Carolina	121,015	200,564	79,549	65.7
Fontana city, California	128,929	196,069	67,140	52.1
Cape Coral city, Florida	102,286	154,305	52,019	50.9
Irvine city, California	143,072	212,375	69,303	48.4
Henderson city, Nevada	175,381	257,729	82,348	47.0
Raleigh city, North Carolina	276,093	403,892	127,799	46.3
Peoria city, Arizona	108,364	154,065	45,701	42.2
Bakersfield city, California	247,057	347,483	100,426	40.6

Note: Size category based on 2000 census population.

Source: U.S. Census Bureau, Census 2000 and 2010 Census.

Fastest Growing Incorporated Places of 100,000 or More Population: 2010 to 2013

Incorporated place	Population		Change, 2010 to 2013	
	April 1, 2010, Census	July 1, 2013, estimate	Number	Percent
Frisco city, Texas	116,989	136,791	19,802	16.9
McKinney city, Texas	131,117	148,559	17,442	13.3
Austin city, Texas	790,390	885,400	95,010	12.0
Cary town, North Carolina	135,234	151,088	15,854	11.7
Midland city, Texas	111,147	123,933	12,786	11.5
Irvine city, California	212,375	236,716	24,341	11.5
Gilbert town, Arizona	208,453	229,972	21,519	10.3
New Orleans city, Louisiana	343,829	378,715	34,886	10.1
Bellevue city, Washington	122,363	133,992	11,629	9.5
Denton city, Texas	113,383	123,099	9,716	8.6