



## DOWNSTREAM NICKEL SULPHATE STUDY UPDATE

Independence Group NL (IGO or the Company) (ASX:IGO) is pleased to provide an update on its Downstream Nickel Sulphate Pre-feasibility Study (the Study).

IGO's strategy is focused on metals critical to clean energy including nickel and cobalt which are used in the manufacture of high energy density lithium-ion batteries. The Study's purpose is to demonstrate a commercially viable process to convert IGO's Nova nickel-cobalt sulphide concentrate into nickel sulphate, a chemical form of nickel required by the lithium-ion battery industry. This would unlock significant additional value for IGO by delivering; a) significantly higher payabilities than traditionally received from raw nickel-cobalt sulphide concentrate offtake agreements; b) a premium price for nickel in nickel sulphate compared to the London Metal Exchange (LME) price for nickel as nickel metal; and c) directly linking IGO to the energy storage supply chain.

### Key Highlights

- IGO has developed a new process (the IGO Process) to produce high-quality nickel sulphate from nickel sulphide concentrate, in respect of which IGO has lodged a patent application.
- Metal recoveries from the IGO Process are extremely high, achieving extraction rates exceeding 97% of both the nickel and cobalt metal in the Nova nickel-cobalt sulphide concentrate feed.
- Based on work completed to date, the IGO Process is low cost and well within the lowest quartile of the cost-curve for the integrated production of nickel sulphate.
- The IGO Process is more environmentally sustainable compared to the traditional production methods for nickel sulphate, due to the method's significantly lower emissions, power consumption and waste generation.
- Although metallurgical testwork is well progressed, significant opportunities remain to optimise the Study, including (i) process flowsheet refinements, (ii) minimising waste streams by maximising by-products, (iii) site selection, (iv) scale and scalability, and (v) external sensing of the nickel sulphate market and potential for partnering and collaboration. Optimisation work streams have commenced and the Study is now expected to be completed during the December 2019 quarter.
- In parallel with the continuing Study, IGO will commence marketing nickel sulphide concentrate offtake agreements for the period from the expiry of existing contracts in December 2019 and June 2020 until the downstream nickel sulphate project could potentially be operational. The offtake terms obtained from this process are expected to be improved as a result of tightening market conditions and will be used to inform the financial evaluation aspects of the Study.

IGO's Managing Director, Peter Bradford, commented: *"Nickel is a strategic metal of the future and is poised to benefit from the structural shift to energy storage and electric vehicles, and importantly the transition to increased use of nickel dominant, higher energy density NMC and NCA lithium-ion battery technologies in electric vehicles that deliver better battery performance. This, combined with continued demand growth for nickel from the stainless steel and specialist nickel alloy markets, will transform our industry."*

*"IGO has embraced this transformation to strategically focus on nickel and other metals critical to clean energy, with an interest in both upstream and downstream opportunities. Upstream, we have expanded our generative and Greenfields exploration to drive the discovery of new nickel and copper projects – to provide the nickel*

and copper the world needs. Downstream, we are investing in innovative processing technologies to more efficiently produce nickel sulphate for electric vehicle batteries, at a lower cost and in a more environmentally sustainable manner.

*“We have made great progress with our nickel sulphate downstream processing studies. We have achieved high extraction rates for nickel and cobalt, in excess of 97%, and have produced high-quality, battery grade nickel sulphate and saleable copper-cobalt mixed sulphide products. Further work remains to be done to optimise the process design to minimise waste and maximise by-product credits. We also continue to do trade off studies to determine the optimum project location, with key drivers including access and availability of power, water, transportation options, workforce and environment and community considerations. We are excited by the results to-date but plan to spend more time to test all strategic options for the Study.*

*In parallel with the continuing studies, we will commence negotiations for the Nova concentrate offtake in the September 2019 quarter. There is strong demand for Nova style Class I nickel sulphide concentrates, and, as a Company, we will be in a position to negotiate higher payabilities than currently received.”*

## Nickel Sulphate

As demand for lithium-ion batteries expands in line with increasing sales of electric vehicles and energy storage systems, so too does the demand increase for high-quality battery raw materials. Nickel sulphate is critically important in certain electric vehicle battery cathodes, particularly for battery technologies using nickel-cobalt-manganese (NCM) and nickel-cobalt-aluminium (NCA) cathode chemistries. NCM and NCA technologies are becoming increasingly popular given their high energy density which, in electric vehicle applications, results in longer driving range. There is also a transition to increased proportions of nickel in the cathode for both these battery types.

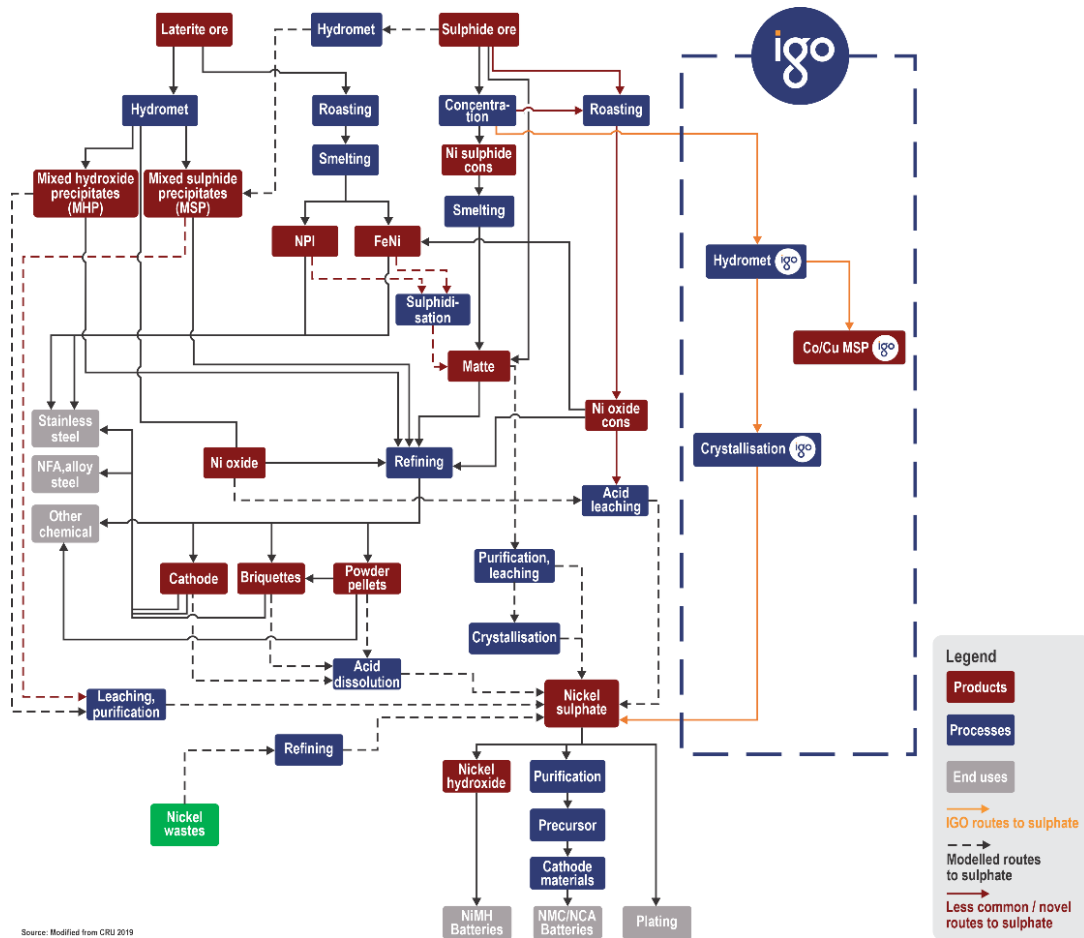
Typically, nickel sulphate is produced from intermediate or refined nickel products that have been subject to multiple complex metallurgical processes. These additional processes have resulted in nickel sulphate trading at a premium to the LME nickel metal price. The quantum of the premium is largely driven by market supply and demand, quality and provenance.

The IGO Process, demonstrated to be highly efficient in bench and pilot scale testwork, is designed to optimise the production of nickel sulphate directly from nickel sulphide concentrates without the requirement to first produce intermediary or refined nickel products. Figure 1 on the next page is a diagram of the IGO Process.

## Process

The IGO Process flowsheet combines several proven technologies, which are commonly used in the mining industry, but which have not been previously used in the nickel industry for the commercial integrated production of nickel sulphate. The IGO Process can be simplified into four sequential steps, as follows:

- **Stage 1 Leaching:** A finely-ground, high-grade nickel sulphide concentrate slurry is pumped into an autoclave, at relatively low temperature and pressure, where oxygen injection is used to partially oxidise the sulphide concentrate into soluble metal sulphate species (nickel, cobalt, copper, iron etc), sulphuric acid and sulphur.
- **Stage 2 Primary & Secondary Neutralisation:** A two-stage neutralisation process for the removal of free acid, iron and other metals to achieve the required feed solution for subsequent solvent extraction.
- **Stage 3 Cobalt and Copper Solvent Extraction and Precipitation:** Cobalt, copper, zinc, manganese and magnesium are removed from solution. The cobalt, copper and zinc are then stripped from the resulting organic solution by sulphuric acid and recovered as a Mixed Sulphide Precipitate (MSP), which is a readily saleable product.
- **Stage 4 Nickel Solvent Extraction and Crystallisation:** Further impurities are removed from solution in the nickel solvent extraction circuit before crystallisation by IGO’s direct crystallisation (DXTL™) process step.



Source: Modified from CRU 2019

Figure 1: Typical metallurgical processes to produce nickel sulphate, compared with the IGO Process, which is expected to be more cost effective and environmentally sustainable (image modified from CRU 2019).

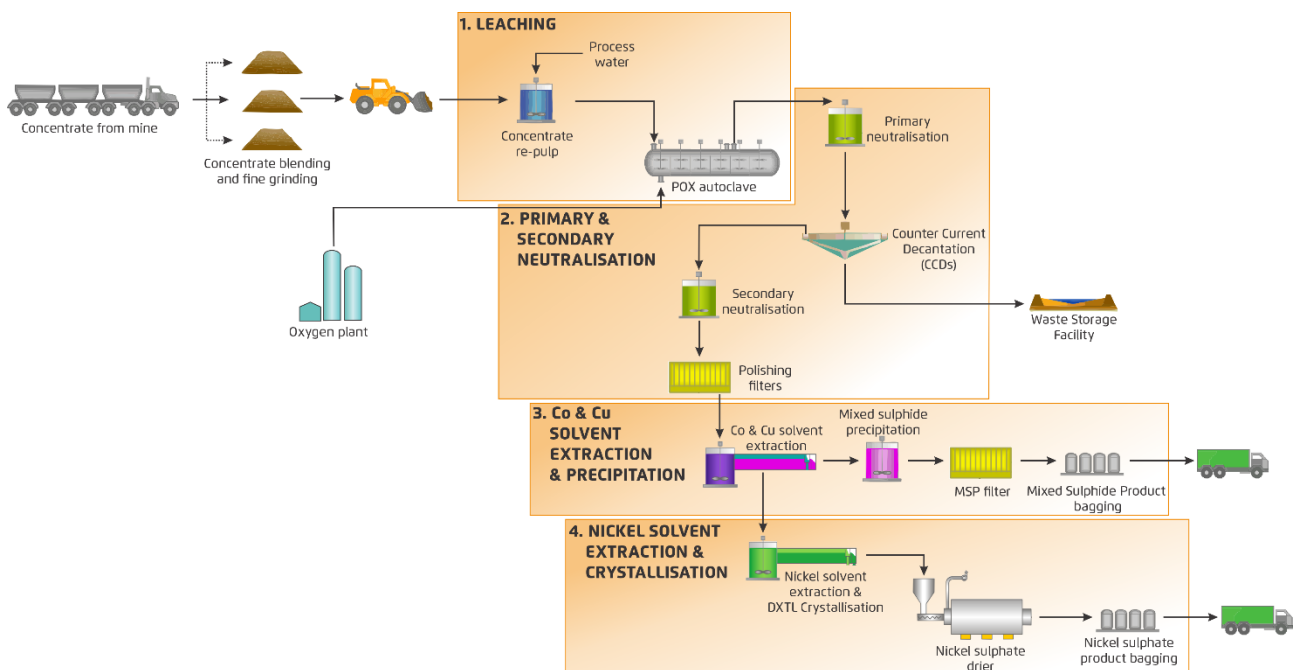
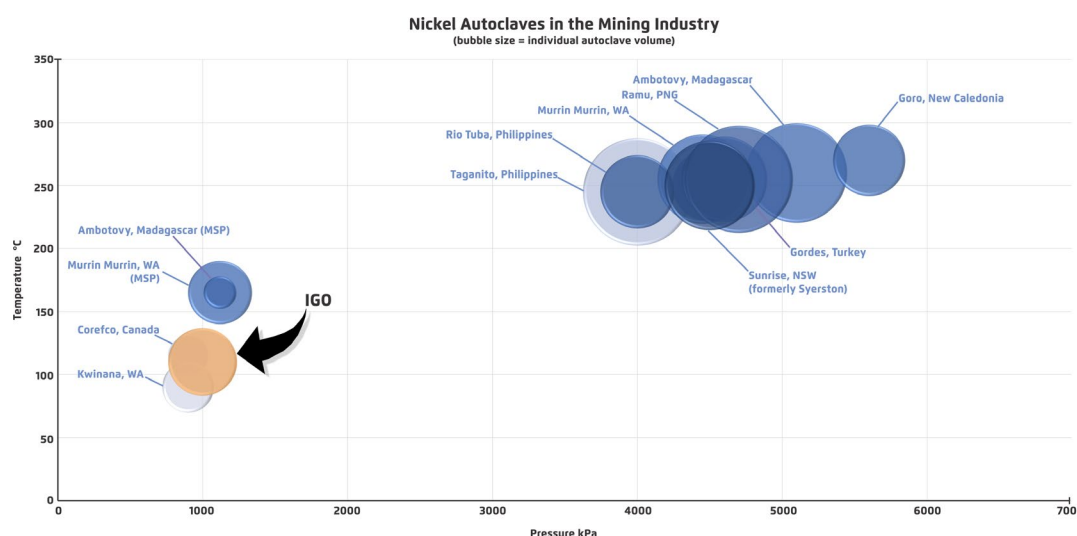


Figure 2: Proposed IGO Process flowsheet to convert sulphide nickel concentrate directly to nickel sulphate.

Importantly, the IGO Process differs significantly from Pressure Acid Leach (PAL) and High Pressure Acid Leach (HPAL) “whole of ore” processes, which are both designed to treat nickel-cobalt rich lateritic ore. Specific differences include:

- The IGO Process is a value-enhancement refining process designed to treat high-grade nickel sulphide concentrate (18%-20% nickel) as opposed to a low-grade “whole of ore” laterite feed.
- The significantly lower temperatures and pressures used in the IGO Process autoclave have lower risk and capital intensity than those used in PAL and HPAL projects (See Figure 3).
- The autoclave leaching circuit uses oxygen to oxidise the sulphide minerals, which allows the metals to be selectively leached into solution. In contrast, the sulphuric acid in the PAL and HPAL projects dissolves many other gangue minerals present in the laterite ore feed.

The IGO Process is less complex compared to PAL and HPAL circuits with both lower capital cost and operating risk.



**Figure 3: The IGO Process uses an autoclave technology that has much lower temperature and pressure to leach the metal into solution compared to other autoclave processes in the nickel industry.**

### Product

The Study pilot plant trials have produced battery-grade crystalline nickel sulphate hexahydrate product (NiSO<sub>4</sub>·6H<sub>2</sub>O). The nickel sulphate has been produced from both IGO’s DXTL™ crystallisation process and from more typical mechanical crystallisation methods. Table 1 is a comparison of the IGO Process nickel sulphate product compared to a range of other market products and offtake requirements. The IGO Process nickel sulphate product is expected to meet the highest end-user specifications.

**Table 1: IGO’s nickel sulphate product specifications compared to other producers and offtakers’ minimum requirements**

Element	IGO	Europe 1	Europe 2	China 1	China 2	China 3	WA 1	Others
Ni (%)	22.1 -22.3	22.3	22.3	22.2	22	22.2	22.3	22.2
Co (ppm)	40-140	2	10	30	10	30	80-120	100-250
Cu (ppm)	1-9	1	2	1	10	1	1	5
Al (ppm)	1	1	-	10	-	10	1	-
As (ppm)	1-2	1	-	-	2	-	-	-
Ca (ppm)	1	1	-	7	5	7	2	5-10
Cd (ppm)	1	1	2	2	10	1	1	-
Cr (ppm)	1	1	-	3	-	3	1	5-10



Element	IGO	Europe 1	Europe 2	China 1	China 2	China 3	WA 1	Others
Fe (ppm)	1-6	1	2	4	10	3	1	5
K (ppm)	1	1	-	-	-	-	1	-
Mg (ppm)	1-4	1	-	20	-	20	1	5-10
Mn (ppm)	1	1	-	-	-	-	1	5-10
Na (ppm)	1	5	-	30	-	30	5	-
P (ppm)	1	2	-	-	-	-	-	-
Pb (ppm)	1	1	2	6	10	5	1	5-10
Si (ppm)	1	5	-	10	-	10	2	-
Zn (ppm)	1-5	1	2	2	10	1	1	5

Modified from multiple sources. The character “-“ represents zero or unknown data.

The IGO Process also produces a by-product of mixed copper/cobalt sulphide precipitate (MSP), which will have a copper grade of 32-34% and a cobalt grade of 28-30%. This MSP product is expected to be highly desirable and readily saleable.

### Cost Structure

Based on the Study work completed to date, the IGO Process would generate a low cost and high purity nickel sulphate product for either an integrated business or as a stand-alone offtaker and refiner of nickel sulphide concentrate products. This competitive position is driven by:

- An integrated facility to convert a relatively unrefined product (nickel-cobalt sulphide concentrate) directly to nickel sulphate
- Low cost of feed stock available (nickel concentrate versus more refined nickel products like MSP, nickel powder, briquets etc)
- High extraction rates for both nickel and cobalt
- Efficiencies in the use of power, water and reagents
- Production of by-products that could be used in other industries.

Based on a range of assumed nickel sulphate premiums, the IGO Process could deliver significantly higher payabilities than those traditionally received by nickel sulphide concentrate producers selling product to smelters and refineries designed for the stainless-steel supply chain. This is illustrated in Table 2, which is a comparison of the offtake payability that would need to be achieved to match the expected financial outcome of the IGO Process for a range of nickel sulphate price premiums.

**Table 2: Relative payabilities as a sensitivity to the nickel sulphate premium that could be achieved at the targeted study nickel sulphate conversion cost.**

Nickel Sulphate Premium (US\$/t)	\$1,500	\$2,000	\$2,500	\$3,000	\$3,500
Relative Payability Equivalent	76%	79%	82%	85%	88%

By way of further explanation: for the mid-case, a nickel sulphide concentrate offtake payability of 82% (for nickel) would be required to deliver the same economic benefit as the downstream nickel sulphate project in the event that a US\$2,500 per tonne nickel sulphate price premium was achieved.

### Nickel Sulphate Marketing

IGO has produced approximately 8kg of high-quality nickel sulphate product from the Study testwork. As part of the continuing study, IGO will now formally engage with nickel sulphate end users including, cathode precursor producers, electric vehicle battery manufacturers and vehicle manufacturers with the aim of identifying potential preferred offtake and/or project partners.

## Nova Current Offtake

IGO has two existing offtake agreements for the Nova nickel concentrate. These agreements expire in December 2019 and June 2020 respectively and IGO intends to commence offtake negotiations in the September 2019 quarter for the nickel sulphide concentrate production for, as a minimum, the period of time until the nickel sulphate downstream project could potentially be operational.

Early indications are that the market for nickel sulphide concentrate has tightened and therefore significant demand for Nova's nickel sulphide concentrate is expected. We anticipate that this will result in improved offtake contract terms. The process will also provide a basis for the assessment of the trade-off economics between nickel sulphate downstream processing and the continued production and marketing of nickel sulphide concentrate. Timing on terms will dovetail with future strategic decisions on the downstream processing facility.

## Next Steps

Testwork to date for the core processes, including leaching and solvent extraction/crystallisation, has included both bench scale and continuous pilot plant testwork. While such detailed testwork is not normally completed at the pre-feasibility study stage, the results have significantly increased the level of confidence in the technical aspects of the IGO Process.

There are however opportunities for further optimisation and therefore, we will continue the Study to develop the final business case to carry forward into the feasibility study stage. We expect that this will be completed by the December 2019 quarter. Key components of the continuing work include:

- Optimisation of the process flowsheet, with consideration of alternative neutralisation reagents to deliver both lower capital and operating costs and more marketable by-products, in addition to the MSP by-product. The assessment of these alternatives will change the chemistry for the solvent extraction and crystallisation stages which will require additional testwork.
- Conversion of the existing waste stream into by-products to reduce cost, provide alternative revenue streams and improve the environmental sustainability of the IGO Process.
- Completion of process plant location trade-off studies linked to the finalisation of the flowsheet design considering factors such as, permitting time, power, water, transport options, workforce availability, industry synergies, environment and community considerations.
- The project scale also remains a key workstream to ensure an optimum level of capital intensity.
- Testing products with potential customers, with this work expected to generate additional collaborative project opportunities.

## Study Background

Following the successful completion of proof-of-concept testwork in early 2018, in collaboration with Wood PLC (Wood)(trading as Amec Foster Wheeler Australia Pty Ltd), IGO commissioned Wood to undertake the Study. Wood has been an integral partner in all aspects of the Study through the provision of technical direction and testwork oversight to achieve high-quality products and detailed engineering data requirements for completion of the Study.

## FORWARD LOOKING STATEMENTS

This announcement contains forward-looking statements regarding future events, conditions and circumstances including but not limited to statements regarding plans, strategies and objectives of management, anticipated timelines and expected costs and levels of production. Often, but not always, forward-looking statements can be identified by the use of forward-looking words such as "may", "will", "expect", "intend", "plan", "estimate", "anticipate", "continue" and "guidance", or other similar words.

These forward-looking statements are not a guarantee of future performance and involve unknown risks and uncertainties, many of which are beyond IGO's control, which may cause actual results and developments to differ materially from those expressed or implied. These risks include but are not limited to economic



conditions, stock market fluctuations, commodity demand and price movements, access to infrastructure, timing of approvals, regulatory risks, operational risks, reliance on key personnel, reserve and resource estimations, native title and title risks, foreign currency fluctuations, exploration risk and mining development, construction and commissioning risk.

Forward-looking statements in this announcement apply only at the date of issue. Subject to any continuing obligations under applicable law or regulations, IGO does not undertake to publicly update or revise any of the forward-looking statements in this announcement or to advise of any change in events, conditions or circumstances on which any such statement is based. Readers are cautioned not to place undue reliance on any forward-looking statements contained in this announcement.

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