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Precipitated Calcium Carbonate

Limestone Investment Package

Jamaica's Limestone Industry Value Chain Development Project

Prepared by PricewaterhouseCoopers

pwc

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1.0 Executive Summary

Overview

Limestone is the largest mineral resource possessed by Jamaica and is an essential raw material for multiple industries such as steel, cement, agriculture, pharmaceutical and construction. It is estimated that there are over 150 billion metric tonnes in limestone reserves in Jamaica of which 50 billion metric tonnes are deemed recoverable. A significant portion of these reserves are of high purity limestone, which is defined by a high concentration (i.e. 95% to 98%) of calcium carbonate.

In Jamaica, the production of limestone is supported by one hundred and forty-six licenced mining and quarry operators situated in all parishes across the island. Over the past four years, the country's production has been increasing. Approximately 10% of extracted limestone is exported, while the remaining 90% is consumed domestically and the total value of limestone exports from Jamaica is just above 1% of the total value of limestone imported in the nearby regions. Although Jamaican limestone is used primarily as construction material and road base, limestone can be utilised in a wide range of sectors. The high value of import in prominent markets in North America, South America and the CARICOM region presents an opportunity for Jamaica to enter the value-added market of limestone which is significant in terms of value.

Why Jamaica?

The Government of Jamaica (GoJ), in its 'Vision 2030 Jamaica' document, has identified Mining and Quarrying as one of the key and strategic sectors to achieve its vision to make Jamaica a developed nation by 2030. The GoJ has secured funding from the World Bank to finance a project entitled Foundations for Competitiveness and Growth Project (FCGP) that is designed to enable private sector-led growth in the Jamaican economy, in an inclusive and sustainable way.

The limestone industry in regions near to Jamaica, namely CARICOM, North and South America has been primarily driven by the growth in construction activities in the residential and commercial building sectors and other infrastructure developments. In addition, low, stable economic growth, infrastructure development, increasing populations and rising disposable incomes have further increased the demand for value-added limestone products across sectors. The central location of Jamaica provides a strategic advantage where it is closer to the import destinations as compared to the countries from which limestone is currently imported. Other important indicators of the need for the development of Jamaica's value-added limestone industry and other key success factors are highlighted in the table below.

Table 1 Jamaica's limestone value-added success factors

The Value-Added Opportunity	Sustainable Growth Factors
• Jamaica has large quantities of limestone reserves and high-purity limestone. • The export market for limestone as well as value-added products has been growing and there is opportunity for the development of higher products for export globally.	• Increasing stability in the region • Increasing transparency both in government and local authorities • Inflation stability • Decreasing unemployment levels

The Value-Added Opportunity	Sustainable Growth Factors
• Increased growth in limestone consumption in the Americas region presents an opportunity for Jamaica. • The cost of labour in Jamaica represent one of the lowest in the Americas for accounting to the IDB Labour market division. • Various trade agreements exist between Jamaica and the Caribbean and developed nations with growing demand such as the USA, Canada and the European Union (EU).	• Strong relationship with international development partners • Increasing access to regional and world markets • Jamaica's geographic location makes it is strategically placed to become a regional player in transhipment. Kingston Port has been predicted to become region's biggest transhipment hub. • Growth is being driven by a more stable and increasing income and lower debt levels

Product Overview

Limestone has many industrial uses and can be processed into a variety of products. It is used as a filler in a variety of products, including paper, plastic and paint. The highest purity limestone is used in food and medicines such as breakfast cereals and calcium pills. Value-added limestone products such as Calcium Carbonate (i.e. Ground Calcium Carbonate (GCC) and Precipitated Calcium Carbonate (PCC)), Lime (Quicklime, Slaked Lime and Hydraulic Lime), Dimension Stones (i.e. stones, tiles, blocks.) and Cultured Marble are used across industries.

This Information package focuses on Precipitated Calcium Carbonate (PCC).

Table 2 Summary of PCC

Product	Description	Application/Industries
Precipitated Calcium Carbonate (PCC)	PCC is synthetically formed calcium carbonate ($CaCO_3$) that is produced via a series of chemical processes. Its production involves: calcination (heating of limestone to produce quick lime); hydration (mixing quick lime with water to form hydrated lime slurry); carbonation (conversion of lime slurry that is treated with CO_2 to $CaCO_3$) and filtration ($CaCO_3$ in slurry form is filtered and dried to form powder).	• Food & Pharmaceuticals • Paper and Pulp • Plastic • Paint • Agriculture and Animal feed • Rubber

Financial Highlight

An assessment of the valued-added production for PCC in Jamaica indicates that for a total production of 30,000 tonnes per annum, an investment in this product could be financially feasible. The analysis was conducted under two scenarios,

I. On a standalone (start-up)
II. An incremental basis (existing operation)

On an indicative basis, the internal rate of return (IRR) could range from 25.6% to 32.3% and net present value (NPV) range from US$12.1M to US$13.2M on a standalone and incremental basis respectively.

2.0 Introduction and Overview

The Jamaican Context

It is estimated that Jamaica has over 150 billion metric tonnes in limestone resources of which 50 billion metric tonnes are deemed recoverable. Over the past four years, the country's production has been increasing. Limestone is the largest mineral resource possessed by Jamaica and is an essential raw material for other industries such as steel, building and cement, agriculture and paper and pulp. It is usually extracted in open pits and predominantly used as a construction material and road base. The production of limestone is supported by one hundred and forty-six licenced mining and quarry operators situated in all parishes across the island.

As of 2019, Jamaica is exporting limestone valued at US$4.0m per annum. The total existing export market in the region (Americas and CARICOM) stands at US$300 million and is expected to grow by at least US$7 million every year. The annual increase in limestone import in the nearby region is itself double the value of the existing export market of Jamaica.

The Limestone Value-Added Opportunity

Despite the vast quantity of limestone reserves and the large number of quarries operating in the island, the industry remains largely underdeveloped as many of the quarries operate under capacity, and the sector lacks financing. Approximately 10% of extracted limestone is exported while the remaining 90% of the production is used to meet local demand. Exports are directed to the USA, South America, Canada, and CARICOM. More importantly, the value of limestone exported from Jamaica is slightly above 1% of the total value of limestone import in the nearby regions.

A large proportion of Jamaica's limestone is considered to be "high purity" due to its concentration of calcium carbonate (<95%-98%). Geographical studies conducted on limestone deposits in Jamaica reveal large deposits of reserves in the parishes of Portland, St. Elizabeth and Trelawny, with high to very high purity limestone, as shown in Table 3 below, suitable for end use in multiple industries from construction to pharmaceuticals.

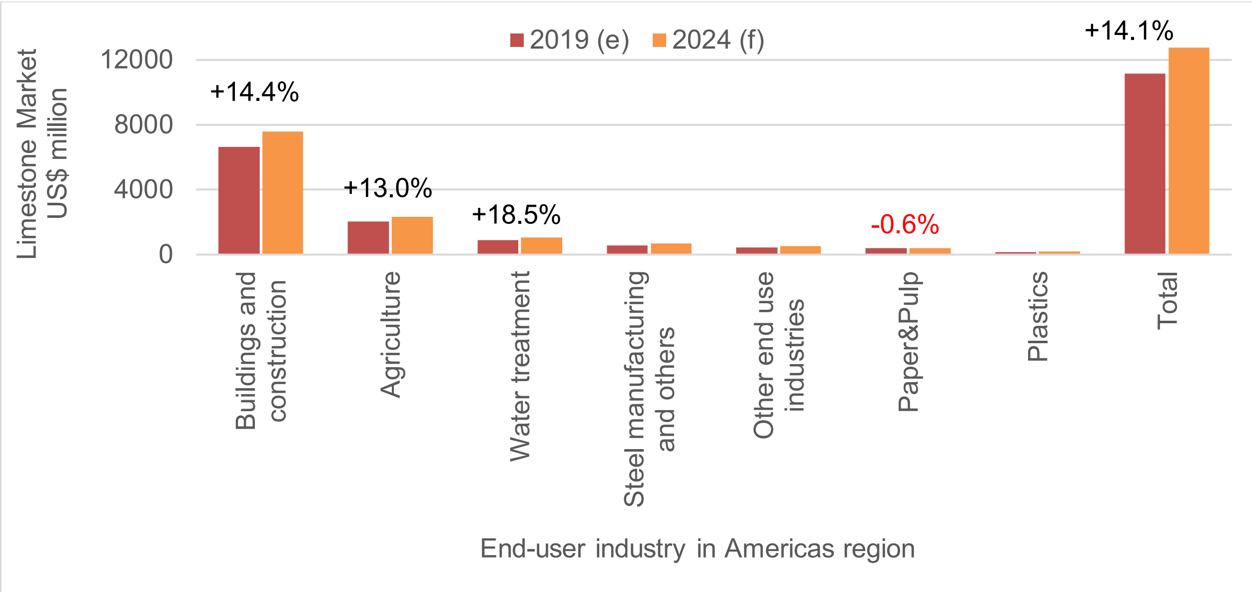
Table 3: Quality of limestone in Jamaica

	Portland (Average)	Trelawny (Average)	St. Elizabeth (Average)
Calcium Carbonate, $CaCO_3$ (%)	>99	>99	>98
Magnesia, MgO (%)	~0.60	~0.2	~0.3
Silica, SiO_2 (%)	<0.20	0.50	<0.20
Iron oxide, Fe_2O_3 (%)	<0.10	0.05	0.20
Aluminium Oxide Al_2O_3 (%)	<0.10	<0.15	0.35

Source: PwC Research, MGD reports

Limestone is used in a wide variety of applications depending on whether it is crushed, ground or is converted to lime. These include construction materials, water treatment, food & beverage, pharmaceuticals, iron & steel, agriculture, plastics and paper. In the Americas region, all the end use sectors are set to grow with a Compound Annual Growth Rate (CAGR) in double digit value terms with an exception of the paper and pulp industry which is expected to see a reduction in demand. The key end-use industries of limestone are collectively set to grow by 14.1% between 2019 and 2024.

Figure 1: Limestone end-use industry consumption in the Americas region



Source: Mordor Intelligence; e: estimated, f: forecasted

Global Trends

The global limestone market exceeded US$5.7 billion in 2017 and is estimated to surpass US$9 billion while growing at a CAGR of 6.5% over the period of 2019 to 2024. This growth is primarily due to an increase in consumption in iron & steel processing, building & construction and agricultural industries. As per International Trade Centre (ITC) Trademap statistics, the total quantity of limestone exported across the world in 2018 increased by 10 million tonnes from 47 million tonnes to 57 million tonnes.

Top Exporters and Importers of Limestone in 2018

As shown in Table 4, the five largest limestone exporters in 2018 were United Arab Emirates, Japan, India, Oman and Turkey. These countries represent 72% of world production.

Table 4: Top Limestone Exporters

Rank	Exporters	Quantity Exported in 2018 (Million Tonnes)	Percentage of Global Export by Quantity	Export Value in 2018 Million US$
1	United Arab Emirates	24.53	44.3%	229.90
2	Japan	5.15	9.3%	52.28
3	India	3.30	6%	61.55
4	Oman	2.95	5.3%	66.86
5	Turkey	2.60	4.7%	6.72

Source: ITC calculations based on UN COMTRADE and ITC statistics (accessed on March 24, 2020)

As shown in Table 5, the five largest limestone importers in 2018 were India, Germany, Bangladesh, Taiwan and Kuwait.

Table 5: Top Limestone Importers

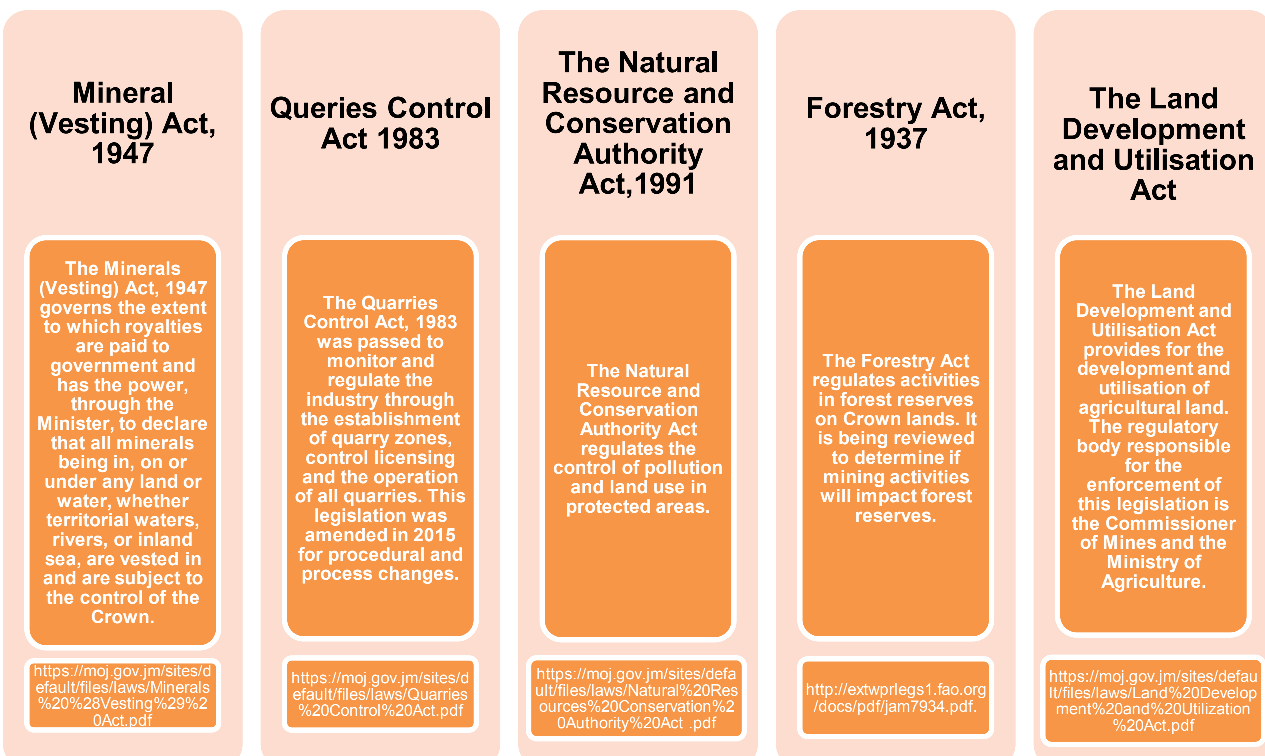
Rank	Importers	Quantity Imported in 2018 (Million Tonnes)	Percentage of Global Import by quantity	Import Value in 2018 Million US$
1	India	22.85	39.6%	453.63
2	Germany	3.65	6.3%	43.11
3	Bangladesh	3.61	6.3%	43.23
4	Taiwan	3.21	5.6%	64.38
5	Kuwait	2.94	5.1%	31.74

Source: ITC calculations based on UN COMTRADE and ITC statistics (accessed on March 24, 2020)

Regulatory Environment

The main legislation / regulations that impact the mining and quarrying industry in Jamaica include:

Figure 2: Jamaica regulations for Mining & Quarrying



According to the Minerals Policy, the GoJ has separated its regulatory role through the Ministry of Transport and Mining (MTM) and its ownership in the mining industry and its operations through the Jamaica Bauxite Mining Limited (JBM) and Clarendon Alumina Production Limited (CAP). The Ministry's main responsibilities are the overall policy responsibility and development of the industry. The Mines and

Geology Division (MGD) has statutory authority under the Mining Act and the Quarries Control Act to exercise general supervision over all prospecting, mining and quarrying operations throughout the island. The MGD also manages the investigation, characterisation, documentation and release of information on all aspects on the geology of Jamaica.

Investing in Jamaica

As an emerging market Jamaica relies on foreign direct investment (FDI) to spur its growth and international competitiveness. Jamaica has welcomed FDI as a major part of the development of several industries. In 2018 the inflow of FDI to Jamaica valued approximately USD$ 775 million. The ability to conduct business efficiently has been improving over the past 10 years. Jamaica's ease of doing business current ranking improved to 71 in 2019 from 75 in 2018, according to the latest World Bank annual ratings, Jamaica is ranked 71 among 190 economies

The Jamaican economy provides many benefits to foreign investors such as stable and positive economic growth and improved competitiveness in the region. Jamaica also boasts a strategic geographic location, stable democracy, a relatively large English-speaking market and access to major shipping paths such as the Panama Canal.

The limestone industry in the region is driven by construction in the residential and commercial building sectors and other infrastructural development. As the region continues to grow with the increased population, rising disposable incomes and continued infrastructural development the demand for value-added products across sectors is expected to rise.

With billions of limestone reserves and the strategic advantage of being closer than most import destinations such as India and Japan, Jamaica's value-added limestone industry is uniquely positioned to tap into the growing market. Table 6 below highlights the position of the market and other key success factors of limestone value-added production.

Table 6: Investing in Jamaica Limestone - The Opportunity

The Value-Added Opportunity	Sustainable Growth Factors
• Jamaica has large quantities of limestone reserves and high-purity limestone. • The export market for limestone as well as value-added products has been growing and there is opportunity for the development of higher products for export globally. • Increased growth in limestone consumption in the Americas region presents an opportunity for Jamaica. • The cost of labour in Jamaica represent one of the lowest in the Americas for accounting to the IDB Labour market division. • Various trade agreements exist between Jamaica and the Caribbean and developed nations with growing demand such as the USA, Canada and the European Union (EU).	• Increasing stability in the region • Increasing transparency both in governments and local authorities • Inflation stability • Decreasing unemployment levels • Strong relationship with international development partners • Increasing access to regional and world markets • Jamaica's geographic location makes it is strategically placed to become a regional player in transhipment. Kingston Port has been predicted to become region's biggest transhipment hub. • Growth is being driven by a more stable and increasing income and lower debt levels

Economic Profile

Jamaica has a mixed economy that is heavily reliant on services. Approximately 70% of the country's Gross Domestic Product (GDP) is derived from services, and most of its foreign exchange comes from tourism, remittances, and bauxite/alumina exports. Over the last decade, Jamaica's GDP (at market price) has grown by 88%. The country's GDP for FY2019 stood at JM$ 2,053 bn, representing an increase of about 6.5% over FY 2018.

High public service debt obligation and vulnerability to frequent natural disasters are the key concerns to the macroeconomic stability of the island. In terms of the public service debt obligation to GDP, Jamaica was previously at 147% of GDP. In 2019 Jamaica successfully completed its economic reform programme supported by the International Monetary Fund (IMF) and through the programme the debt obligation to GDP ratio fell to 94%. This indicates strong political will and a strong future of economic growth and development.

Table 7: Key economic indicators for Jamaica

Indicator	FY 2016	FY 2017	FY 2018	FY 2019
Total Gross Domestic Product at Market Prices (JM$ million)	1,688,754	1,787,954	1,927,202	2,053,185
Mining & Quarrying sector contribution to the GDP (JM$ million)	32,845	35,246	46,852	60,573
Central government gross debt (JM$ million)	2,068,760	2,158,846	2,028,154	1,998,668
Gross Debt to gross GDP (%)	123%	121%	105%	94%
Interest rates (Domestic currency, %)	3.51%	3.75%	2.85%	2.51%
Interest rates (Foreign currency, %)	1.65%	2.07%	1.90%	1.83%
Exchange rate (US$ to JM$)	118.75	127.13	127.99	130.60

Source: Statin, Bank of Jamaica

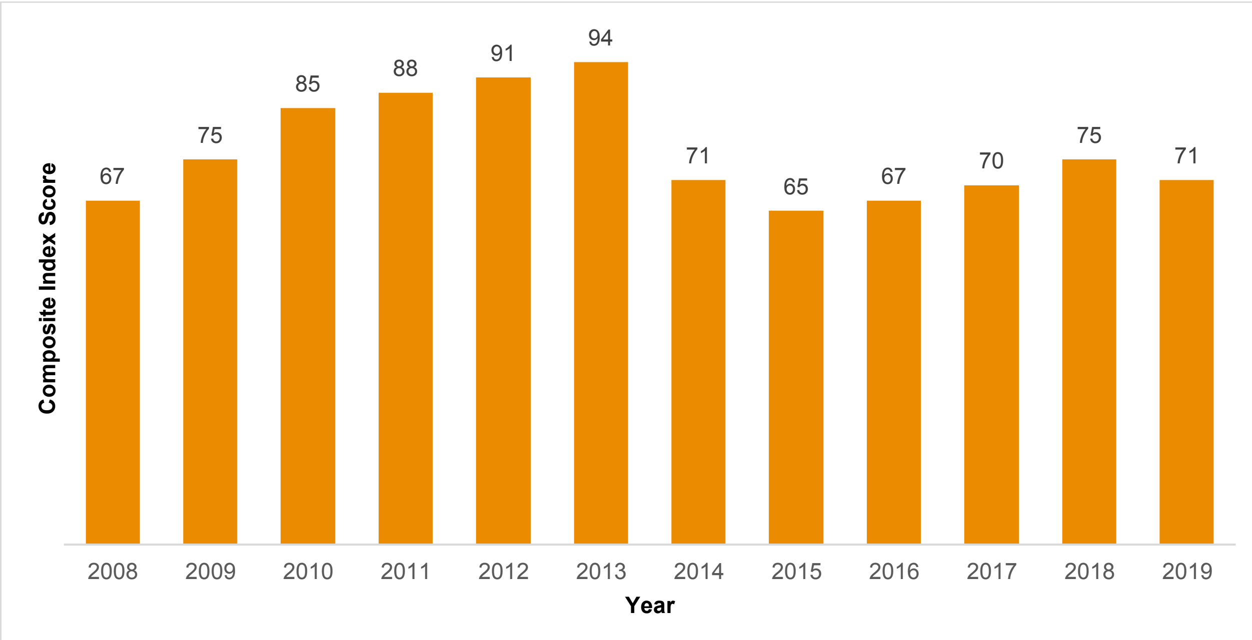
Table 8: Jamaica's credit rating by leading Credit Rating Agencies (CRA)

No.	CRA	Rating	Outlook	Date (as of)	Remarks on CRAs' ratings
1	Fitch	B+	Positive	January 29, 2020	For Fitch, a bond is considered investment grade if its credit rating is BBB- or higher. Bonds rated BB+ and below are speculative grade, sometimes also referred to as "junk" bonds.
2	Moody's	B2	Stable	December 11, 2019	For Moody's, a bond is considered investment grade if its credit rating is Baa3 or higher. Bonds rated Ba1 and below are speculative grade, sometimes also referred to as "junk" bonds.
3	Standard and Poor's (S&P)	B+	Stable	September 27, 2019	For S&P, a bond is considered investment grade if its credit rating is BBB- or higher. Bonds rated BB+ and below are speculative grade, sometimes also referred to as "junk" bonds.

Investor Friendly Reforms

Jamaica has been trying to attract investors to the island through business-friendly reforms. Since 2013, Jamaica's Parliament passed numerous pieces of legislation to improve the business environment and support economic growth through a simplified tax system and broadened tax base. This has allowed improvement in Jamaica's Doing Business Ranking as depicted in the figure below.

Figure 3: Jamaica's historical Ease of Doing Business ranking

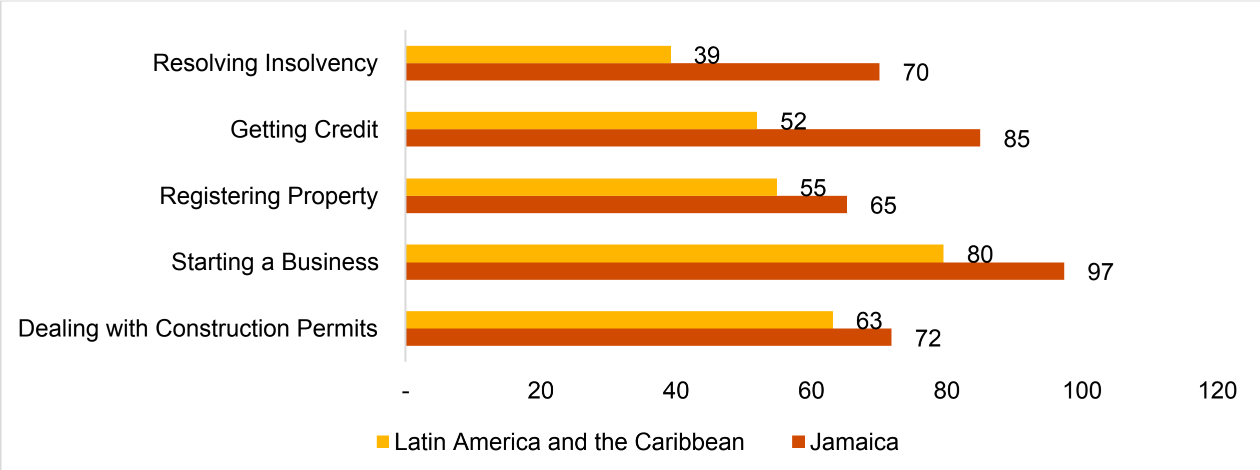


Source: The World Bank

The establishment of credit bureaus and a Collateral Registry under the Secured Interest in Personal Property (SIPP) legislation are improving access to credit. Jamaica made starting a business more streamlined by consolidating forms and made electricity less expensive by reducing the cost of external connection works. The GoJ is also open to foreign investment in all sectors of its economy and is currently in the process of developing a National Investment Policy to guide future FDI reform.

The graph below compares Jamaica's ranking in key doing business ranking factors within the region. Compared to the region, it is clear Jamaica has made significant gains in absolute terms, and there are further reforms currently in the works including process re-engineering for construction permits, as well as reforms around decreasing the length of time it takes to gain an electrical connection. Taken together, this demonstrates a focus on creating a further business-friendly environment in Jamaica.

Figure 4: Doing Business Indicators in Jamaica compared to the Latin America and Caribbean Region



Source: The World Bank

Enabling Environment

The Government of Jamaica provides vast support for the development and expansion of the sector, including:

- Incentives to investors including income tax relief, duty concessions on production- related imports
- Introduction of online registration for importers and exporters that allows access to all trade related agencies
- Provision of information on commerce and industry such as information on product marketing, trade statistics and government incentives
- Large scale improvements to the transport infrastructure and services

Taxation Environment

The incentive regime came into effect in Jamaica on January 1, 2014 and provides for varying levels of relief, via the following legislation:

Table 9: Key Legislations to Consider when Doing Business in Jamaica

	Key Legislation	Summary
1	The Fiscal Incentives (Miscellaneous Provisions) Act, 2013	The standard tax rate is 25% for non-regulated entities. This Act provides for: • the reduction of the effective corporate income tax rate by applying an Employment Tax Credit (ETC) at a maximum value of 30%, which reduces income tax from standard rate 25% for unincorporated company to an effective tax rate of 17.5% • Capital Allowances that cover, among other things, a broadened definition of 'industrial buildings' to include Duty-free Importation of Equipment and Machinery, as well as revised tariff rates ranging from 0% to no higher than 20% (with some exceptions).

	Key Legislation	Summary
		If designated as SEZ Reduced income tax from standard rate 12.5% for unincorporated company to an effective tax rate of 7.5% or 0%
2	The Income Tax Relief (Large Scale Projects and Pioneer Industries) Act, 2013	This provides for an improved and more attractive rate of income tax for projects that are considered to be large scale or of a pioneer nature. As of the date of this investment package the related regulations regarding how this benefit will be administered have not yet been promulgated.
3	The Customs Tariff (Revisions) (Amendment) Resolution, 2013	This Act provides for the duty-free importation of capital equipment and raw material.
4	The Stamp Duty (Amendment of Schedule) Order 2013	Provides stamp duty exemption on raw materials and non-consumer goods.

The above acts provide relief through tax credits, duty-free importation, stamp duty exemptions and capital allowances as it relates to specific industrial buildings. With the development of new manufacturing plants to process the limestone into value added products, the limestone industry can draw on these acts to mitigate the costs associated with manufacturing. Particularly, the income tax relief will improve profits and the customs tariff resolution will significantly reduce the heavy charges that are accompanied with importation of capital equipment.

Special Economic Zones

The Jamaica Special Economic Zone Authority (JSEZA) was created to implement and manage special economic zones within Jamaica. These zones are areas in which the regulations of the country do not apply or are modified to allow for increased investment, employment and job creation.

Under the SEZ Act, many reforms were introduced. Under the previous free zone regime, manufacturing entities were only allowed to supply up to 15% of production locally. Entities under the SEZ are now able to sell goods both locally and for export with no restrictions. It can be noted however that the JSEZA highly prefers exportation of locally produced goods. The SEZ also provides a number of additional tax benefits and incentives which includes a 12.5% reduction in income tax, no General Consumption Tax (GCT) on electricity and telephone services and stamp duty relief.

Implications for the Limestone Industry

Although an SEZ cannot be applied to mining and quarrying operations they can be applied to manufacturing and other related industries which would provide support for value-added products. JSEZA highly recommends Single or Multi-Occupancy for this purpose; however, there must be a clear separation of business from mining. The limestone industry can seize the opportunity offered by SEZ legislation to become Multi-Occupancy by setting up a Special Purpose Vehicle (SPV) for value-added products that they plan to market or export.

JSEZA has also introduced a business centre to facilitate quick application processing for prospective SEZs. Provided that the required regulations and licences are approved by the respective authorities the timeline for an application review is at least forty-five (45) days, with a pre-approval timeline of approximately thirty (30) days.

Trade Agreements

Jamaica has negotiated trade agreements with the world's major trading powers such as the European Union, Canada, and the United States, as well as in our important domestic CARICOM markets. These trade pacts provide a range of opportunities for Jamaican exporters. The main trade agreements that Jamaica is party to include:

Figure 5: Summary of Key Trade Agreements

The European Partnership Agreement

- The accords immediate duty-free/quota-free market access for CARIFORUM goods into the EU except sugar.

Caribbean Basin Initiative (CBI)

- The CBI comprises the Caribbean Basin Economic Recovery Act of 1983 (CBERA) and the Caribbean Basin Trade Partnership Act of 2000 (CBPTA). The CBI Act was established by the US in 1984 to provide economic aid to Jamaica (and 23 other countries in the Caribbean and Central America) through the waiver of tariff benefits. Most products manufactured or grown in CBI beneficiary countries are eligible for duty-free entry into the United States.

Caribbean-Canada Trade Agreement (CARIBCAN)

- CARIBCAN is a preferential arrangement guaranteeing duty free access to Canada for a wide range of products excluding textiles and apparel, footwear, luggage and handbags, leather garments, lubricating oils and methanol.

Caribbean Single Market Economy (CSME)

- Established by CARICOM to create economies of scale in the region. It offers Jamaicans the right to establish a business in another territory in the CSME without restriction. Jamaican goods that have already entered a CSME country will also be eligible for export/import into another CSME territory without duty. Capital from Jamaica can also 11 circulate freely in other CSME countries. Jamaica has also negotiated and signed Free Trade Agreements (FTA) with Argentina, Colombia and the Dominican Republic.

Potential risks and constraints

Jamaica has a world class quality and abundant quantities of limestone. The limestone in Jamaica is readily accessible but there is a need for evaluation of reserves along with improved mining techniques, upgraded state-of-the-art machinery and equipment and modernization process. The industry also faces several risks to the limestone market such as:

- Inadequate record keeping
- High cost of energy
- Lack of bulk shipping of products
- Lack of security of the precious material

The Jamaican government is willing to provide an enabling environment to reduce these risks and have started the process through active engagement with stakeholders, implementing the Draft Minerals Policy and improving access to finance. JAMPRO also has a specialist to assist investors and market players with entering the value-added industry.

The table below highlights common issues associated with limestone and respective factors used to mitigate them.

Table 10: Common Issues associated with Limestone

Problems associated with Limestone		
Weathering	Limestone is more prone to chemical weathering than other stones, such as graphite, owing to the presence of calcium carbonate which readily reacts with rainwater. Rainwater gets acidic when it combines with carbonic acid and causes weathering in limestone walls.	After extraction mined limestone can be stored to prevent weathering by rain and other atmospheric elements.
Erosion	Limestone walls when exposed to continuous air or water, is prone to erosion. The airborne abrasives floated by wind cause erosion on limestone.	Erosion can be mitigated by planting in areas surrounding limestone walls.
Staining	Staining is also known as discolouring of limestone. Different types of organic and inorganic oils that limestone absorbs, organic matters, such as leaves, flowers or tea and coffee, animal droppings, and metals, like copper or iron, which causes rust, are the major reasons of staining on the limestone.	Limestone surfaces can be cleaned to prevent long-term stain.
Crumbling	The most critical problem of limestone and limestone materials is crumbling. Limestone has a brittle structure and inherent weakness of the stone along with external factors and gradual breakdown of the binders used in the building affects the durability and strength of the stone, thus causing crumbling in the limestone walls.	Potential sources of crumbling can be repaired if detected early.

3.0 Product Overview – Precipitated Calcium Carbonate

Overview

PCC is a synthetic compound made from high-purity limestone. It is produced via a series of chemical processes that involves the heating limestone to make quicklime via a process called calcination. During the hydration process, quicklime is mixed with water in a calculated ratio to form hydrated lime slurry (“slurry”). The slurry is treated with carbon dioxide (CO_2) during the calcination process and is converted back to calcium carbonate ($CaCO_3$). The calcium carbonate slurry is filtered and dried to form powder.

Figure 6: Typical representations of PCC

Key Applications of PCC

PCC can be used in a wide range of applications. The synthetic production of PCC allows for consistency, greater fineness and purity as well as the optimisation of properties such as size, shape and surface chemistry that suits its intended end use.

The end-uses for PCC are described in the table below.

Table 11: Key Applications of PCC

Product		Uses
Agriculture (fertilizers)		PCC is used as topsoil for agriculture, stabilising the acidity of soil and providing essential calcium for the support of crops.
Animal and Pet Feeds		PCC is incorporated into animal feed as a dietary supplement.

Product		Uses
Paper		PCC in fine grades is used in paper manufacturing. As an alkaline material, it reduces the acidity of paper, improving the brightness and durability of the printed material.
Plastic		PCC is used as a filler in plastic products, adding density, improving rheology and reducing cost. PCC is often blended with additives to aid bonding within the plastic.
Paints and Surface Coatings		PCC is used to bulk-out or extend the resins and polymers in paints. PCC is used as an aid to pigmentation and to help control the finish (matte or gloss).
Rubber and Elastomers		PCC is used as an extender and in controlling the rheology of products that are to be moulded. A widespread application is in latex carpet backing materials.
Food, Pharmaceuticals and Household		PCC is used as a dietary calcium supplement and antacid, or as a chemical binder. It can be used in less obvious ways, for example in polishing and cleaning rice or a cleaning component in shoe polish.
Toothpaste		PCC is used as an abrasive in certain types of toothpaste, which functions as a scrub to remove plaque and other solid materials from the surface of teeth.
Buildings and Construction		PCC is used in building product applications including roofing shingles, vinyl floor tile and sheeting, tape joint compounds, glass, stucco, concrete, masonry, and swimming pool plasters.

Production Process

The production process for PCC is detailed in the table below.

Table 12: PCC Production Process

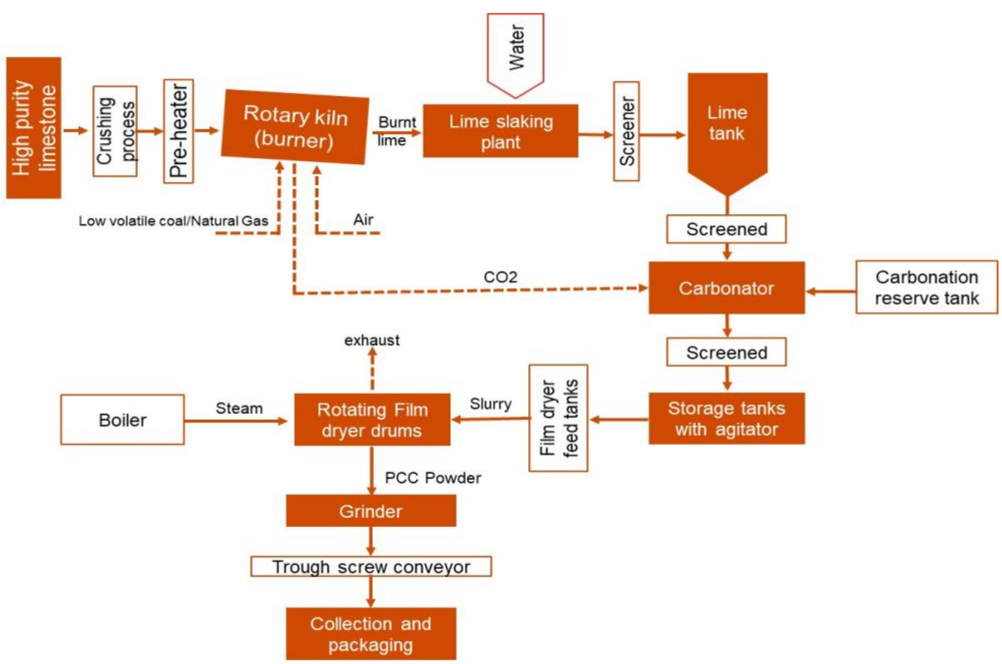
Production	Process
Transportation and storage of raw material (feed)	High purity limestone is transported to the PCC plant location after primary crushing and stored in a storage yard inside the plant boundary. General sorting may be done to ensure that the maximum feed size of the limestone does not exceed the rated intake capacity of the jaw crusher (~340mm).
Two-Stage Crushing	A two-stage crushing system is used to reduce the size of feed suitable for input to the lime kiln. The output size of the two-stage crushing is determined according to the specification of the end-use product and the kiln system being used. The raw material from the storage yard is fed into the hopper with the help of a wheel loader. The hopper discharges the limestone feed to a vibrating feeder which is capable of continuously and evenly sending materials to the jaw crusher and roughly screening them. The jaw crusher crushes the limestone feed to about 40mm to 80mm size. The output of the jaw crusher is fed to the hammer crusher with the help of a belt conveyor. The hammer crusher further reduces the size of the particles to approximately 6.4mm to 20mm which is then fed into the lime kiln system for calcination and quicklime production.
Calcination	After two-stage crushing has been completed, the crushed limestone is transported to the lime kiln system via a conveyor belt. The conveyor belt discharges the crushed and screened limestone through a bucket elevator up to the kiln where it is fed into a multi-stage pre-heater. Preheating is done to preserve the amount of energy required during the kiln stage. Heat is generated from burning low volatile coal, natural gas or fuel oil. The usage of natural gas is preferred for calcination to ensure purity of the product. Limestone particles from the preheater are discharged into a lime kiln which uses heat, air flow and motion for the calcination process. In order to complete the thermal decomposition of limestone into lime (quicklime), limestone is heated to a temperature of approximately 850°C to 1340°C. The chemical reaction that takes place in calcination is: $CaCO_3$ + Heat = CaO (quicklime) + CO_2 In order to resist the re-carbonisation of quicklime, the CO_2 gas produced during calcination is trapped and transported to the carbonation chamber where it is used in the carbonation of lime slurry. Lime produced in the kiln through the calcination process is known as quicklime. The quicklime produced is cooled and inspected.
Slaking	The quicklime obtained from the calcination process is collected at the discharge end of the kiln and is transported to the slaking plant. Slaked Lime or Hydrated Lime is produced in a vessel called a hydrator by adding a calculated amount of water to the quicklime and stirring the mixture using a turbine style agitator. This hydration process is called dry hydration. In this case the hydrate material is a dry powder. If excess water is used for hydration, the process is called slaking. The chemical reaction which takes place in the hydration/ slaking process is: $CaO + H_2O = Ca(OH)_2$

Production	Process
	The lime slurry produced post slaking is screened to remove impurities and un-burnt material. The resulting hydrated lime is a fluffy, dry white powder, which is conveyed to an air separator for storage/ packaging. The lime slurry after screening is standardised to attain a particular concentration per the product requirement and envisaged end-use application.
Carbonation	The purified and standardised hydrated lime slurry is fed into the carbonation tanks where hydrated lime slurry is carbonated with carbon dioxide obtained from the calcination process. Recycled carbon dioxide (CO_2) from the lime kiln may be used in the carbonation process while the tanks are also connected to a CO_2 reserve tank. The chemical reaction involved in the carbonation process is: $Ca(OH)_2 + CO_2 = CaCO_3 + H_2O$
Filtration and Drying	Following the completion of the carbonation process, a suspension of calcium carbonate ($CaCO_3$) is formed. The suspension is filtered using a technique which generates a cake comprising 40% to 60% solid matter (depending on particle diameter). The cake is stored in storage tanks and fitted with an agitator. This filter cake is then dried using steam from a burner in rotary film dryers. The dried powder (PCC) is subsequently de-agglomerated in grinders.
Storage and Packing	The PCC powder obtained after the de-agglomeration step is conveyed for storage and packaging through a trough screw conveyor. The product is packaged in bags and is transported to consumers/market.

Process Flow

A dry process line involves a series of crushing and fine milling stages followed by classification that produces a fine micronised PCC product. It is suitable for producing powder with a particle size of three (3) microns. The dry process line provides flexibility in production at a lower cost and capital investment relative to wet process lines. This is reflected in the figure below.

Figure 7: Dry process flow for PCC



General Industry Best Practices for Minimising Environmental Footprint

Some of the key areas which may lead to the generation of unwanted waste in the production line of PCC are stated below.

- Particulate matter or fugitive dust emissions – raw material handling & storage, crushing, screening, conveyors & transfer points, kiln & cooler operation, boiler, rotary drying, product storage in silos, packaging & dispatch
- Gaseous pollutants – exhaust gases of kiln and boiler containing SO, NO, CO_2, or CO
- Solid waste – unburnt particles during calcination in kiln, screening of slaking and carbonation product, boiler dust and bag filter dust
- Wastewater – drainage water, hydration system, filtration water
- Metals – kiln refractories, metals present in raw material

Good Practices for Minimising the Environmental footprint of PCC Operations

Focus area (Emissions)	Good Industrial Practices (Control Measures)
Particulate Matter (associated with crushing of raw material, material handling and material storage)	• Use a simple and linear layout design to reduce number of transfer points. • Use of dust extraction systems in conjunction with hoods and enclosures covering transfer points and conveyors. • Minimise material drop distances by the use of adjustable conveyors. • Store raw material, intermediate and final products in covered silos or enclosures. • Store raw material and the waste generated during the process in an environment protected from wind and weather conditions. • Use dust separators like cyclones or bag filters for removing and collecting dust generated during crushing, grinding and material handling operations. • Use bag filters for collecting dust generated from product silos. • Utilise a semi-automatic or fully automatic system for packaging finished products. • Suppress fugitive dust emissions by using a vertical tube air filters or Dry Fog Dust Suppression System. The dust recovered from it can be re-circulated in the process. • Curb dust on roads and pavements by using a vacuum type or brush type sweepers. • Use proper personal protective equipment (PPE) such as safety goggles and respiratory masks. • Install air quality detectors at strategic locations of the plant to keep a regular check on the air quality and take preventive measures accordingly.
Particulate Matter (associated with the operation of kiln systems, coolers and rotary dryer)	• Use an electrostatic precipitator and bag house for capturing fine particulate dust generated during kiln operation and to prevent its removal along with exhaust gases. The collected dust can be recycled back to the kiln along with its feed.

Focus area (Emissions)	Good Industrial Practices (Control Measures)
	• Use a dust extraction system along with bag filters to capture and separate particulates from cooler and rotary dryer operation. The collected particulates can be mixed with final product or can be used for construction work at the site along with aggregates.
Sulphur Oxide	• Use low Sulphur fuels (preferably natural gas). • Use low Sulphur limestone as a raw material input. • Design the kiln and selection of combustion conditions to ensure that most of the emitted Sulphur Oxide (SOx) is retained in the kiln along with quick lime.
Nitrogen Oxide	• Use low nitrogen oxide (NOx) burners which operate by avoiding localised hot spots. • Use finely pulverised coal so that complete combustion can be achieved with low excess air or usage of natural gas for fuel in the calcination process. • Control kiln temperatures and stabilize the temperature to below 1400_o to minimize the generation of NOx.
Greenhouse Gases	• Deploy energy efficiency measures to reduce combustion emissions. • Use high-quality processing material where applicable to lessen the amount of emissions generated. • Recycle carbon dioxide produced during calcination to be used in the carbonation process • Utilise a fuel with a lower ratio of carbon content to calorific value (preferably natural gas, fuel oil, etc.) to emit less greenhouse gases.
Metals	• Select raw materials with a low content of metals. • Stabilise the kiln conditions including temperature, heating zones, mixing of materials to minimise removal of metals along with gases and maximise capturing along with burnt lime.
Industrial Wastewater	• Investigate the landscape, geology and groundwater in the area. • Utilise surveillance and continuous monitoring of ground water quality. • Use techniques such as sedimentation using thickeners or clarifiers to remove suspended solid particles. • Use neutralisation methods (Effluent Treatment Tank) for pH adjustment before water recirculation into the process. • Design a proper drainage system for the collection and processing of rainwater. • Monitor plant drainage and disposal measuring the pH level, conductivity, solid dissolution, hardness, calcium and sulfide content.
Noise	• Design appropriate acoustics to limit the amount of noise which reaches nearby communities.

Focus area (Emissions)	Good Industrial Practices (Control Measures)
	• Install vibration-dampening mounts and concrete foundations for the installation of heavy equipment such as crushers and mills. • Use a muffler in the grinding mill to arrest noise pollution. • Select machines which generate less noise (if practically feasible). • Use silencers for fans, room enclosures for mill operators and noise barriers. • Use of PPE like noise cancelling ear headphones. • Select a site away from communities (if possible) otherwise install outdoor silencers at site to prevent noise from affecting local people. • Install noise level sensors for continuous monitoring.
Other waste (Solid wastes) or by-product	• Plan disposal route and standard operating procedures (SOP) based on environmental regulations and dispose of waste by identifying disposal areas (wherever permissible). • Maintain systems to keep the record of quantity, origin, nature and frequency of waste being disposed. • Use dust generated or screened out material during the process for construction work at site along with aggregates or for soil stabilisation work. • Segregate and recycle waste back into the process for the reduction of environmental footprint. • Develop storage areas away from watercourses and sensitive boundaries. • Designate appropriate storage facilities for substances which require special treatment such as for substances that are flammable, sensitive to heat or light. • Inspect storage containers and dumps regularly for compliance.

Appendix 6.3 details waste and pollution control for the production of PCC.

Equipment Required for PCC Production

The type of equipment required for production of PCC includes:

- Crushing Unit - Charging Hopper, Primary Crusher (Jaw Crusher), Vibrating Chute, Secondary Crusher
- Lime Kiln System
- Lime Slaking or Hydration System – Hydrator unit equipped with an agitator
- Carbonation system – Carbonation tank, Carbonation reserve tank, Screener
- Packaging Unit - Product Silos
- Other Units - Storage silos with agitator, Grinder, Rotating film dryer, Trough screw conveyor, Boiler, Blower, Elevator, Feeder, Discharge Screen Conveyor, Pulse Dust Collector, Air Compressor

4.0 Potential Markets for Jamaican PCC and Competitive Profile

Limestone trade in the Americas

The core markets for limestone exports from Jamaica are CARICOM, North America and South America. The import trend in prominent markets in North America, South America and CARICOM region presents an opportunity to Jamaica to enter the value-added market of limestone which is significant in terms of value.

Table 13: Limestone import in Americas and CARICOM

Markets	Total Limestone Import (in Million US$)	Import of Aggregates and Stones (in Million US$)
USA	99.9	13.0
Canada	79.2	11.5
Mexico	4.6	0.0
Brazil	29.5	6.9
Chile	81.3	0.0
CARICOM excluding Jamaica	5.2	0.6
Total imports in the region	**300**	**32**
Jamaica's exports	**3.8**	**3.78**

Source: ITC Trademap (accessed March 24, 2020)

The total value of imports of the studied markets in Americas was estimated at more than US$300 million while Jamaica is currently exporting approximately US$3.8 million (approximately 1% of the regional value).

Calcium Carbonate Market in Global Perspective

Calcium Carbonate is available commercially in two types, namely ground calcium carbonate (GCC) and precipitated calcium carbonate (PCC). Both GCC and PCC have the same chemical formula (i.e. $CaCO_3$) and are traded under a common HS code. However, the two products are different in their production process, purity, and end uses.

The physical and chemical properties of PCC (for example greater fineness, consistency and purity) give rise to a number of advantages. It is a more cost-effective mineral for producing in certain end use industries and is preferred in applications such as for food and pharmaceuticals. Furthermore, the price per tonne of PCC is approximately 30% higher than that of GCC.

For the analysis of potential markets of PCC, calcium carbonate (having a Harmonized System (HS) code of 283650 and product name: calcium carbonate) was used which combines the data of GCC and PCC. It is to be noted that PCC has no separate HS code for import-export analysis hence the combined code (Product HS code: 283650) was used.

As per ITC Trade map data, global imports of calcium carbonate were estimated at 5.65 million tonnes, an increase of 15% from quantity imported in 2018. In terms of value, the global imports were estimated at US$ 844.8 million in 2019. The imports mainly are driven by countries in Asia and Europe. The leading global importers of calcium carbonate are presented in the table below:

Table 14: Global import statistics of calcium carbonate

Country	2017		2018		2019	
	Quantity, thousand tonnes	Value, thousand US$	Quantity, thousand tonnes	Value, thousand US$	Quantity, thousand tonnes	Value, thousand US$
World	4,688	848,948	4,908	881,294	5,647	844,802
India	800	95,933	1,021	120,138	1,171	127,435
Netherlands	102	17,611	91	17,014	792	62,414
Germany	428	84,323	541	93,353	541	88,779
Belgium	341	29,760	279	33,505	487	47,142
Saudi Arabia	392	31,344	224	31,156	280	37,101

Source: ITC Trade map accessed on 20th April 2020

India leads the import market of calcium carbonate accounting for 15% of the total import value in 2019. India is followed by key European countries such as Netherlands, Germany and Belgium which together accounted for 23% of the total global imports.

The global export of calcium carbonate appears to be fragmented and competitive in nature with Vietnam leading the exports accounting for 10% of total exports value followed by Malaysia (9% of total export value) and Belgium (7% of total export value).

In Jamaica's context, it is important to observe that some of the leading importers of calcium carbonate source their products from countries in Americas region, mainly the USA. Also, some of the key importing countries source their products from distant countries, for instance Netherlands importing from Japan. These observations coupled with availability of high purity limestone indicate the possibility of market entry for Jamaica in global calcium carbonate supplier market, provided Jamaica can scale-up and remain cost competitive.

Calcium Carbonate Market from a Regional Perspective

The Americas region has been selected for the assessment of a potential market for calcium carbonate for Jamaican exports. The region's total import of calcium carbonate accounted for 10% of the global total imports by value in 2019. As per ITC Trade map data, Americas imports of calcium carbonate were estimated at 319 thousand tonnes, a decrease of 7% from quantity imported in 2018. In terms of value, the global imports were estimated at US$ 87.5 million in 2019. The leading importers of calcium carbonate in Americas region are presented in the table below:

Table 15: Americas' import statistics of calcium carbonate

Country	2017		2018		2019	
	Quantity, thousand tonnes	Value, thousand US$	Quantity, thousand tonnes	Value, thousand US$	Quantity, thousand tonnes	Value, thousand US$
America Aggregation	318	91,720	344	92,303	319	87,525
USA	40	28,653	46	29,240	42	29,210
Canada	54	29,210	26	14,740	25	15,013
Brazil	15	5,849	25	7,972	30	7,891
Chile	47	5,709	79	7,620	60	6,706
Ecuador	12	8,532	15	5,126	13	5,333
Guatemala	9	3,295	11	4,009	14	4,721
Peru	88	4,474	92	4,725	87	4,648

Source: ITC Trade map accessed on 20th April 2020

The imports mainly are driven by USA, Canada and Brazil together accounting for almost 60% of the total imports in the region; while, other key importing countries include Chile, Ecuador, Guatemala and Peru which together contributes about 25% to the total regional imports.

The major suppliers of calcium carbonate to the America region are segmented in the table below: -

Table 16: Major suppliers of calcium carbonate to the Americas

S.N.	Supplier by geography	Value in 2019 (in US$ thousand)
Suppliers within the Americas region		
1	USA	16,626
2	Canada	5,133
3	Mexico	3,879
4	Brazil	2,623
5	Guatemala	1,573
6	Dominican Republic	1,343
7	Argentina	959
8	Others	1,165
	Total	**33,301**
Suppliers outside the Americas region		
1	Vietnam	6,726
2	Spain	6,154
3	Japan	5,693
4	France	5,304
5	United Kingdom	4,908
6	China	4,619
7	Malaysia	3,607
8	Others	17,215
	Total	**54,226**

Source: ITC Trade map accessed on 20th April 2020

About 38% of imports of calcium carbonate is derived from within the Americas region; while, 62% of total imports coming into the Americas region is contributed by countries outside the region. Some of the major suppliers to the region are far-flung countries such as Vietnam, Spain, Japan and France. The Dominican Republic with five integrated cement plants and two grinding plants is currently a major player in the region and is currently exporting to these markets. Jamaica could replicate this model once it increases it's exporting capacity. Jamaica's central location and proximity, coupled with its availability of high purity, raw material (limestone) may enable it to penetrate the regional market and increase its share of exports, provided it can scale up and be cost competitive with other export competitors within as well as outside the region.

Potential Markets in Caribbean Community (CARICOM)

CARICOM accounts for 3% of the total import value in the Americas region. Albeit, low in import value, CARICOM's import was estimated at US$ 2.3 million in 2019, showing an increase of more than 50% from import value in 2018. The vast growth in import was mainly contributed by increased imports of calcium carbonate in Suriname.

Table 17: CARICOM's import statistics of calcium carbonate

Country	2017		2018		2019	
	Quantity, thousand tonnes	Value, thousand US$	Quantity, thousand tonnes	Value, thousand US$	Quantity, thousand tonnes	Value, thousand US$
CARICOM Aggregation	6.00	1,398	7.02	1,495	10.01	2,301
Suriname	0.20	116	-	-	4.47	1,190
Trinidad and Tobago	2.31	516	2.39	623	1.75	395
Jamaica	0.11	116	0.11	58	0.66	338
Barbados	0.33	140	0.20	129	0.18	119
Guyana	0.93	161	1.11	285	0.77	102
Rest of countries in CARICOM	2.13	349	3.21	400	2.18	157

Source: ITC Trade map accessed on 20th April 2020

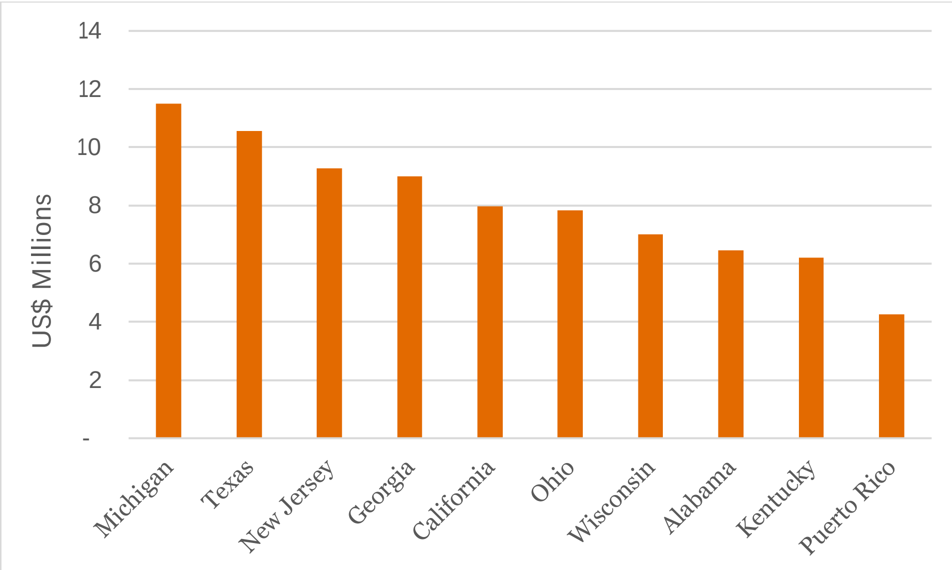
In CARICOM, approximately 70% of the total imports by value in 2019 were contributed by Suriname and Trinidad & Tobago. In addition, Jamaica's import value of calcium carbonate rose by more than five (5) times the value in 2018 to US$ 338,000 in 2019. The consistent import dependency of Jamaica in calcium carbonate gives an opportunity for local producers to capture the local market. In addition, easier access (trade partnership) to the CARICOM markets can allow Jamaica to capture the entire nearby market which has an estimated total import value of US$1.6 million (in 2019).

Potential Markets in United States

The chart below represents the top ten (10) states that import Calcium carbonate[1], these states represent 76.7% of total demand/importation within the US. Calcium carbonate products such as GCC and PCC are mainly used as fillers, additives and processing aids for various industries such as paper and pulp, plastics, construction, food and pharmaceuticals and iron and steel. The table below shows the top 10 US state importers of Calcium Carbonate.

[1] For the analysis of import data of Calcium carbonate, Harmonised System (HS) code: 283650 was used.

Figure 8: Top 10 importers of Calcium Carbonate



States such as Texas, Ohio, Georgia and Kentucky have naturally occurring limestone that is mined/quarried for production of calcium carbonate. Inclusive of Michigan, New Jersey these states are all automobile manufacturing states. Car manufacturing requires plastic, paints and tyres which is possibly driving the usage for GCC/PCC.

New Jersey also contains top pharma life sciences companies such as Novartis, Johnson & Johnson, Merck & Co., Pfizer, Bristol-Myers Squibb, Novo Nordisk and Bayer Healthcare. Key global producers of value-added calcium carbonate such as American Elements, United States Lime and Huber Carbonates are all located in the top ten (10) importing states. Key importers of calcium carbonate are shared in the table below.

Table 18: Key Importers of Calcium Carbonate

S.N.	Competitor	Location
1	American Elements	Bluffdale, Utah
2	Graymont LLC	Superior, Wisconsin
3	Lhoist North America Inc.	Lhoist North America Ariz Inc: Fort Worth, Texas Lhoist North America Tenn Inc: Brentwood, Tennessee (Multiple operations across USA, Canada)
4	Carmeuse Lime Inc	Pittsburgh, Pennsylvania
5	United States Lime and Minerals	Dallas, Texas (Operations in Arkansas, Colorado, Louisiana, Oklahoma and Texas)
6	Mississippi Lime	St. Louis, Missouri (Operations in Missouri, Alabama, Kentucky, Mississippi, West Virginia, South Carolina, Illinois, Pennsylvania)

7	Legacy Vulcan LLC	Vestavia, Alabama
8	Shelly Materials Inc	Thornville, Ohio
9	Omya Industries Inc	Blue Ash, Ohio
10	Wendling Quarries Inc	De Witt, Iowa

End Use Industries and Market Forecasts

As stated, Precipitated Calcium Carbonate (PCC) is a versatile product which is widely used in several industrial and pharmaceutical applications. The suitability of PCC in different industries mainly depends on particle size, colour and chemical purity. The key major applications of PCC in various industries are mentioned below:

- In agriculture and farming, PCC finds its use as an active ingredient in agricultural lime as it helps in neutralising soil acidity. It is also used in animal feed; specifically, it is used to boost milk production from cows, in pig feed to provide essential calcium and it also helps in robust egg development.
- In terms of industrial use, PCC is commonly used as fillers and binders in paper, plastics, paints, sealant, adhesive and coatings industries. PCC also finds its application in cosmetics and automobile industry including in automotive sealants, ceramics and reinforced plastics.
- In personal health and food industries, PCC is used as an effective dietary calcium supplement, antacid, phosphate binder, or as base material in medicinal tablets. In addition, it is also used in manufacturing of toothpaste, baking powder, dessert mixes, doughs and wine.

Use of PCC over GCC

The production process in PCC allows for increased control over the quality of the product as compared to GCC and its raw limestone inputs. Given this, from a particular grade of limestone, better quality PCC can be produced as compared to the same raw limestone inputs and the production of GCC. The PCC production process therefore leads to better quality, homogeneous particle size and a lower amount of impurities when compared to GCC.

The lower size particles of PCC provide it with better impact resistance, reduced level of impurities leads to better opacity and brightness and the synthetic production process makes it less abrasive in environmental uses. These properties of PCC make it better suited for various end use applications over GCC.

Overall, PCC is considered to be purer than the limestone from which it is made and contains lower impurities as compared to other calcium carbonates. During the production process, the size and shape of PCC may be controlled, and impurities removed, thus making PCC more suitable in specific end use applications as compared to GCC. Given that certain purity requirements are met, PCC can be used as a direct food additive, pharmaceutical or as an indirect additive in paper products that come in contact with food. Also, PCC gives better impact resistance over GCC in certain applications such as Plastics. Based on global demand within the respective end use industries, the demand for PCC is immense and therefore is a good product to venture.

Key End Use Industries of PCC and Quality Requirements

Agriculture and Animal Feed

PCC with a calcium carbonate content of >92% can be quarried and used by the agricultural sector. By crushing the raw limestone, various grades (based on particle size) can be produced. These products are marketed as 'agricultural lime'.

Soil acidity is one of the factors that can influence plant growth and can seriously limit crop production. By spreading agricultural lime onto the soil, the calcium carbonate content of the limestone is capable of neutralising a portion of the acid in the soil. This also has the effect of releasing soil minerals, such as phosphates, and making them available for absorption into plants.

In animal feed, PCC serves as a supplemental source of calcium. Specifically, it is used to boost milk production from cows, in pig feed to provide essential calcium and in chickens support robust egg development.

Table 19: Quality parameter of limestone for usage in agriculture and animal feed

Quality parameters	Mean	Range
Calcium Carbonate, $CaCO_3$ (%)	95.55	92 - 99.35
Lime, CaO (%)	54.09	51.55 - 55.67
Magnesia, MgO (%)	0.66	0.22 - 0.96
Silica, SiO_2 (%)	1.28	0.06 - 4.5
Iron oxide, Fe_2O_3 (%)	0.01	0.037 - 0.1
Brightness (%)	81.8	70 - 95.5

Paper and Pulp

In the pulp and paper industry, PCC is used as a filler to fill the grooves in the sheets of cellulose, forming a smooth surface. PCC is also used as a constituent in the pigments that are used to coat certain types of paper in order to give colour and gloss to the surface.

In 2019, the paper and pulp industry contributed an estimated US$408.4 million, accounting for approximately 3.7% of the Americas total limestone market by value. The value is further estimated to remain stable at US$ 406 million in 2024.

The pulp, paper and paperboard capacities of the USA, Canada and Brazil were valued at 51.98 million tonnes per annum (MTPA), 9,900 tonnes per annum and 23,530 tonnes per annum, respectively. The overall demand for limestone in the paper and pulp industry in the region has declined, due to a gradual decline in the USA in recent years owing to the decline of manual, paper-based processes in favour of automated, digital processes. Despite the decline, paper market in USA is very large and can be an attractive export market for Jamaica.

Moreover, countries outside of the USA are still seeing growth including Canada and Mexico. The growing need for cardboard packaging and increasing e-commerce activities are the key driving factor for the paper industry in these countries.

Table 20: Quality parameters for limestone to be used in Paper Industry

Quality parameters	Mean	Range
Calcium Carbonate, $CaCO_3$ (%)	98.46	96 - 99.35
Lime, CaO (%)	55.17	53.79 - 55.67
Magnesia, MgO (%)	0.45	0.15 - 1.2
Silica, SiO_2 (%)	0.11	0.05 - 0.4
Iron oxide, Fe_2O_3 (%)	0.04	0.01 - 0.1
Brightness (%)	96.7	93.5 - 99

Advantage of the use of PCC over GCC in the Paper Industry

PCC is preferred over GCC in paper industry because PCC yields better quality paper over those products which are manufactured with the use of GCC. PCC with the lower amount of impurities is preferred in the production of lightweight paper products. Moreover, PCC has superior brightness over

GCC, therefore it is preferred for high quality printing paper and paperboard as it provides a smoother surface, greater gloss, less defects and better opacity for the paper. The flexibility to control the shape, size and crystal structure of PCC makes it a preferred choice in the industry.

Plastic

PCC is added as a filler in plastic and is used, in part, to modify the material's physical behaviour under certain conditions. In 2019, the plastic industry contributed an estimated US$169.2 million, accounting for approximately 1.5% of Americas total limestone market by value. The value is further estimated to grow at a CAGR of 2.4% reaching US$ 190.4 million in 2024.

The North American plastics industry has grown in recent years. According to the American Chemistry Council (ACC) and Plastics Industry Producers Statistics (PIPS) Group, North American plastic resin production grew by 5.85% from 113 billion pounds to 119.6 billion pounds during 2017-18. The growth of plastic production in North America is due primarily to the capacity expansions of petrochemical producers in the USA.

The plastic market in South America is expected to contract, as a result of shrinking global economic and political uncertainties, as well as the shift in consumer trends to use materials which are biodegradable. The expansion in North American operators' ethylene/polyethylene capacity has resulted in lower prices offered to Mexico and South American plastic markets. Given this, despite a drop in the growth rate, the South American plastic industry is expected to witness a positive growth rate in the coming years. The overall demand for limestone in the plastic industry in the region is expected to show marginal growth, however the USA and Canada can be a potential target market where the demand is growing.

Table 21: Quality parameters for limestone to be used in Plastic Industry

Quality parameters	Mean	Range
Calcium Carbonate, $CaCO_3$ (%)	97.97	92 - 99.35
Lime, CaO (%)	54.89	51.55 - 55.67
Magnesia, MgO (%)	0.46	0.15 - 1.2
Silica, SiO_2 (%)	0.46	0.05 - 4.5
Iron oxide, Fe_2O_3 (%)	0.04	0.01 - 0.1
Brightness (%)	92.7	75 - 98.1

Advantage of the use of PCC over GCC in the Polymer Industry

The finer and homogeneous particle size of PCC provides better gloss and a smoother surface finish as well as reduces surface defects in the end-use products. This property of PCC also provides flexibility to form different coated products during the production process

Additionally, PCC improves the profitability of the industry by reducing the manufacturing downtime, reducing the rejection rate due to fewer surface defects and reducing in cost as no further processing aid is required.

Paint

PCC is commonly used in paint and coating applications. It is used as an extender, an agent to either reduce or enhance gloss, an extender/spacer for titanium dioxide, a rheology modifier and as a paint and coating additive to increase the density of the product.

PCC used in paints and coatings has a spatial steric effect. It can increase the whiteness and lustre of the paint film without reducing covering ability. These performance-enhancing qualities have ensured the large-scale acceptance of ultrafine calcium carbonate by the paint industry.

Table 22: Quality parameters for limestone to be used in Paint Industry

Quality parameters	Mean	Range
Calcium Carbonate, $CaCO_3$ (%)	97.80	92 - 99.35
Lime, CaO (%)	54.80	51.55 - 55.67
Magnesia, MgO (%)	0.42	0.15 - 1.2
Silica, SiO_2 (%)	0.72	0.05 - 4.5
Iron oxide, Fe_2O_3 (%)	0.04	0.01 - 0.1
Brightness (%)	92.8	78 – 99

Rubber

Ultrafine PCC is primarily used as a filler by the rubber industry as it increases processing performance. It does not influence vulcanisation and gives the product a smooth surface. Ultrafine PCC can be used together with other reinforcing agents such as carbon black, white carbon black, clay and activated calcium carbonate for oil resistance.

Table 23: Quality parameters for limestone to be used in Rubber Industry

Quality parameters	Mean	Range
Calcium Carbonate, $CaCO_3$ (%)	97.37	92 - 99.35
Lime, CaO (%)	54.56	51.55 - 55.67
Magnesia, MgO (%)	0.62	0.15 - 1.2
Silica, SiO_2 (%)	0.82	0.05 - 4.5
Iron oxide, Fe_2O_3 (%)	0.04	0.01 - 0.1
Brightness (%)	90.6	75 - 98.5

Food, Pharmaceutical and Household

PCC may also be used in production of dairy, healthcare, and consumer goods. In the food industry, high purity PCC is used as an additive to cereals. High-purity calcium carbonate, which is made from dissolving limestone in acid, is used in manufacturing pharmaceutical products, like milk of magnesia, pills, antacids and calcium supplements. In the consumer goods industry, calcium carbonate made from limestone is applied in several everyday items, like cleaning products, washing powder, cosmetics, toothpaste, etc. Some variants of grounded limestone may further be processed to lime form and used in the sugar processing and dairy industry.

Table 24: Quality parameters for limestone to be used in Food and Pharmaceutical Industry

Quality parameters	Mean	Range
Calcium Carbonate, $CaCO_3$ (%)	98.29	97 - 99.5
Lime, CaO (%)	55.07	54.35 - 55.75
Magnesia, MgO (%)	0.29	0.24 - 0.42
Silica, SiO_2 (%)	0.11	0.1 - 0.12
Iron oxide, Fe_2O_3 (%)	0.06	0.011 - 0.1
Brightness (%)	96.5	90-99

Toothpaste

PCC is widely used in toothpastes where it functions as an abrasive as well as filler and is preferred over the other alternates such as silica and dicalcium phosphate because of the price advantage. The abrasive functions as a scrub to remove plaque and other solid materials from the surface of teeth. The abrasive is also formulated to give the toothpaste a desired consistency, which affects the behaviour of the paste, as it is forcibly discharged from its tubing. Fine limestone acts as a mild abrasive and helps in cleaning/maintaining teeth, which are made up of calcium compounds. PCCs, when compared to other dentifrice abrasives such as silica and dicalcium phosphate

Table 25: Quality parameters for limestone to be used in Toothpaste

Quality parameters	Mean	Range
Calcium Carbonate, $CaCO_3$ (%)	98.5	97 - 99.5
Lime, CaO (%)	55.18	54.35 - 55.75
Heavy metal as Pb (%)	0.002	0.001 - 0.003
Lead (%)	0.0003	0.0002 - 0.0004
Iron oxide, Fe_2O_3 (%)	0.06	0.011 - 0.1
Brightness (%)	94	90-98

Advantage of the use of PCC over GCC in the Food Industry

PCC is preferred over GCC in food industry due to its higher purity and lower heavy metals content as per the permissible limit in the industry. Further, the high specific mass, lower particle size and narrow and homogenous particle distribution properties of PCC make it a preferred choice over GCC to be used as filler used in the industry.

Advantage of the use of PCC over GCC in the Pharmaceutical Industry

Purity is the most important criteria for selection of raw materials for use in the pharmaceutical industry. PCC with a lower lead content is therefore preferred over GCC in the industry. The controlled particle size (fine to ultrafine), shape (scalenohedral crystal structure) and size distribution (lower variation in the size of individual particles) makes it a preferred choice as these properties increase the absorption property, make it easy to disperse and reduces the time required for the drug to act against a specific medical condition.

Further the high opacity and brightness of PCC is desirable over GCC as per the standards in pharmaceutical industry.

Other Uses

Additionally, PCC is also used in other end use industries such as building & construction in roofing, flooring and tiles, pool plaster. and in cosmetics for bulking of ointments or creams.

Qualitative Assessment of Jamaica's Limestone and Its Suitability for Manufacturing of End Use Products using PCC

MGD reports reveal large deposit of limestone reserves in the parish of Portland, St. Elizabeth and Trelawny. These deposits are located within the white limestone group, and the research revealed that both the surface and subsurface geology yielded high to very purity limestone (i.e. calcium carbonate concentrations of 97% and above) suitable for the different end use applications.

Table 26: Quality of limestone found in Jamaica

Quality parameters	Portland (Average)	Trelawny (Average)	St. Elizabeth (Average)
Calcium Carbonate, $CaCO_3$ (%)	>99	>99	>98
Magnesia, MgO (%)	~0.60	~0.2	~0.3
Silica, SiO_2 (%)	<0.20	0.50	<0.20
Iron oxide, Fe_2O_3 (%)	<0.10	0.05	0.20
Aluminium Oxide Al_2O_3 (%)	<0.10	<0.15	0.35

Source: Mines and Geology Division (MGD) report

From the existing quality data, it is observed that there is presence of high purity, white limestone formations in many areas with very low to trace concentrations of iron (Fe) and other impurities. In addition to data from MGD, Jamaica already has value-added limestone producers situated in the parishes of St. Ann and St. Elizabeth. Therefore, comparing the quality requirements of different end use industries and MGD's quality data along with existing value-added producers in the island, it is may be inferred that the limestone found in the island is suitable for various value-added products.

Investment opportunity: Growth in the key end use industries

Except for the paper industry, the key end use industry segments of PCC like Agriculture, Water treatment, food and beverage, and Plastic are estimated to grow between 2019 to 2024 period. The paper industry is the only industry which is forecasted to contract on account of switching from physical copies to digital copies in the USA. Despite the decline the overall size of the paper market in USA is very large and can be an attractive export market for Jamaica. Moreover, in Canada and Mexico, a positive growth in the paper industry is envisaged.

Table 27: Americas limestone market by key end-use applications segments of PCC

End use Industry	2016 (in US$ million)	2017 (in US$ million)	2018 (in US$ million)	2019 (est.) (in US$ million)	2024 (f) (in US$ million)	% Growth (2019-2024)
Building and Construction	6,106	6,247	6,465	6,643	7,602	14%
Agriculture	1,822	1,902	1,982	2,046	2,312	13%
Water Treatment	761	806	850	887	1,051	19%
Paper and Pulp	404	407	411	408	406	-1%
Dairy, Food and Beverage, etc.	385	406	426	441	501	14%
Plastics	151	158	164	169	190	13%
Total	9,628	9,925	10,297	10,595	12,063	14%

Source: Mordor Intelligence

Strengths, Weaknesses, Opportunities and Threats (SWOT) Analysis

To assess the growth potential of PCC in Jamaica, a SWOT analysis was conducted. The high-level results of the analysis are contained in the figure below. Findings and primary source interviews and surveys suggest Jamaica is in a strong position to be able to develop the PCC industry due to availability of vast high-purity limestone raw material and export potential in nearby region. In addition, there are opportunities in bringing in new types of financing agreements as well as incentivising new entrants with Special Economic Zones (SEZ) for the manufacture of PCC.

Figure 9: Summary SWOT Analysis for Jamaica's PCC industry

5.0 Financial Highlights

The following discussion contains forward-looking statements that involve risks and uncertainties. A potential investor's actual results may differ materially from those discussed in the forward-looking statements as a result of various factors. Although JAMPRO and its independent advisors, believe that in making any such statements its expectations are based on reasonable assumptions, such statements may be influenced by factors that could cause actual outcomes and results to be materially different from those projected. Prospective investors are cautioned not to place undue reliance on these forward-looking statements, which speak only as of the dates on which they have been made and should conduct their own due diligence. Future events or circumstances could cause actual results to differ materially from or anticipated results.

Financial Highlights

A financial assessment of the valued-added production for PCC in Jamaica was conducted under two scenarios, that is (i) on a standalone basis (start-up) and (ii) an incremental basis (existing limestone operation). The financial results demonstrate positive trends, and therefore a business will have the liquidity to finance the growth potential and ongoing initiatives. The expected financial performance below reflects the position once the plant has become operational (i.e. Year 1).

Table 28: Scenario 1: Summary Incremental Financial Performance

Incremental Financial Performance					
(In US$M)	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Revenue	3.0	3.2	3.3	3.5	3.6
% Growth	N/A	5.2%	5.2%	5.1%	3.7%
EBITDA	1.3	1.4	1.6	1.7	1.8
% Sales	43.3%	44.9%	46.5%	48.1%	48.9%
Net Income	0.6	0.7	0.8	0.9	1.0
% sales	20.8%	22.8%	24.8%	26.8%	28.0%
Net Debt	2.1	1.8	1.4	1.1	0.8

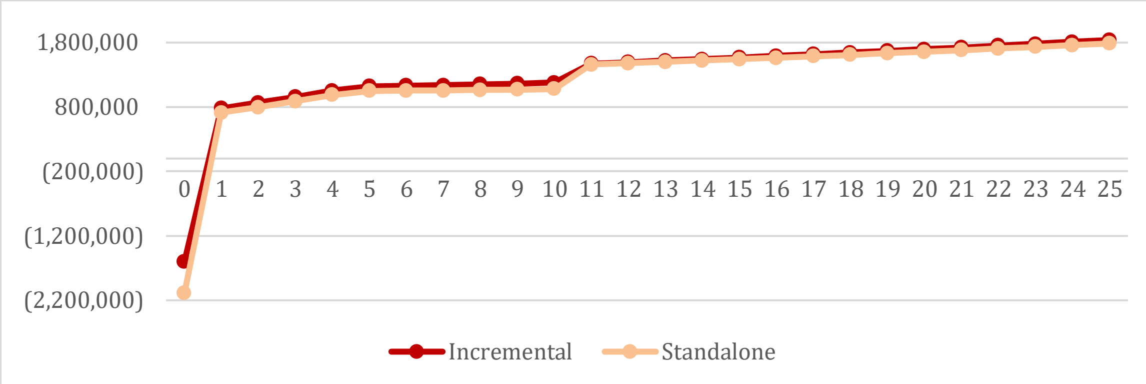
For PCC the projected average net income margin generated is expected to be in excess of 25% and is expected to be adequate to finance assumed debt.

Table 29: Scenario 2: Summary Standalone Financial Performance

Standalone Financial Performance					
(In US$M)	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Revenue	3.0	3.2	3.3	3.5	3.6
% Growth	N/A	5.2%	5.2%	5.1%	3.7%
EBITDA	1.3	1.4	1.5	1.7	1.8
% Sales	43.0%	44.7%	46.3%	47.9%	48.7%
Net Income	0.5	0.6	0.7	0.8	0.9
% sales	17.1%	19.3%	21.6%	23.7%	25.1%
Net Debt	2.7	2.3	1.9	1.5	1.0

For PCC the projected average net income margin generated is expected to be in excess of 20% and is expected to be adequate to finance assumed debt.

Figure 10: Forecasted Cash Flow



Net cashflow in Year 0 of US$1.6 million includes investment in incremental setup of US$4.0 million and debt finance US$2.4 million (60%). The average cash position over the projected period will be +US$1.4 million.

Net cashflow in Year 0 of US$2.1 million includes investment in standalone setup of US$5.2 million and debt finance US$3.1 million (60%). The average cash position will be +US$1.4 million

Investment Cost

The investment required to produce 30,000 tonnes of PCC on a standalone (start-up) basis and an incremental basis is US$5.2 million and US$4.0 million respectively. (See Appendix 1 for details).

Revenue Forecast

PCC is projected to be sold at a price of USD$104.9 per tonne in year one (1). Growth in sales is expected to remain between 3.5%-4.0% in line with market CAGR. For consistency, the price of PCC has been increased in line with the current price inflation within the Americas that produce and sell similar value-added products.

Projected Profit and Loss

Scenario 1: Stand-Alone Basis (start-up)

Table 29 below shows a five (5) year analysis of a start-up operation. The production of PCC on a stand-alone basis is expected to yield a net profit of US$515,111 in year one (1) and this is projected to increase to US$914,879 by year five (5). Gross and net profit margins are forecasted to average 96% and 21% respectively over the 5-year period.

Table 30: Proforma financial performance for PCC on a stand-alone basis

Amounts in USD$'	Year 1	Year 2	Year 3	Year 4	Year 5
Revenue:					
Unit Sales (tonne)	28,784	29,187	29,596	30,000	30,000
Price per (tonne)	104.9	108.8	112.8	117.0	121.3
Total Revenue	**3,019,653**	**3,175,220**	**3,338,800**	**3,509,620**	**3,639,476**
Cost of Sale:					
Raw material	63,932	66,298	68,751	71,295	73,933
Variable Labour	63,932	65,211	66,515	67,845	69,202
Total Cost of Sales	127,865	131,509	135,266	139,140	143,135
Gross profit	**2,891,788**	**3,043,711**	**3,203,534**	**3,370,480**	**3,496,341**
Operating Expenses					
Total operations Expenses	1,592,816	1,624,673	1,657,166	1,690,309	1,724,116
EBITDA	1,298,972	1,419,038	1,546,368	1,680,171	1,772,226
Net Profit / (losses)	**515,111**	**613,492**	**720,947**	**833,201**	**914,879**

Scenario 2: Incremental Basis (existing limestone operation)

Table 31 below shows a five (5) year analysis on an incremental basis. The production of PCC on an incremental basis is expected to yield a net profit of US$628,103 in year one (1) and this is projected to increase to US$1,017,851 by year five (5). Gross and net profit margins are forecasted to average 92% and 26% respectively over the 5-year period.

Table 31: Proforma financial performance for PCC on an incremental basis

Amounts in USD$'	Year 1	Year 2	Year 3	Year 4	Year 5
Revenue:					
Unit Sales (tonne)	28,784	29,187	29,596	30,000	30,000
Price per (tonne)	104.9	108.8	112.8	117.0	121.3
Total Revenue	**3,019,653**	**3,175,220**	**3,338,800**	**3,509,620**	**3,639,476**
Cost of Sale:					
Raw material	63,932	66,298	68,751	71,295	73,933
Variable Labour	63,932	65,211	66,515	67,845	69,202
Total Cost of Sales	127,865	131,509	135,266	139,140	143,135
Gross profit	**2,891,788**	**3,043,711**	**3,203,534**	**3,370,480**	**3,496,341**
Operating Expenses					
Total operations Expenses	1,585,326	1,617,032	1,649,373	1,682,360	1,716,007
EBITDA	1,306,463	1,426,679	1,554,162	1,688,120	1,780,334
Net Profit / (losses)	**628,103**	**724,649**	**829,422**	**939,009**	**1,017,851**

Return on Investment

On an indicative basis over a projected duration of 25 years, the internal rate of return (IRR) could range from 25.6% to 32.3% and net present value (NPV) range from US$12.1M to US$13.2M on a standalone and incremental basis respectively when future cash flows were discounted using a discount rate of 14.3%.

Table 32: Investment appraisal results

Scenario	NPV	IRR	Payback Period
Stand-Alone Basis	**US$12.1M**	**25.6%**	**2.8 years**
Incremental basis	**US$13.2M**	**32.3%**	**2.1 years**

Sensitivity Analysis

A sensitivity analysis was conducted to ascertain the variability and vulnerability of the investment to macro or micro environmental factors. The result is presented in Table 32 below.

Table 33: Sensitivity Analysis – Impact of Change in Sales Growth

Scenario	NPV	IRR	Payback Period (years)	NPV	IRR	Payback Period (years)
	Stand-Alone Basis			**Incremental Basis**		
-0.75	-3.3	-	-	-2.2	-	-
-0.50	-1.9	-5.7%	-	-0.8	1.1%	-
-0.25	2.3	12.3%	7.5	3.5	17.4%	2.7
0.00	12.1	25.6%	2.8	13.2	32.3%	2.1
+0.25	31.1	39.3%	2.3	32.3	47.6%	1.8
+0.50	64.0	53.3%	2.1	65.4	63.0%	1.6
+0.75	116.6	67.2%	2.0	118.3	78.2%	1.5

Key Assumptions

To assess the indicative feasibility of the production of PCC as a value-added product in Jamaica, the following key assumptions were made:

Input	Inputs/ Assumptions	Source for Information
Production Capacity	Peak production capacity has been considered to be 30,000 tonnes per annum	The peak production capacity is considered based on typical start-up level plant set-up or an incremental build up to an existing operation.
Sales Volume	Sales volume is estimated at 95% of production level. It is assumed that the Jamaica could take 0.1% of the market share of the sales volumes within the Americas for PCC end user products.	
Revenue	US$105 per tonne. Growth in revenues are expected to remain at 2% plus indexation in line with market CAGR.	This represent average prices derived from primary researched in North America and the Caribbean
Cost of Sales	Raw Material US$ 2.0 per tonne Variable Labour US $2.0 per tonne	Average cost is determined by market survey of operators for cost to produce limestone within the local market.
Operational Expense	US$ 52.8 to US$53.9 per tonne (includes: Environment Management Cost, Power Cost, Plant Cost, Admin Cost, Logistics and Transfers, Advertising and Corporate Social Responsibility, Other Utilities, Other Expenses)	This represents the average cost derived from primary market research.
Financing Option	Debt Vs Equity Mix of 60%/40%. Interest rate 6% Debt tenure- 10 years.	These assumptions represent cost to finance investment both on a start-up and incremental level. Capital Expenditure (CAPEX) replacement is assumed to be financed by working capital thereafter.

Role of JAMPRO

JAMPRO is the national trade and investments promotions agency in Jamaica. One of our key functions is the packaging and promotion of investment opportunities and the conversion of investment prospects into viable projects. JAMPRO was first established in 1988 to stimulate, facilitate and promote the development of trade and industry, export and investment activities in all sectors of the island's economy. The agency drives this process through focusing on a number of targeted sectors which include tourism.

JAMPRO works closely with local and global entrepreneurs seeking to tap into the many investment and trade opportunities in Jamaica. In facilitating both local and foreign direct investment, JAMPRO guides investors through the necessary processes and offers support in partnership with key government agencies and ministries, even after their investments are operational.

JAMPRO also provides an array of services to the export community – including export registration and provides export development advice and export promotion (exposure for goods and services entering the export markets).

6.0 Appendices

6.1. Appendix 1: Financial Model

Input	Inputs/ Assumptions	Source for Information
Land Cost	Land acquisition cost has been arrived at based on cost of each hectare of land as obtained through primary research (US$ 30,000/hectare).	Where the mine/ quarry establishments will already be there plant set-up, one (1) hectare of additional land has been considered for PCC. The land estimate typically includes area required for plant facility, workshop, storage area, waste dump, worker camps, etc.
Equipment Cost	The vehicles required for transportation within plant premises will be procured. The vehicles considered for capital investment includes truck and wheel loader. Further, it is considered that for in-bound and out-bound logistics, hired vehicles will be used and the associated costs will be covered in operating expenses.	For truck and wheel loader, the landed cost in Jamaica is estimated after considering the equipment cost in the USA with provisioning and contingencies added for transportation cost and duties. No additional cost is considered for these for where facility already exist.
Processing Capital Cost	Crushing, screening, grinding and packaging systems, lime kiln, hydration and carbonation unit along with supporting plant equipment has been considered under processing capital cost for PCC.	For PCC the processing equipment has been assumed to be procured from China (due to lower procurement cost of the required equipment when compared to the procurement cost from the USA) with provisioning and contingencies added for transportation and duties. In addition, a semi-mechanised packaging facility will be used, due to the very fine mesh size of the grounded limestone which is not suitable for manual packaging.
Power	It is considered that power will be available from grid. However, in case of power cuts, the plant will be operated using a Diesel generator.	It is considered that grid connection will already be in the establishment along with backup generators and hence no incremental cost is taken for power connection/ set-up for financial analysis.
Infrastructure	This will cover the necessary infrastructure required for operations covering shed, laboratory facilities and other relevant infrastructure facilities.	The infrastructure cost is based on typical industry standard costs for additional infrastructure required for setting up of the value-added plants.
Laboratory	A laboratory is considered for testing basic mineral content and size. A capital expenditure of US$ ~0.43 Million would be sufficient for basic grade testing in Jamaica.	Based on industry standard cost for basic laboratory testing equipment.
Contingency	A 5% contingency on total capital cost is applied to cover the budgetary effect of project threats or uncertainties	-

Table 34: Estimated capital expenditure for a PCC Plant

#	Description	Stand alone Capital Cost (US$ Millions)	Incremental Capital Cost (US$ millions)
1.	Land cost	0.39	0.08
2.	Equipment cost (truck, wheel loader, etc.)	0.64	0.50
3.	Processing set-up cost	2.72	2.72
4.	Power cost	0.68	-
5.	Infrastructure cost	0.10	0.07
6.	Laboratory set-up cost	0.43	0.43
7.	Contingency @5%	0.25	0.19
	Total Estimated Capital Expenditure	**5.21**	**3.99**

Source: PwC Analysis

Table 35: Summary Pro Forma Income Statement Summary – Incremental Basis

Precipitated Calcium Carbonate (PCC)					
Income Statement Summary					
Incremental Case					
	Year 1	Year 2	Year 3	Year 4	Year 5
Income	3,019,653	3,175,220	3,338,800	3,509,620	3,639,476
Cost of Sales	127,865	131,509	135,266	139,140	143,135
Gross Margin	**2,891,788**	**3,043,711**	**3,203,534**	**3,370,480**	**3,496,341**
Operating Expenses					
Staff cost	312,404	318,652	325,025	331,526	338,156
Technical consultancy	31,240	31,865	32,503	33,153	33,816
Insurances	23,940	24,419	24,907	25,405	25,913
Logistics and transfers	192,780	196,636	200,568	204,580	208,671
Equipment	69,491	70,881	72,299	73,745	75,220
Plant expenses	456,551	465,682	474,995	484,495	494,185
Power	233,255	237,920	242,678	247,532	252,483
Other Utilities	111,525	113,756	116,031	118,351	120,718
Advertising services	95,208	97,112	99,054	101,035	103,056
Security services	15,620	15,933	16,251	16,576	16,908
Other Expenses	38,550	39,321	40,108	40,910	41,728
Total Operating Expenses	**1,580,565**	**1,612,177**	**1,644,420**	**1,677,308**	**1,710,855**

Precipitated Calcium Carbonate (PCC)					
Income Statement Summary					
Incremental Case					
	Year 1	Year 2	Year 3	Year 4	Year 5
Environmental	4,760	4,856	4,953	5,052	5,153
Depreciation	326,455	326,455	326,455	326,455	326,455
Loan Interest	142,537	134,026	121,812	109,653	96,745
Total Non-Operating Expenses	**473,752**	**465,336**	**453,219**	**441,160**	**428,352**
Profit Before Taxes	837,471	966,198	1,105,895	1,252,012	1,357,134
Taxes	209,368	241,550	276,474	313,003	339,284
Net Income	**628,103**	**724,649**	**829,422**	**939,009**	**1,017,851**

Source: PwC Analysis

Table 36: Summary Pro Forma Income Statement Summary – Standalone Basis

Precipitated Calcium Carbonate (PCC)					
Income Statement Summary					
Standalone Case					
	Year 1	Year 2	Year 3	Year 4	Year 5
Income	3,019,653	3,175,220	3,338,800	3,509,620	3,639,476
Cost of Sales	127,865	131,509	135,266	139,140	143,135
Gross Margin	**2,891,788**	**3,043,711**	**3,203,534**	**3,370,480**	**3,496,341**
Operating Expenses					
Staff cost	312,404	318,652	325,025	331,526	338,156
Technical consultancy	31,240	31,865	32,503	33,153	33,816
Insurances	31,248	31,873	32,510	33,161	33,824
Logistics and transfers	192,780	196,636	200,568	204,580	208,671
Equipment	69,491	70,881	72,299	73,745	75,220
Plant expenses	456,551	465,682	474,995	484,495	494,185
Power	233,255	237,920	242,678	247,532	252,483
Other Utilities	111,525	113,756	116,031	118,351	120,718
Advertising services	95,208	97,112	99,054	101,035	103,056
Security services	15,620	15,933	16,251	16,576	16,908
Other Expenses	38,733	39,508	40,298	41,104	41,926
Total Operating Expenses	**1,588,056**	**1,619,817**	**1,652,213**	**1,685,258**	**1,718,963**

Precipitated Calcium Carbonate (PCC)					
Income Statement Summary					
Standalone Case					
	Year 1	Year 2	Year 3	Year 4	Year 5
Environmental	4,760	4,856	4,953	5,052	5,153
Depreciation	426,109	426,109	426,109	426,109	426,109
Loan Interest	186,048	174,939	158,997	143,127	126,278
Total Non-Operating Expenses	**616,918**	**605,904**	**590,058**	**574,287**	**557,540**
Profit Before Taxes	686,815	817,990	961,263	1,110,935	1,219,839
Taxes	171,704	204,497	240,316	277,734	304,960
Net Income	**515,111**	**613,492**	**720,947**	**833,201**	**914,879**

Source: PwC Analysis

6.2. Appendix 2: Excerpts from Mordor Intelligence Report

Americas Limestone Market, By End-user Industry, 2016-2024 (in US$ Million)

End-user Industry	2016	2017	2018	2019 (est.)	2024 (f)	(%) CAGR (2019-2024)
Paper and Pulp	403.62	406.53	410.59	408.35	405.87	-0.12%
Water Treatment	761.01	806.11	850.26	886.88	1,051.24	3.46%
Agriculture	1,821.85	1,901.76	1,981.71	2,046.36	2,312.14	2.47%
Plastics	150.77	157.51	163.96	169.22	190.44	2.39%
Building and Construction	6,105.74	6,247.16	6,464.50	6,642.60	7,601.84	2.73%
Steel Manufacturing and Other Industries (including Energy)	493.14	527.14	557.89	579.96	687.40	3.46%
Others	384.94	405.76	425.77	441.45	501.47	2.58%
Total	10,121.08	10,451.96	10,854.68	11,174.84	12,750.40	2.67%

Americas Limestone Market, By End-user Industry, 2016-2024 (in kilometric tonnes)

End-user Industry	2016	2017	2018	2019 (est.)	2024 (f)	(%) CAGR (2019-2024)
Paper and Pulp	19,179.25	18,901.78	18,595.46	18,263.53	17,847.98	0.46%
Water Treatment	36,609.73	37,772.54	38,884.27	39,960.22	46,038.91	2.87%
Agriculture	73,742.33	74,963.56	76,211.45	77,535.55	85,583.14	1.99%
Plastics	6,853.15	6,997.10	7,127.19	7,253.24	7,949.25	1.85%
Building and Construction	449,940.35	450,210.95	456,097.43	461,806.59	17,059.20	2.29%
Steel Manufacturing and Other Industries (including Energy)	25,226.35	26,403.56	27,363.07	27,990.61	32,276.74	2.89%
Others	17,488.10	17,902.65	18,297.19	18,693.00	20,736.89	2.10%
Total	629,039.25	633,152.13	642,576.06	651,502.74	727,492.11	2.23%

6.3. Appendix 3: Waste and Pollution Control in the Production of PCC

Introduction

Precipitated Calcium Carbonate (PCC) is generally produced in continuity with quicklime and slaked lime and includes steps such as raw material handling, crushing, calcination, cooling of calcined product, slaking/hydration of quicklime along with screening, carbonation, filtration, drying and packaging. The conversion of limestone to PCC may lead to generation of pollutions in the form of air emissions, wastewater generation, solid waste generation and noise pollution. Although, such pollution through PCC production may not cause significant footprint on a global or even regional scale; however, PCC production plants may lead to significant pollution on a local scale. Therefore, best industry practices shall be followed during the plant operation to minimize or control pollution within permissible limits.

Waste generation and pollutants in production line

Some of the key areas which may lead to the generation of unwanted wastes in the production line of Precipitated Calcium Carbonate are stated below: –

- Particulate Matter or Fugitive Dust emission – raw material handling & storage, crushing, screening, conveyors & transfer points, kiln & cooler operation, boiler, rotary drying, product storage in silos, packaging & dispatch
- Gaseous pollutants – exhaust gases of Kiln and boiler containing SO, NO, CO_2, CO, etc.
- Solid waste – unburnt particles during calcination in Kiln, screening of slaking and carbonation product, boiler dust and bag filter dust
- Wastewater – drainage water, hydration system, filtration water
- Metals – kiln refractories, metals present in raw material, etc.

The key wastes and pollutants generated in the process may lead to various forms of pollution and may cause a significant damage to the local environment, if not treated properly. Below, the wastes and pollutants are segmented into different categories and their generations are discussed briefly.

a. Air pollution

PCC production leads to emissions of particulate matter (PM), gaseous pollutants (including carbon monoxide (CO), carbon dioxide (CO_2), sulfur oxides (SO), and nitrogen oxides (NO) and Metals.

- **Particulate Matter (PM)**

Particulate matter is the sum of all solid and liquid particles suspended in air many of which can be hazardous in nature. This complex mixture includes both organic and inorganic particles, such as dust, soot, smoke, and liquid droplets, etc.

The Rotary Kiln, used for calcination, is the largest source of PM emissions during the production of limestone products. Dust from attrition within the kiln system and from fuel ash generated in kiln and boiler burner is the major sources of emission. Further, PM emissions can also occur from coolers, but these are limited only in plants where exhaust gases are not recycled back through the kiln. In addition to these sources, PM emissions can also occur at primary and secondary crushers, screens, mechanical & pneumatic transfer points, rotary drying, storage piles, packaging and in-plant machineries.

- **Other Gaseous pollutants**

Unwanted gaseous pollutants like Sulfur oxides, Nitrogen oxides, Carbon monoxide and Carbon dioxide are produced along with limestone products.

  - **Sulphur emissions**

    Sulphur Oxides emissions are influenced by several factors, including

1. Sulphur content in the fuel used in kiln and boiler operation are a major cause of emission, particularly coal and petroleum derived coke with high level of Sulphur (~5% by weight) may cause significant emissions. Therefore, natural gas may be considered the preferred form of fuel.
2. Sulphur content and mineralogical form (metal sulphide such as pyrite, or sulphates such as gypsum) of Sulphur present in the limestone feed. During the calcining operation, sulphide and sulphates present in the limestone gets decomposed to yield sulphur dioxide. The release is mainly in the form of SO_2 (99%) although some SO_3 is also produced (generally in permissible limits).
3. Quality of PCC being produced, will also have impact on SO emissions, as the fuel type and operating conditions may vary based on the requirement.
4. Type of kiln being used for calcination also affects the amount of SO release from the kiln exhaust. As the SO is mainly arrested within the kiln by its reaction with quicklime therefore, the SO arresting capacity changes significantly with the kiln design.

- **Nitrogen emissions**

The oxides of nitrogen are produced through the reaction of the nitrogen and oxygen in the air and through the oxidation of the nitrogen compounds contained in the fuel. There is a significant increase in the amount of oxides of nitrogen (mainly nitric oxide) which is formed at temperatures above 1400°C. The production and emission of such nitrous pollutants are dependent on: -

1. Temperature inside the kiln as the formation of NO_x steeply increases above 1400°C.
2. Amount of excess air present in the flame, with higher oxygen content enhancing formation.
3. Quality of raw material feed to the kiln can also be a major factor affecting the NO_x production.

- **Carbon emissions**

Carbon monoxide and Carbon dioxide are the major gaseous pollutants of carbon formed during manufacturing of PCC from limestone. The pollutants are formed either due to direct or indirect emission: -

1. Due to the incomplete combustion of carbonaceous fuel and even with good combustion control some amount of CO will be present in combustion gases. (Direct emission)
2. Dissociation of limestone produces up to 0.8 to 1.2 tonnes of carbon dioxide (CO_2) per tonne of quicklime, and varies depending on the composition of the limestone, the degree of calcination, chemical composition of fuel and heat used per tonne of quicklime production (Direct emission). Although, in PCC production, the CO_2 produced in the kiln is taken for carbonation process, however there is still some amount of Carbon emissions along with the kiln exhaust.
3. The carbon emissions can also take place from the burning of fuel in boilers for the generation of steam used in rotary dryer operation.
4. Indirect emission relates to the generation of utilities, e.g. electricity, used all through the value chains. From a regulatory standpoint the indirect emissions are allocated to the source, i.e. the power plant.

Further, the total carbon emission can be divided into two types according to its process of formation i.e. either through process emission (dissociation of limestone) or through combustion emission (fuel burning, incomplete combustion, etc.).

- **Metal emissions**

Metals released from the kiln system arise from quantities contained in the raw materials and fuel. The release of metals is characterized by cycles within the kiln system and their volatility. Metals (and their compounds) fall into three major classes:

1. Refractory (relatively non-volatile), including barium, beryllium, chromium, arsenic, nickel, vanadium, aluminium, titanium, calcium, iron, manganese and copper;
2. Semi volatile, such as antimony, cadmium, lead, selenium, zinc, potassium and sodium;
3. Volatile, such as mercury and thallium.

Metals released from the kiln system are absorbed into the quicklime or in the kiln exhaust gases or in the lime dust. The high alkali content and the scrubbing action within kilns favours retention of metals within the quicklime.

b. Water pollution

In the PCC production plant, wastewater is generated mainly from utility operations i.e. water used for cooling purposes in different phases of the process (e.g. bearings, kiln rings) and water recovered during filtration of carbonated product. Also the water used for washing of heavy machineries or equipment reports to wastewater stream. Process wastewater with high pH and suspended solids may be generated in some operations like Slaking/Hydration and during filtration of carbonated products as well. Further, the storm or rain water may carry dust particles settled on the floor along with it and may result in waste water generation and pollute ground water table.

c. Noise pollution

Noise pollution is related to several PCC manufacturing phases, including raw material storage, crushing, intermediate and final product handling and transportation, operation of exhaust fans, etc. These processes can be categorized as follows:

- **Material handling** – Storage of raw material and extraction for feeding to process
- **Heavy machinery** – Primary & secondary crushers, fan casings, motors / couplings and compressors.
- **Air-flow generator** – Primarily stack exhausts, fan inlet/outlet or air intake and ventilation units.
- **Internal transport –** Within the curtilages of the site, the transport of raw materials and finished products are technically associated activities.

d. Other wastes or by-products

The most significant potential solid waste from PCC production process is particulate matter collected in dust abatement devices. This dust tends to concentrate trace impurities in fuels and raw materials such as certain semi-volatile metals. Whether recycling of solid waste is possible or not will depend on process-specific factors such as the particular fuels, raw materials, products and methods of operation. In general, the waste streams comprise:

- Dust collected in particulate abatement devices
- Materials arising from process clean outs
- Spent kiln liner bricks
- Screened out Un-burnt particles from kiln product
- Waste oils and lubricants
- Chemical containers and general inert industrial waste

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