



HPQ PUREVAP™ QRR WILL USHER IN ZERO CO₂ EMISSION SILICON METAL MANUFACTURING

HPQ's QRR PROCESS HAS THE POTENTIAL TO GENERATE CARBON CREDITS, HIGHLIGHTING ITS SIGNIFICANT ENVIRONMENTAL ADVANTAGES FOR PIVOTAL MARKETS

MONTREAL, Canada, June 27, 2023 — [HPQ Silicon Inc.](#) ("HPQ" or the "Company") ([TSX-V: HPQ](#)) ([OTCQX: HPQFF](#)) ([FRA: O08](#)), a technology company specializing in green engineering processes for silica and silicon material production, is pleased to provide shareholders information on the significant environmental benefits of the *PUREVAP™ Quartz Reduction Reactor (QRR)* process currently being developed in collaboration with technology provider [PyroGenesis Canada Inc.](#) ([TSX: PYR](#)) ([NASDAQ: PYR](#)) ([FRA: 8PY](#)) (Pyrogenesis).

As the GEN3 QRR pilot plant testing progresses toward commercial validation, HPQ can now highlight a distinctive environmental advantage of its proprietary QRR process. This advantage, combined with recently acquired intellectual property from PyroGenesis, will enable HPQ to achieve more than just the milestone of zero CO₂ emissions in silicon metal manufacturing—it will also incorporate a carbon recycling step that should also yield an additional significant reduction in feedstock usage.

These developments will further enhance the sustainability and efficiency of the QRR production process.

"By modernizing the production of high-purity Silicon, our QRR process has the potential to transform a century-old industrial process, known for its significant CO₂ emissions, into a carbon credit-generating solution," stated Bernard Tourillon, President & CEO of HPQ Silicon. *"Amidst the global focus on reducing carbon emissions and achieving sustainability goals, the advancements of HPQ hold immense significance in driving the transition towards cleaner and more environmentally responsible silicon production."*

Silicon Manufacturing is Currently the Largest Emitter of CO₂ Among Metals And Non-Ferrous Metals

In traditional silicon metal manufacturing, a carbothermic process involving the reduction of Silica (SiO₂) using carbon sources (Coal, Coke, or Charcoal) as reductant at high temperatures > 1,800° C in Open Electric Arc Furnaces (OEF) is used to make Silicon metal (Si). The carbothermic process alone results in 5 tonnes (t) of CO₂ emissions per tonne (t) of silicon produced [1]. This makes Silicon Metal manufacturing the largest emitter of CO₂ among all metals and non-ferrous metals, based on a tCO₂/t product basis, as per the Intergovernmental Panel on Climate Change (IPCC), a United Nations body focused on climate change research [2].

Currently, traditional silicon metal manufacturers have only one option to reduce their carbothermic carbon footprint, and this involves replacing fossil-based carbon with an organic carbon source [3]. While adopting this alternative allows manufacturers to effectively mitigate a part of their overall carbon footprint by offsetting the CO₂ emissions associated with the organic carbon source, it will never allow them to produce zero CO₂ emissions silicon metal.

PUREVAP™ QRR Zero CO₂ Silicon Metal Advantage: A Closed Electrical Arc Furnace Design

The QRR, *by design*, is a Closed Electric Arc Furnace (CEAF) with the ability to operate under controlled atmospheric conditions. This innovative furnace enables the semi-continuous feeding of Silica (SiO₂) and a carbon reductant, facilitating the production of 3N+ silicon in a single step. Notably, the QRR's design eliminates air infiltrations within the reactor, ensuring that the CO gas ("Co(g)") generated during the carbothermic reaction remains unoxidized. Consequently, the QRR produces a gas composition enriched with CO(g), which can be readily captured for further utilization.



The recently acquired IP from PyroGenesis encompasses a process that involves capturing the CO(g) stream emitted by the QRR. This captured CO(g) is subsequently converted back into a solid carbon form, creating the potential for its reuse in generating the carbothermic process for silicon production once again.

By harnessing the unique CO(g) sequestration ability of the QRR in combination with the utilization of an organic carbon source, HPQ is poised to achieve the production of Zero CO₂ Silicon Metal. This innovative approach enables carbon-neutral silicon metal production and holds the potential for generating carbon credits. According to management estimates, the QRR potential carbon credits should be between 1.5 tCO₂/t product basis and 2.6 tCO₂/t product basis [4].

HPQ intends to commercialize its Zero+ CO₂ Silicon Metal under the brand name *SILICIUM_x*.

Zero Nitrogen Oxides emission, another environmental advantage of the QRR process

The size, complexity, and open-top nature of Open Electric Arc Furnace facilities contribute to the heating of atmospheric nitrogen, causing it to enter a reactive state and releasing highly reactive and poisonous Nitrogen Oxides (NO_x) gases. However, the unique design of the QRR inhibits air infiltrations within the reactor, effectively preventing the formation of NO_x. This environmental advantage is another positive aspect of the QRR process.

Quantifying the Environmental Benefits of the QRR: A Zero CO₂ Emission Process

HPQ's QRR Zero CO₂ emission silicon metal manufacturing can have a profound environmental impact, as exemplified by its significance in key markets:

- Market research indicates a need for 1 million tonnes of additional silicon metal production capacity in the coming decade, exacerbating the carbon emission issue [5]. By fulfilling just 25% of this demand with QRR systems, worldwide CO₂ emissions could be reduced by 1.25 million tonnes annually, equivalent to removing 278,163 gasoline-powered passenger vehicles from the road yearly [6], or >50% of the cars produced in Canada in a year.
- Canada's annual silicon metal production of approximately 50,000 tonnes [7] could see a remarkable reduction of 206,000 tonnes in annual carbon emissions by adopting QRR systems [8].
- With an annual silicon metal production of around 310,000 tonnes in the United States [9], replacing old legacy plants with QRR systems could lead to a substantial reduction of 1.55 million tonnes of CO₂ emissions per year [10].
- European countries, with an annual silicon metal production of approximately 450,000 tonnes [11], have the potential to achieve an impressive reduction of 2.25 million tonnes of CO₂ emissions annually by transitioning to QRR systems [12].

These figures, not including the QRR carbon credit potential, highlight the significant environmental impact that can be realized by implementing QRR systems in these key markets.

Quantifying the Economic Impact of the QRR: A Zero CO₂ Emission Process

Silicon metal manufacturing incurs significant carbon taxes in numerous markets, calculated based on the per-tonne price of CO₂ emissions. The deployment of each 2,500t/y system utilizing the innovative and proprietary design of the QRR process, along with the recently acquired Intellectual Property (IP) from PyroGenesis, will result in substantial cost savings.

HPQ management has calculated the Net Present Values of carbon tax savings for each 2,500t/y system over a 25-year period to estimate the potential cost savings. This analysis considers a projected 5% compounded increase in the carbon tax and applies discount rates of 7.5%, 10%, and 12%. The results provide an order of magnitude for the potential financial benefits in different markets.

- For a Quebec-based operation, with a carbon tax of \$27 per tonne of CO₂ emissions [13], the Net Present Values of potential savings range from \$4 million (12% discount rate) to \$6.5 million (7.5% discount rate).
- In a ROC (Rest of Canada) based operation, with a carbon tax of \$50 per tonne of CO₂ emissions [14], the Net Present Values of potential savings range from \$5.1 million (12% discount rate) to \$8.5 million (7.5% discount rate).
- For a European-based operation, with a carbon tax of 90 € (≅ C\$126) per tonne of CO₂ emissions [15], the Net Present Values of potential savings range from 9.3 million € (or ≅ C\$13 million) (12% discount rate) to 15.3 million € (or ≅ C\$21 million) (7.5% discount rate).

These significant potential carbon tax savings highlight the substantial financial advantages and environmental benefits of adopting the QRR, a Zero CO₂ Emission Process, in these markets.

HPQ Acquisition of New Intellectual Property From PyroGenesis

HPQ has acquired a new intellectual property from PyroGenesis for \$3,600,000. This significant IP pertains to a "Low Carbon Emission Process for the production of Silicon," which holds the potential to achieve zero CO₂ emissions and introduce a circular carbon usage approach through carbon recycling. By incorporating this IP, HPQ strengthens its QRR patent portfolio and gains a unique competitive advantage over traditional silicon metal manufacturers.

Under the agreement, the parties are currently negotiating a complementary agreement focusing on the research and development phases necessary for implementing this IP. This collaboration will propel HPQ's capabilities in implementing the low carbon emission process, further solidifying its position as an industry leader in sustainable silicon production and Pyrogenesis' position as a world leader in innovative industrial technologies.

SOURCE

- [1] Gudrun Saevarsdottir, Thordur Magnusson & Halvor Kvande. (2021) [Reducing the Carbon Footprint: Primary Production of Aluminum and Silicon with Changing Energy Systems](#). *Journal of Sustainable Metallurgy*, 7, 846-857.
- [2] Bernstein L, Roy J, Delhotal KC, Harnisch J, Matsushashi R, Pricel, Tanaka K, Worrell E, Yamba F, Fengqi Z (2007) Industry. In: [Climate change 2007: Mitigation. Contribution of working group III to the fourth assessment report of the intergovernmental panel on climate change](#). Cambridge University Press, Cambridge, UK and New York, USA
- [3] FerroQuébec Inc. [Empreinte carbone du silicium métal, Usine de Port-Cartier, Rapport d'empreinte carbone](#), 25 mars 2015, Ernst & Young, Groupe – Changements climatique et développement durable.
- [4] Since the report listed under point [3] is related to a Quebec based operations, management used the life cycle carbon footprint numbers found in table 5.2 on page 30 of the Ernst & Young report and from TM-2016-708 on the QRR Carbon footprint to calculate two different reference scenarios that would incorporate the effect of the QRR CO(g) capture capability. Under HPQ reference scenario #1, (using FerroQuebec data with a carbon capture efficiency of 95%) HPQ could generate a carbon credit of 2.6 tCO₂/t product basis. Under HPQ reference scenario #2, (using the information from PyroGenesis TM-2016-708 on the QRR Carbon footprint, with a carbon capture efficiency of 95%) HPQ could generate a carbon credit of 1.5 tCO₂/t product basis.
- [5] Data compiled from information found in the presentations made by CRU International Limited ("CRU"), a world leading metal market research firm, during their Silicon Market Outlook conferences of November 2018, November 2020, and October 2022.



- [6] The 1.25 M t in annual CO₂ emission reduction was calculated by management which took 25% of 1 M t of additional demand of Silicon described under point [5] and multiplied it by 5, which is the quantity of CO₂ emissions per t of silicon produced described under point [1]. (250,000 t * 5). The estimate of the equivalent number of ICE passenger vehicles reduced from the roads was calculated by using the [EPA Greenhouse Gas Equivalencies Calculator](#).
- [7] Data for [silicon production in Canada](#) from the web site www.statista.com
- [8] Annual reduction of CO₂ emissions for Canada was calculated by management at 206,000 t by multiplying the 50K t of annual production by 4.12, the CO₂ emission number for Canada as per the information found in the report described under point [3].
- [9] Data for [silicon production in United States](#) from the web site www.statista.com
- [10] Annual reduction of CO₂ emissions for United States was calculated by management at 1.55 M t by multiplying the 310K t of annual production by 5.
- [11] Data for silicon production in Europe extracted from the following quote from [CRU analyst Jorn de Linde that estimates that Europe accounts for 13%-15% of global silicon production, or about 3 million tonnes](#).
- [12] Annual reduction of CO₂ emissions for Europe was calculated by management at 1.55 M t by multiplying the 410K t of annual production by 5.
- [13] Quebec Government: [The Carbon Market: Auctions](#)
- [14] Government of Canada: [The Federal Carbon polluting pricing benchmark](#)
- [15] The Wall Street Journal article, April 18, 2023, ["World's First Carbon Import Tax Approved by EU Lawmakers"](#)

About PyroGenesis Canada Inc.

PyroGenesis Canada Inc., a high-tech company, is a leader in the design, development, manufacture and commercialization of advanced plasma processes and sustainable solutions which reduce greenhouse gases (GHG) and are economically attractive alternatives to conventional "dirty" processes. PyroGenesis has created proprietary, patented, and advanced plasma technologies that are being vetted and adopted by multiple multibillion dollar industry leaders in three massive markets: iron ore pelletization, aluminum, waste management, and additive manufacturing. With a team of experienced engineers, scientists and technicians working out of its Montreal office, and its 3,800 m² and 2,940 m² R&D and manufacturing facilities, PyroGenesis maintains its competitive advantage by remaining at the forefront of technology development and commercialization. The operations are ISO 9001:2015 and AS9100D certified, having been ISO certified since 1997. For more information, please visit: www.pyrogenesis.com

About HPQ Silicon

[HPQ Silicon Inc. \(TSX-V: HPQ\)](#) is a Quebec-based TSX Venture Exchange Tier 1 Industrial Issuer.

HPQ is developing, with the support of world-class technology partners [PyroGenesis Canada Inc. \(TSX: PYR\)](#) ([NASDAQ: PYR](#)) and [NOVACIUM SAS](#), new green processes crucial to make the critical materials needed to reach net zero emissions.

HPQ activities are centred around the following five (5) pillars:

- 1) Becoming the only Zero CO₂ Emission, low-cost (Capex and Opex) producer of High Purity Silicon (2N+ to 4N) using our proprietary **PUREVAP™ "Quartz Reduction Reactors" (QRR)** being developed by PyroGenesis.
- 2) Becoming a producer of micron size High Purity Silicon (3N & 4N) powders for high value applications.
- 3) Working to become the first producer of nano silicon materials from High Purity Silicon chunks using our proprietary **PUREVAP™ Nano Silicon Reactor (NSiR)** being developed by PyroGenesis.
- 4) Becoming a green low-cost (Capex and Opex) producer of Fumed Silica using our proprietary



FUMED SILICA REACTOR being developed by PyroGenesis.

- 5) Developing a small and compact process for the on-demand production of green hydrogen via hydrolysis of Silicon and other materials, in cooperation with Novacium SAS..

For more information, please visit [HPQ Silicon web site](#).

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- 30 -

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