MTM Critical Metals Limited (MTM)

One man's trash is another man's treasure.

SPEC BUY $0.50
Current $0.225

23rd January 2025

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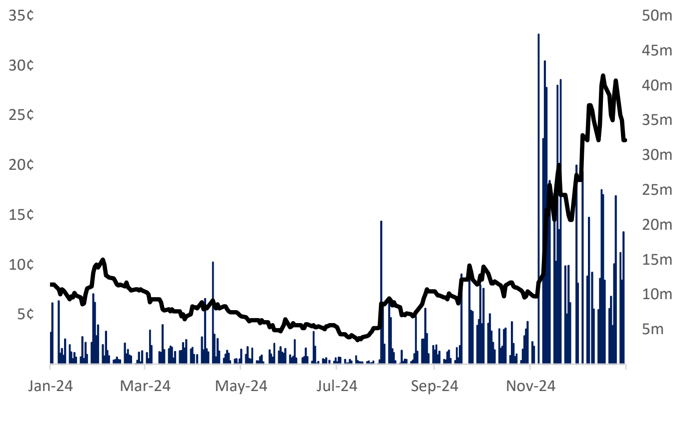
- Chinese export restrictions on rare earth elements (REEs) and critical metals such as Gallium and Germanium have prompted US efforts to strengthen domestic supply chains and reduce reliance on foreign processing.
- MTM holds strategic REE exploration assets in Quebec and Western Australia however has pivoted to being a specialist in advanced metal recovery technologies.
- Flash Joule Heating (FJH) is a patented technology invented by Dr James Tour from Rice University and is provided to MTM under an exclusive global license agreement.
- FJH technology has the potential to revolutionise metal recovery by reducing energy consumption, reagent use, waste, and offering a more environmentally friendly alternative.
- MTM has achieved breakthrough efficiency gains in REE processing, augmenting the FJH technology with chlorination, eliminating the reliance on energy-intensive, and reagent heavy traditional sulphuric acid baking and multi-stage leaching.
- Recently, MTM achieved 93% conversion of REEs from a dried monazite flotation concentrate containing ~31% Total Rare Earth Oxides. Using a single FJH-carbochlorination process and a water wash, all 17 REEs were successfully chlorinated with resultant REE-chloride product showing >90% purity.
- MTM are working with Knighthawk Engineering to develop a 1TPD Pilot processing unit and are on track for design completion by Feb 2025. This is expected to be followed by procurement, construction, and commissioning phases.
- MTM has demonstrated the FJH process can deliver required product yield and purity levels for several feedstock strategies. It is simultaneously bringing this up to commercial scale having successfully developed a continuous induction flashing reactor.
- MTM concurrently maintains testing programs across multiple feedstock types to deliver further validation for the technology and strives to achieve commercialisation via the negotiation of formal scrap supply and offtake agreements, on terms conducive to an ongoing business relationship.
- **We initiate coverage of MTM with an initial target price of $0.50 reflecting modest scale up of the FJH process using 1TPD Pilot Units which are currently on track for design completion in February 2025.**

Company Data	
Number of shares (M)	458.3M
Options (M)	66.5M
Diluted number of shares (M)	524.8M
Market capitalisation – undiluted (A$M)	$103.1M
Market capitalisation – diluted (A$M)	$118.1M
Net Cash / (Debt) (A$M)	$16.0M
Enterprise Value - undiluted (A$M)	$87.1M
Enterprise Value - diluted (A$M)	$102.1M
12-month high/low	$0.290 / $0.024
12-month average daily volume	4,784,587

Substantial Shareholders & Associates	
Terra Capital	9.4%
Pengana Capital Group	6.0%

Board of Directors
John Hannaford, Non-Executive Chairman
Michael Walshe, Managing Director
Paul Nardione, Non-Executive Director
Anthony Hadley, Non-Executive Director

12-Month MTM Share Price (¢, LHS) and Volume (m, RHS)



Specific Disclosure: Peloton Capital raised $8m for MTM Critical Metals Limited (MTM), announced October 2024, and was Joint Lead Manager for a placement raising a further $6m, announced 23rd December 2024, for which it earned fees.

MTM CRITICAL METALS LIMITED (ASX:MTM)

Closing Price	**$0.225**	**Market Cap Fully Diluted**	**$118.1m**
Target Price	**$0.50**	**Enterprise Value**	**$102.1m**
Expected Return	**122%**	**Shares on Issue Fully Diluted**	**524.8m**

Unit Economic Inputs at 1 Tonne Per Day						
BY STRATEGY:	A	B	C	D	E	F
Feedstock % Total REEs	5%	15%	20%	25%	30%	35%
Recovery Rate %	55%	60%	65%	70%	75%	80%
Average Price (US$/kg)	100	200	300	400	500	600
Revenue (US$'000)	3	18	39	70	113	168
COGS PD (US$'000)	10	10	10	10	10	10
Gross Margin PTPD (US$'000)	-7	8	29	60	103	158

Daily Gross Margin, with Multiple 1TPD Units, by Strategy (US$k)						
1TPD UNITS / STRATEGY	A	B	C	D	E	F
1	-7	8	29	60	103	158
2	-15	16	58	120	205	316
3	-22	24	87	180	308	474
4	-29	32	116	240	410	632
5	-36	40	145	300	513	790
6	-44	48	174	360	615	948

Annual Gross Margin Based on 250 Working Days PA (US$M)						
1TPD UNITS / STRATEGY	A	B	C	D	E	F
1	-1.8	2.0	7.3	15.0	25.6	39.5
2	-3.6	4.0	14.5	30.0	51.3	79.0
3	-5.4	6.0	21.8	45.0	76.9	118.5
4	-7.3	8.0	29.0	60.0	102.5	158.0
5	-9.1	10.0	36.3	75.0	128.1	197.5
6	-10.9	12.0	43.5	90.0	153.8	237.0

Annual Production Output (Tonnes)						
1TPD UNITS / STRATEGY	A	B	C	D	E	F
1	7	23	33	44	56	70
2	14	45	65	88	113	140
3	21	68	98	131	169	210
4	28	90	130	175	225	280
5	34	113	163	219	281	350
6	41	135	195	263	338	420

Valuation Range at 20 times (A$m at USDAUD 0.625)						
1TPD UNITS / STRATEGY	A	B	C	D	E	F
1	0	64	232	480	820	1,264
2	0	128	464	960	1,640	2,528
3	0	192	696	1,440	2,460	3,792
4	0	256	928	1,920	3,280	5,056
5	0	320	1,160	2,400	4,100	6,320
6	0	384	1,392	2,880	4,920	7,584

Valuation Per Share (A$) based on 524.8m Fully Diluted Shares						
1TPD UNITS / STRATEGY	A	B	C	D	E	F
1	$0.00	$0.12	$0.44	$0.91	$1.56	$2.41
2	$0.00	$0.24	$0.88	$1.83	$3.12	$4.82
3	$0.00	$0.37	$1.33	$2.74	$4.69	$7.23
4	$0.00	$0.49	$1.77	$3.66	$6.25	$9.63
5	$0.00	$0.61	$2.21	$4.57	$7.81	$12.04
6	$0.00	$0.73	$2.65	$5.49	$9.37	$14.45

Source: Peloton Capital

Catalyst 1:
Announcements of further flash test results for given feedstock

Catalyst 2:
New commercial partners securing supply of high value feedstock and/or offtake

Catalyst 3:
Establishment of 1 TPD Pilot Facility through design / procurement / fab / commissioning and testing phases

Catalyst 4:
Securing additional US Government non-dilutive capital funding through existing programs

Catalyst 5:
Strategic tailwinds as new US Govt Administration escalates REEs as a strategic priority

Catalyst 6:
Ongoing volatility in global REE markets

Catalyst 7:
Creation of new industrial verticals targetting other critical metals and REEs

Catalyst 8:
Further results of MTM's FJH process costs compared with incumbent REE producers

INVESTMENT SUMMARY

China has strengthened its control over critical metals, unveiling its first comprehensive regulation on Rare Earth Elements (REEs) effective 1 Oct 24. New export controls will affect supply and drive Critical Metal prices higher. The new regulations introduce a set of rules governing the mining, refining and separation, metal smelting, integrated utilization, product distribution, import and export of rare earths, and specify severe penalties for violations. This follows the implementation of export license administration on critical metals germanium and gallium effective 1 Aug 23, and on antimony effective 15 Sept 24. These restrictions on "dual use" (civilian and military) technologies are a tit for tat response to US restrictions on the export of semiconductor manufacturing equipment.

With EVEN STRONGER Chinese control over REEs, there are unacceptable strategic vulnerabilities in the US supply chain. Authorities are accelerating their policy response and reducing offshore reliance with policy changes expected that further support onshoring and incentivise domestic manufacturing. **Metal recycling plays a crucial role in mitigating the shortage of critical metals and reduces reliance on primary mining.** Current liquid hydrometallurgy involves substantial water and chemical consumption with troublesome secondary waste streams, while pyrometallurgy lacks selectivity and requires substantial energy input.

FJH efficiently extracts metals like lithium from spodumene, gallium from scrap, and gold from E-Waste. FJH technology has the potential to revolutionise metal recovery by reducing energy consumption, reagent use, waste, and offering a more economical and environmentally friendly alternative. MTM has made significant advancements towards target at scale parameters and commercialisation. If target 1 Tonne Per Day output from FJH is successfully achieved using the Ga/Ge feedstock, we expect this will lead to the negotiation of formal scrap supply and offtake agreements, on terms conducive to an ongoing business relationship.

Critically, MTM has:

- Secured key FJH technology and technology rights from Rice University.
- Partnered up with specialist consulting engineers Knighthawk Engineering.
- Identified Multiple Potential Industrial Verticals (e.g. REEs from Monazite, Ga/Ge from E-Waste, Li from Spodumene)
- Achieved significant technology development milestones vis Chlorination, Batch Processing and Recovery Rates.
- Formed a Strategic Collaboration with Indium Corp significantly de-risking supply of Gallium/Germanium-rich feedstock.

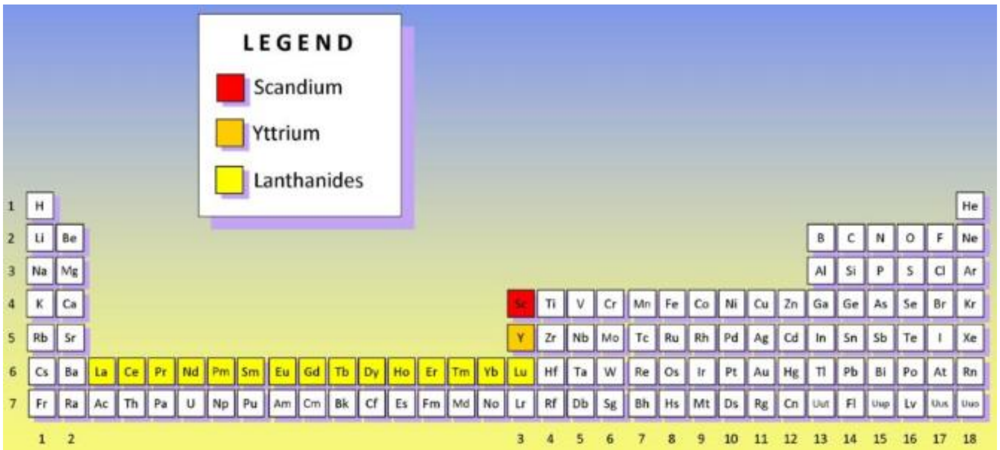
MTM has tested a range of metals using FJH, reporting encouraging laboratory results across the spectrum of critical metals and rare earth elements. The dual strategy involves using FJH to provide required technical product outcomes such as yield and purity – profitably and sustainably. The FJH process has shown it can meet the viability criteria established by the US Defense Advanced Research Projects Agency (DARPA) in March 2022. Furthermore, using the example of the ultra-high value scrap from Indium Corporation, our preliminary assessment is that profitability is strongly positive

Catalysts

- **Announcement of further flash testing results – particularly in relation to monazite which contains REEs**
- **New commercial partners – securing sources of feedstock'**
- **Establishment of pilot facility through the design / procurement / fabrication / commissioning / testing stages'**
- **Achievement of 1TPD target'**
- **MTM securing new Government funding, both a source of non-dilutive capital and serving as verification of the FJH concept'**
- **New Government policies following the US election'**
- **Further dislocation in REE and critical metals markets'**
- **Further details of costing advantages compared with incumbent REE producers.**

CRITICAL METALS MARKET RESTRICTIONS SOUND STRATEGIC ALARM

While we popularly view new technologies as driving growth, efficiency, prosperity and decarbonisation, this is proving problematic because most of these new technologies require Rare Earth Elements (REEs). REEs describe the 15 lanthanides of the periodic table {Lanthanum (La) – Lutetium (Lu)}, plus Scandium (Sc) and Yttrium (Y). REEs are abundant in the earth's crust, it's just that they occur in low concentrations and are hard to separate. This makes them "rare".



Demand for these elements is projected to spike in coming years as governments, organizations, and individuals increasingly invest in clean energy technologies. An electric car requires six times the mineral inputs of a conventional car, and a wind plant requires nine times more minerals than a gas-fired plant. With current estimates, demand for REEs could increase six-fold by 2040. Lithium and cobalt demand could increase ten to twenty times by 2050 because of electric cars. Demand for dysprosium and neodymium is estimated to increase seven to twenty-six times over the next 25 years from electric vehicles and wind turbines.

Production of these new technologies requires REEs to be dug up. There are two primary methods: the first involves removing topsoil and creating a leaching pond where chemicals are added to the extracted earth to separate metals. This form of chemical erosion is common since the chemicals dissolve the rare earth elements, allowing them to be concentrated and then refined. The process involves multiple stages – sulfuric acid cracking, leaching, and complex solvent extraction – which require significant acid, large volumes of water, and generate substantial by-products, including iron phosphor-gypsum and magnesium-rich gypsum. It also produces troublesome secondary waste streams. The leaching ponds, full of toxic chemicals, may leak into groundwater when not properly secured and can sometimes affect entire waterways. The second method involves drilling holes into the ground using PVC pipes and rubber hoses to pump chemicals into the earth, which also creates a leaching pond with similar problems. Additionally, PVC pipes are sometimes left in areas that are never cleaned up.

Both methods produce large amounts of toxic waste, with high risk of environmental and health hazards. For every tonne of rare earth metals produced, the mining process yields 13kg of dust, 9,600-12,000 cubic meters of waste gas, 75 cubic meters of wastewater, and one tonne of radioactive residue. Rare earth ores are often laced with radioactive thorium and uranium, which result in especially detrimental health effects. Overall, for every tonne of rare earth, 2,000 tonnes of toxic waste are produced. (Harvard International Review)

China now dominates the REE market with an estimated 60% - 70% of production and 90% of processing as it imports REEs from other countries and processes them domestically. This strong foothold has been enabled by China's low costs and lax environmental regulations. China has taken steps to address the increasing domestic pollution problems generated by its extensive REE Empire, but it understands the value of this monopoly and has been moving operations to Africa and other countries, where it has done deals for mining rights in exchange for building key infrastructure such as roads, hospitals and data centres.

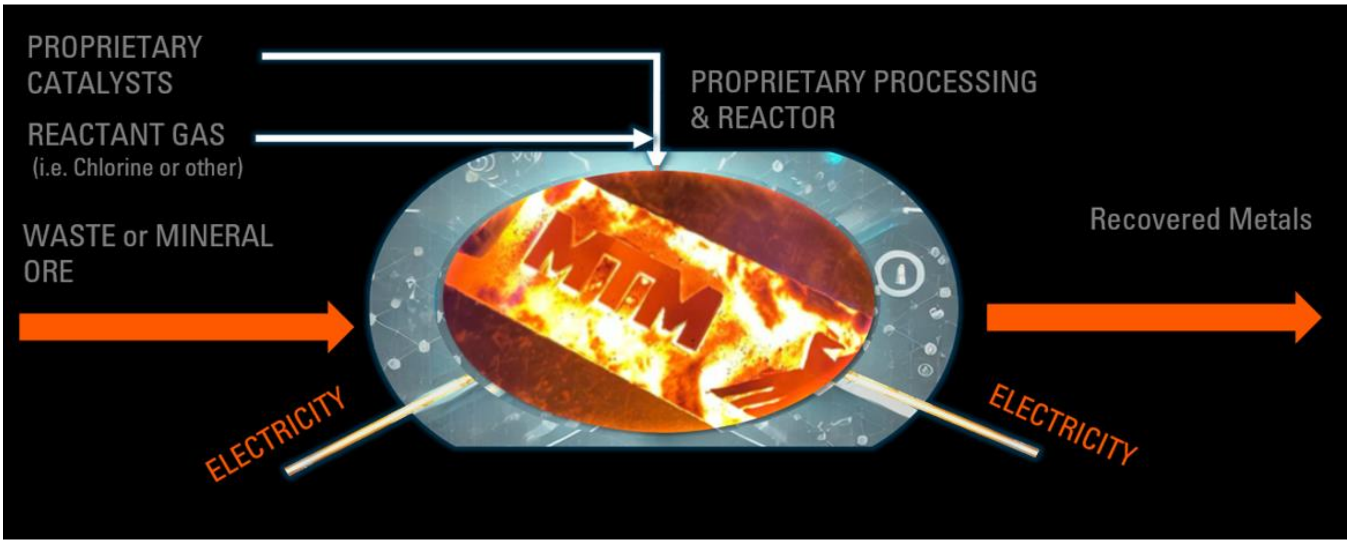
New export controls will affect supply and drive prices higher. China has strengthened its control over rare metals, unveiling its first comprehensive regulation on rare earth resources effective 1 Oct 24. The new regulations introduce a set of rules governing the mining, refining and separation, metal smelting, integrated utilization, product distribution, import and export of rare earths, and specify severe penalties for violations. This follows the implementation of export license administration on critical metals germanium and gallium effective 1 Aug 23, and on antimony effective 15 Sept 24. These restrictions on "dual use" (civilian and military) technologies are a tit for tat response to US restrictions on the export of semiconductor manufacturing equipment.

FLASH JOULE HEATING (FJH) ADDRESSES STRATEGIC SUPPLY CHAIN CONCERNS

With EVEN STRONGER Chinese control over REEs, there are unacceptable strategic vulnerabilities in the US supply chain. Authorities are accelerating their policy response and reducing offshore reliance with policy changes expected that further support onshoring and incentivise domestic manufacturing. **Metal recycling plays a crucial role in mitigating the shortage of critical metals and reduces reliance on primary mining.** Current recycling strategies include liquid hydrometallurgy, which involves substantial water and chemical consumption with troublesome secondary waste streams and pyrometallurgy, which lacks selectivity and requires substantial energy input.

Flash Joule Heating (FJH) is an electrothermal process that enhances REE and other critical metal recovery including from waste. Current prototypes use a specialized compact reactor for the selective separation of individual critical metals from electronic waste (e-Waste). The process uses a programmable, pulsed current input to achieve precise control over a wide temperature range (from room temperature to 2,400 °C), short reaction durations of seconds and rapid heating/cooling rates (103°C / second) during the process.

FJH efficiently extracts metals like lithium from spodumene, gallium from scrap, and gold from E-Waste. FJH technology has the potential to revolutionise metal recovery by reducing energy consumption, reagent use, waste, offering a more economical and environmentally friendly alternative.



Source: MTM Presentation

This patented technology was invented by Dr James Tour at Rice University, Houston Texas and is provided to MTM under an exclusive global license agreement per ASX dated 31 May 2024.

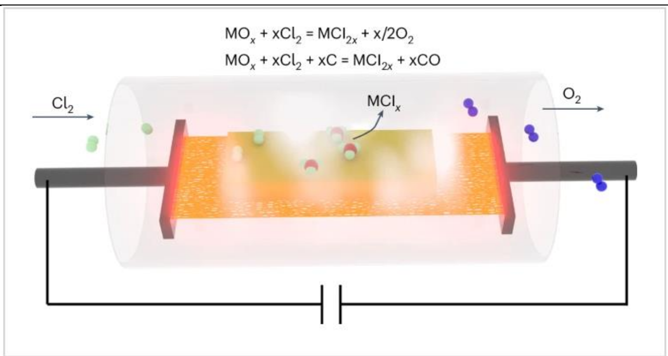
The license agreement gives MTM the right to the proprietary technology under the associated patents for recovery of REEs and other critical metals and metallic compounds from industrial waste (including coal fly ash and bauxite residues), ores, e-Waste and end-of-life batteries.

Rice will receive consideration comprising fees, royalties (based on revenue generated directly from the license) and milestone development payments, as well as an equity payment in the form of unlisted options.

MTM's FJH process can be enhanced by chlorination and carbochlorination to directly convert flotation concentrate into REE chlorides, potentially elimination the need for sulfuric acid. The FJH process offers ***Multiple Potential Advantages*** over traditional techniques.

1. ***Reduced Acid Consumption*****:** By focusing on FJH chlorination/carbochlorination, the process could minimise or even eliminate the need for sulfuric acid, reducing overall costs.
2. ***Lower Water Requirements***: FJH technology may involve dry chlorination reactions, potentially reducing the need for extensive water-based dissolution stages.
3. ***Targeted REE Recovery***: Chlorination and carbochlorination are highly selective and could enable more direct separation of REE chlorides, which may simplify downstream processing compared to complex solvent extraction systems.
4. ***Improved By-Product Management***: FJH may potentially produce fewer or different by-products, possibly easing waste management challenges.

The process (schematic below left) capitalises on the differences in the free energy formation of the metal chlorides (below right). Once conversion to a specific metal chloride is achieved (Fe and Ti examples shown), that compound distils from the mixture in seconds. This allows both thermodynamic and kinetic selectivity for desired metals with minimisation of impurities, based on the fine tuning of the temperature and the voltage applied in the reaction vessel. The process is facilitated by the conductive nature of the feedstock powder used.



Capitalizing on the ΔG_{form} of the metal chloride, whereupon it immediately distills from the system

Boiling points

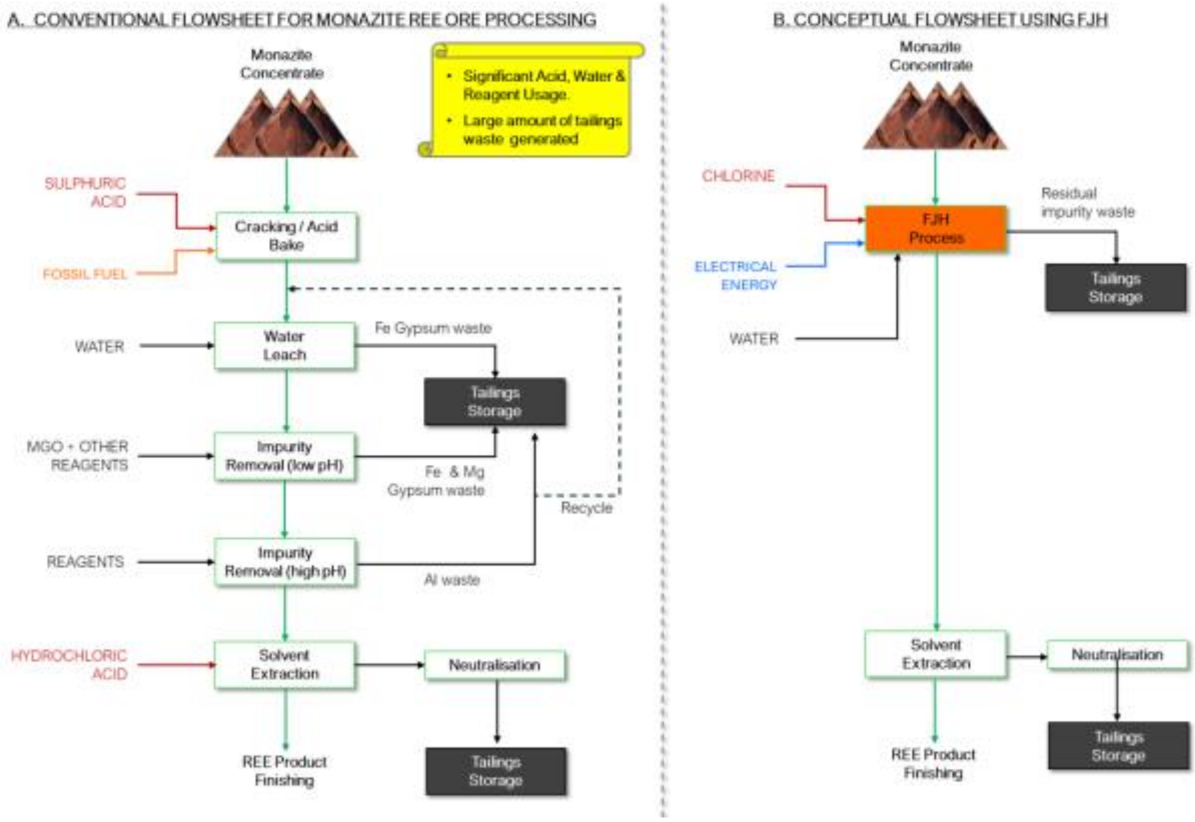
Fe_2O_3 = 3,414 °C → Fe(0) = 2,862°C → $FeCl_3$ = 315°C

TiO_2 = 2,972°C → Ti(0) = 3,287°C → $TiCl_4$ = 136°C

FJH involves rapidly heating materials in a controlled atmosphere process. Various feedstock alternatives that readily conduct electricity have been evaluated by MTM including Gallium Scrap (yielding Gallium, Germanium and Selenium), E-Waste (yielding multi-metals such as gold, silver, copper, tin and palladium), Spodumene (yielding lithium), Monazite ore (yielding REEs). In each case, a crucible of feedstock material is “flashed” in a controlled electrothermal reaction using the Flash Joule Technology.

In targeting specific REEs, MTM have sought to get the right balance between the heat applied to the flash crucible and the amount of energy used in the flash process. MTM has found that the right balance will determine which chlorides are formed and liberated as volatiles or gases. Different REE-Chlorides have different formation temperatures when the Chlorine reacts with the REE from the feedstock. MTM use this property to target and extract the desired REE, as shown in the mozanite example below:

Flowsheet Comparison of Conventional vs FJH Process for treating Monazite REE concentrate:



Source: Company Presentation

CHANGES DRIVE PIVOT TO INDUSTRIAL PROCESSING

Recently, MTM has:

- **Appointed recycling industry executive Steve Ragiel as President of Flash Metals USA Inc. (15 April 2024)**
- **Appointed mineral processing executive Michael Walshe to the position of CEO. (9 August 2024)**
- **Appointed experienced company executive Paul Niardone as an independent NED. (15 April 2024)**
- **Managing Director since July 2021 and CEO since April 2024, Lachlan Reynolds resigned. (2 July 2024)**
- **David Izzard (originally appointed a NED 15 July 2021) ceased to be a director. (27 November 2024)**
- **New CEO Michael Walshe was elected as Executive Director. (27 November 2024)**

MTM has accelerated its pivot to an **industrial processing company Using Flash Joule Heating technology**. This has been achieved in a relatively short period of time. MTM's development progress this calendar year to date has been impressive:

Date	Description
19/12/2023	MTM enters binding agreement to acquire 100% of the shares in Flash Metals Pty Ltd.
11/02/2024	Lodges Prospectus in relation to Flash Metals Acquisition.
13/03/2024	MTM exercises its FJH Licensing option to technology and development work carried out by Rice University and specialist consulting engineers Knighthawk Engineering.
03/04/2024	Flash Joule Heating (FJH) Prototype Complete
06/05/2024	FJH Prototype Test Increases Rare Earth Element (REE) Recovery
31/05/2024	Global License Agreement Secured for FJH with Rice University
24/06/2024	Positive Advances with Metal Recovery Test Work
09/07/2024	Positive Lithium Extraction Results from FJH
13/08/2024	Addition of Chlorination enhancement to FJH License
21/08/2024	FJH converts Spodumene to Lithium Chloride
27/08/2024	Gallium Recovered from Semiconductor Waste Using FJH Technology
06/09/2024	MTM Advances FJH Commercialisation with 1 Ton Per Day (TPD) Demo Plant
12/09/2024	High Gold Recovery from E-Waste using FJH Technology
18/09/2024	Further Advances in Lithium Refining with FJH
25/09/2024	High Silver & Copper Recovery from E-Waste using FJH
08/10/2024	Significant Multi-Metal Recovery from E-Waste Including Palladium & Tin
30/10/2024	Progress Update on 1 TPD FJH Demo Plant with design on track for Q1 2024
25/11/2024	FJH Technology Delivers Breakthrough in REE Processing
29/11/2024	MTM & Indium Inc. Enter Strategic Collaboration for Recovery of Gallium, Germanium and Other Critical Metals.
8/01/2025	Announce further improvements in REE chloride production – 93% conversion @ >90% purity REE Chloride product

Source: Peloton Capital, ASX

Critically, MTM has:

- **Secured key FJH technology and technology rights from Rice University.**
- **Partnered up with specialist consulting engineers Knighthawk Engineering.**
- **Identified Multiple Potential Industrial Verticals (e.g. REEs from Monazite, Ga/Ge from E-Waste, Li from Spodumene)**
- **Achieved significant technology development milestones vis Chlorination, Batch Processing and Recovery Rates.**
- **Formed a Strategic Collaboration with Indium Corp significantly de-risking supply of Gallium/Germanium-rich feedstock.**

MTM has made significant advancements towards target at scale parameters and commercialisation. If target 1 Tonne Per Day output from FJH is successfully achieved using the Ga/Ge feedstock, we expect this will lead to the negotiation of formal scrap supply and offtake agreements, on terms conducive to an ongoing business relationship.

STRATEGY: DELIVER REQUIRED CRITICAL METAL YIELD & PURITY – PROFITABLY

MTM has tested a range of metals using FJH, reporting encouraging laboratory results across the spectrum of critical metals and rare earth elements. The dual strategy involves using FJH to provide required technical product outcomes such as yield and purity – profitably and sustainably.

Objective 1: The FJH process delivers acceptable combination of Yield and Purity for a given industrial vertical and choice of feedstock

Objective 2: The FJH process achieves an adequate buy/sell spread between the material input costs and the offtake price less production costs and other costs.

The following is a current summary of MTM's progress to date in the commercialisation of the FJH process:

Verticals	Progress on Yield/Purity	Buy/Sell Spread Progress
Gallium and Indium Scrap	>70% recovery of available gallium from wafer discs and industrial residues. High-purity $GaCl_3$ as the target product.	Since Indium Corp has already incurred the cost of acquiring their waste feedstock and currently lacks a viable method for extracting value from it, we believe MTM has the potential to secure a significant share of the residual metal value. This could result in a highly favourable buy/sell spread. While specific figures not yet available, we are confident in the viability of this approach.
Rare Earth Elements (REEs)	Testing chlorination and carbochlorination to remove impurities from monazite concentrate and generation of REE chlorides. >93% recovery of available REEs into 90%-pure water-soluble chlorides. All 17 REEs converted. Average 95% reduction in impurities	Discussions with a major REE player are underway. Market-driven pricing benchmarks to ensure competitive positioning.
Lithium from Spodumene	Successful alpha-to-beta spodumene conversion & separate generation of high purity LiCl. Yield information not available at this stage. If this works at scale, it will be a true breakthrough for spodumene processing	MTM are currently exploring collaborations with major industrial players. Buy/Sell spread under evaluation as partnerships evolve.
E-Waste Metals	High recovery potential for copper, gold, and other valuable metals. Early-stage validation ongoing. Recoveries to date have been very encouraging (copper>80%, Gold ~ 70%, Tin > 80% etc). High purity rates due to refined nature of feedstock.	Input cost of ~$3,000/ton for PCBs with significant upside potential for high-value E-Waste.

Source: Peloton Capital, MTM

The possibilities are endless: FJH is also a candidate technology for recycling of fibre reinforced plastics from wind-turbine blades; Li-Ion "black mass"; Tantalum from Tantalum capacitor waste; Fe removal from "red mud" a large-scale toxic industrial waste from Aluminium Oxide mining; Hydrogen from Plastic Waste.

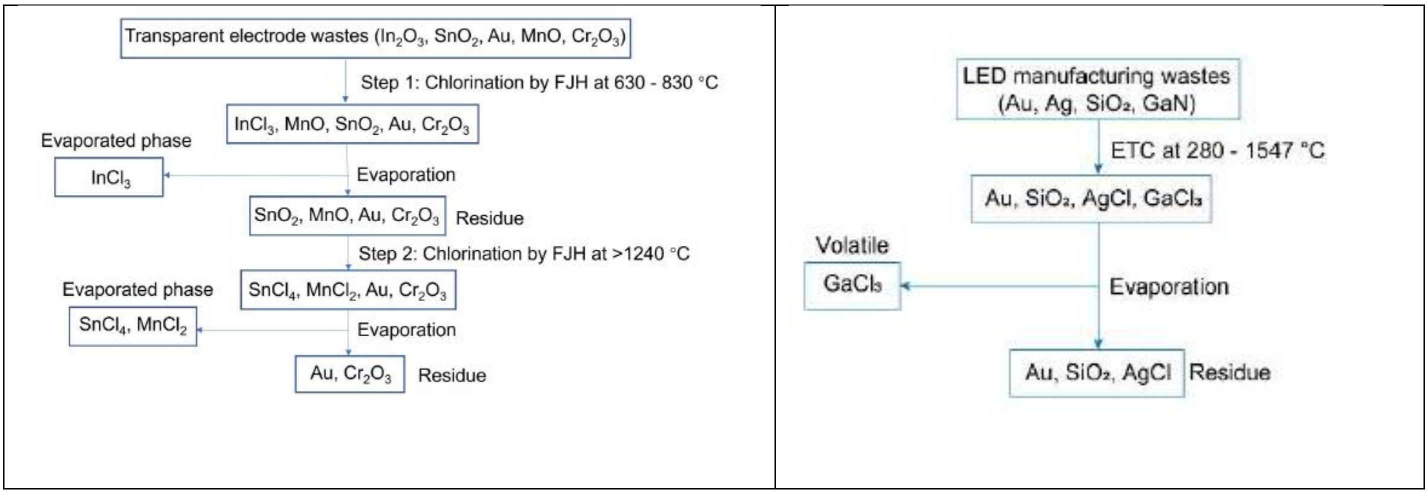
DELIVER REQUIRED YIELD AND PURITY

MTM aims to achieve the highest possible yield of valuable critical metals and REEs while ensuring product purity meets or exceeds market requirements. This is achieved by optimising the FJH process for temperature, chlorination/carbochlorination chemistry, feedstocks etc without significant trade-offs in purity.

We are encouraged that FJH has shown it can meet the viability criteria established by the US Defense Advanced Research Projects Agency (DARPA) in March 2022.

FEEDSTOCK TYPE	TARGET ELEMENT	%W /%W	CHLORINATION FJH RESULTS: VOLATILES OR RESIDUE	PURITY	YIELD	RATE g/hour	EXCEEDS DARPA PHASE 2 REQUIREMENTS FOR: PURITY	YIELD	RATE	COMMENT
							95%	70%	>40	
Indium Tin Oxide (ITO) Transparent film used for solar panels, touchcreens etc. The fim is calcined (reduced) at 800°C for 2 hours to get a fine powder	Indium (In)	20%	Vol (Flash #1)	95%	92%	180	✓	✓	✓	Primary Flash @ 105 Volts, Temp 630 - 830°C
	Gold (Au)	70%	Res (Flash #1)	80%						Primary Flash @ 105 Volts, Temp 630 - 830°C
			Res (Flash #2)	96%	82%	na				Improves with Secondary Flash @ 1,240°C
LED Wafers for Gallium (Ga) Separation. After liftoff of the SiO_2/Si substrate, the mass is reduced to 1.43% of the original weight	Gallium (Ga)	26%	Volatiles	97.5%	86.5%	315	✓	✓	✓	Control temp to range 280 - 1,547°C in order to boil off the more volatile $GaCl_3$ and leave behind the AgCl with the higher boiling point
			Residue							Residue is ~20% Au, ~80% SiO_2

The flowcharts corresponding to the above reactions with INDIUM TIN OXIDE (ITO) – (LHS) and GALLIUM (Ga) separation – (RHS)



In addition, The ITO flowchart confirms that FJH technology can harvest multiple critical metals from the same batch of feedstock. Clearly, indium chloride is initially targeted in the flow chart above (left), while the secondary flash at 1240° produces vapour containing Tin (Sn) and Manganese (Mn) chlorides and residue containing Gold and chromium trioxide which is used in coatings applications. Multi-metal extraction strategies provide additional revenue opportunities with the use of the FJH process and have the potential to significantly enhance unit economics depending on scrap types.

ENSURE COMMERCIAL PROFITABILITY AND THE “BUY/SELL SPREAD”

On 25th November 2024, MTM announced it had successfully used FJH to achieve a 48% reduction in impurities from a high iron & other impurity monazite REE feedstock in a dual step chlorination and carbochlorination process. The process delivered a 50% increase in the concentration of the Total Rare Earth Oxide (TREO) from 30.84% TREO concentration in the feedstock compared to 46.2% post treatment. This is proof of concept only but highlights significant future potential.

On 8th January 2025, MTM reported further efficiency gains using a single FJH carbo-chlorination flash accompanied by a water wash. The process used the same feedstock as per the 25th November 2024 announcement. Results include:

- 93% of REEs converted into Chlorides
- All 17 REEs converted into Chlorides
- **Average 95% reduction in impurities (Fe, Al, P) – PREVIOUSLY 48%**
- REE-Chloride product achieved >90% purity

MTM maintains a laser focus on the cash costs to produce critical metals. This is in a market where feedstock or scrap costs will differ depending on the source and concentration. MTM take this into consideration when evaluating different industrial verticals. For example, some feedstock will otherwise have an attached liability requiring further treatment and expense by the supplier/owner to take it through the disposal and remediation process. Other sources will be inherently valuable containing considerably higher concentrations of the target metal than others. For example, ultra-high value scrap from Indium Corporation contains 15% w/w Gallium, 18% w/w Germanium and 20% w/w Indium.

Business profitability will be the result of commercial negotiations and any formal scrap supply and/or offtake agreements. Our analysis does not make any specific allowance for scrap supply and/or offtake arrangements, nor does it allow for refining of the chlorides produced by the FJH process into pure metal if required.

We have nonetheless undertaken to evaluate the potential profitability of the FJH part of the process that MTM can directly control, which will ultimately drive success.

Using the example of the ultra-high value scrap from Indium Corporation, our preliminary assessment of the buy sell spread is strongly positive. The following table assumes a pilot facility rated at 1TPD is operating under current market conditions:

Per 1,000kg Ultra High Value Scrap from Indium Corp (Assuming a 1TPD facility)	Ga 31 Gallium	Ge 32 Germanium	In 49 Indium	
Metal in Feedstock (kg/1,000kg))	150	180	200	NB:
Recovery Rate	70%	70%	70%	GROSS MARGIN POTENTIAL
Metal Recovered (kg/1,000 kg)	105	126	140	EXCLUDES THE IMPACT OF
Price (US$ per kg)	600	1,700	690	TERMS NEGOTIATED FOR ANY
Revenue (US$)	63,000	214,200	96,600	POTENTIAL SUPPLY AND
Cost per 1,000kg UHV Scrap	10,000	10,000	10,000	OFFTAKE AND/OR SCRAP
Gross Margin Potential (US$)	**53,000**	**204,200**	**86,600**	SUPPLY AGREEMENTS

The profitability potential is clear: At the above daily 1TPD production rate, and based on 250 days operation per annum, the implied annual gross margin is: Gallium US$13.2m / Germanium US$51.0m / Indium US$21.6m.

If all 3 elements are extracted from the same tonne of ultra-high value scrap from Indium Corporation, by recirculating the solid residue and successively flashing it at higher temperatures, then the gross margin potential is the sum of all three elements, a potential US$85m pa subject to satisfactory supply and excluding yet to be negotiated scrap supply and/or offtake agreements which would recognise that Indium Corporation paid good money for this “scrap” as it forms in input into their semiconductor manufacturing operations.

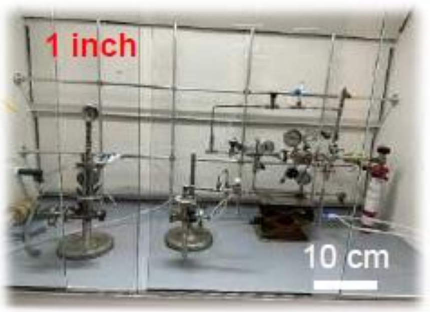
KNIGHTHAWK PARTNERSHIP – ACCELERATING PROCESS SCALE UP

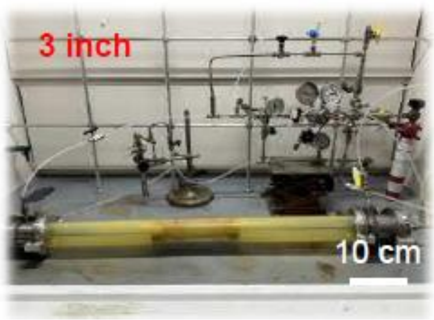
Knighthawk Engineering (KHE) is a Houston TX based engineering solutions specialist founded in 1991. It has a reputation for developing unique solutions in the industrial sector and has worked for several well-known companies as well as local entrepreneurs (listed below). MTM's formal partnership with Knighthawk Engineering began with the March 2024 acquisition of Flash Metals Pty Ltd. However, back then Knighthawk was well advanced on the FJH prototype, having previously collaborated with the vendors of Flash Metals Pty Ltd.

- Ameri-Forge Corporation
- Allied Signal
- Alstom (Schmidt'sche)
- Aristech Chemical Corporation
- B&B Electromatic
- Babcock
- BASF Corporation
- Bilco Tools
- BOC Gases
- BP Amoco Chemical
- BP Amoco Refinery
- Calciner Industries, Inc.
- Cargill, Inc.
- Chemical Waste Mgmt.
- Chemtura Corporation
- Chevron Chemical
- Chevron/Phillips Chemical
- Ciba-Geigy
- Cit-Con Oil Corporation
- Citgo Petroleum
- Citgo Refinery
- Coastal Refining
- Coffeeville Resources Nitrogen Fertilizers
- Coffer Corporation
- Conoco Incorporated
- Condea Vista
- Conoco-Phillips Company
- Copolymer
- Crall Products, Inc.
- Crown Vintage
- Dakota Gasificiation
- Dolphin Energy
- Dynegy Power
- Dow Chemical
- Dupont
- Ecodyne MRM
- Engineering Designs Transfer, Inc.
- Eni Chem Americans, Inc.
- Entergy
- Equistar
- Excel Para Lubes
- Exxon Chemical
- Exxon Mobil
- Fonco Engineering
- GB Bioscienes
- GE Aero Power Systems
- Geo Heat Exchangers
- Georgia Gulf
- Georgia Pacific
- Global Octanes
- Global Sante Fe
- Houston Refining Lp
- Huntsman Corporation
- Hydrochem, Inc.
- Hydro Machinery
- Imc-Agrigo Company
- International Piping Sys.
- Invista
- Jacobs Engineering
- James River Corporation
- Kaldair, Inc.
- Kaiser Aluminum And Chemical
- Kerr Mcgee
- Kimberly-Clark
- Lafayette Utilities
- Laroche Chemicals
- Louisiana Generating, LLC
- Lucite International, Inc.
- Lyondell Petrochemical
- Marathon LLC
- Master Foods
- Melamine Chemicals, Inc.
- Merichem Chemicals & Refinery
- Metal Works Corp.
- Millennium Chemicals
- Mississippi Chemical Nitrogen LLC
- Mobil Oil Corporation
- Monsanto Company
- Motiva Enterprises LLC
- MTM Critical Metals
- Nalco Chemical Company
- Natureworks LLC
- Nelson Industrial Steam Company
- O&M Manufacturing
- Occidental Chemical
- Ohmstede Heat Exchangers
- Onyx Environmental Services
- Orion Refining
- Oteco Incorporated
- P.T. Smelting
- Petrex, Inc.
- PPG Industries
- Placid Refining
- Pellerin Milnor
- Reflange, Inc.
- Reliant Energy Coolwater, Inc.
- Resource Rig Supply, Inc.
- Rohm & Haas Company
- Rubicon, Inc.
- Sasol Synfuels (PTY)
- Selas Fluid Processing
- SG Solutions
- Shell Chemical Company
- Shell Offshore, Inc.
- Sierra Pacific
- Solvey Polymers
- S.S.&S. Fabricators
- Stp Nuclear Operating Company
- Stone & Webster
- Stowe Power
- Taper-Lok Corporation
- Technip USA Corporation
- Temple Innland
- Tenaska Gateway Partners
- Terra Industries
- Texaco Development Corp
- Texas Eastman
- Thermon Manufacturing
- Titan Petrochemicals
- Total Petrochemicals
- Triad Chemical Company
- Turner Industries
- TXU Electric
- Uniroyal Chemical
- Vogt-Nem
- Vulcan Chemicals
- Weeks Marine Incorporated
- Westlake Petrochemical
- Westvaco
- Weyerhaeuser Company
- Williams Olefins

TO BEGIN WITH: THE RICE UNIVERSITY LABORATORY PROTOTYPE

Early-stage lab prototypes were **basic single batch designs** and explored scale using larger diameter reactor tubes (1" –> 2" –> 3")



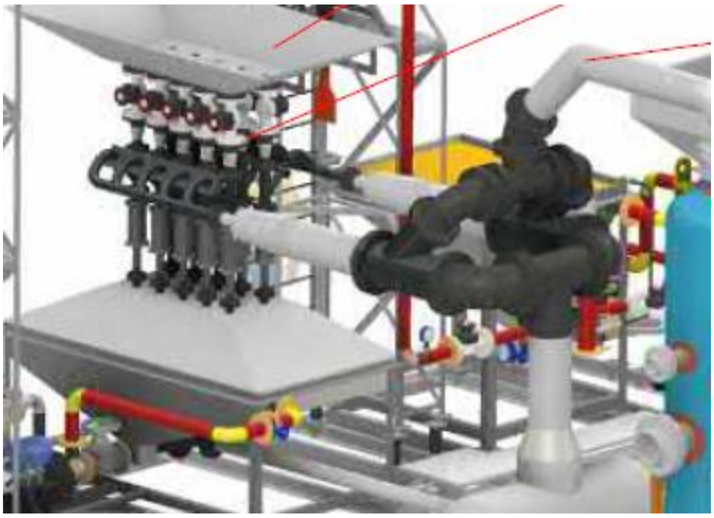


MTM – KHE: TRANSITIONING TO SEMI-BATCH, THEN CONTINUOUS FEED PROCESSING

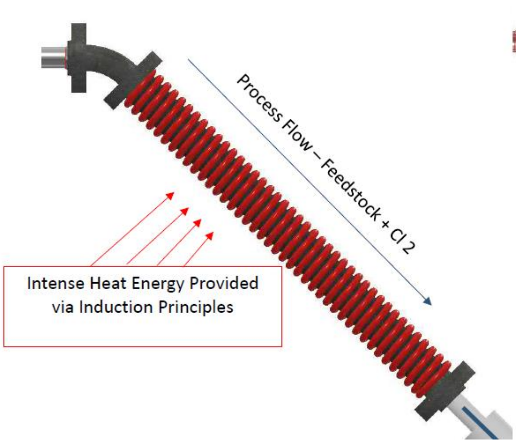
Pilot Unit concepts have been identified and include both a **sophisticated multi-chamber semi-batch design** and a **continuous feed induction flashing design**. Both designs accommodate a 1TPD feedstock input requirement (based on a 12 Hr Shift), will be modular and able to be deployed to a customers' operating site.

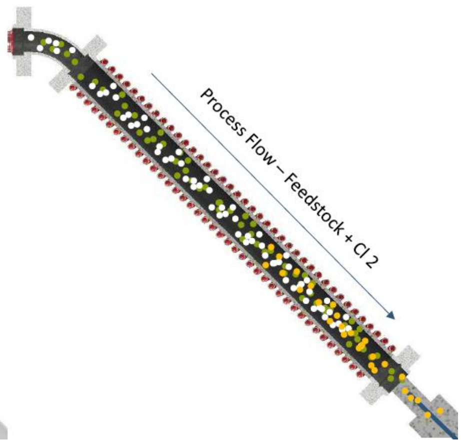
The semi-batch system utilises multiple cylindrical induction reactors/crucibles. The system fluidises feedstock in a crucible using Chlorine gas while inductively heating it to promote metal chloride formation. **Feedstock remains stationary** in the induction reactor/crucible while it is being flashed. The gaseous metal chlorides are then extracted, washed and condensed into brine.

Once flashed, the crucible discharges the remaining solids through the bottom of the reactors ready for the next batch. This process can be mechanised and expanded to achieve scale. Advantages of this system are that it has potential for "series" configuration and that it permits flexibility for the resident time or duration of core reactions, or "flashes". On the other hand, however, the inner reactor workings will potentially involve a complex mechanical design.



On 25th November 2024, MTM advised that it had achieved a major technical advancement by transitioning from a batch system to a continuous operating design with a 2,000-fold scale up from the original laboratory-scale process.





The cutaway diagram on the right shows the process flow with feedstock [white] and chlorine gas [green] entering the reactor.

It reacts together to form Metal Chlorides [yellow] and leaves the reactor with excess chlorine gas.

Downstream washing with water [not shown] then creates product brine and separates solids from chlorine gas.

The continuous operating design is an updated concept which similarly heats the feedstock and Chlorine inductively in a linear reactor to produce a mixture of the residual solids, excess chlorine gas, and volatile discharge which includes the target Metal Chlorides. The difference is that the feedstock is continuously fed into the reactor and flashed as it transits over the length of the reactor. Variables include the speed of transit, the induction additive used, the reaction temperature and the physical size and length of the reactor body. Downstream washing creates product brine and separates the solids and excess chlorine gas. This design concept is inherently simpler and is more suited to continuous operation due to having fewer moving parts.

ACCELERATED TIMELINE TO 1TPD FACILITY

MTM – KHE aims to have completed design, project schedule and budget review by the end of February 2025.

Then the following steps could potentially include:

Another 3 months for fabrication of the 1 TPD Pilot Unit. **(March 2025 – May 2025)**

Another 2 months for commissioning and testing phase which takes another couple of months. **(June 2025 – July 2025)**

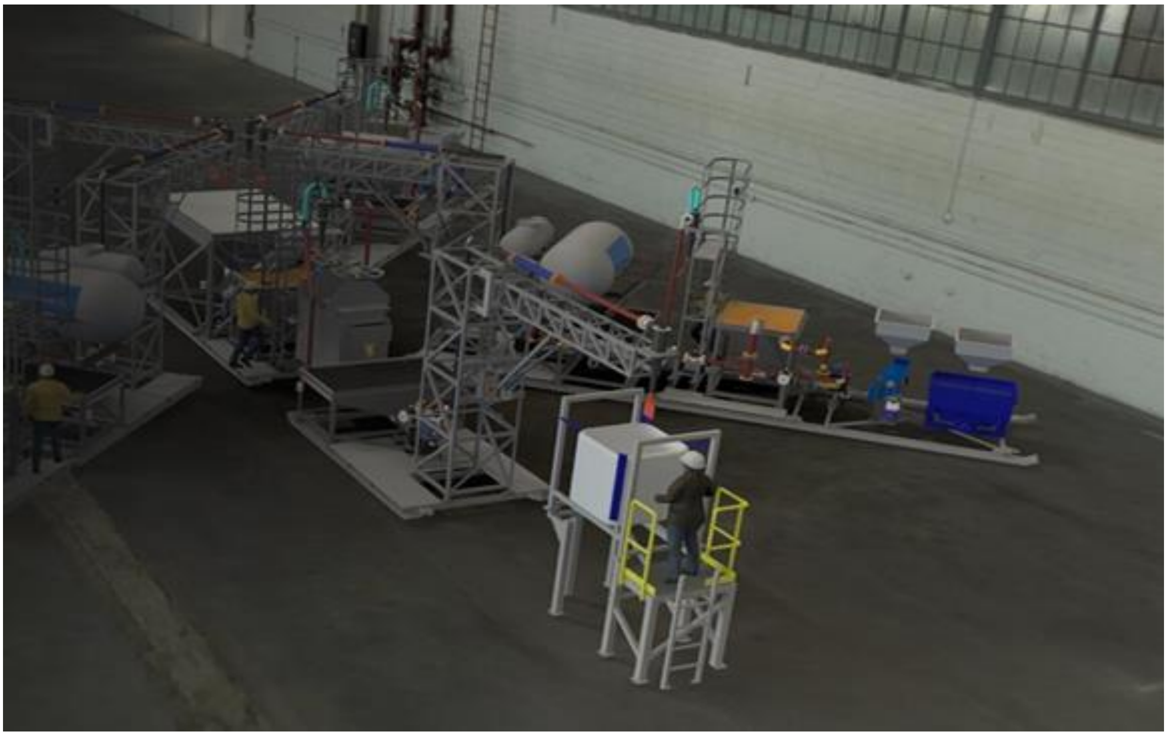
Another 3 months for operational shake down and further testing. **(August 2025 – October 2025)**

MTM have negotiated an incentive-based fee structure with KHE which includes a substantial success-based component once the 1TPD target has been achieved.

In parallel, MTM – KHE will evaluate site options and consider the optimal energy requirements of the process as this will be a factor in the commercial viability of the 1TPD Pilot Unit.

The following graphic extract from a company presentation **shows the scale of the 1 TPD Pilot Unit. Details of key engineering components remain confidential; however, we note the units are skid mounted, designed to be deployable at customer sites, and appear to be designed to operate on a stand-alone basis.**

The unit includes a material handling section which accepts feedstock for sieving, crushing, grinding and drying before it is accepted for induction chlorine flashing and capture of the Metal-chloride off-gas. Downstream treatment involves separation of the Metal Chloride brine, excess chlorine gas and solid residue.



URBAN MINING AND THE TRANSITION TO A CIRCULAR ECONOMY

Urban mining is the idea of extracting valuable materials from waste, much of which would otherwise go to landfill or incineration. Much of our diminishing landfill resources are filling up with material obtained from the construction sector via demolitions and alterations, as well as common metals and plastics and rarer but valuable elements from the growing volumes of e-Waste.

It makes sense to salvage materials where there is a finite supply and limit the environmental impact of their disposal. Urban mining reduces the need for new extraction of additional materials, which damages ecosystems and causes toxic pollution. Urban mining forms part of the emerging circular economy, which promotes a more sustainable use of resources by keeping them in use for as long as possible. Rather than just going into landfill and harming the environment, there is a significant opportunity in using recycled materials to manufacture new products.

Global E-Waste production is out of control: a record 62 million tonnes (Mt) of e-waste was produced in 2022, Up 82% from 2010. It is forecast to rise another 32%, to 82 million tonnes, in 2030. Unfortunately, the recycling technologies and facilities have not been developed to cope with expected increases in supply, with current recycling rates estimated at less than 25%.

For example, the European Union is not rich in mining resources and is keen to address the shortage of critical minerals by supporting greater levels of e-Waste recycling. They have found that for some metals, recycling is more efficient than mining. Extracting aluminium through recycling, for example, requires 10 to 15 times less energy than primary production. Minerals such as cobalt, lithium, copper and nickel are essential to produce electric cars as well as renewable energy components such as solar panels. **In an uncertain world where tensions and conflict influence supply there is an urgency to transition to more urban mining.**

The extensive testing of the FJH process has demonstrated its flexibility and technical ability to target different critical metals. MTM have identified **other verticals** and have been testing these using the expanded development capacity of Rice University, MTM and their partners Knighthawk Engineering. These potential verticals include:

1. The reduction of glass reinforced and fibre reinforced plastics (from wind-turbine blades otherwise dumped in landfill);

2. Battery Recycling (Li-Ion “black mass”);

3. Tantalum from Tantalum capacitor waste;

4. Fe removal from “red mud” a large-scale toxic industrial waste from Aluminium Oxide mining;

5. Hydrogen from Plastic Waste.

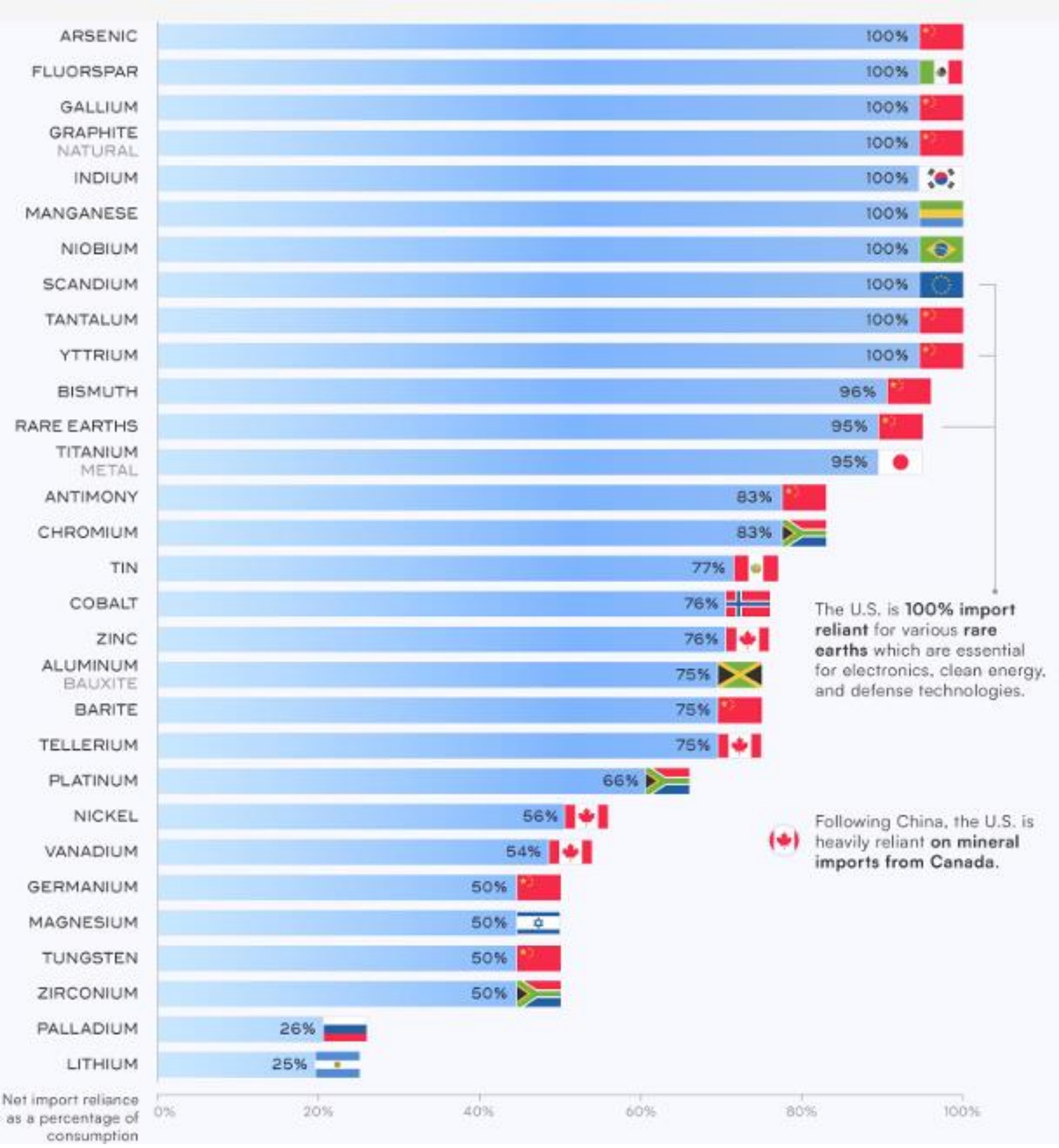
These potential verticals represent a very broad range of potential applications in addition to those already under more advanced testing by MTM – KHE. This is a testament to the flexibility of the FJH process which we believe can be adapted and/or fine-tuned for the recovery of many metals from many different waste types. Ultimately, the success of metal recovery using FJH will be driven by individual scrap/metal unit economics depending on the availability of scrap, transport to recycling hubs, production costs, market prices etc.

Beyond cash economics, there are other factors such as dwindling landfill, toxic pollution and strategic access to critical metals which will produce long-term tailwinds for the recovery of metals from waste until the industrial landscape moves towards a circular economy. Governments will increasingly respond with incentives in the form of tariffs, subsidies and direct (non-dilutionary) investment. We are starting to see this with the US Government who are tackling the problem head on at multiple levels including the military (via DARPA) and the US Department of Energy (DoE).

MTM believe that the upcoming Trump administration with its US industrial and economic independence agenda, is expected to drive significant policy shifts. This may include tariffs on the import of critical metals such as Gallium and Germanium from China, enhanced incentives for domestic manufacturing, and expanded federal funding for critical mineral recovery and recycling technologies. MTM under its strategic partnership with Indium Corporation, is well positioned to benefit from these potential initiatives.

US DEPENDENCY ON CRITICAL METALS

MTM has highlighted the following research from Visual Capitalist (2023) which shows the US is >95% reliant on imports for the 13 most critical metals, with China being the primary import source for >50% of these. These critical metals include Gallium, Germanium, Arsenic, Graphite, Tantallum, Bismuth, and several Rare Earth Elements including Yttrium. Following China, the US is heavily reliant on Canada for mineral imports such as Zinc, Tellerium, Nickel and Vanadium. The following graphic has been reproduced by MTM and shows the US Net Import Reliance as a percentage of consumption.

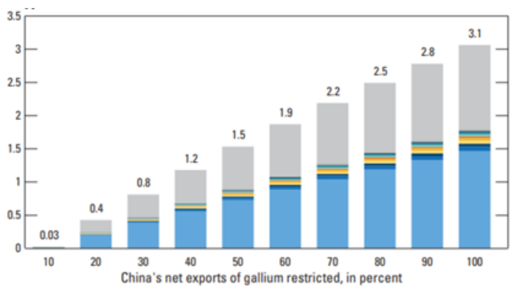


POLICY SHIFT REQUIRED TO AVOID ECONOMIC IMPACT

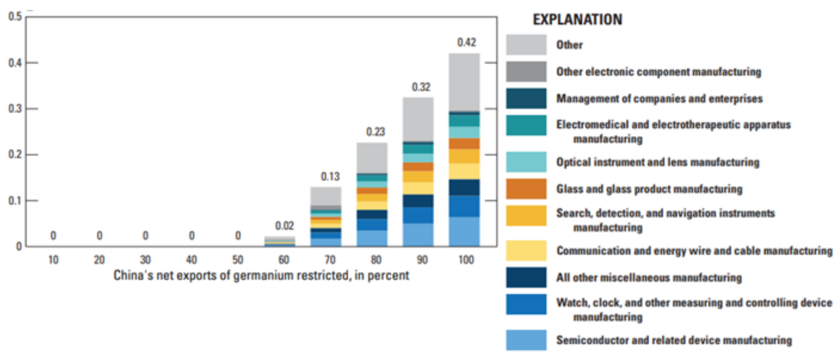
Supply chain risks have been quantified in at least two metals with MTM sharing research from Nassar et al. in conjunction with the US Geological Survey, titled “USGS Critical Minerals Study: Bans on Gallium and Germanium Exports Could Cost the US Billions”. This highlights the net decrease in US GDP in the event of supply chain disruptions of gallium and germanium. The semiconductor industry would bear the brunt of this with downstream impacts on other industries such as electronics and defence.

USGS Report Summary: China’s export controls on gallium and germanium illustrate concerns about the reliability of supplies of mineral commodities that are essential to economic development, national security, and transitioning to renewable energy. The U.S. Geological Survey created a new model to quantify the potential effects of mineral commodity supply disruptions from Chinese net export restrictions of gallium and germanium on U.S. gross domestic product (GDP). The results indicated that a complete restriction of China’s net exports of gallium and germanium could cause the U.S. GDP to decrease by $3.1 billion (with lower and upper estimates of $1.7 billion to $8.2 billion) and $0.4 billion ($0.01 billion to $1.1 billion), respectively, if disrupted separately, and $3.4 billion ($1.7 billion to $9.0 billion) if disrupted simultaneously.

Est. Decrease in US GDP (US$Bn) by % Chinese Net Export Restrictions - **GALLIUM**



Estimated Decrease in US Gross Domestic Product (US$Bn) by % Chinese Net Export Restrictions – **GERMANIUM**



MTM is bidding for US Government grants from the US Department of Energy (DoE) pertaining to “Advancing Technology Development for Securing a Domestic Supply of Critical Minerals and Materials”. The grant amount is US$3-10m with final figures to be decided by April 2025. As a part of its submission, MTM has received a Letter of Support from local partner Indium Corporation where Indium Corporation agree to supply ultra-high value scrap to support the application.

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