



--	--	--	--	--	--	--

REV.	DESCRIPTION	DATE	PROJ.	EXEC.	CHECK.	APPR.
3	ISSUED	4/4/18	SAG	MES	MES	MES
2	FINAL	8/14/16	SAG	MES	MES	MES
1	FOR REVIEW	7/30/16	SAG	SAG	KJS	MES
0	FOR REVIEW	6/9/16	SAG	SAG	KJS	MES

 Pure Fonte Ltée	<b>PURE FONTE LTÉE</b> <b>PIG IRON PRODUCTION PLANT – FEASIBILITY STUDY</b> <b>CUSTOMER N°: 1821</b>
--	--

  	TENOVA TECHINT ENGINEERING & CONSTRUCTION
	<b>SECTION 1 - SUMMARY</b> <b>CHAPTER 1.2</b> <b>PROJECT TARGET AND JUSTIFICATION</b>

TENOVA RESERVES OWNERSHIP OF THIS DOCUMENT, WITH THE PROHIBITION TO REPRODUCE, MODIFY OR TRANSFER TO OTHER COMPANY OR PERSON, IN WHOLE OR IN PART, WITHOUT PREVIOUS WRITTEN PERMISSION.		<b>REVISION 3</b>  REVISION
	ESC.: N/A      JOB: CD-335	

---

# CONTENTS

---

1.2	PROJECT TARGET AND JUSTIFICATION .....	4
1.2.1	<i>Project objectives</i> .....	4
1.2.1.1	PURE FONTE LTÉE Mission .....	4
1.2.1.2	Target market.....	6
1.2.1.3	Product Quality .....	8
1.2.1.4	Environment.....	10
1.2.2	<i>Project Highlights</i> .....	11
1.2.3	<i>Expected business lifetime</i> .....	12
1.2.3.1	Foundry Market .....	12
1.2.3.2	EAF Steel Market.....	13
1.2.3.3	MPI Pricing .....	14
1.2.3.4	Possible business expansion .....	14
1.2.4	<i>Future business routes</i> .....	15

---

## FIGURES AND REFERENCES

---

FIGURE 1.2-1.: NORTH AMERICAN MPI IMPORTS BY ORIGIN AND DESTINATION, SOURCE CRU .....	7
FIGURE 1.2-2.: CONSUMPTION OF MPI IN USA, CANADA AND EUROPE, SOURCE CRU .....	7
FIGURE 1.2-3.: SOLID PIG IRON BEFORE BEING UTILIZED IN A FOUNDRY AND LIQUID METAL PROCEEDING FROM PIG IRON MELTING.....	8
FIGURE 1.2-4.: DIFFERENT TYPES OF MPI.....	9
FIGURE 1.2-5: CO <sub>2</sub> EMISSIONS FROM DIFFERENT STEELMAKING ROUTES SHOWING THAT THE PROCESS SELECTED BY PURE FONTE LTÉE HAS THE LOWEST ENVIRONMENTAL FOOTPRINT AND PHOTO OF A CO <sub>2</sub> ABSORPTION PLANT .....	10
FIGURE 1.2-6: PURE FONTE LTÉE INVESTMENT WILL BE OF HIGH SIGNIFICANCE FOR THE QUEBEC REGION.....	12
FIGURE 1.2-7.: GLOBAL MPI MARKET OPPORTUNITY 2014-2025 .....	12
FIGURE 1.2-8.: GLOBAL EAF STEEL PRODUCTION, SOURCE CRU.....	13
FIGURE 1.2-9.: MPI & IRON ORE PRICES, SOURCE CRU .....	14
TABLE 1.2-1.: TYPICAL PIG IRON SPECIFICATIONS [1] .....	8
TABLE 1.2-2.: SOLID PIG IRON BEFORE BEING UTILIZED IN A FOUNDRY AND LIQUID METAL PROCEEDING FROM PIG IRON MELTING .....	9
TABLE 1.2-3.: TOP 10 IRON CASTING PRODUCING COUNTRIES, 2013 T [2] .....	12
TABLE 1.2-4.: IMPORTS OF MPI 2005-2015 [3] .....	13

### Chapter's references:

- [1] IIMA, "Nodular Pig Iron for Foundries Producing Ductile Iron Castings," [Online]. Available: <http://metallics.org.uk/nodular-pig-iron-for-foundries-producing-ductile-iron-castings/>.
- [2] Modern Casting Staff, "48th Census of World Casting Production - Steady Growth in Global Output," Modern Casting, 2014.
- [3] IIMA, [Online]. Available: <http://metallics.org.uk/document-library/>.

## 1.2 Project target and justification

### 1.2.1 Project objectives

#### 1.2.1.1 PURE FONTE LTÉE Mission

PURE FONTE LTÉE has defined four main mission statements and for each one of them a market justification is presented. These mission statements have been the basis for the development of the Feasibility Study, in the selection of the technology and the definition of project construction and execution details.

Volumes:

- Become the dominant supplier of MPI to the Western Hemisphere's iron foundry industry

Market justification:

- The United States and Western Europe have two of the world's largest iron foundry industries and little MPI capacity
- 75% of MPI supplied to the United States is imported from Brazil or Russia. Russia and the Ukraine supply the majority of MPI to Western Europe

Quality:

- Produce high quality MPI using local resources

Market justification:

- PURE FONTE LTÉE's production flowsheet will allow for the use of iron ore pellets from Quebec, electricity from Hydro Quebec & natural gas from Gaz Metro

Value chain:

- Complement, rather than compete with, Canada's established iron ore mining industry

Market justification:

- PURE FONTE LTÉE will be a customer of, not a competitor to, Canadian iron ore miners

Cost:

- Utilize inherent advantages of Quebec and Port Saguenay to produce pig iron in the 1st quartile of the global cost curve

Market justification:

- Significant shipping cost advantage to the U.S. and Western Europe compared to Brazilian/Russian exporters
- Available low cost production inputs; iron ore, electricity and natural gas, lowers conversion costs
- Low cost basis allows for production throughout economic cycles

Environmental Stewardship:

- Be a global leader on minimizing environmental emissions

Market justification:

- Environmental stewardship is increasingly important to government partners, as well as investors and other stakeholders
- Leadership in GHG emissions, water management and overall environmental impact is required for new projects in Western Jurisdictions

### 1.2.1.2 Target market

MPI is a source of metallic iron derived from smelting of iron ore concentrate. It is used, along with scrap steel, to produce steel and iron castings in foundries, and to make high value crude steel in EAFs. Pig iron has a consistent chemistry and high iron content and thus trades at a premium to scrap steel.

PURE FONTE LTÉE plans to sell to the United States and European MPI markets, two of the largest consumers of MPI. MPI comprises three main types:

- Basic pig iron (“BPI”): used in both EAF steel making and iron foundries for less specialized products. It is the most commonly traded MPI product
- Foundry pig iron (“FPI”): used in mainly in the manufacture of grey iron castings in cupola furnaces
- Nodular pig iron (“NPI”): used in the manufacture of ductile iron castings

The difference between the three types of MPI is their chemistry and impurity levels. NPI has the most stringent requirements and the lowest levels of undesirable elements such as manganese, phosphorus and sulfur.

NPI trades at a significant premium to BPI which can reach levels over US\$100/t.

PURE FONTE LTÉE will produce NPI targeting the highest grades and highest prices.

MPI of all qualities is largely imported into the United States and Europe from Brazil, Russia and the Ukraine, creating a market opportunity for a new entrant.

While a majority of the MPI imported into the United States enters through New Orleans (“NOLA”), or the Gulf Coast, a significant portion of this is consumed in the Midwest and must be barged up the Mississippi River. This creates a market opportunity for a supplier to ship from Canada, along the St Lawrence Seaway, at a cost below that to barge from NOLA thus capturing profit margin over competitors.

The NPI market in the United States and Western Europe is each around 400,000 to 500,000 mtpa. This market has the potential to grow both through organic growth of the foundry industry, as well as increased consumption should more product become available.

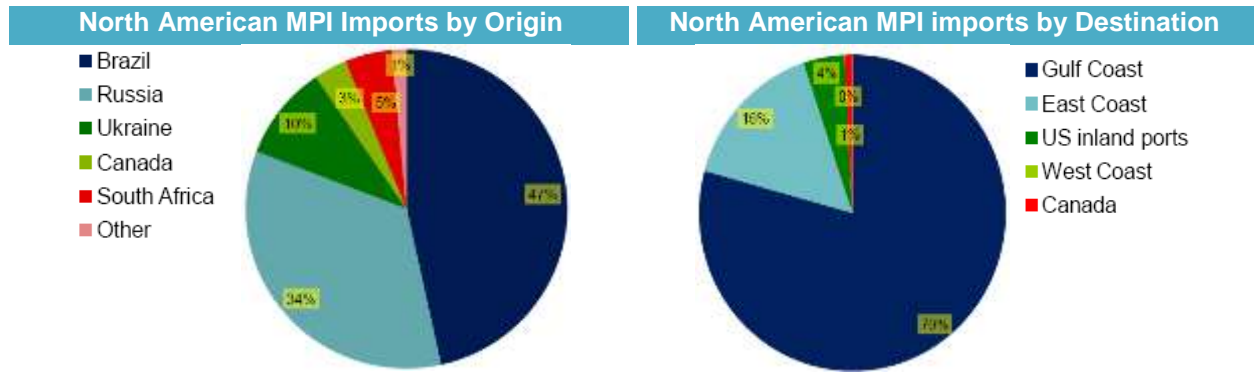


Figure 1.2-1.: North American MPI imports by origin and destination, source CRU

NPI is currently being offered FOB ship at Brazilian port for US\$380/t. After transportation and logistics, including ocean transport to NOLA, transhipping to barges and barging from NOLA to the Midwest, this equates to US\$450/t warehouse in Chicago. Based on its logistical advantages, PURE FONTE LTÉE would be able to sell its NPI at over roughly US\$425/t FOB ship in Saguenay, based on today's market conditions.

Consumption of MPI										
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
<b>USA</b>	7.7	5.6	5.0	2.2	3.2	3.6	4.4	4.1	4.6	4.5
<b>Canada</b>	0.0	0.1	0.3	0.2	0.1	0.0	0.0	0.0	0.1	0.1
<b>Europe</b>	10.0	11.0	10.5	7.0	7.2	7.1	7.2	5.2	4.8	4.8
<b>Total</b>	<b>17.7</b>	<b>16.7</b>	<b>15.8</b>	<b>9.4</b>	<b>10.5</b>	<b>10.7</b>	<b>11.6</b>	<b>9.3</b>	<b>9.4</b>	<b>9.3</b>

Figure 1.2-2.: Consumption of MPI in USA, Canada and Europe, source CRU

PURE FONTE LTÉE intends to start producing **425,000 tons per year of NPI**

### 1.2.1.3 Product Quality

Considering the typical Canadian BF pellet that PURE FONTE LTÉE intends to utilize, the final composition of the Pig Iron that will be produced by PURE FONTE LTÉE will be better than the Nodular Pig Iron specified by the International Iron Metallic Association (IIMA).

Typical Pig Iron Chemical Specifications

	<b>C</b>	<b>Si</b>	<b>S</b>	<b>P</b>	<b>Mn</b>
Basic	3.5 – 4.5	< 1.5	< 0.05	< 0.12	0.5 – 1.0
Foundry	3.5 – 4.5	1.5 – 3.5	< 0.05	< 0.12	0.5 – 1.0
<b>Nodular</b>	3.5 – 4.5	<b>0.05 – 2</b>	<b>&lt; 0.02</b>	<b>&lt; 0.04</b>	<b>&lt; 0.05</b>

Table 1.2-1.: Typical Pig Iron specifications [1]

The PURE FONTE LTÉE process foresees that iron ore pellets are reduced and carburized in the Energiron<sup>®</sup> ZR module to reach a value of 5% C and 94% iron metallization. The subsequent melting process will bring the pig iron to the required range of 3.5% to 4.5%, while the other elements will stay below the limits set by IIMA.



Figure 1.2-3.: Solid Pig Iron before being utilized in a foundry and liquid metal proceeding from pig iron melting

For certain foundry applications, called nodular ductile castings or spheroidal ductile castings, pig iron specs are even more strict, as per the following table.



**Pig Iron for special foundry applications**

	<b>C</b>	<b>Si</b>	<b>S</b>	<b>P</b>	<b>Mn</b>
<b>Triple Five</b>	3.5 – 4.5	< 0.5	< 0.020	< 0.050	< 0.050
<b>T35</b>	3.5 – 4.5	< 0.5	< 0.002	< 0.035	< 0.035
<b>Russian</b>	3.5 – 4.5	< 1.0	< 0.020	< 0.055	< 0.090

Table 1.2-2.: Solid Pig Iron before being utilized in a foundry and liquid metal proceeding from pig iron melting

The requirements of these grades is to minimize Silicon, Sulphur, Manganese and Phosphorous content. Triple-Five grade is the main grade used in these particular foundry applications for ductile castings.

Another important characteristic of the pig iron used for ductile castings is to have very low values of the so called trace elements like Titanium, Vanadium, Chromium and Tin. Foundries can tolerate up to and around 0.03% or 0.04%. There is also a cumulative effect, particularly with Vanadium and Titanium, for these two elements the limit is 0.04% in aggregate.

With the process proposed in this Feasibility Study (using a clean raw material source), PURE FONTE LTÉE will be able to hit these tight limits and so will enjoy a particularly high premium price for its product.

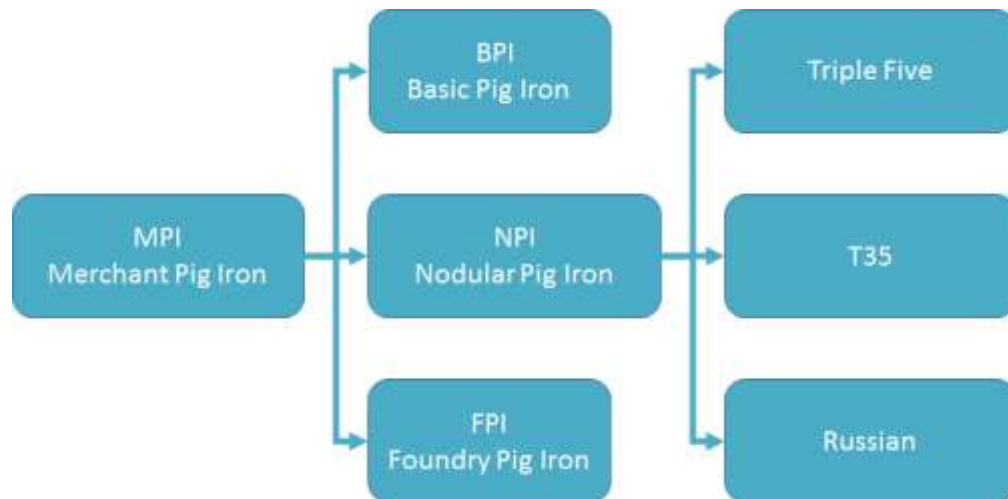


Figure 1.2-4.: Different types of MPI

PURE FONTE LTÉE intends to produce **T35 and Triple Five nodular pig iron grade**

### 1.2.1.4 Environment

PURE FONTE LTÉE will produce pig iron with the most modern equipment and the lowest environmental impact of all pig iron producers. In particular, the plant presented in this Feasibility Study allows the selective capturing of more than 60% of the carbon dioxide (CO<sub>2</sub>) produced in the reduction process. Comparing the typical steel cycle of a Blast Furnace (BF) route with the direct reduction (DRI) route, depending on the ability of PURE FONTE LTÉE to sell the captured CO<sub>2</sub>, PURE FONTE LTÉE CO<sub>2</sub> emissions will be 50% to 70% lower.



Figure 1.2-5: CO<sub>2</sub> emissions from different steelmaking routes showing that the process selected by PURE FONTE LTÉE has the lowest environmental footprint and photo of a CO<sub>2</sub> absorption plant

This Feasibility Study also presents the details of a process to minimize water usage and the discharge of minimal volumes of water at or below the required values foreseen by environmental regulations.

## 1.2.2 Project Highlights

- **Compliments current mining industry:** the PURE FONTE LTÉE plant in Port Saguenay will be a major purchaser of IO pellets from existing Canadian suppliers.
- **Value added production model:** PURE FONTE LTÉE will bring a significant transformation industry to Quebec and north east Canada's iron ore supply chain.
- **Potential for adjacent steel production:** PURE FONTE LTÉE is designing the capability for steel production using its own pig iron as a potential future expansion
- **Profitability through pricing cycles:** PURE FONTE LTÉE is focused on high margin not high volume. This business focus insulates the Company from market fluctuations
- **Proven technology for low completion risk:** this Feasibility Study proposes to use proven equipment and technology, utilized at other operations with decades of commercial operation. The main equipment supplier will provide a comprehensive process guarantee covering volume and quality of the product.
- **Best in class environmental profile:** While any heavy industry and iron smelting process entails the release of greenhouse gas emissions, PURE FONTE LTÉE is projected to set the industry standard for CO<sub>2</sub> per ton of MPI produced at less than 1.0 ton of CO<sub>2</sub> per ton MPI
- **Strong contributor to local and provincial economies:** PURE FONTE LTÉE will provide significant direct investment to the Saguenay region and the Province of Quebec through capital expenditures, operating costs and by being the anchor customer for the development of the Port of Saguenay.



Figure 1.2-6: PURE FONTE LTÉE investment will be of high significance for the Quebec region

### 1.2.3 Expected business lifetime

#### 1.2.3.1 Foundry Market

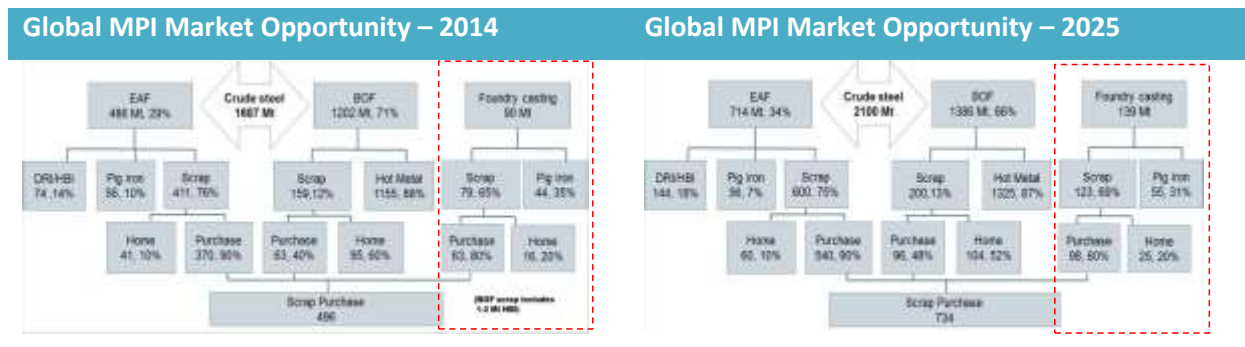


Figure 1.2-7.: Global MPI Market Opportunity 2014-2025

According to the Iron & Metallica Association (“IIMA”), MPI consumption by the foundry industry will grow from 44 mtpa in 2014 to 55 mtpa in 2025. PURE FONTE LTÉE will be selling into a growing market.

Additionally, due to its chosen location in Port Saguenay, PURE FONTE LTÉE will have easy access to 4 of the top 10 iron foundry industries.

Country	Gray Iron	Ductile Iron	Total Iron
China	20,550,000	11,600,000	32,150,000
<b>U.S.</b>	<b>4,083,000</b>	<b>4,251,500</b>	<b>8,334,500</b>
India	6,700,000	1,000,000	7,700,000
<b>Germany</b>	<b>2,381,462</b>	<b>1,541,737</b>	<b>3,923,199</b>
Japan	2,135,794	1,683,250	3,819,044
Russia	1,811,765	988,235	2,800,000
Brazil	1,825,000	746,300	2,571,300
Korea	1,086,400	705,100	1,791,500
<b>France</b>	<b>635,414</b>	<b>703,141</b>	<b>1,338,555</b>
<b>Italy</b>	<b>689,000</b>	<b>387,600</b>	<b>1,076,600</b>
<b>Total</b>	<b>41,897,835</b>	<b>23,606,863</b>	<b>65,504,698</b>
<b>Total ex- China</b>	<b>21,347,835</b>	<b>12,006,863</b>	<b>33,354,698</b>

Table 1.2-3.: Top 10 Iron Casting Producing Countries, 2013 t [2]

### 1.2.3.2 EAF Steel Market

In the steel industry, electric arc furnace production is expected to grow. Global steel production will continue the shift from blast furnaces to scrap based steel production.

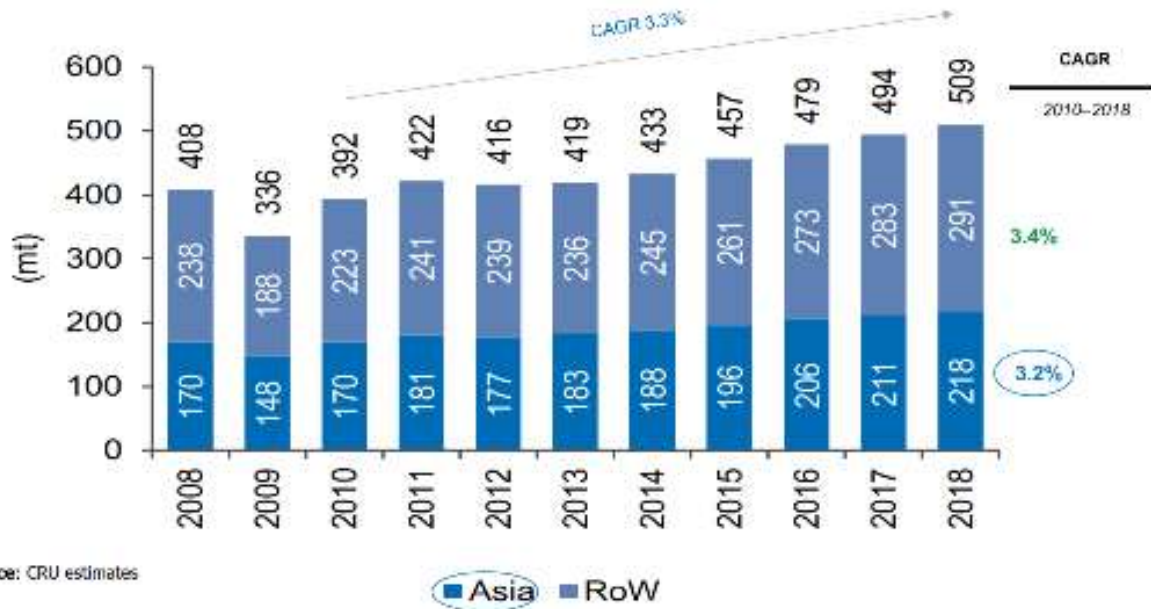


Figure 1.2-8.: Global EAF Steel Production, source CRU

In the United States, though Nucor completed a large DRI facility in Louisiana (2.5 mtpa) in 2014, pig iron imports into the United States have not decreased.

Imports of MPI											
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
<b>USA</b>	6.3	7.7	5.6	5.0	2.2	3.2	3.6	4.4	4.1	4.6	4.5
<b>Canada</b>	0.1	0.0	0.1	0.3	0.2	0.1	0.0	0.0	0.0	0.1	0.1
<b>Europe</b>	9.3	10.0	11.0	10.5	7.0	7.2	7.1	7.2	5.2	4.8	4.8
	<b>15.7</b>	<b>17.7</b>	<b>16.7</b>	<b>15.8</b>	<b>9.4</b>	<b>10.5</b>	<b>10.7</b>	<b>11.6</b>	<b>9.3</b>	<b>9.4</b>	<b>9.3</b>

Table 1.2-4.: Imports of MPI 2005-2015 [3]

### 1.2.3.3 MPI Pricing

MPI is correlated to the price of iron ore. Basic MPI is currently trading towards the bottom of current pricing cycles, similarly to iron ore.

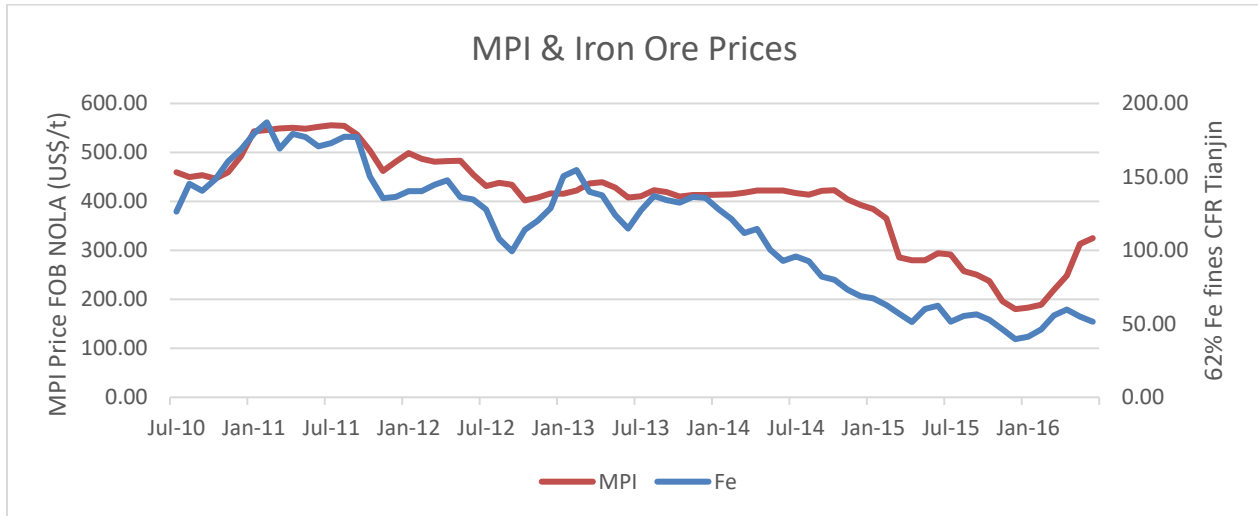


Figure 1.2-9.: MPI & Iron Ore Prices, source CRU

NPI trades at a premium to basic MPI (the price shown in the chart above). There is no replacement for NPI for foundry customers.

Currently the premium is roughly US\$100/t. PURE FONTE LTÉE determines the current price of NPI by directly speaking to buyers and traders as there is no published price as there is with basic MPI (published bi-weekly by CRU).

A more detailed analysis of the MPI market, including customers, correlations to iron ore, currencies and other relevant information is available below in this feasibility study.

### 1.2.3.4 Possible business expansion

During the life of the plant, PURE FONTE LTÉE will have the opportunity to increase production volumes to at least the double of the capacity foreseen for the project outlined in this Feasibility Study

The plant layout is designed in such a way that production can be doubled in future by duplicating certain parts of the plant equipment. The plant infrastructure will be prepared for a total product output of 850,000 tpy.



#### 1.2.4 Future business routes

Another important characteristic of the plant layout is that PURE FONTE LTÉE will not only have the chance to double its production capacity, but if the market conditions will allow and PURE FONTE LTÉE will find merit in pursuing alternative markets, the plant could be transformed from a pig iron production plant into, alternatively:

- **High Carbon DRI** – high carbon direct reduced iron (DRI) is an intermediate product between the raw material purchased by PFL and its final Pig Iron product. With the adoption of an external cooler to the process equipment, PFL will be able to produce HC-DRI, which is an important raw material for the Steel Industry.
- **HBQ** – High quality bar, through the adoption of decarburization equipment, secondary metallurgy equipment (such as ladle furnace and vacuum degassing) and continuous casting machine
- **Small structural profiles and merchant bars** – also through the adoption of decarburization equipment, secondary metallurgy equipment (such as ladle furnace and vacuum degassing) and continuous casting machine
- **Special Ingots** – through the adoption of decarburization equipment, secondary metallurgy equipment, vacuum degassers, ingot casting equipment and vacuum ingot re-melting

All three the above indicated alternatives are in line with PURE FONTE LTÉE philosophy of low production volumes at high margins and based on the future market conditions, PURE FONTE LTÉE could decide to implement a plant transformation project. The PURE FONTE LTÉE plant layout has been designed in such a way that a transformation project like that will not hamper the pig iron production for most of the project duration, minimizing the down time required for the change.