Maginito Limited

Rare Earth Recycling for the New Green Economy

November 2020

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Maginito – Green Technology Incubator

- Cleantech growth company established by Mkango and Talaxis to pursue downstream technology opportunities in the rare earths supply chain

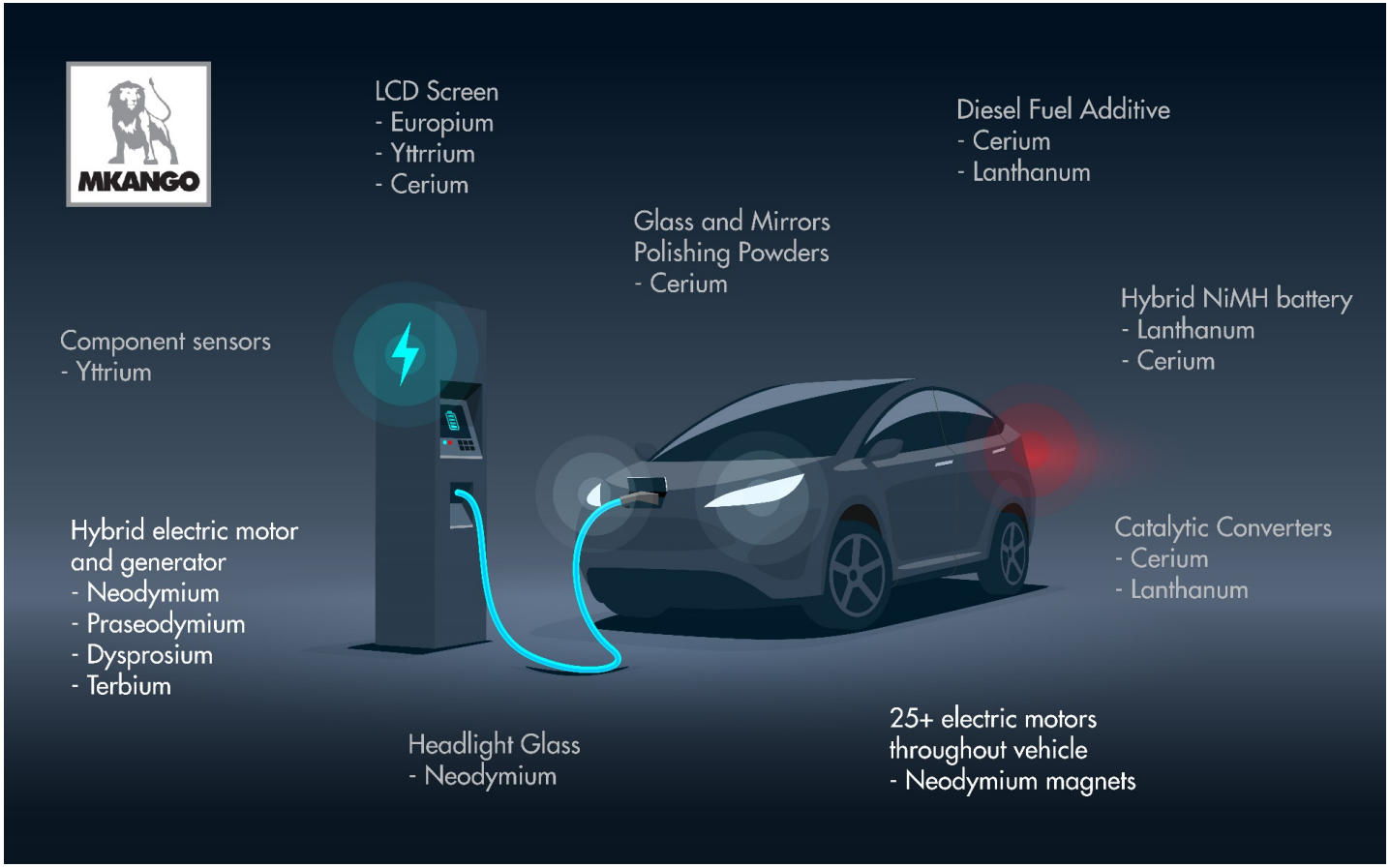
- Initial investment in HyProMag completed in January 2020, focused on short loop NdFeB magnet recycling using hydrogen based technology

- Investment satisfied HyProMag's matched funding requirements for £2.6m Innovate UK grant funded RaRE project announced May 2020, alongside **Bentley**, **Unipart**, **Advanced Electrical Machines**, **Intelligent Lifecycle Solutions**, **University of Birmingham**

- Project pipeline under evaluation, including complimentary technologies and further matched funding opportunities

Rare Earths Critical for EV Growth

Most important rare earths used in an electric vehicle (EV) are neodymium and praseodymium (NdPr) – used in a permanent magnet electric motor



>90% of EVs use rare earth permanent magnet motors

Each permanent magnet motor uses **0.7kg** NdPr

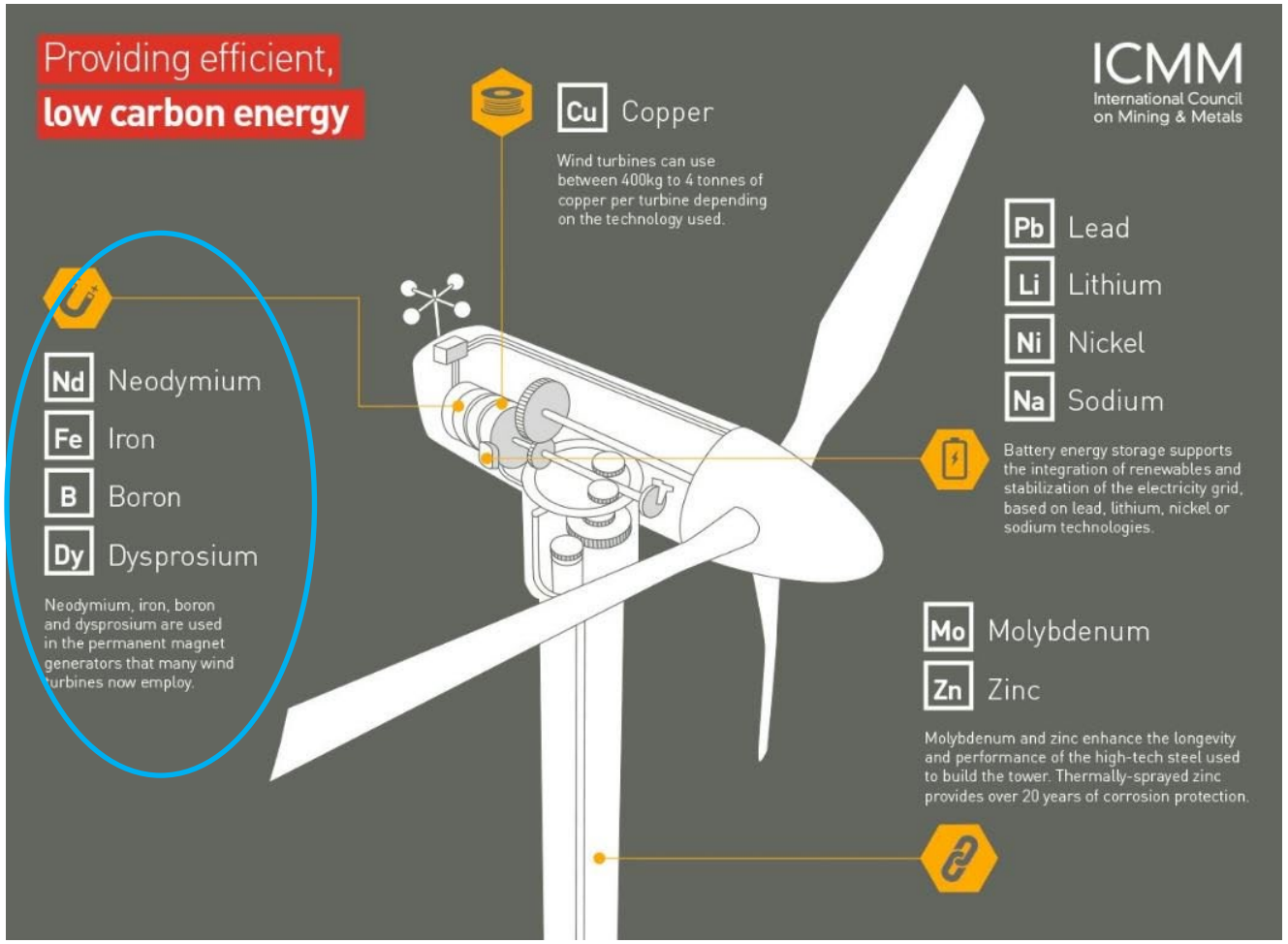
Rapid rise in EV sales to fuel a 275% increase in demand for rare earths used in EV traction motors between 2019 and 2025

Source: Adamas Intelligence

Growing Offshore Wind Demand

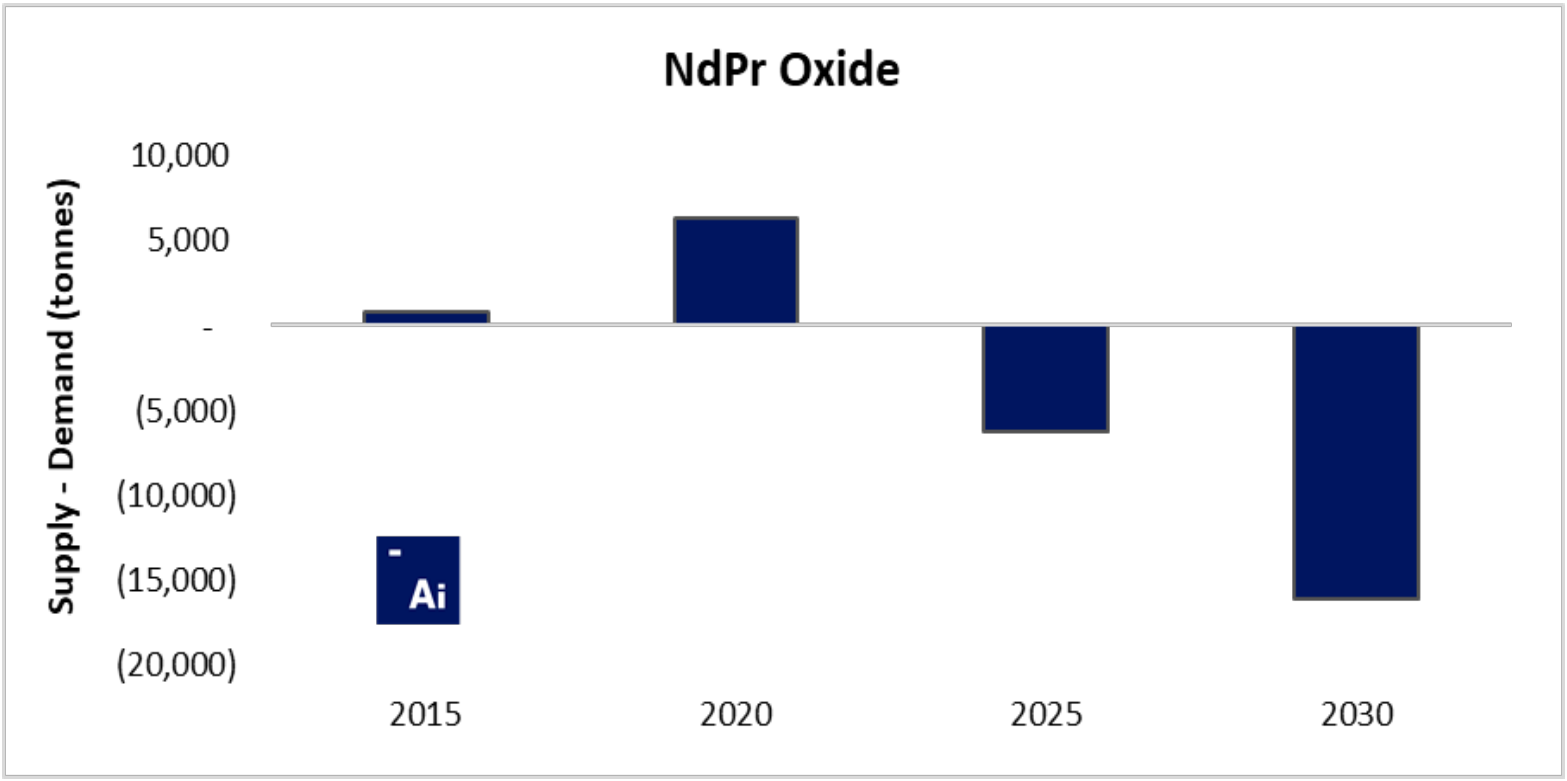
Each 3MW direct drive wind turbine uses around 1.7 tonnes of NdFeB magnets

IEA forecasts offshore wind installations will double in next 5 years and grow fivefold by 2030



Very few advanced stage rare earths projects positioned to meet the demand growth from electric vehicles and wind power

Growing Supply - Demand Deficit

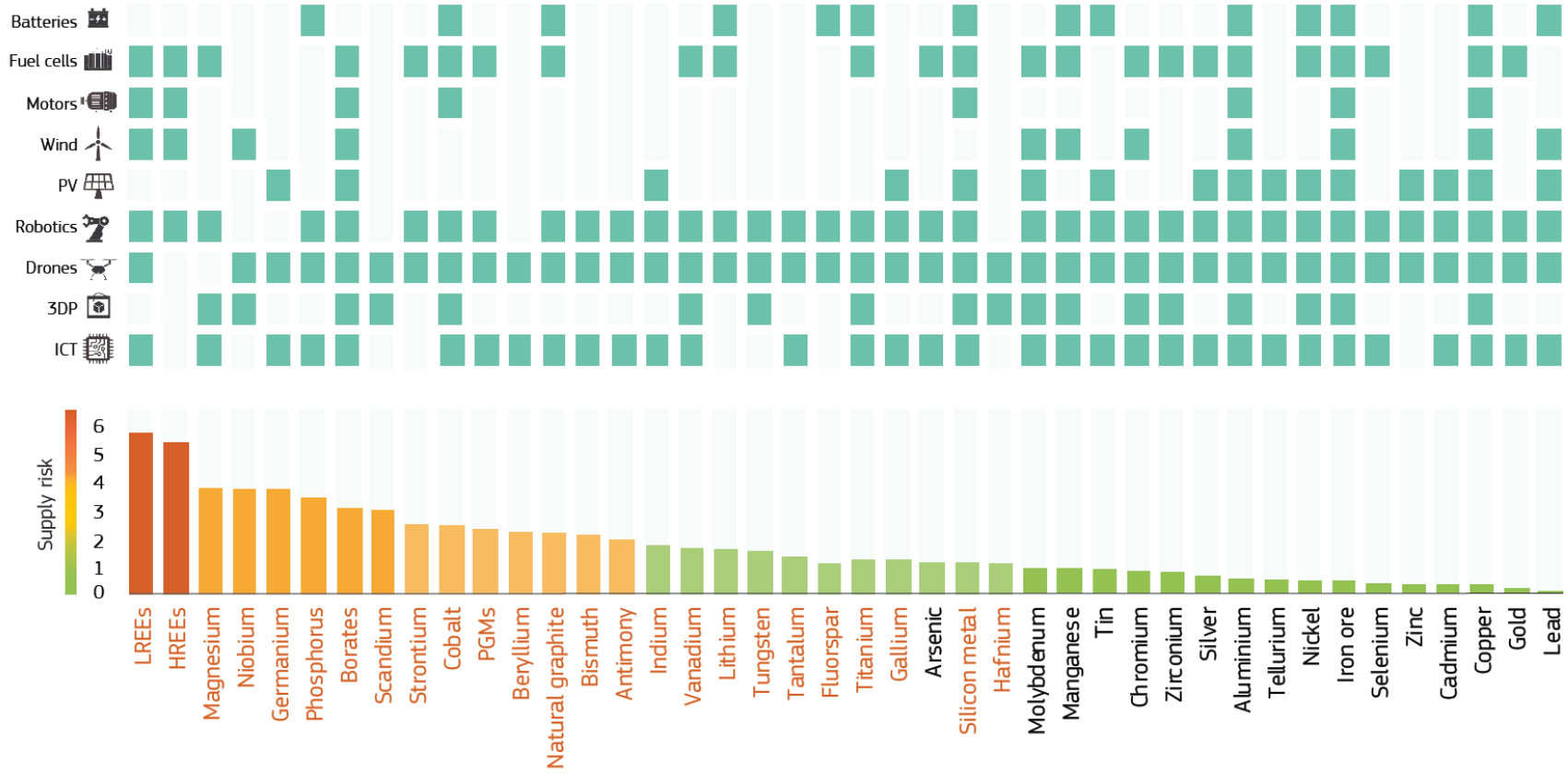


Even with substantial production increases in China and the development of 55,000 tpy new REO production capacity outside China, Adamas Intelligence forecasts a 16,000t NdPr oxide deficit in 2030 – equal to the amount of material needed for production of approximately 20 million EV traction motors

Source: Adamas Intelligence

RE Market Vulnerable to Bottlenecks

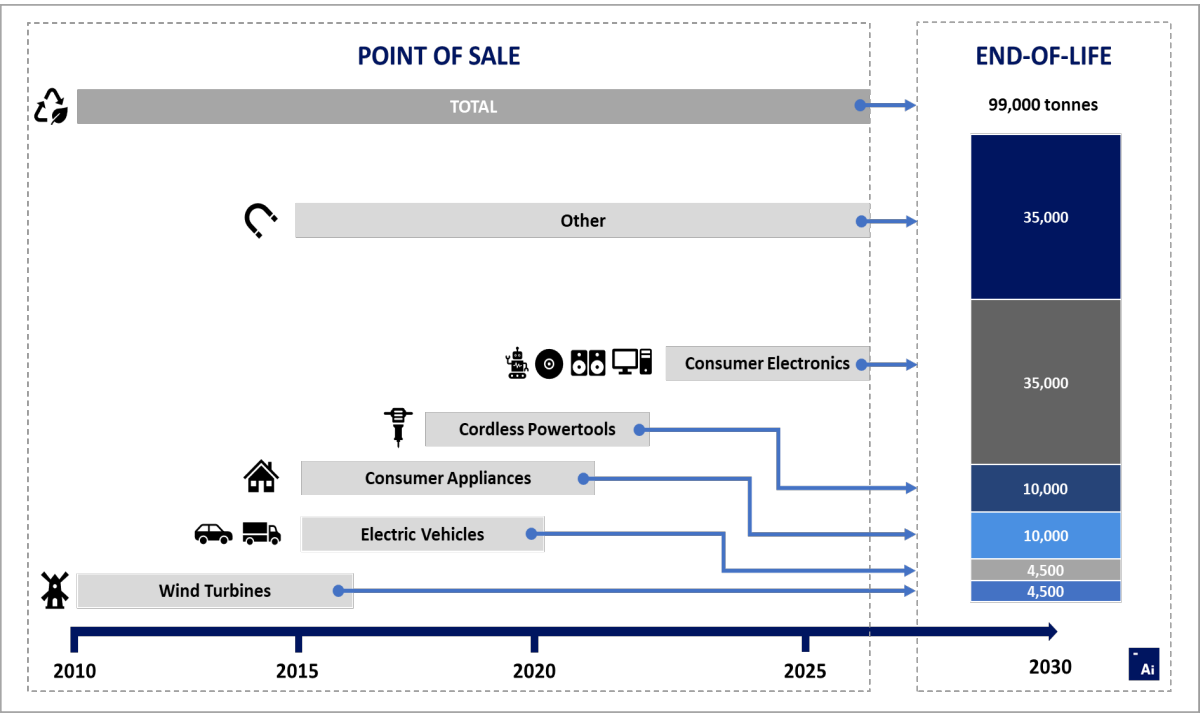
SUPPLY RISK OF RAW MATERIALS FOR KEY TECHNOLOGIES



Source: European Commission JRC 2020

Rare earths (LREE & HREE) are highlighted as having the greatest supply risk of raw materials for key technologies

Magnet Recycling to Play a Key Role

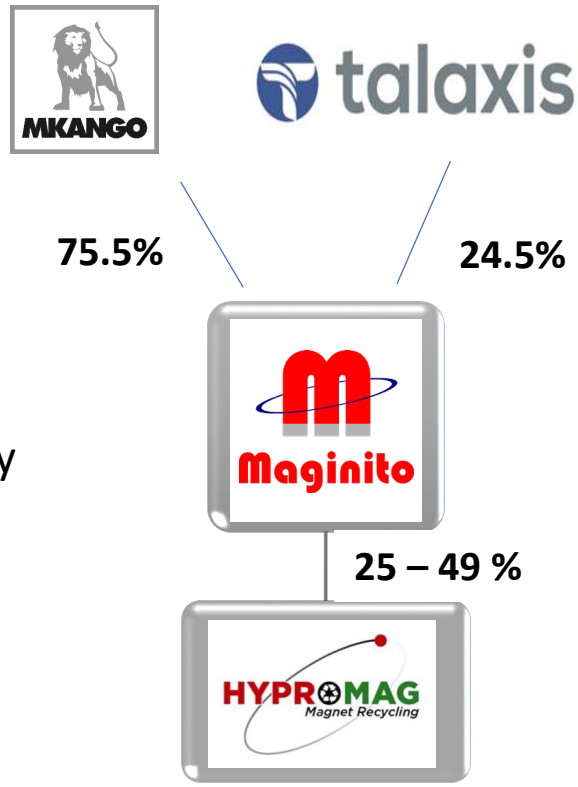


- Adamas Intelligence projects that in 2030 alone 99,000 tonnes of NdFeB magnets will be entering waste streams globally
- If just 5 to 10% of the NdFeB magnets entering waste streams globally each year by 2030 could be viably recovered and recycled it would make a substantial contribution to global supply

Maginito and HyProMag are well positioned to benefit from market growth and will play a key role as an enabler of NdFeB magnet recycling

Maginito Asset Portfolio and Strategy

- 25% interest in HyProMag with £1m option to increase to 49% - use of option proceeds to provide matched funding for additional grants
- First right to supply primary sourced rare earths to HyProMag for blending with recycled NdFeB powder
- Offtake and marketing rights for NdFeB powder produced by HyProMag
- Offtake rights for rare earth carbonate and oxides produced by Songwe Hill Rare Earths Project in Malawi



Mission Statement – focused on building a complimentary portfolio of downstream green technologies, encompassing NdFeB magnet recycling, and new low impact rare earth alloy and separation technologies, underpinned by offtake of sustainably sourced primary and secondary raw materials

Experienced International Team

William Dawes is a founding Director and CEO of AIM/TSXV listed Mkango Resources, and a Director of LeoMinEx and HyProMag. He has over 25 years experience in exploration, business development and investment banking. Having trained as a geologist in South Africa, he worked as a mining analyst based in London and then for Rio Tinto's exploration division. Subsequently, he gained significant global mining transaction experience at Robert Fleming & Co, Chase Manhattan Bank and JPMorgan. He holds a BSc Geology from Bristol University and MSC Mineral Exploration with distinction from Royal School of Mines, Imperial College.

Alexander Lemon is a founding Director and President of AIM/TSXV listed Mkango Resources, and a Director of LeoMinEx. He has over 25 years experience in exploration and operations management. From 1994 to 2001 he was the Managing Director of a producing gold mining company in Central Asia, where he gained extensive operating experience in emerging markets including government negotiations and project management. From 2001 to 2005, he worked for a family office, Allied Commercial Exporters as an investment adviser. He holds a BSc Geological Sciences from Oxford Brookes University and MSC Mineral Exploration from Royal School of Mines, Imperial College.

Daniel Mamadou is head of the technology metals division of Noble Group and the Executive Director of Talaxis. From 1997 until 1999, Daniel was at Deutsche Bank in London, where he ran the fixed income derivatives structuring desk for Iberia. In 1999, Daniel joined Goldman Sachs within the FICC division in London. In 2003, he was appointed head of the Corporate Markets and Treasury Solutions team at Deutsche Bank in Hong Kong, covering Asia-Pacific, and subsequently joined Nomura Securities, as Head of the Corporate Solutions and Financing Group for the Asia-Pacific region. Daniel holds an MSc in International Securities and Banking from the ICMA Centre University of Reading and a BA in Business Management from ESIC-Valencia.

Giovanni Curci is the investment analyst of Talaxis and the vice president of the board of directors of the global rare earth industry association (REIA). In his early career he worked as process engineer for major EPC companies on the development of greenfield and brownfield oil & gas facilities in different geographies. More recently he has gained experience as sustainability analyst in biodiesel trading at Petroineos Trading Ltd and as transaction due diligence consultant at DNV GL. He is a chartered chemical engineer and holds a MSc in Chemical Engineering from "La Sapienza" University of Rome and a MSc in Energy Trade and Finance from Cass Business School

HyProMag Investment

- Maginito has invested £300,000 for an initial 25% interest in HyProMag in addition to a £200,000 convertible loan facility. Option to increase interest to 49%.

- HyProMag has licenced a patented process from University of Birmingham for extracting and demagnetising NdFeB alloy powders from magnets embedded in scrap and redundant equipment (Hydrogen Processing of Magnet Scrap - HPMS)

- The founding directors of HyProMag, comprising Professor Emeritus Rex Harris, Professor Allan Walton and two Honorary Fellows, Dr John Speight and Mr David Kennedy, are leading world experts in the field of rare earth magnetic materials, alloys and hydrogen technology, and have significant industry experience

- Maginito's initial investment of £300,000 will fully satisfy HyProMag's matched funding requirements for the three year, £2.6 million Innovate UK grant funded project, "Rare-Earth Recycling for E-Machines" ("RaRE")

HyProMag - Highly Experienced Team with Strong Network of Partnerships

HyProMag Limited - new company set up in 2018, with investment from Maginito Ltd, to scale up and commercialise the HPMS technology

Mr Nick Mann
Hypromag Operations General Manager

Mr Rob Arnold
HyProMag Metallurgist

Prof Rex Harris
Emeritus Professor

David Kennedy
Honorary Research Fellow

Dr John Speight
Honorary Research Fellow

Prof Allan Walton
Head of the MMG

Mr Will Dawes
CEO Mkango

Innovate UK

Rare project (Rare Earth Recycling for E-Machines) aimed at scaling the downstream re-sintering processes for NdFeB magnets

BENTLEY

UNIPART

HYPROMAG Magnet Recycling

Advanced Electric Machines

UNIVERSITY OF BIRMINGHAM

Intelligent Lifecycle Solutions

HyProMag - Founding Directors

Prof Emeritus I R Harris

Formerly Head of School of Metallurgy, University of Birmingham. Supervised 160 PhD Projects, published 550 papers and edited 4 books. Fellowships in IoM3, IoP, elected fellow of RAE. Many other awards and accreditations and continues to create new ideas such as the recent co-invention of the patented Hydrogen Ductilisation (HyDP) process for NdFeB magnet materials.

Prof A Walton

Head of the Magnetic Materials Group (MMG) at the University of Birmingham and Co-Director of the Birmingham Centre for Strategic Elements and Critical Materials. Over 70 publications and co-inventor of 4 patents. Runs a group of over twenty people including PhD projects and international collaborations totalling over £5m in Research finance.

Dr J D Speight

Industrial and Scientific Materials Scientist. Experience in the prestigious Bell Labs and California Institute of Tech.

Extensive experience in senior positions in BT Research and procurement. Director of Manufacturing for BT-DuPont joint venture. Involved in over 70 published documents; several patents. Senior Visiting Research Fellow with MMG.

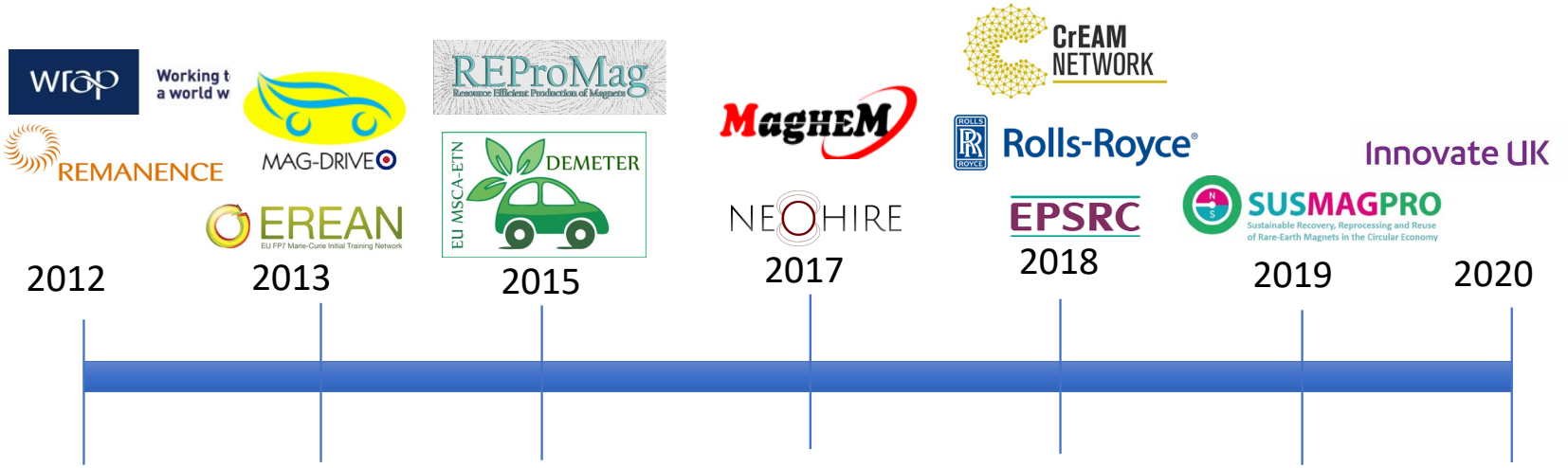
Experienced in writing and managing EU and UK research grants.

Mr D Kennedy

Industrial Metallurgist and Owner/Manager of small businesses. Specialising in rare earth metals and alloys since 1980.

Co-author and contributor to a number of publications. Production and Technical Manager for Johnson Matthey Rare Earth Products and founder Less Common Metals Ltd in 1992. Former CEO of Rareco and Steenkampskraal Monazite Mine South Africa. Currently Director/Co-Owner Cheshire Seals and Components Ltd. Honorary Research Fellow with MMG.

Longstanding Track Record in Magnetic Materials at University of Birmingham



Remanence EU project – extraction and reprocessing of magnets from HDDs using HDDR and re-sintering

EREAN (EU) – Separation of Nd and re-sintering of NdFeB.

Magdrive – new method for producing nanocrystalline magnets vis SPS

ERECON – Policy in the EU for REs.
Repromag – Metal injection moulding of magnets.
DEMETER – separation and reprocessing of magnets from auto waste.

Neohire (EU) – Recycling of wind turbines.
Maghem (Japan), casting of rare earth alloys

IAA EPSRC funding – HyDP & **CREAM** network on critical materials

Rolls Royce (UTC). Working on high temp magnetic materials (SmCo)

SUSMAGPRO EU. Scale up of recycling technologies for NdFeB

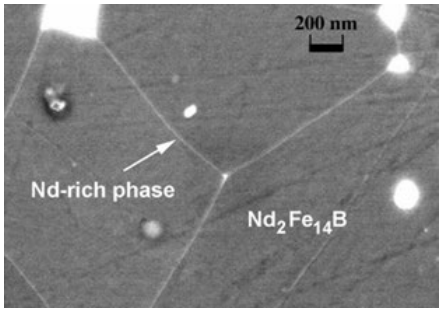
Rare project (Innovate) Scale up in Hypromag

UNIVERSITY OF BIRMINGHAM

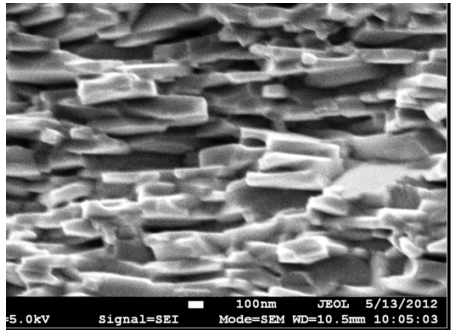
Centre of excellence in magnetic materials and hydrogen technologies
Significant development and de-risking of HPMS during past and ongoing projects

NdFeB Magnet Types

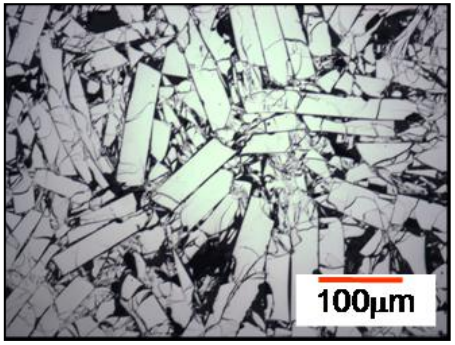
Sintered (above) and polymer bonded (below) NdFeB Magnets



Microstructure of a sintered magnet



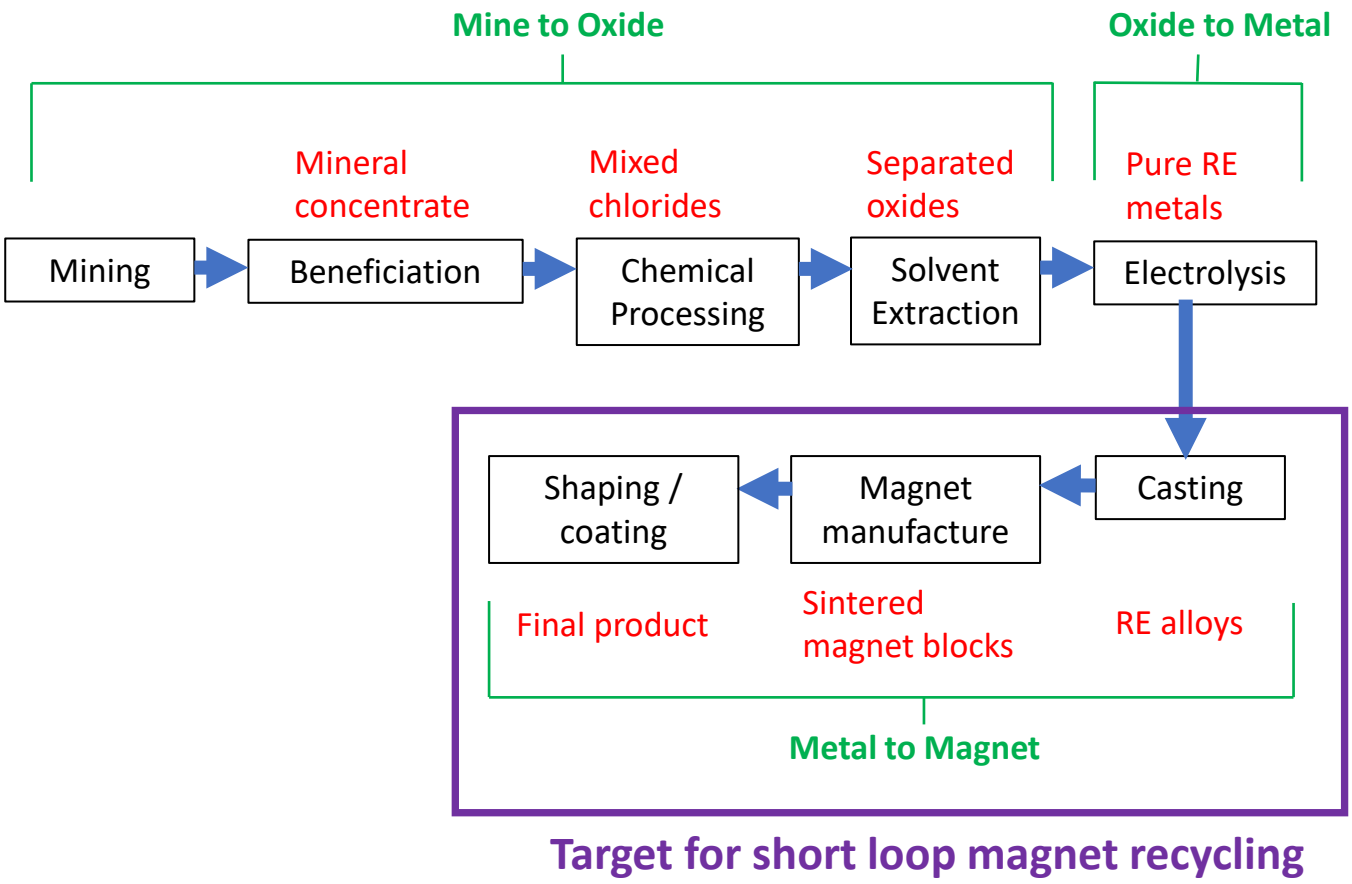
Microstructure of an MQ3 magnet (back extruded).



Polymer bonded magnet

Source: University of Birmingham / HyProMag

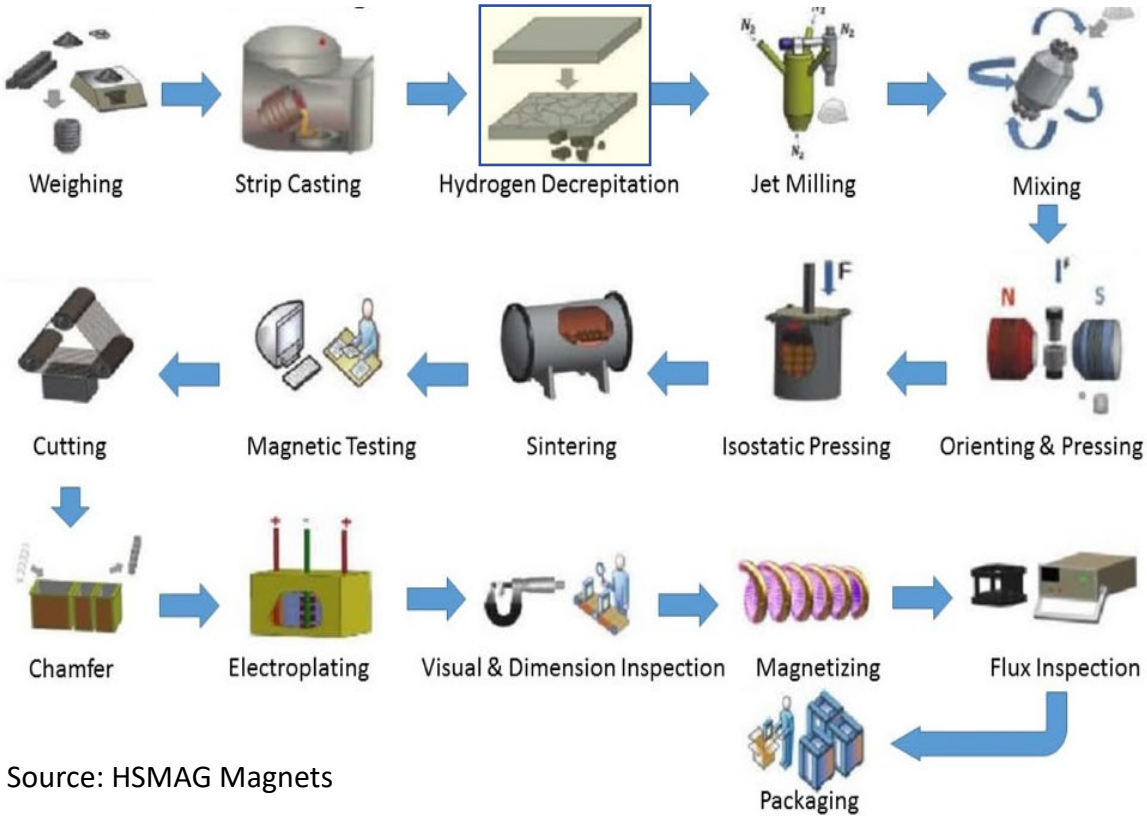
Rare Earth Mine to Magnet



Source: University of Birmingham / HyProMag

Hydrogen is an Integral Part of NdFeB Sintered Magnet Making

Sintered NdFeB magnet making

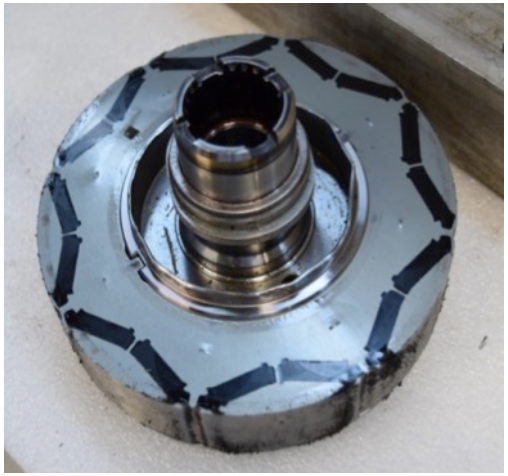


Source: HSMAG Magnets

- Professor Rex Harris (University of Birmingham), founding director of HyProMag, pioneered the work on hydrogen decrepitation (HD), co-authoring the first paper on producing a permanent magnet using the HD route in 1986
- The HD process is now used in magnet processing worldwide
- The Magnetic Materials Group at University of Birmingham have made major contributions to the development of short loop recycling of magnets using HD

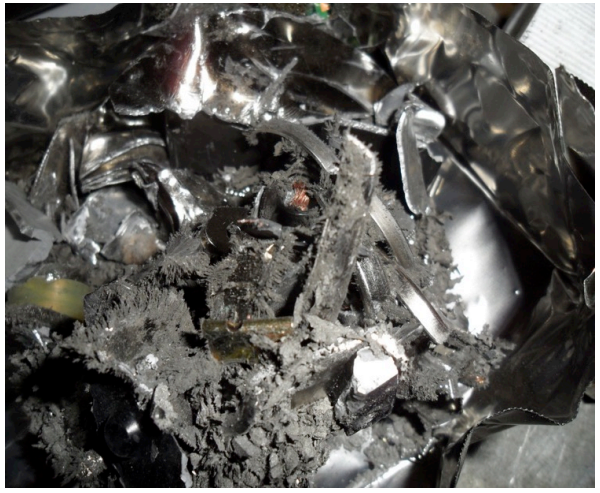
Hydrogen can also Liberate Magnets Embedded in Scrap (HPMS process)

Hard disk drives



Rotor from an automotive drive motor

Mobile phones



Shredded HDDs

Source: University of Birmingham / HyProMag

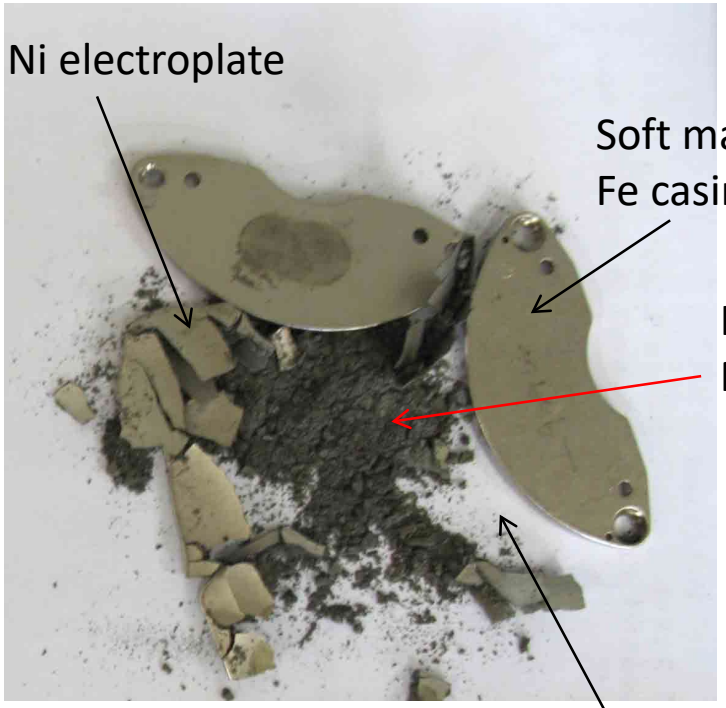
Shredded automotive motor – courtesy of Axion

Products are not designed with recycling in mind

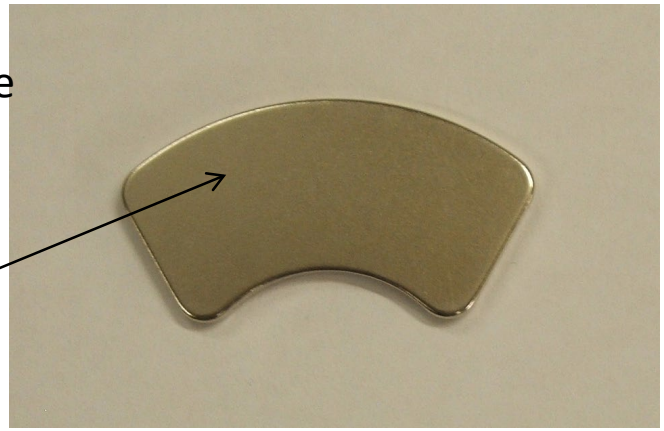
Current recycling processes are not suitable for NdFeB magnets

Separation of NdFeB Using HPMS

Voice coil assembly extracted from hard drive



Voice coil assembly after HD process



Ni electroless plated voice coil magnet

US patent – No.13/169839

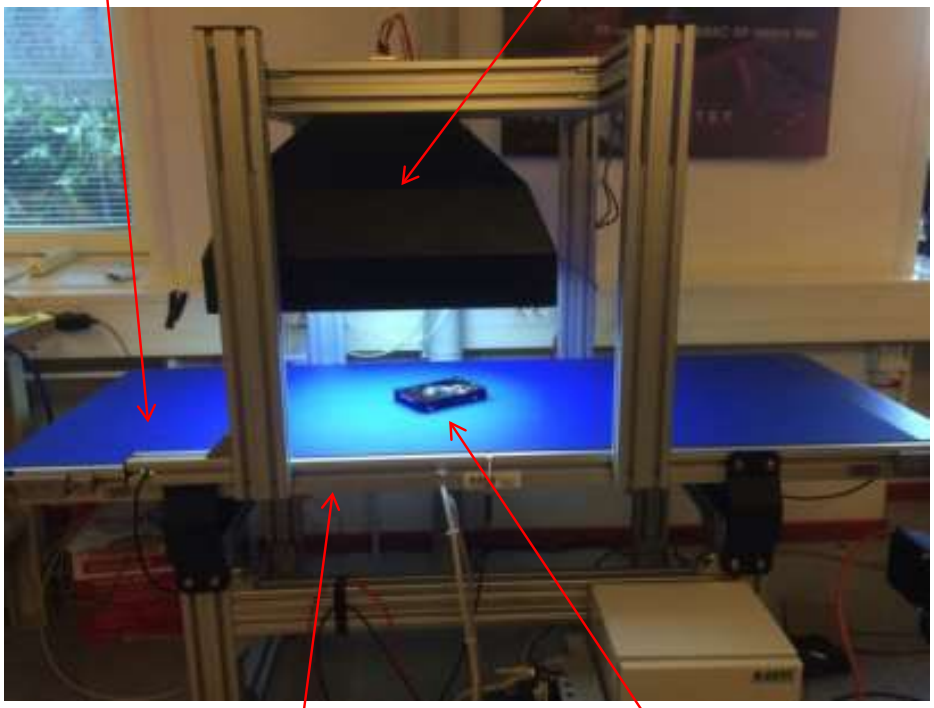
Source: University of Birmingham / HyProMag

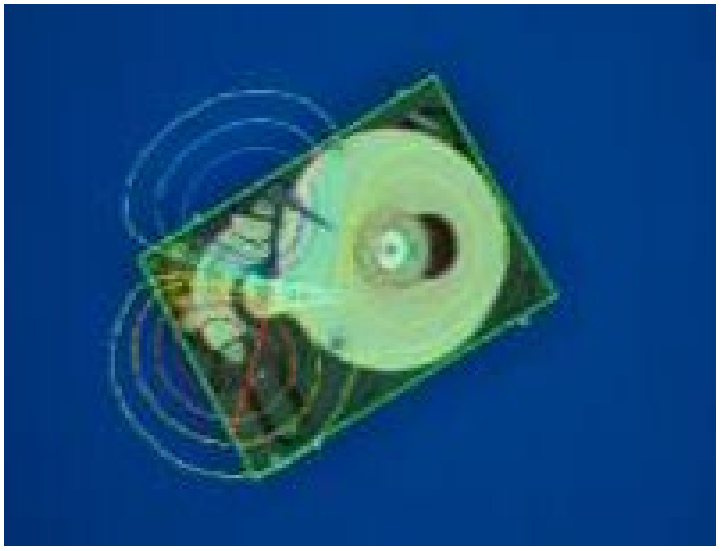
Hydrogen Decrepitation in Action

HPMS – HDD Voice Coil Magnet Assembly

Source: University of Birmingham / HyProMag

Sorting and Cropping



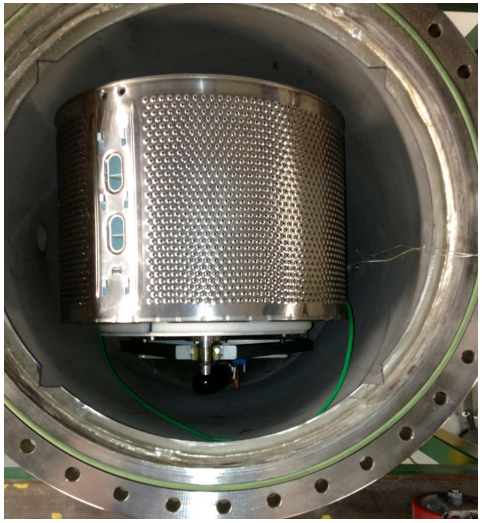


Magnetic field superimposed over optical image of HDD

Source: University of Birmingham / HyProMag

NdFeB Liberation using Hydrogen

HDDs loaded into porous drum

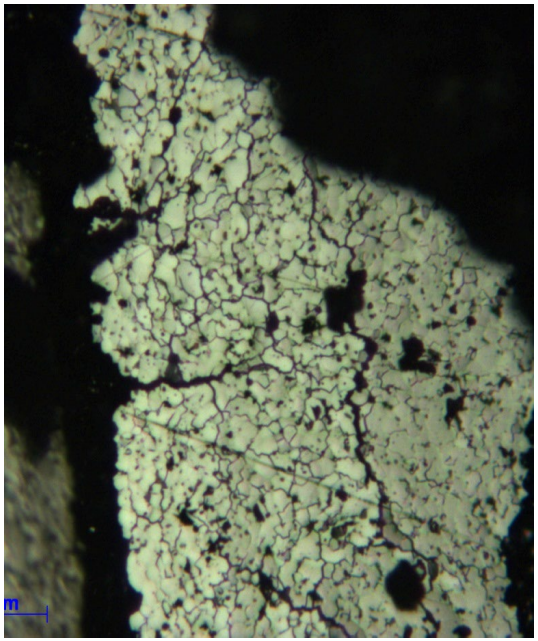


Porous rotating stage inside vessel

Source: University of Birmingham / HyProMag

Extracted NdFeB Powder

Material extracted from tumbling stage (10 sectioned HDDs).



Optical micrograph of a cross section through a HD processed sintered NdFeB magnet particle

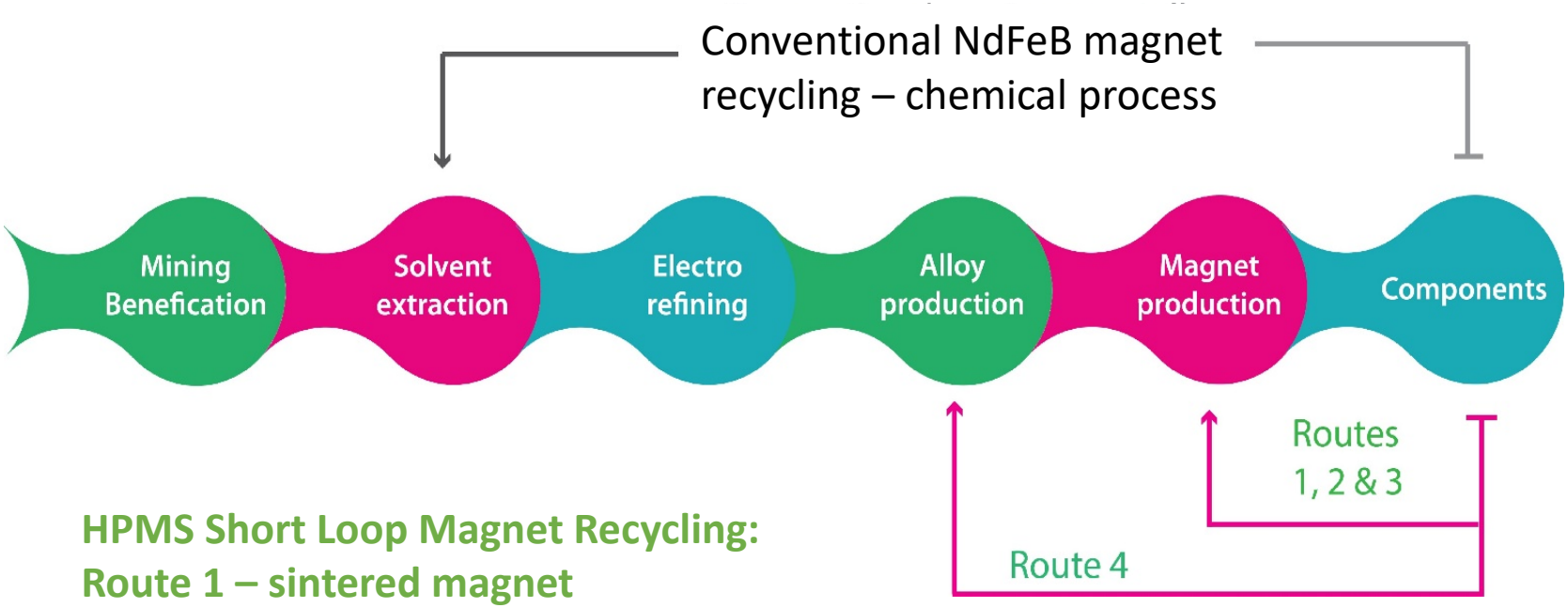
Sieving with ball bearings has been used to preferentially break down the NdFeB compared to the Ni and other impurities

The Ni content of the extracted powders for 5kg of material was around 400ppm after sieving to 90 microns

A.Walton et al - Journal of Cleaner Production 104 (2015)

Source: University of Birmingham / HyProMag

Short Loop Magnet Recycling

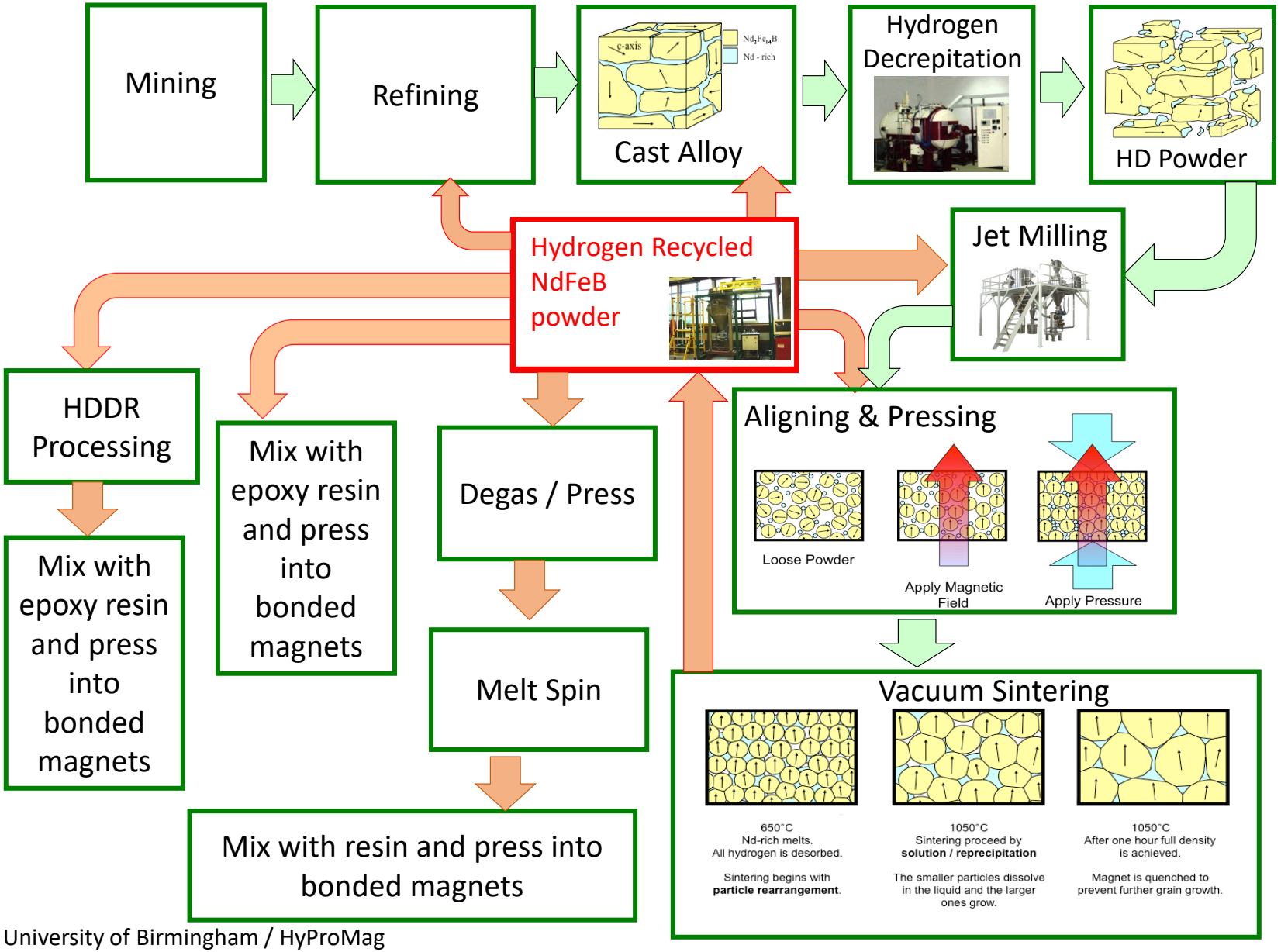


HPMS Short Loop Magnet Recycling:
Route 1 – sintered magnet
Route 2 – HDDR powder
Route 3 – HD powder
Route 4 – alloy

NdFeB magnet recycling is currently very limited and almost exclusively involves scrap being put back into the chemical processing or solvent extraction stages. Short Loop Recycling avoids not only these stages but also electrolysis and casting.

Source: Susmagpro / University of Birmingham

Product Options for NdFeB Powder

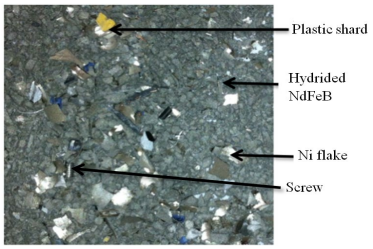


Source: University of Birmingham / HyProMag

Sintered Magnet Production

Incoming components

Coating / binding material left in reactor

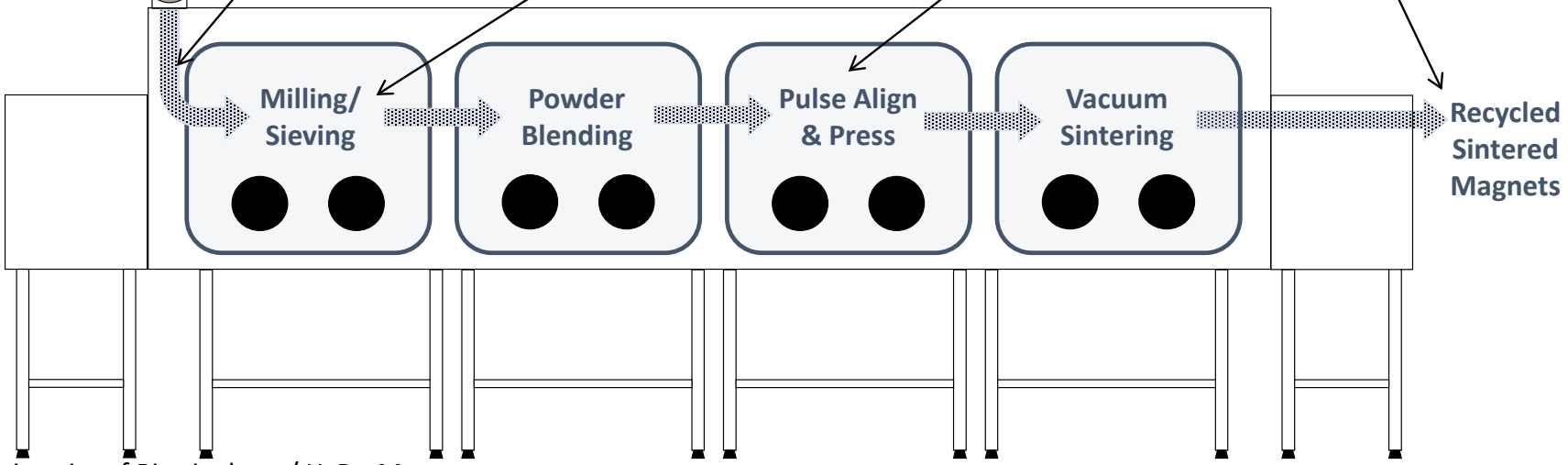


Material extracted from porous drum

Purified NdFeB powder blended

Isostatically pressed / aligned green compacts

Uncoated sintered magnets



Source: University of Birmingham / HyProMag

RaRE Project – Production of Sintered Magnets for Use in an EV

Three year, £2.6 million Innovate UK grant funded project, “Rare-Earth Recycling for E-Machines” (“RaRE”)

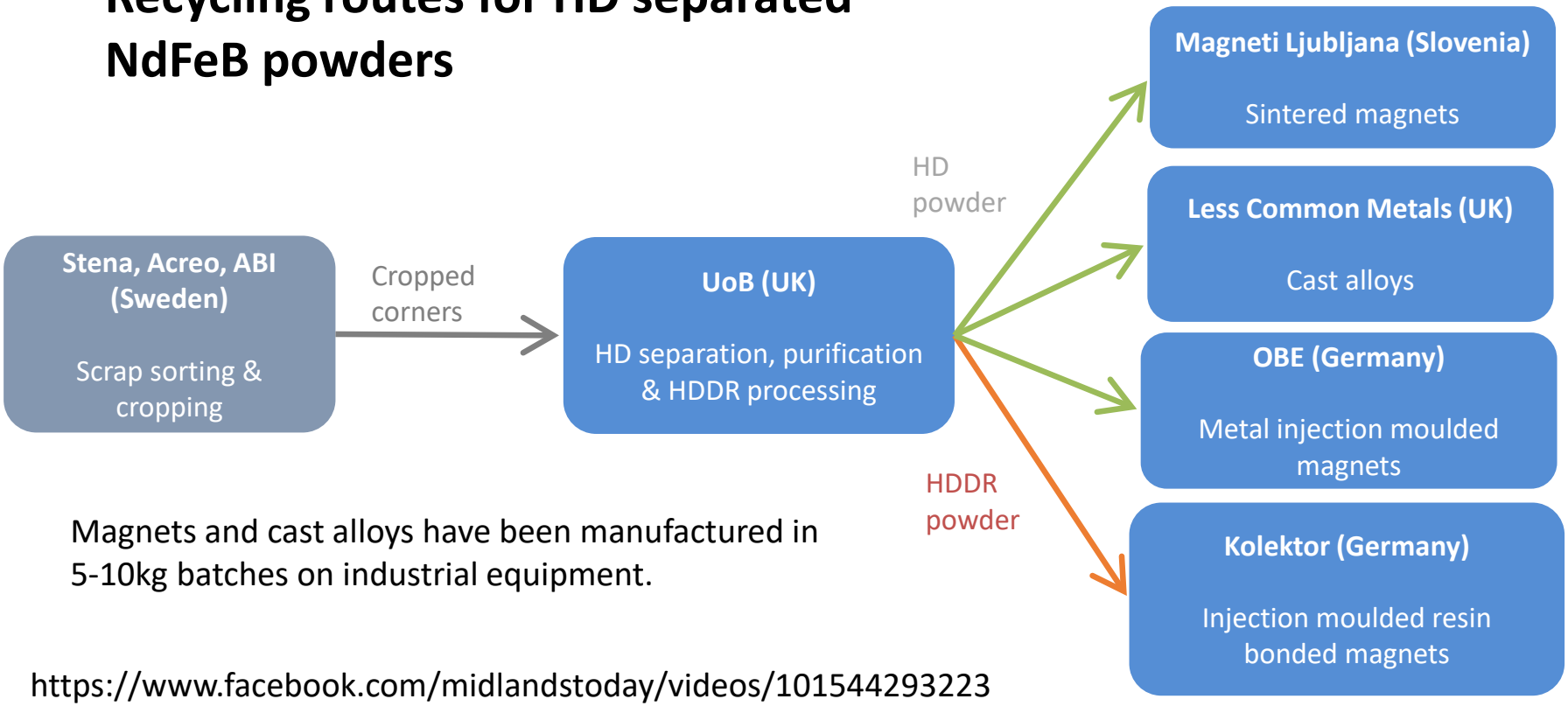
RaRE will for the first time establish an end to end supply chain to incorporate recycled sintered rare earth magnets into electric vehicles - recycled magnets will be built into an ancillary electric motor to ultimately support the development of a commercial ancillary motor suite.

In addition to **HyProMag** and **University of Birmingham**, RaRE features a strong set of partners with complementary expertise:

- **Advanced Electric Machines Research Limited** - extensive experience in designing motors for customers including Airbus and Tevva Motors
- **Bentley Motors Limited** - an iconic automotive brand and part of the VW Group, one of the world’s largest car manufacturers
- **Intelligent Lifecycle Solutions Limited** - a global leader in the processing of electronics waste working with Fortune 500 companies and UK government agencies
- **Unipart Powertrain Applications Limited** - one of the largest UK based Tier 1 automotive partners and a recognised volume automotive supplier able to supply globally

Other Closed Loop Recycling Routes Demonstrated on a Batch Scale

Recycling routes for HD separated NdFeB powders



Magnets and cast alloys have been manufactured in 5-10kg batches on industrial equipment.

https://www.facebook.com/midlandstoday/videos/10154429322309761/

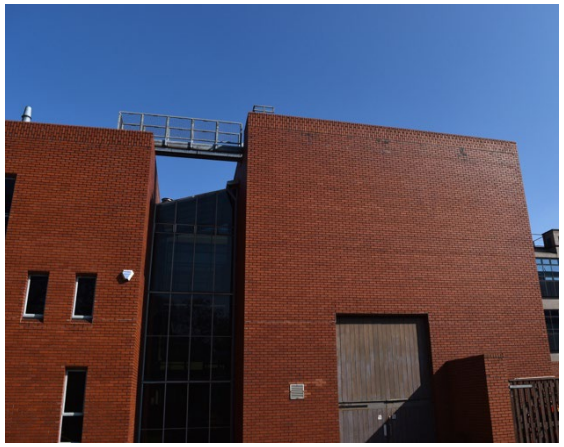
Source: Susmagpro / University of Birmingham / HyProMag

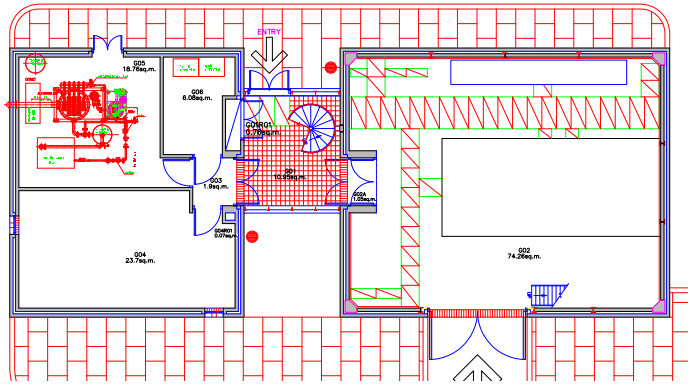
SusmagPro Further Derisks Technology for Range of Product Options

SusmagPro (EU project) €14 million

1. Pforzheim University (HSPF) Coordinator
2. University of Birmingham (UOB)
3. Stena Technoworld AB (STNA)
4. RISE Acreo (ACR)
5. Inserma Anoia S.L. (INS)
6. Less Common Metals Ltd (LCM)
7. OBE Ohnmacht & Baumgärtner GmbH & Co KG (OBE)
8. Magneti Ljubljana (MGI)
9. Kolektor Magnet Technology GmbH (KMT)
10. ZF Friedrichshafen AG (ZF)
11. B&C Speakers (B&C)
12. Grundfos (GBJ)
13. Bunting Magnetics Europe (BME)
14. Universiteit Leiden (UL)
15. FOTEC GmbH (FOTEC)
16. Sennheiser GmbH (SHR)
17. Montanuniversität Leoben (MUL)
18. Jožef Stefan Institute (JSI)
19. Steinbeis Europa Zentrum (SEZ)
20. Siemens Wind Power A/S (SIE)

Plasma building is being converted into a pilot magnet manufacturing facility





Source: Susmagpro / University of Birmingham / HyProMag

HyProMag Strategy

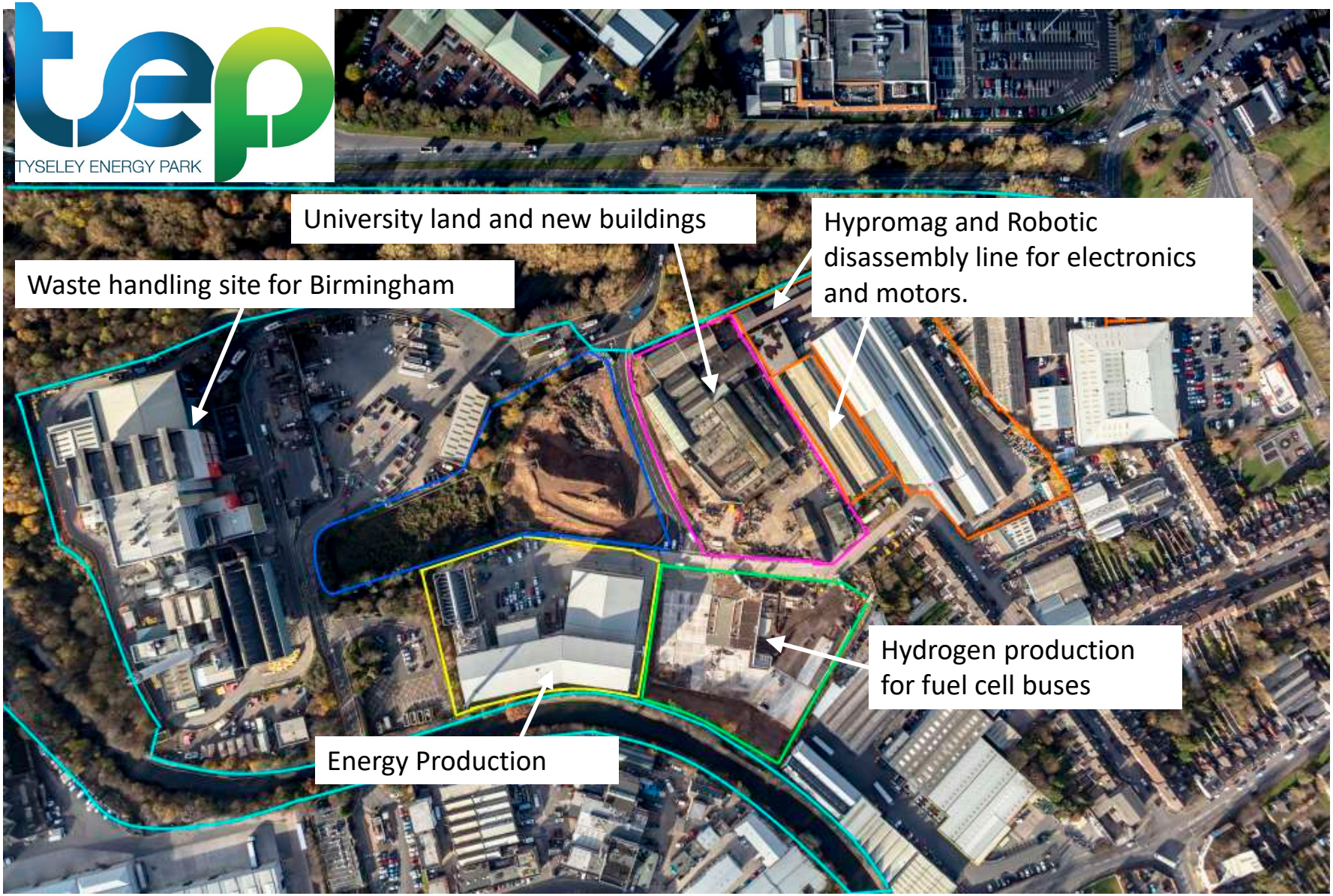
- Scale up and commercialise the technology with the support of grant funding
  - RaRE
  - SusmagPro
  - Other potential grant funded opportunities

- Establishing the manufacture of rare earth magnetic materials at the Tyseley Energy Park, Birmingham UK.

- Evaluating four types of product for potential commercial exploitation:
  - Hydrogen Decrepitated (HD) demagnetised powders suitable for magnet producers
  - Alloy ingot remelted from HD powders. Suitable for alloy feed or magnet production
  - Anisotropic alloy powders (HDDR) for bonded magnets.
  - Sintered NdFeB magnets as required by the RaRE project for automotive application

Uniquely positioned in the rare earth magnet recycling sector underpinned by innovative technology delivering significant competitive advantages versus its peer group

Phased Transfer of HyProMag to Tyseley Energy Park



Source: University of Birmingham / HyProMag

Maginito - Summary

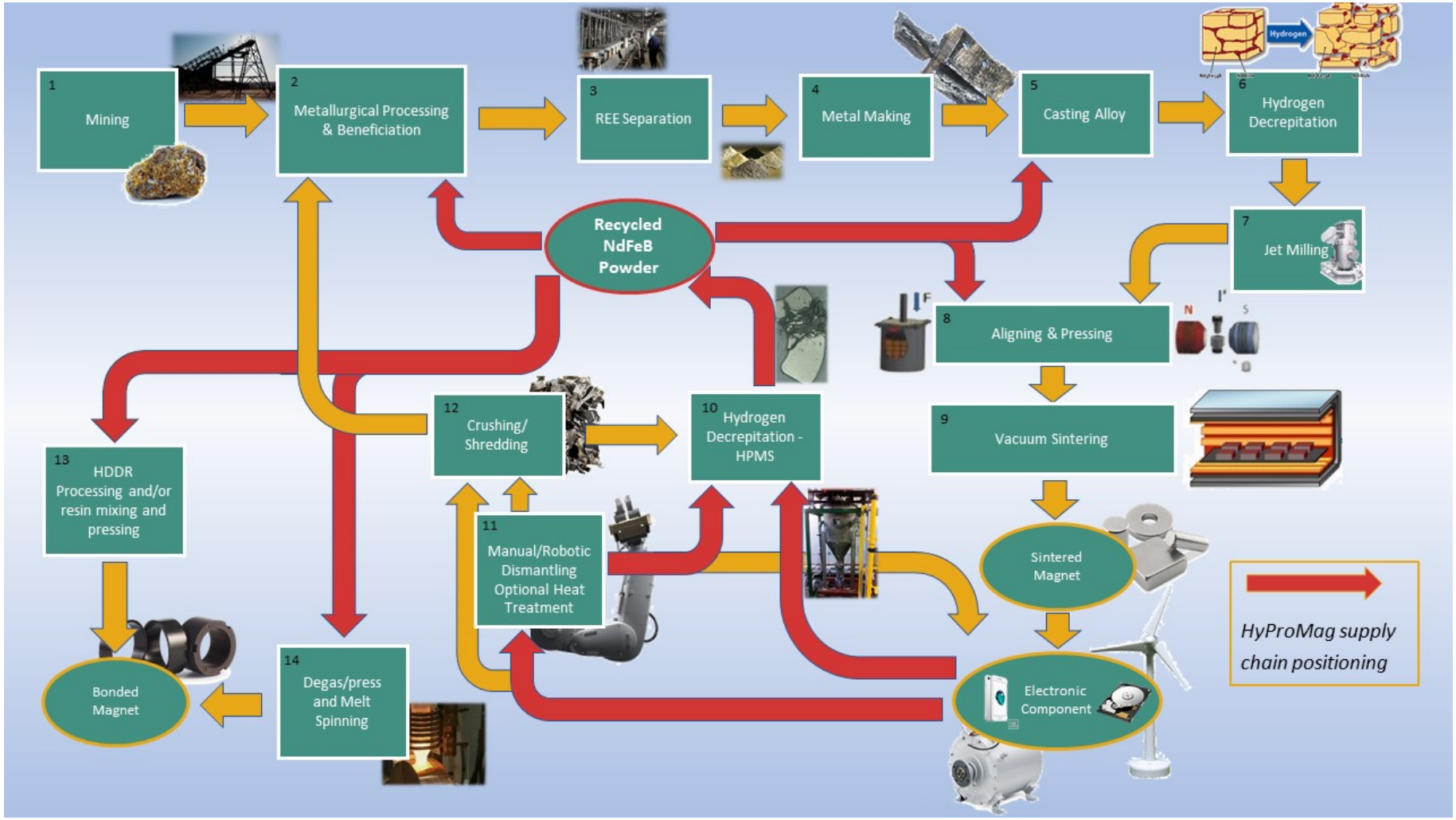
- Strategically positioned in the NdFeB magnet supply chain with strong growth profile – unique integrated structure
- Opportunity to leverage off the Group's financing network, marketing platform and technical expertise – global footprint with presence in UK, Europe and Asia

- Strategic interest in HyProMag and related offtake agreement unlocks secondary raw material sources for further value addition

- Access to primary raw materials originating from sustainable development of Songwe Hill rare earth project in Malawi
- Evaluating options to raise further growth capital - use of proceeds to fund acquisitions and JVs, participate in further matched funding opportunities

THANK YOU

Appendix – HyProMag Supply Chain Positioning



Source: University of Birmingham / HyProMag

Appendix – HyProMag Supply Chain Positioning

1. **Mining**: Mining of ores containing rare earth elements. This provides primary rare earth elements to the supply chain and is currently the source for almost all rare earth containing products and components due to current lack of end-of-life recycling in the supply chain.

2. **Metallurgical Processing and Beneficiation**: In the case of material sourced from mining, this step is necessary to process the ore, removing minerals containing no rare earth elements and other impurities before separation of the individual rare earths. This step also encompasses processing technologies to remove impurities from recycled magnet scrap, for example commingled metal from shredding, iron and boron. This usually involves extraction technologies such as hydrometallurgy or other alternative processes such as electrolysis and bioleaching.

3. **REE Separation**: Conventional hydrometallurgy using nitric or hydrochloric acids with appropriate extractants are used in all commercial RE separation plants. This separates individual REEs from a mixed RE-rich phase. Other technologies such as ionic liquid solvents, electrowinning, chromatography, and electrophoresis are being researched and piloted for integration into the supply chain.

4. **Metal Making**: Rare earth metals are prepared from their respective oxides through processes such as calciothermic or electrolytic processes. In these methods, the oxides are reduced to form the metal at high purity. The exact method undertaken depends on the lanthanide being processed and the required purity of the metal.

5. **Casting Alloy**: To produce NdFeB magnet alloys, neodymium is alloyed directly with iron in an electrolytic process using a pure cast iron cathode. Neodymium reacts with the iron cathode to produce molten alloy which drips into a crucible. Other alloys such as Dy-Fe and Nd-Dy-Fe are made in a similar way. The exact composition of the alloy will depend on the downstream application of the material. Recycled NdFeB powder can also be used as a feed to this process as well as primary material.

6. **Hydrogen Decrepitation**: Passing hydrogen over the rare earth alloy material causes it to demagnetise and decrepitate into a friable powder. The metal-hydride powder formed can then be processed further with ease.

7. **Jet Milling**: Jet milling is employed following hydrogen decrepitation to further reduce the grain size of the material by using high speed jets of compressed air. Small grain sizes allow for better magnetic properties of the formed magnet downstream

8. **Aligning & Pressing**: The milled, fine NdFeB powder is aligned in a magnetic field whilst being mechanically compressed into the required shape for the application. Recycled NdFeB as well as primary material can be combined as a feed to this processing step

9. **Vacuum Sintering**: High temperature sintering causes the density of the pressed NdFeB material to increase significantly, forming the sintered magnet. This is performed in a vacuum to prevent oxidation of the material which would cause defects in the structure of the magnet, negatively impacting magnet properties. Appropriate cutting can then shape the magnet into its required dimensions.

10. **Hydrogen Decrepitation - HPMS**: Hydrogen processing of magnet scrap (HPMS), developed at the University of Birmingham and licenced by HyProMag, can be applied directly, or after appropriate dismantling, to electronic waste components to produce recycled, demagnetised, fine NdFeB powder. This facilitates short loop magnet recycling as this powder can be used as a feed in various parts of the life cycle: sintered and bonded magnet making, REE separation, alloy making and blending.

11. **Manual/Robotic Dismantling** with **Optional Heat Treatment**: Manual or automated dismantling enables the magnet to be fully or partially isolated from a component where it may be deeply embedded and difficult to access. Depending on the component, heat treatment can be used in this step to demagnetise the magnet and facilitating its removal from the device. The isolated magnet can then be further processed with fewer impurities compared to if the whole device was to be shredded/crushed for recycle.

12. **Crushing/Shredding**: Crushing and/or shredding of electronic waste is used to both decrease the size of the magnet material and to gain access to embedded magnets. This material often contains impurities from the component, so requires further processing to isolate the NdFeB material.

13. **HDDR Processing and/or resin mixing and pressing**: The hydrogen decrepitation process can be used in conjunction with the hydrogen, disproportionation, desorption, and recombination (HDDR) process with appropriate mixing with polymer resins for the formation of bonded magnets. This provides a potential short loop recycling route for recycled NdFeB powder.

14. **Degas/press and melt spinning**: A route for recycled NdFeB powder is degassing and pressing for the formation of bonded magnets. Melt spinning with suitable resin binders can be used to produce the bonded magnet.