PROJECT: MaXycle

Date: **28.09.2017** **FULLPROPOSAL**

ID: 142

PROJECT TITLE

A novel circular economy for sustainable RE-based magnets

TOPIC

3. Processing, Production and Remanufacturing

YOUR PROJECT IS RELATED TO

2.1: Product design for increased raw material efficiency, 2.2: Product design for reuse or extended durability of products, 2.3: Product design to promote recycling , 3.2: Increase resource efficiency through recycling of residues or remanufacturing, 3.3: Increase resource efficiency using information and communication technologies (ICT), 4.1: End-of-life products collection and logistics , 4.2: End-of-life products pre-processing: pre-treatment, dismantling, sorting, characterisation, 4.3: Recovery of raw materials from End-of-life products, 4.4: Increase recycling of End-of-Life products through information and communication technologies (ICT), 5.1: New business models, 5.2: Improvement of methods or data for environmental impact assessment

PROJECT DURATION	TOTAL REQUESTED FUNDING	TOTAL COSTS
36 Months (03 / 2018 to 02 / 2021)	965.970 €	1.056.380 €

CONSORTIUM

P 1	Prof Spomenka Kobe Jozef Stefan Institute	Jamova cesta 39, 1000 Ljubljana Slovenia	spomenka.kobe@ijs.si Tel.: 0386 14773251 http://www.ijs.si
P 2	Dr Irena Škulj Magneti Ljubljana, d.d. R&D	Stegne 37, 1000 Ljubljana Slovenia	Irena.Skulj@magneti.si Tel.: 0386 1 511 13 04 Fax: 0386 1 511 12 95 http://www.magneti.si
P 3	Dr Oxana Weber OBE Ohnmacht & Baumgärtner GmbH & Co. KG Research & Development	Turnstr. 22, 75228 Ispringen Germany	Oweber@obe.de Tel.: 0049 7231 802158 https://www.obe.de/en/
P 4	Prof Carlo Burkhardt Pforzheim University of Applied Sciences STI, Institute for Materials and Manufacturing Technology	Tiefenbronner Str. 65, 75175 Pforzheim Germany	carlo.burkhardt@hs-pforzheim.de Tel.: 0049 7231 28 6063 Mobile: 0049 162 2046 435 https://hs-pforzheim.de
P 5	Dr Maria Wallenius Henriksson IVL Swedish Environmental Research Institute Chemistry and Environment	Aschebergsgatan 44, Box 530 21, 400 14 Göteborg Sweden	maria.wallenius.henriksson@ivl.se Tel.: 0046 107886852 Mobile: 0046 736200442 http://www.ivl.se

KEYWORDS

Supplementary keywords	Circular economy, magnet recycling, NdFeB magnets, end-of-life magnets, Eco-labelling

ABSTRACT

Magnets are one of the most crucial materials necessary for modern Europe, as they are integral to energy conversion across the renewable energy and electric mobility sectors. Unfortunately, even though the alloying constituents of NdFeB magnets have been classified as EU Critical Raw Materials and 90% are produced outside of the EU, there is still no circular economy to reuse and capture value for these types of materials. With the prediction that the need for RE magnets will double in the next 10 years, this problem becomes even more urgent. At present, the only way to recover end of life (EOL) magnets from waste streams of electric and electronic equipment is by shredding and recycling by chemicals and pyrometallurgical routes, which is expensive and energy intensive. Another problem is that the quality of the recollected materials varies significantly, especially with respect to alloying constituents and state of corrosion and employed corrosion protection, with no classification system for recyclate grades of EOL NdFeB magnets. The objective of the proposed project MaXycle is the creation of a much more environmentally friendly 'short cycle' re-processing route enabling a new circular economy ecosystem. This will be achieved by: a) the development of an eco-labelling system for newly produced RE permanent magnets to clearly identify different magnets types and qualities in order to categorise the EOL NdFeB magnets by technical pre-processing requirements, b) using the highly effective HPMS process for re-processing extracted materials directly from NdFeB alloy, c) better treatments to eliminate pre-processing residue which contaminates the HPMS process, d) upgrading the magnetic properties of EOL NdFeB magnets by tailoring the microstructure, phase ratio and phase composition, and e) developing industrial up-scalability, including thorough life cycle assessments. Maxycle will have a great impact by overcoming existing low recycling rates due to poor collection, high leakages of collected materials into non-suitable channels, and inappropriate interface management between logistics, mechanical pre-processing and metallurgical metals recovery. It is estimated that Maxycle will increase the recycling quantities of NdFeB by 90%, this introducing a sustainable source of raw materials allowing the increase of EU magnet production without recourse to foreign suppliers. Further revenues and jobs would be generated from manufacture, EU sales and export of the specialist process equipment needed for NdFeB recycling, and further development of recycled NdFeB magnet raw materials will open up new markets for specialised recycled magnet products, strengthening competitiveness and economic growth.

PUBLISHABLE ABSTRACT

Even though the alloying constituents of rare-earth (RE) based magnets have been classified as Critical Raw Materials in the EU and 90% of it is produced outside of the EU, there is still no developed recycling or circular economy for these types of materials. With the prediction that the consumption of RE magnets will double in the next 10 years, this problem becomes even more critical. Today's only way to recover end of life (EOL) magnets from waste of electric and electronic equipment is by shredding and recycling by chemicals and pyrometallurgical routes, which is expensive and energy intensive, and the quality of the recollected magnets varies significantly. The objective of MaXycle is to create a much more environmentally friendly 'short cycle' re-processing route achieved by: a) the development of an eco-labelling system for newly produced RE permanent, b) using the highly effective HPMS process by re-processing the extracted materials directly from the NdFeB alloy, c) better treatments to eliminate pre-processing residue, d) upgrading the magnetic properties of EOL NdFeB magnets by tailoring the microstructure and phase composition and e) elaborating the industrial up-scalability, including a thorough life cycle assessment. MaXycle will have a great impact to overcome the issue of low recycling rates suffering from poor collection, high leakages of collected materials and inappropriate interface management between logistics, and mechanical pre-processing and metallurgical metals recovery. It is estimated that MaXycle will increase the recycling quantities of NdFeB by 90%, intorducing a sustainable source of raw materials and increasing EU magnet production without recourse to foreign suppliers, further increasing revenues and creating jobs. Further development of recycled RE-based magnet raw materials should open up new markets for specialised recycled magnet products, strengthening competiveness and economic growth.

OBJECTIVES

The objective of the MaXycle project is to use a more systematic approach when recycling EOL NdFeB magnets, which would help to recycle 15% of all the magnets produced by 2025. RE magnets play a fundamental role in the shift to a clean energy future. They are used in wind turbine generators, electric vehicles, efficient cooling systems and across other sectors, with an industry worth of over $1 trillion worldwide (2015) [1]. But in recent years the supply of rare-earths used in NdFeB magnets has come under considerable threat. Driven by increased adoption of electric vehicles and green technologies, the global demand for NdFeB magnets (~80,000

tonnes/annum 2017) is predicted to double to 150.000 t in 2020 [2] and could grow at 15-20% p.a. for the next decade [1]. With Chinas near-monopoly supply of RE materials and the fact that currently less than 1% of the world's REs are being recycled, advanced research and innovation to improve exploitation as a secondary resource is therefore needed. With the total recycling potential for RE magnets of around 20,000 t/a worlwide and 3,000 t/a in the EU by 2020 [4,5], it represents an exciting circular-economy opportunity for the project and the EU as a whole.

In order to recycle end-of-life magnets (EOLM) from waste of electric and electronic equipment (WEEE) and EOL vehicles, devices must be separated from waste streams and magnets liberated from components. As currently most electronics are shredded, recycling by associated chemical and pyrometallurgical routes is expensive, energy intensive [6] and still far from an efficient "circular economy".

The highly effective HPMS process (Hydrogen Processing of Magnet Scrap) [7] to re-process extracted materials directly from the NdFeB alloy is a very promising alternative. With HPMS, NdFeB magnets break down into a friable, demagnetised powder, which can be separated mechanically from remaining impurities [8]. Work done in the EU projects REMANENCE [9] and REProMag [10] demonstrated feasibility with known chemical compositions, creating much more environmentally friendly 'short cycle' re-processing routes.

However, depending on their origin, purpose, place of installation and operational life time, the quality of recollected magnets vary significantly, especially of alloying constituents, state of corrosion employed corrosion protection and other residues. As these differences influence the quality and process stability for recycled magnets [11,12], innovation must be embedded into broader contexts, including regulatory innovations, to improve knowledge of products and materials.

In accordance with the targets of ERA-MIN 2 on secondary resources supply, MaXycle will develop and validate a systematic approach to overcome the barriers currently hindering a successful circular economy for NdFeB-type magnets on an industrial scale. It will provide the tools to identify different quality grades of NdFeB EOLM and provide the most suitable methods to upgrade their properties with respect to costs and sustainability for large scale reprocessing through the:

1. Definition of standardised quality criteria for EOLM and a classification system for contamination levels to categorise products by pre-processing requirements.

2. Development of a labelling system for newly produced RE magnets to identify different magnet types and qualities, including provision of reliable and durable marking methods.

3. Investigation of treatments to eliminate pre-processing residues/coatings to avoid contamination in the HPMS process.

4. Investigation to upgrade properties of recycled EOLM based on powders of different contamination levels.

5. Circular economy evaluation of impacts for industrial upscaling of new methods by means of LCA and TEA investigations.

The project will create a new circular economy around the sustainable supply and (re)use of precious raw materials and will create eco-innovations, boosting competitiveness and job creation in the EU.

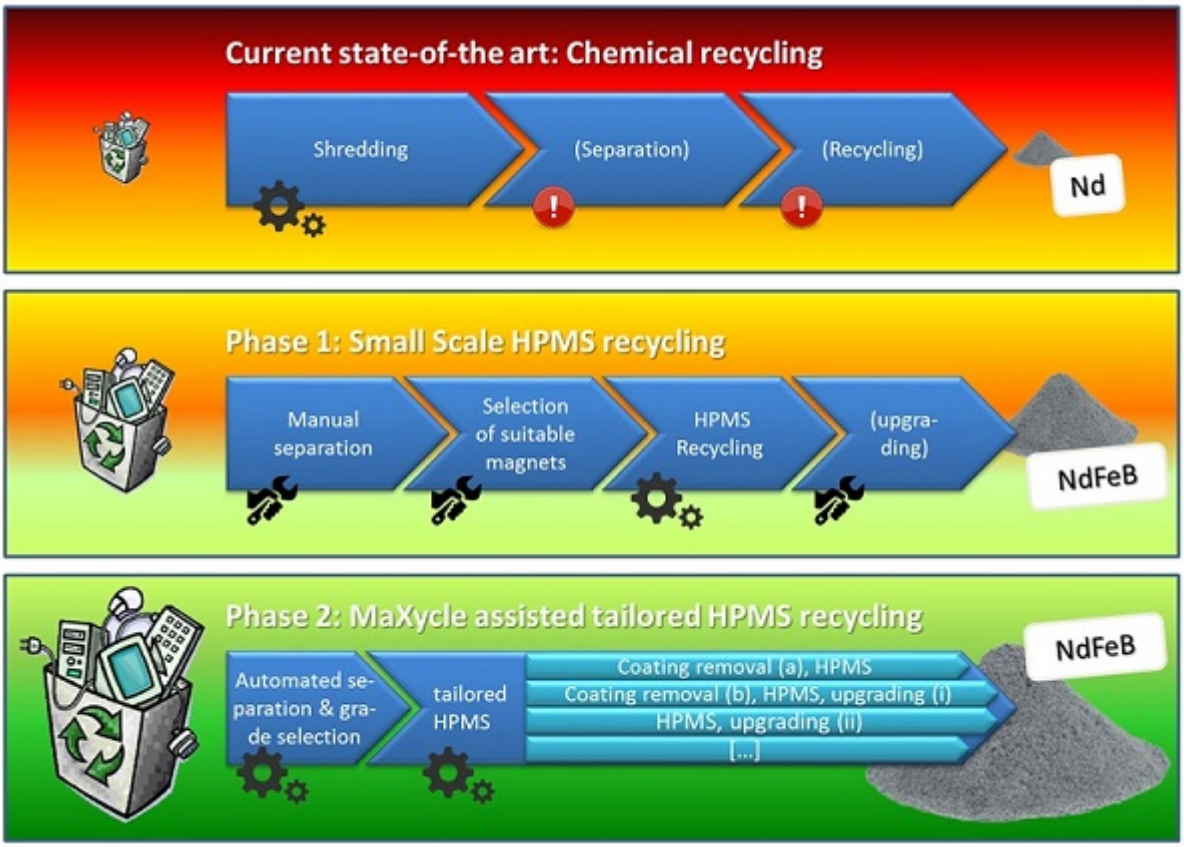

Figure 1 illustrates the MaXycle concept in comparison with existing technology.

METHODOLOGY

MaXycle addresses existing challenges in 7 multidisciplinary WPs. These will be divided between 5 partners and 2 associated partners (University of Birmingham UOB and Rocklife RKL). The partners have the skills, facilities and experience necessary for knowledge transfer within the consortium without any significant duplication or overlap.

WP1: Project Management (JSI, all partners). WP1 will ensure efficient and proactive coordination through the effective administration, organisation and monitoring of the technical, administrative and financial components of the project to ensure the highest quality of project results.

WP2: Classification system for EOL magnets (HSPF, JSI, MGI, UOB, RKL). In WP2, standardised quality criteria for EOL NdFeB magnets will be translated into a classification system per WP3's recycling-relevant criteria. Further informed by WP4 and WP5, this recyclate grading system will indicate how cost effectively any EOL magnet can be recycled. New methods will provide fast and reliable testing for EOL magnets from different sources.

WP3: Eco-labelling system for hard magnets (HSPF, OBE, RKL, UOB). WP3 will define information essential for recycling, such as chemical composition, manufacturing and coating methods. A universal, durable, corrosion-resistant labelling system for new magnets will be developed, ensuring that stored information will be readable by recyclers in an automated manner.

WP4: Coating removal from EOL NdFeB magnets (JSI, HSPF, MGI). WP4 investigates methods to remove corrosion protection from magnets before/during HPMS treatment, and separation from the recycled powders on an industrial scale. Existing lab methods will be evaluated for feasible upscaling, new methods developed to ensure minimum contamination of recycled powders. Identified methods will remove corrosion protection layers of EOL magnets classified in WP3 per the new grading system, providing starting material for the trials in WP5.

WP5: Upgrading EOL NdFeB magnets (MGI, OBE, JSI, HSPF). WP5 researches upgrading of HPMS-recycled powders including reduction of particle size, addition of Nd via casted master alloys/powder blending, removal of oxidised Nd-rich phase, blending with new NdFeB type material in various ratios, and increase of Dy-content via casted master alloys, powder blending or via grain boundary diffusion for powders of different contamination levels per the grading system. The focus is on contamination-free processes, especially with respect to oxidation and corrosion. Effects of upgrading on properties of recycled magnets in sintering, polymer-bonding and the SDS processes [10,13] will be evaluated. For different contamination levels, the most suitable methods will be identified.

WP6: Circular economy impacts evaluation (IVL, all partners). In WP6, the potential impact of processes developed in WP3 and WP4 will be quantified. Scenarios for industrial upscaling will be elaborated; including a thorough LCA, comparing NdFeB from mined sources to demonstrate environmental benefits of developed technologies. TEA will be used to guide the most promising reprocessing routes for performance and costs, and the creation of by-products and waste will be considered, and how they will exit/enter the circular system.

WP7: Dissemination & Exploitation (JSI, all partners). WP7 is dedicated to communication and exploitation of project results and achievements to identified target audiences to maximise active involvement and impact. For this a Communication plan (CP) and an Exploitation plan (EP) will be developed. They will help to promote the project and its results, identify the team requirements, include a market analysis, product concept development materials, exploitation strategy (including IPR and standardisation issues) and actionable capitalisation strategy and financial models for sustainability of exploitation efforts will coordinate activities on patents and safeguarding know-how across the project.

Figure 2 illustrates the MaXycle process.

PROGRESS

As currently most electronics are shredded, recycling of EOL magnets from WEEE or EOL vehicles by chemical and pyrometallurgical routes employs many processing steps [13], including the difficult extraction of materials from waste streams (Figure 3) resulting in low output and an expensive and energy intensive process.

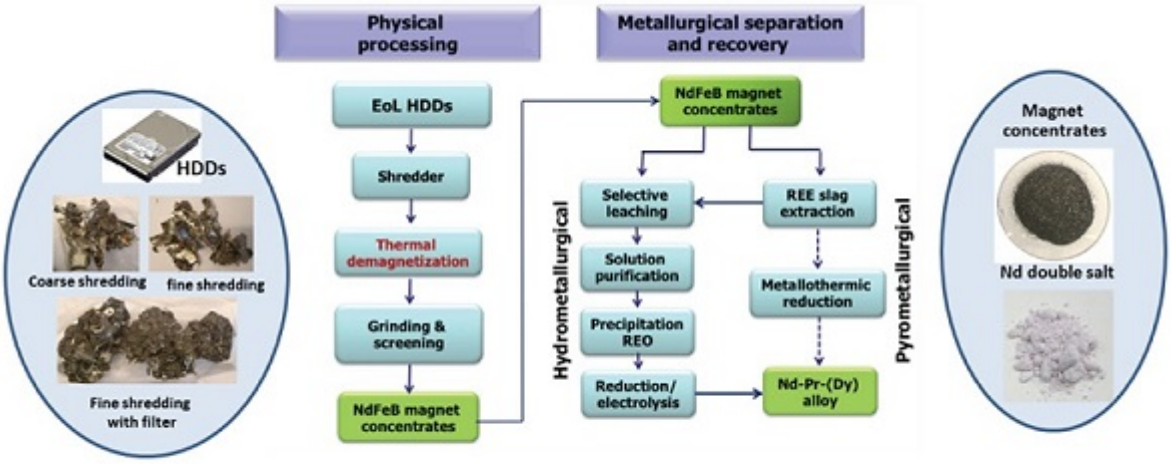

Fig. 3: Recycling of NdFeB material from hard disk drives (HDD) by chemical or pyrometallurgical processes [13]

With **HPMS** [7] it is possible to reprocess extracted materials directly from NdFeB alloy. As NdFeB magnets break down into a friable, demagnetised, hydrogenated powder that can be separated mechanically from remaining impurities, by e.g. tumbling electronics in a rotating hydrogen reactor and collecting the powder [8], allowing the now magnet-free component to be recycled much more easily. Figure 4 illustrates the HPMS process to hard disk magnet.

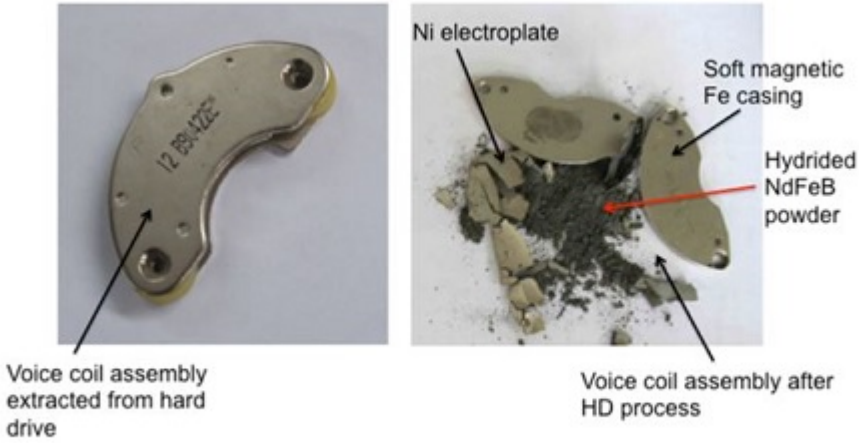

Figure 4: Illustration of the HPMS process applied to the voice coil assembly of a hard disk drive

However, several challenges hinder remanufacturing from unknown waste sources via HPMS:

a) Identification of different types of scrap magnets and levels of contamination

b) Measures to deal with impurities in waste streams

c) Fluctuations in properties of recycled materials of varying compositions

d) Recycling-“unfriendly” designs

In a systematic approach, MaXycle will recycle EOL NdFeB magnets (EOLM), by the HPMS process, in different conditions (different chemical compositions, different state of corrosion, different coating materials and other contaminations/impurities such as glue, resin, paint etc.) and subsequently classify the magnets for recyclability in a standardised grading system. This work will lay the foundation for the establishment of a future labelling system for hard magnets and the development of a unified classification system for EOLM. The amount of residues/impurities with respect to the magnetic material and where applicable, its environmental impact will be part of the classification, too, as will recommendations to OEM manufacturers about recycling-friendly design and manufacturing for maximum recyclability.

Public availability of the generated classification system will not only help the circular economy on recycling, but raise awareness of how

cost effective any magnet may be recycled, thus providing valuable information to end-users and decision makers about environmental impacts, helping to facilitate efficient eco-design.

As currently no information is available on the magnet itself, MaXycle will compile the newly gathered recycling-relevant information and create a durable, universal labelling system for newly produced magnets similar to the ASTM International Resin Identification Coding System (RIC).

Information for industrial hard magnets is more complex as not only the chemical composition is relevant, so to choose appropriate recycling methods data about manufacturing routes and corrosion protections is needed, encoded in a small and robust machine readable encoding.

MaXycle will investigate **data matrix codes** (DMC) to encode large amounts of data applied directly into forming tools or printed/engraved into coating surfaces as small as 300 micrometres, while ensuring error recovery when contaminated or damaged. As DMCs can be applied before or after coating, the chemical resistance of the magnet against corrosion and its magnetic properties are believed to remain unaffected. However, experiments to answer these questions will be part of the MaXycle project work plan.

A second, also very promising route will be the use of **powder markers** (Polysecure system). The unique crystalline and ceramic particles, which size in the micro-/nanometer range, have a complex composition that carries the entire information to be stored [15]. Being temperature resistant up to 1600°C, chemically inert and mechanically very robust, powder markers are homogeneously distributable in the respective raw material or coating. As only a small fraction of the product is sufficient to clearly identify the stored information, this system may work also with highly damaged magnetic scrap. Because of its fundamental stability and the measurability of the concentration of its components, powder markers reproduce a vast number range. In the basic system, 14 million numbers can be generated and expanded to 280 trillion numbers, more than sufficient to create a flexible, universal labelling system expandable to other magnetic materials and beyond. The numerical code of the powder marker exists at any spot of the product or coating and can be read out by mobile RFA (X-ray fluorescence spectrometer) in less than one minute. Readers for powder marker technology can be integrated into sorting machines, which could be very interesting for the automation of the recycling process. Being chemically inert, the powder markers are believed not to influence magnetic properties and corrosion resistance of NdFeB magnets.

MaXycle will investigate the suitability of powder markers for a reliable marking system for permanent magnets, making experiments to test the mixability of the powders with the magnetic materials and corrosion coating materials, test the readability of the markers on scrap in different EOL conditions, and the influence of the powder markers on magnetic properties and corrosion resistance of samples. The effect of multi-recycling and the effect of a possible contamination of multi-recycled materials with “old” markers on the reliability of the system will also be tested as part of the MaXycle work plan.

Standardised quality criteria for EOL NdFeB magnets will be translated into a recyclate grade classification system per WP2’s criteria, and integrating results of WP4, WP5 and WP6, a standardised grading will allow the cost effectiveness of recycling any EOL magnet to be assessed, and will be made available for producers and recyclers.

Various types of EOL magnets will be classified to supply starting material for WP4 where removal techniques for coatings will be evaluated and optimised. Figure 5 illustrates the need by comparing different coatings: while nickel-coating on the left flakes off during HPMS, the polymer coated magnet at right remains unaffected without coating removal.

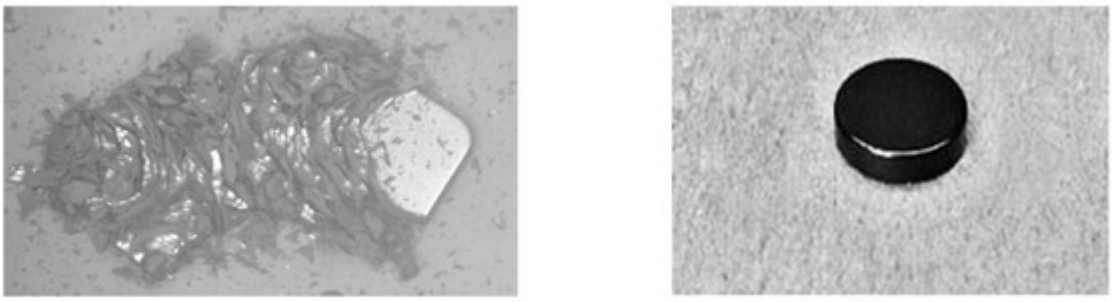

Figure 5: left: Ni-coated magnet in HD process with coating flaking off during the treatment, right: polymer coated magnet

The project will then compare magnetic properties of reprocessed magnets: HPMS recycling material of different quality grades will provide baselines for upgrading by reducing particle size [16] and by systematic addition of extra RE to replace the oxidised grain boundary phase by mechanical blending with cast alloys or with hydrided material [17]. A potential replacement of oxidised grain boundary phase with fresh material prior to re-manufacturing will also be investigated [12], as will the influence of Dy on magnetic properties, either by blending Dy into the powders [18] or by grain boundary diffusion [19] in the re-processed state.

Upgrading methods will be benchmarked against the requirements of primary materials and a techno-economic assessment for potential

recycling routes (including the respective upgrading processes) performed alongside LCA to assess environmental benefits over primary production.

MaXycle is very innovative, advancing the state of the art towards the emergence of a circular economy.

Table 1 outlines the current TRL levels for the technologies outlined above, as well as the expected TRL levels generated in the MagCycle project.

Technology	Current TRL	TRL in MaXycle	Lead Partner
Development of a future labelling system for hard magnets	4	6	HSPF
Development of a classification system for EOL NdFeB magnets	4	6	HSPF
Coating removal from EOL NdFeB magnets	3	4-5	JSI
Upgrading the magnetic properties of EOL NdFeB magnets	2-3	5	MGI

Figure 6: Technology readiness levels for key technologies in MaXycle

INTERDISCIPLINARY

The recycling of NdFeB material requires innovation throughout the entire life cycle and needs to be embedded into a broader interdisciplinary context to develop new business models to close the loop. In a truly interdisciplinary approach, the MaXycle consortium will execute an ambitious work programme, depending upon strong interdisciplinary interaction and cooperation between academia and industry:

Prof. Dr. Spomenka Kobe from the Jozef Stefan Institute **(JSI)** as project coordinator has 40+ years of experience in research projects in the area of magnetic materials. She is Scientific Advisor, Head of the Department for Nanostructured materials and professor at the International Postgraduate School “Jozef Stefan”. As recipient of two state awards for scientific research and two innovation awards from industry for the successful transfer of technology, she will ensure excellent management of the project, delivering applied and ready-to-use solutions.

Prof. Dr. Carlo Burkhardt from thePforzheim University of Applied Sciences **(HSPF)** has 20+ years of industrial experience as R&D director and general manager of large industrial companies in Germany and 30+ years experience in NdFeB materials technology. He will act as the interface between science and industry and in the economic focusing of MaXycle results. As coordinator of the H2020 NdFeB recycling project “REProMag” (GA 636881 - just selected as “European Success Story” by the Commission and won the Eco-Science Award 2017 for Material Efficiency in the German state of Baden-Württemberg), he has successful experience in managing EU R&D projects.

Dr. Oxana Weber from Ohnmacht & Baumgärtner GmbH & Co. KG **(OBE)** and Dr. Irena Skulja from Magneti d.d. **(MGI)** both have strong records in the development of magnetic materials and magnet recycling with 5+ years experience in the field of NdFeB magnets. They will ensure that MaXycle will produce first class scientific results that are ready to use, meet the need of the manufacturers of permanent magnets and thus fit to the business case of the two very successful industrial partners, providing new business solutions.

Mia Romare from the Swedish Environmental Research Institute **(IVL)** is a critical materials expert with industrial experience as an environmental engineer at Volvo Group Trucks Technology. There she focused on environmental assessment in product development and planning, combined with her current experience on performing Life Cycle Assessments (LCA) on products and processes of heavy duty vehicles, batteries and drivelines (conventional and electrified) will ensure a strong interaction with the industrial and academic partners of the project in order to perform first class LCA and TEA.

Dr. Allan Walton from the University of Birmingham **(UOB)** will act as advisor and consultant for the MaXycle goals and their feasibility. Being Co-Director of the Birmingham Centre for Strategic Elements and Critical Materials, he has played a central role in formulating the EU’s response to the problem of CRMs (heading the Working Group on the Recycling of Rare Earths in the ERECON project).

Leonard Ansorge, Managing Director of Rocklife **(RLK)** will also act as advisor and consultant for MaXycle. RLK has worked in the field of

rare earth recycling for decades and is aware of the challenges of sourcing rare earth scrap from EOL materials and production residues worldwide as well as the increasing demand for higher quality secondary products. RLK will assure the provision of scrap materials for material characterisation and upgrading, will give vital technological input to the feasibility and industrial relevance of the classification system and labelling approaches, monitor prototype application of the eco-labelling system, and supply first hand input for LCA and TEA.

IMPACT

MaXycle will make the vision of the circular economy for RE permanent magnets real, by suppling technical solutions throughout the circular system, combined with social innovation approaches of standardised labelling of magnet qualities, the introduction of recyclate gradings and best-practice recommendations. Current recycling methods for EOLM lead to severe losses along the product and material life cycle and are commercially unattractive, with currently less than 1% of the world's REs are being recycled [2]. A lack of transparency of material flows along the recycling chain and illegal and dubious export streams result in greatly reduced amounts of recycled material and because of the high variance in primary production methods of magnets and in the mining of raw materials, it is very difficult to assess the true carbon and energy footprints of magnets now entering the EU. The project will facilitate the recycling of NdFeB magnets with high yields at reasonable costs, with low energy consumption and minimum environmental impact by delivering:

1) a functional, reliable, easy-to-use **eco-labelling system** for magnets, allowing clear identification of materials and containing all recycling-relevant information, laying the foundation for a European standard and reference handbook on environmental labelling for magnets

2) a standardised recyclate grade **classification system for EOLM**, giving a clear indication of how cost effective any magnet can be recycled, and providing valuable information to end-users and decision makers about the environmental impact, helping to facilitate efficient eco-design

3) a systematic comparison of currently available coating methods and their suitability for HPMS-treatment at industrial scale; investigation/development of new **coating removal methods** and classification of the currently employed coatings/residues with respect to recyclability incl. an estimation of today's and expected future quantities, to integrate these materials into recycling concepts

4) an extensive investigation to compare currently available **upgrading routes for recycled magnets** as a function of the quality of recycled ingot material based on performance, quality and price benchmarked against requirements of primary materials and assessed for environmental benefits over primary production

Thus, MaXycle will support the EU integrated strategy "Raw Materials Initiative" (2008) and the European Innovation Partnership on Raw Materials (2012) by introducing a sustainable source of raw materials and increase EU magnet production. While most of the embedded magnets in consumer electronics entering the European markets today are rather small in size (e.g. loudspeaker magnets in mobile phones weigh less than 5 grams and those in voice coils of computer hard disk drives 10-20 grams), will the applications in the EU dominated growth fields of renewable energy (wind turbines ~600kg of RE magnets per MW) and electric vehicles (EV) (~10-30 kg) need large quantities of RE magnetic materials. This will allow the EU to use these drivers to take a leadership position in recycling and re-use.

With the total recycling potential worldwide estimated as being in the range 14,000–20,000 t/a by 2020 [4,5], MaXycle thus represents an exciting circular-economy opportunity. The project targets a near doubling of the recycling rate, i.e. from an estimated 800 t/a today to around 1,500 t/a in 2021. Having a progressive vision about how it's impact will radically change the recycling and use of RE magnets, an exponential increase of the rates is expected as soon as the first eco-labelled magnets are reaching their EOL, being then suitable to be sorted and HPMS treated in automated systems. **It is the consortium's ambition that by 2025, with the new labelling and recycling standards being in place, an effective recycling rate of 15% is achieved**, meaning that ~ 20,000 tons of magnets will be recycled p.a. Additionally, the project will impact primary production recyclability, (i) making magnets themselves inherently more recyclable and more eco-friendly, and (ii) radically raise awareness of the need for recycling, in addition to the methods used. Combined with (iii) increasing demand in green technologies and (iv) larger quantities of EOL EVs and wind turbines magnets being fed into the recycling loop, in the year 2035 a recycling rate of 30% is predicted (being in the range of other technology metals like Pt and Pd), resulting in a quantity of more than 130.000 t/a of recycled RE material. An scenario for the development of the recycling quantities is given in fig. 7.

MaXycle KPIs and projections

Year	2017	2025	2035	2050
Demand (tonnes)*	80,000	244,000	500,000	1,000,000
Percent possible to recycle	5	18	30	30
Percent recycled (of possible)	1	15	25	30
Percent secondary production	0.5	12	20	28
EU REE import percentage	97	85	75	70
Percent in EU using tagging	0	30	90	97
Percent in EU using HDP	0.2	20	40	60
Percent in world adopting methods	0	25	50	70
EU manufacturing market share	3	15	25	30

*based on an annual growth of ~15% until 2035, then slowing down due to new technologies

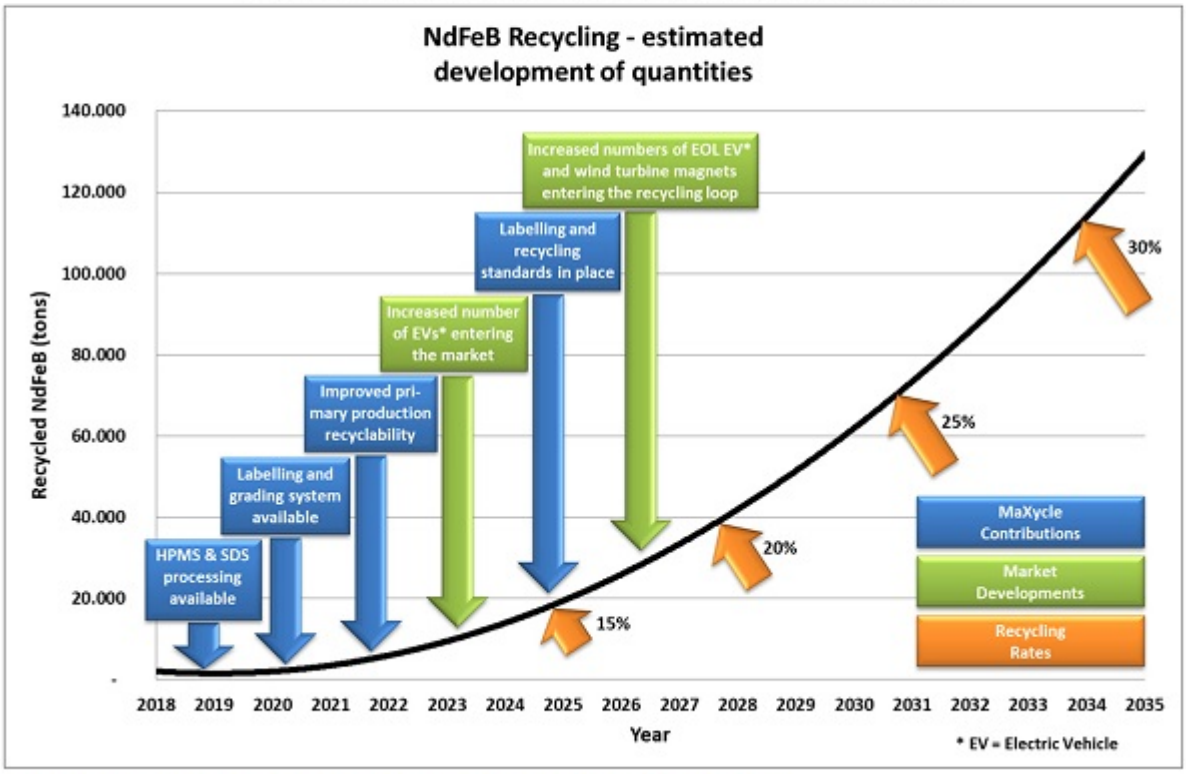

Fig. 7: NdFeB Recycling – estimated development of quantities

Further revenues and jobs will be generated from manufacture, EU sales, and export of specialist process equipment, and further development of recycled NdFeB magnet raw materials will open new markets for specialised recycled magnet products, strengthening competitiveness and economic growth. With key innovations like HMPS [7,8] and SDS [19] protected by patents, know-how on magnet recycling will be extended into scrap recovery from new sectors using innovative upgrading and coating removal techniques, where new patents are likely to emerge. To support and promote R&I cooperation, MaXycle project results will be published in international journals, and public interest and uptake of sustainable products and recycling will be encouraged through MaXycle's website, and articles in relevant news and media. Briefings on economic and social benefits will be issued regularly to the appropriate ministries and agencies across the EU, and outreach materials on the recycling of NdFeB magnets designed for junior, secondary and tertiary students will be used to promote the concepts and advantages of innovative raw materials technology. Public workshops targeted at end users to demonstrate the capabilities of recycled magnets will also be organised.

Through consideration of technical, economic, and social aspects, MaXycle will therefore:

• develop tools and technologies to create transparency about material flows along the entire EoL- / recycling chain

• investigate treatments to eliminate pre-processing

• investigate the possibilities to upgrade the properties of recycled NdFeB magnets based on powders of different contamination levels to meet EU goals on green energy and electromobility

• evaluate the impacts for industrial upscaling of the new methods in a circular economy by means of LCA and TEA investigations.

With its ambitious workplan, MaXycle will provide innovative tools and solutions to:

• reduce the high losses of these precious technology metals during pre-processing

• to reduce impurities degrading product/residue quality, and inappropriate management of interfaces to pre-processing, both upstream (collection & logistics) and downstream (metallurgy),

• develop economic, energy efficient and environmentally sound pre-processing technologies for complex products to generate output fraction,

• develop criteria for appropriate grouping of EoL-product types into collection categories in order to improve pre-processing performance while considering logistics efforts and costs (upstream interface optimisation) and

• develop information and awareness raising tools to improve collection and recycling quality and recycle-friendly design

MaXycle's innovative and reliable eco-labelling and material classification system with integrated database will provide a vital contribution to standards for systematic collection and filing of data across Europe to feed the urban mine inventory. It will lay the foundation for the build-up of a systematic product inventory of NdFeB resources and expertise on the regional and European scales, to develop suitable Resource Efficiency Indicators based on technology, recyclability, economics, environmental impact, distribution models, etc., to provide economic incentives and support for more and better recycling and energy and material use efficiency.

DISSEMINATION

2.2.1 Communication

The MaXycle dissemination workflow aims at communicating with the "global recycling society", i.e. researchers, key stakeholders in recycling and manufacturing industry, customers and environmental service providers, trade groups and working groups, standard groups, environmental awareness groups and policy makers in Europe as well as interested private persons on a world-wide basis in order:

• to raise awareness of the real costs of magnets and the rarity of the materials involved,

• to introduce the development of the grading and labelling system,

• to describe the benefits of MaXycle's techniques for removal of residues and upgrading methods,

• to promote their fast implementation on a way to a true circular economy of RE-permanent magnets.

It will be of prime importance to get the message across that both insufficient collection of WEEE and high leakages of collected products and materials by illegal and dubious exports, high losses of secondary raw materials before and within the recycling chain are a societal problem, where real solutions are needed and can be provided by MaXycle.

To do so, all MaXycle partners will be actively involved in the creation of a detailed communication plan. As good communication about the project's activities and achievements is the key to success, the consortium will carefully analyse the relevant industrial landscape and catalogue in a spreadsheet, prioritised by sector and market weight in order to dispatch emissaries with high quality materials and messages to attend in person meetings, trade events and conferences in a mix of both interpersonal and mass communication.

Communication and dissemination activities (see also WP7 description) overlap somewhat and include:

• Direct proactive communications and physical visits to stakeholders: attendance at seminars and conferences, one-to-one communication, e-mailing stakeholders, periodic newsletters etc.

• Clustering activities: contacting parallel related projects on an international basis, attendance of cross-field events

• Mass and general communication project website, social media presence, targeting of technology-focused blogs and websites, posters and leaflets

• Outreach to the general public through open events, scientific fairs and conferences and the production of an online video

A focus will be upon "translating" sometimes complex scientific results into easy to understand media resources in order to meet the requirements of different target groups.

In a truly international approach, key for the successful introduction of the grading and labelling system, dissemination will include:

• Participation in at least three industrial fairs (e.g Hannover industrial fair, recycling conferences in the US and Asia), to present the project's industrial achievements. This is of prime importance to reach potential policy makers, mediators, recycling companies and other users of MaXycle technologies.

• Participation in at least three world-class scientific conferences (e.g Rare Earth and Future Permanent Magnets and Their Applications, WorldPM, European conference on powder metals and particulate materials, CIRP conference on life-cycle engineering) to present the scientific/technical breakthroughs of the project, assuring thus a swift technology transfer through making generated knowledge available to specialised audiences.

• Publication of four or more cross-thematic peer-reviewed scientific/industrial articles in international journals (e.g. Materials Processing Technology, IEEE Transactions on Magnetics, Journal of Cleaner Production ...) and a final publication booklet summarising all project results.

• A "European standard and reference handbook on environmental labelling for magnets".

• Organisation of at least two thematic training workshops (e.g. on the World Resources Forum and the European Raw Materials Week) to promote the grading and labelling system and MaXycles approach to the removal of residues and upgrading of HPMS magnets. The training documents will be used for take-up activities and further exploitation of the project results e.g. as e-learning modules by facilitating access to information in how to turn the turn the raw materials value chain of NdFeB into a circular economic cycle where dissipation and waste is minimised.

• Integration of project results into university courses in the field of eco-innovation and manufacturing. This will enable future use of the MaXycle achievements through the immediate involvement of the next generation of engineers.

• Networking with R&D projects in the same field and clustering activities with regional, national and European networks on eco-innovative, material and green technologies.

• At least 6 in-person visits with key stakeholders per year, increasing as the project reaches maturity.

The MaXycle project expects that part of the dissemination materials (e.g. industrial publications, trainings materials and project final publication) will guide the professional community to the implementation of the proposed solutions and tools well beyond the project period.

2.2.2 Exploitation of results

The consortium is highly committed to bring the novel MaXycle solutions to a state of maturity that allows its use as a standard in commercial products, to turn the raw materials value chain of NdFeB into a circular economic cycle where dissipation and waste is minimised. The project will ensure the successful, sustainable and economically viable exploitation of project results in the form of more competitive EU magnet production, new coating (removal) and recycling methods, and their licensing as tools and solutions to industry as well as academic exploitation in the form of publications, consulting, and new co-operations. At project start the rules for the distribution of Industrial Properties Rights (IPR) among partners will be elaborated in a consortium agreement, which will then be the basis for the development of an Exploitation Plan (EP) within WP7.

The MaXycle exploitation and business strategy to reach its short-term and long term exploitation goals includes the following steps:

1) Identification and mapping of key stakeholders across all sectors, including industry, research, standards, safety and regulatory, primary and secondary production channels, material recycling groups, government, and policy and trade groups. Also of key markets, possible channel partners, and the identification of unique selling points, key performance indicators, and possible products offerings and market approach mechanisms.

2) Two exploitation workshops for the consortium: definition of IP generated (based on the identification of background IP already defined in the consortium agreement and foreground IP generated in the project), definition of the flow of IP between the partners, exploitable results, exploitation claims and access rights of individual partners

3) Development of an exploitation plan (EP) resulting in individual business plans taking into account partner development strategies, main target markets and, where applicable, secondary markets (adaptation of project results to other applications) of each partner, focusing on opportunities, challenges and barriers for the individual exploitation strategies, while being flexible enough to accommodate changes arising during the project duration.The EP will include team requirements, market analysis, product concept development materials, exploitation strategy (including IPR and standardisation issues) and actionable capitalisation strategy and financial models for sustainability of exploitation efforts. The EP will cover in detail analyses and potential cooperation with end-users, mediators, networks, competitors, suppliers, state regulators and policy makers and implementers, which is especially relevant for the created grading and labelling system, which should be easily accessible on a world-wide basis in order to foster the needed standardisation.

CONTRIBUTION

As the project will provide essential tools necessary for industrial scale recovery of NdFeB magnets and innovative reprocessing for the benefit of the three largest industry sectors in the EU, namely automotive, electronics and energy generation, the project will directly contribute to the overall aim of the EIP, by contributing to the target of raising EU industrial GDP to 20% by 2020.

RE magnets based upon NdFeB play a fundamental role in the shift from fossil fuels to a clean energy future. They are used in wind turbine generators, in electric vehicles and across other sectors. RE magnets underpin an industry worth in excess of $1 trillion worldwide (2015) [1], but in recent years the supply of neodymium, dysprosium and praseodymium used in NdFeB magnets has come under considerable threat. Driven by increased adoption of electric vehicles and green technologies, the global demand for NdFeB magnets (~80,000 t/a 2017) could grow at 15-20%/annum for the next decade [1]. The ability of European companies to participate fully in these markets is restricted by the near-monopoly supply of rare earth materials in China. Added to this, currently less than 1% of the world's REs are being recycled [1]. However, in the present context of growing demand for RE permanent magnets in the high-tech sector, including green technologies, securing of supplies has therefore become crucial. As the EU has no large, easily exploitable deposits of rare earths (RE), its member states import far more Nd-Fe-B magnets than they manufacture (approximately 1,000 tonnes per year) [3]. Advanced research and innovation to improve exploitation as a secondary resource is therefore needed, with several authors having estimated the total recycling potential for RE magnets worldwide as being in the range 14,000–20,000 tonnes per year by 2020 [4,5]. In the EU this figure can be put at around 2,000–3,000 tonnes/annum, which means it represents an exciting circular-economy opportunity for the project and the EU as a whole. This places MaXycle in full accordance with the target of the ERA-MIN research agenda, and the resulting tool sets will contribute to the extension of the availability of an urgently needed recycled raw material and drive its adoption into a range of new magnet products for the EU.

By facilitating a circular economy of NdFeB magnets, the economic and social impacts of supply restrictions within Europe can be reduced and supply will be diversified. This will give the EU rare earth supply chain a competitive advantage and help stabilise this often volatile sector against external influences. It will diversify raw materials sourcing and improve the recycling efficiency of NdFeB magnets by the introduction of a functional, reliable, cheap, and easy-to-use eco-labelling system for magnets, allowing the clear identification of different types of materials and containing all recycling-relevant information, laying the foundation for a European standard and reference handbook on environmental labelling for magnets. It will provide a standardised recyclate grade classification system for EOL magnets giving a clear indication of how cost effectively a certain type of magnet may be recycled, and valuable information to end-users and decision makers about the environmental impact of respective types of magnets, helping to facilitate future efficient eco-design. Combined with the use of innovative processes such as HPMS to liberate NdFeB magnets from complex waste streams, the provision of technical solutions for the removal of coatings and upgrading of recycled powders for reprocessing by standard processing technologies like sintering and injection moulding and the highly innovative, waste free SDS process, MaXycle is directly addressing key objectives and targets of the EIP Strategic Implementation Plan; with its new methods combined with new manufacturing and best practices leading also to improved primary production to allow better secondary production.

CONSORTIUM AGREEMENT

Conditions for use of the knowledge (being protected or not) during and after the end of project will be regulated by the Consortium Agreement and further detailed in the Exploitation Plan. For software development, a "quid pro quo" arrangement is foreseen to be put into the Exploitation Plan.

The Consortium Agreement (CA) will defining among other issues the rules for the following points:

• Confidentiality, secrecy and patenting

• Publication and dissemination

• IP ownership

• IP Use and Access Rights: police the Access Rights to foreground and background IP within the project under the terms of the Consortium Agreements and the General Conditions of the EC Grant Agreement.

Innovation generated during the project by partner who wishes to apply for patent protection will be treated under the appropriate level of secrecy until such time comes and its disclosure does not affect patent applications.

Whilst publication is under the remit individual partners, any intention to publish will be referred to all partners, who could exercise a veto if, in their judgement, this could seriously affect their interests. The rules for vetoing or accepting publication will be given in the Consortium

Agreement, as MaXycle has the obligation under the ERA-NET/Horizon 2020 Work Programme to provide open access to peer-reviewed scientific/technical publications resulting from the project. In concrete terms that means that publication of data under patenting process will be put under an embargo period before providing an open access to them. Moreover, the open access model to be used will be defined by the publisher aiming to publish the publication. In all the cases, publications will be self-archived by the researcher, but also on the project intranet, before and after release in the public domain. The open access to publication will be done in accordance with the guidelines on open access to scientific publications and research data in Horizon 2020 published by the European Commission.

The IPR necessary to exploit the results of MaXycle will be clarified in terms such as:

• Background and foreground that partners bring to, or will develop during the project

• Ownership of this knowledge and access right for use during and after the project

The Access Rights of the project will be based on the General Conditions of the EC contract and deal with:

• Access Rights to pre-existing know-how (Background)

• Access Rights to knowledge resulting from the project (Foreground)Access Rights for third parties and Affiliate

WORK PACKAGES

Table of Work Packages + Tasks

WP	Task	Start Month	End Month	WP / Task Title
1		1	36	Project Management
	1.1	1	36	Scientific coordination of the project
	1.2	1	36	Administrative management of the project
	1.3	1	36	Financial & accounting management
	1.4	1	36	Communication & Knowledge management
2		1	34	Classification system for EOL magnets
	2.1	1	12	Definition and collection of data
	2.2	8	19	Definition of test methods for EOLM
	2.3	13	24	Development of recyclate grading system
	2.4	16	32	Setup of a database system
3		1	25	Eco-labelling system for hard magnets
	3.1	1	12	Development of labelling model
	3.2	8	19	Labelling trials (subsurface labelling)
	3.3	9	20	Labelling trials (surface labeling)
	3.4	13	24	Endurance trials for labelling systems
4		1	34	Coating removal from EOL NdFeB magnets
	4.1	1	12	Analysis of coating layers
	4.2	6	16	Removal of coating layers and residues
	4.3	7	19	Analysis of coating residue

WP	Task	Start Month	End Month	WP / Task Title
	4.4	19	33	New coatings
5		7	34	Enhancing EOL NdFeB magnets
	5.1	7	19	Feedstock preparation
	5.2	9	33	Conventional and SDS processing
	5.3	20	33	Spark plasma sintering
6		1	36	Circular economy impacts evaluation
	6.1	1	9	Literature review
	6.2	6	33	Environmental impact assessment
	6.3	16	33	Economic impact
	6.4	26	36	Health & Security assessment
7		1	36	Dissemination & Exploitation
	7.1	1	36	Dissemination and Communication
	7.2	4	33	Technology and knowledge transfer
	7.3	4	36	Technology and market watch
	7.4	13	36	Management of IP
	7.5	3	36	Exploitation plan (EP)

WP/Task No.	WP Objectives + Description / Task Description	Partner (**strong** = Teamleader)	Person Month(s) (**strong** = Teamleader)
WP1	**Objectives:** Smooth and effective collaboration within the consortium. Submission of deliverables and milestones according to schedule. High quality of the project results. Tracking and effective mitigation of risks. Prevention and resolution of problems and conflicts. Effective management of project planning, budget and expenditure. **Description:** MGT The overarching aim of this work package is to ensure an efficient and pro-active coordination of the project through an effective administration, organisation and monitoring of the technical, administrative and financial components of the project. A common set of rules and structures for the communication inside and outside the consortium will enable the flow of information and knowledge. Two levels of management will be defined: 1. the coordination level (decision-making, overall management and monitoring) which contains a Steering Committee and an Executive Management Board 2. the operational level (operational workflow) which comprises the work package leaders PM could not be devided appropriate because of the limitation of the online system.	P1, P2, P3, P4, P5	2, 1, 1, 2, 1

WP/Task No.	WP Objectives + Description / Task Description	Partner (**strong** = Teamleader)	Person Month(s) (**strong** = Teamleader)
T1.1	The work package leaders will carry out the technical management against the targets set out in the work plan and are responsible for timing, organisation, planning, monitoring, reporting and quality of deliverables of their work package. WP meetings to help achieving a successful integration and progress in and between work packages. The scientific and technical coordinator JSI will be responsible for consolidating the views of the WP leaders and judging the overall progress of the project and the potential impact of changes on achieving the overall goals of the project, by: • Monitoring of project's progress and activities performed by the consortium with respect to the work plan • Ensuring the appropriate and timely completion of projects' tasks • Research risk management • Preparation and submission of reports and deliverables Internal activity reporting will be implemented every 6 months in the project in order to assure a good follow up of the technical achievements of the project. Each partner will be responsible of issuing a report on its own activities. WP leaders will be responsible of issuing a technical report on its WP. JSI as coordinator will be responsible of issuing an overview of the technical progress of the project on the basis of WP reports.	**P4**, P5	**1**, 1
T1.2	JSI as coordinator will ensure a reliable and fast flow of information and project documentation between the project consortium and funding organization(e.g. progress reporting, cost statements, reviews). The administrative management activities will be: • General project administration, • Preparing and post-processing of EC reviews from the consortium-side including support in the implementation of recommendations from the EC and reviewers, • Preparing, executing and post-processing of major project meetings such as Steering Committee, Executive Management Committee and Review meetings with the EC • Drafting and maintaining the dissemination and exploitation plan following the EC's requirements, • Provide project assurance to the EC by validating and monitoring the DoW against progress, keeping the project in line with EC strategies, monitoring changes to the Implementation Plan, Consortium Agreement and contract with the EC • Preparation and submission of the mandatory management reports to the Commission: Midterm and final reports.	**P1**, P2	**1**, 1
T1.3	The financial and accounting management of the project is led by JSI and will concentrate on: • Preparation of the financial and budgetary reports • Controlling of the overall budget MaXcycle will make use of a web-based professional project management tool in order to facilitate the better managing of all administrative and financial activities of the project as well as the preparation of periodic reports. The following budget related activities will be implemented by the coordinator JSI: • To administer the Community financial contribution regarding its allocation between beneficiaries and activities, in accordance with the grant agreement and the decisions taken by the Steering Committee Meeting. • To keep the records and financial accounts making it possible to determine at any time what portion of the Community financial contribution has been paid to each beneficiary for the purposes of the project; • To inform the Commission of the distribution of the Community financial contribution and the date of transfers to the beneficiaries, when required by this grant agreement or by the Commission	**P1**, P3	**1**, 1
T1.4	The major prerequisite for a successful collaboration is a good communication and knowledge management within the consortium. Therefore, the following activities will be performed in this task: • Set-up of common rules and procedures for the communication of information and results within the project. • Handling of the project correspondence and the day-to-day requests from partners and external bodies. • Set-up and maintenance of a project intranet and a data repository for the consortium. For both, security issues for protection of IPR will be taken into account. A dedicated "Stay on track" tool will be used and updated by the consortium on a regular basis to allow an easier and more efficient monitoring of all project activities. It will allow the updating of relevant internal documents related to the project and it will enhance the project management internal procedures. Monthly WP Leaders telephone conference will allow a good follow up of all WP activities and favour management of knowledge as well as synergies between the different WPs A Kick-off meeting will be organised by the project coordinator. The main tasks during this meeting will be presentation of the main objectives of the project. Next MaXcycle partner meetings will be arranged every 6 months to discuss the project achievements and if necessary adapt the work schedule.	**P4**	**1**

WP/Task No.	WP Objectives + Description / Task Description	Partner (**strong** = Teamleader)	Person Month(s) (**strong** = Teamleader)
WP2	**Objectives:** • To define testing parameters necessary to classify End-of-Life Magnets (EOLM) grades • To define test methods for grading EOLM • To test various types of EOLM from different sources • To collect recycling data from WP4 and WP5 • To create a classification system for EOL magnets • To create a suitable database tool for the grading system **Description:** AR/TRL start 4 target 6 Standardised quality criteria for EOL NdFeB magnets will be determined and translated into a classification system. Taking into account the results created in WP4 and WP5, the MaXycle recyclate grading system will give indication of: •how cost effective a certain type of EOLM can be recycled •what kind of magnetic performance can be expected from the respective recyclate •which remanufacturing method (polymer bonding, press sintering, SDS or spark plasma sintering) is recommended for the respective grade Potential test methods will be investigated for suitability to provide fast and reliable testing for EOLM according to the defined criteria. Various types of EOLM from different sources will be tested against the criteria and accordingly classified.	P1, P2, P3, P4	1, 1, 2, 11
T2.1	Definition of the required data to establish a robust, reliable and accurate classification system which gives precise information how to manage EOLM, and which recycling conditions are appropriate for cost effective recycling. Information includes chemical composition, heavy rare earth content, manufacturing method, and coating. The grading system will be open for additional recycling relevant information like field of application, operating and installation conditions, and be fully extensible.	P2, **P4**	1, **2**
T2.2	To acquire the data needed for the selection of appropriate remanufacturing methods and predict achievable quality when remanufacturing EOL magnets graded according to 3.2, appropriate tests will be defined based on the results from Tasks 4.1 and 5.4. Where applicable, additional test methods will be defined with the close collaboration of WPL, with the goal to define testing procedures that are cost efficient and fast.	P1, **P4**	1, **4**
T2.3	Based on the data gathered in 2.2, an alphanumerical grading system will be developed that encodes the info in a machine readable manner that can be stored reliably in the eco-labelling systems developed in WP3. To meet the complex requirements for permanent magnets, one of the main challenges will be to find the balance between detailed information and a simple, easy-to-use system.	P3, **P4**	1, **2**
T2.4	This task will setup of a database system for the recyclate grading system. To access the data gathered in this WP and to make it available to all interested parties, an open-access database with easy interfaces and search features will be created and filled with project results. Made publicly available via the MaXycle website and in conjunction with the eco-labelling system created in WP3, it will form the basis for the project's standardization efforts for the characterization of EOL magnets.	P3, **P4**	1, **3**
WP3	**Objectives:** • To gather data as basis for a universal eco-labelling system • To test suitability of different eco-labelling systems for the application and to investigate their durability in different working conditions • To test the effect of the eco-labelling systems on magnetic properties • To accumulate practical knowledge as a basis for WP3 **Description:** AR/TRL start 4 target 6 Definition of the essential information for a successful recycling of NdFeB type magnets, e.g. chemical composition, manufacturing and coating methods, etc.. Development of a universal, durable, corrosion-resistant labelling system for newly produced magnets, ensuring that the stored information will still be readable by a potential recycler on EOL magnets in an automated manner, while not influencing the properties of the magnet.	P1, P2, P3, P4	1, 2, 1, 13

WP/Task No.	WP Objectives + Description / Task Description	Partner (**strong** = Teamleader)	Person Month(s) (**strong** = Teamleader)
T3.1	All the required data for successful and efficient recycling an EOL magnet defined in WP3 and in close cooperation with the associated partners and other stakeholders (comprehensive questionnaire). The data set will be translated into a labelling system allowing easy identification and sorting at the recycler, taking into account also the requirements for the classification system and database model developed in WP2.	P2, **P4**	1, **3**
T3.2	Powder markers (Polysecure system) with a particle size in the micro/nanometer range will be tested for their suitability as a subsurface eco-labelling method for magnetic materials. The powder markers will be mixed in the magnet powder itself or in the coating of the material. After production of polymer bonded, sintered and SDS magnets, the readability of the system (speed and reliability) and a possible effect of the markers on the magnetic properties will be tested in new magnets.	**P4**	**3**
T3.3	In this task, the suitability of surface labelling based on data matrix code systems (DMC, bar or QR code) will be investigated, taking into account also different application methods (e.g printing, dotting, laser engraving), which will be compared with respect to their effect on the coating of the magnet. Additionally, a more advanced fluorescence marking system (Smartwater) will be investigated: This traceable liquid leaves a long lasting and unique identifier, whose presence is visible under a UV reader.	**P4**	**3**
T3.4	To ensure that the eco-labelling will survive the harsh conditions of the real world, in this task the readability of the selected eco-labelling methods will be tested on EOL magnets. This will be simulated with artificial ageing of labelled magnets, using e.g. scratch tests, environment chamber tests, chemical resistant tests.	P1, P2, P3, **P4**	1, 1, 1, **4**
WP4	**Objectives:** • To define the different coatings used on the market • To find appropriate coating removal methods for different kinds of coatings • To supply information for the classification system • To provide new ideas for easily removable coatings • To provide data for the classification system **Description:** AR/TRL start 3 target 5 WP4 investigates methods to remove corrosion protection coatings from magnets before and during HPMS treatment, and separation from HPMS-recycled powders on an industrial scale. Existing lab methods will be evaluated for feasible upscaling and, where necessary, new methods developed to ensure minimum contamination of recycled powders. Identified methods will remove corrosion protection layers of EOLM classified in WP3 per the new grading system, providing starting material for the trials in WP5.	P1, P2, P3, P4	4, 1, 1, 4
T4.1	Coatings of different magnets provided by recycling companies, Magneti, OBE and other magnets manufacturers will be analysed. With the use of optical and a scanning electron microscope and other techniques, the parameters for appropriate coating removal techniques will be determined (chemistry, layer structure and thickness etc.) Other parameters may be identified during this analysis and added to the list.	P1, **P4**	1, **2**
T4.2	Existing lab methods will be evaluated for feasible upscaling. The usual mechanical coating/residue removal which is already in use by Magneti will be compared to other techniques, like dissolving in acids and reverse galvanization. Additionally, the use of ionic liquids, which are very selective and environmentally less problematic than acids, will be investigated and evaluated under economic and environmental conditions for industrial upscaling. HPMS treated magnets will also be investigated for residues. Findings from coating removals will be added to the classification system in WP3, helping to select future environmentally and recycling friendly coatings.	**P1**, P2, P4	**1**, 1, 1
T4.3	To define the maximum allowance of coating residue in recycled materials, compositions of de-coated magnets and HPMS magnets will be screened for coating residues with SEM/XRD/mass spectroscopy. The magnetic properties of the recycled magnets from these powders will then be compared with those of initial EOLM, helping to define a threshold for coating residue for different recycling classes defined in WP3.	**P1**, P4	**1**, 1
T4.4	This task will research the possibilities of applying new coating techniques to magnets and their possible benefits on magnet recycling (including upscaling potential). Two coatings will be investigated: a self-healing coating, which would extend the life of magnets, and a polymer based coating, which is mechanically resistant, but easily removal by a non-toxic solvent.	**P1**, P3	**1**, 1

WP/Task No.	WP Objectives + Description / Task Description	Partner (**strong** = Teamleader)	Person Month(s) (**strong** = Teamleader)
WP5	**Objectives:** • To produce HPMS-recycled powders out of EOL magnets • To enhance the HPMS recycled powders with various methods • To use state of the art production processes for enhanced magnetic properties • To provide data for the classification system **Description:** AR/TRL start 3 target 5 WP5 researches the upgrading of HPMS-recycled powders. This includes reduction of particle size by sieving/milling, addition of Nd via casted master alloys/powder blending, removal of oxidised Nd-rich phase, blending with new NdFeB type material in various ratios, and increase of Dy-content via casted master alloys, powder blending or via grain boundary diffusion for powders of different contamination levels per the grading system. The focus is on contamination-free processes, especially with respect to oxidation and corrosion. Effects of upgrading on properties of recycled magnets in sintering, and polymer-bonding SDS processing will be evaluated. For different contamination levels, the most suitable methods will be identified.	P1, P2, P3, P4	2, 8, 7, 6
T5.1	In this task, different HPMS recycled feedstocks for magnet production will be prepared. Special focus is given to the state of oxidation, as oxidised Nd does not contribute to liquid phase sintering, resulting in poor magnetic properties. Where the EOL magnets exhibit high oxygen levels, enhancements to the HPMS powder have to be made by increasing the Nd-content via blending with new NdFeB type material, or increasing HRE content by adding e.g. Nd-Hydride or via casted master alloys. Different means of feedstock improvement will be investigated and compared for effectiveness, and findings will be added to the classification system in WP2.	**P2**, P3, P4	**5**, 1, 2
T5.2	This task will produce NdFeB magnets of the 5.1 feedstocks via conventional press sintering, polymer bonding and SDS processing. For the different feedstocks, focus will be on defining optimized processing parameters for all investigated processes; e.g. injection rates, heating ramps temperatures, pressures, and sintering times, as well as necessary protective gas atmospheres.	P2, **P3**, P4	3, **6**, 3
T5.3	With spark plasma sintering (where a pulsed DC current passes directly through a graphite mold and resistive heating plays a dominant role in the densification of powder compacts), near theoretical density can be achieved at lower sintering temperatures compared to conventional sintering techniques in 5.2. In this task, the suitability of spark plasma sintering for the production of HPMS recycled powders will be investigated and the results compared with those of 5.2.	**P1**, P4	**2**, 1
WP6	**Objectives:** • To support and guide the design of the labelling and recycling route from environmental and economic perspectives. • To consider the environmental perspective by conducting a Life Cycle Assessment (LCA). • To directly compare the new recycling method to the state-of-the-art by considering polluting emissions, and resource use and energy consumption per kg of magnetic material. • To consider the economic perspective, a Life Cycle Cost (LCC) model will be developed to compare the costs of the new approach across the whole life cycle. **Description:** AR To foster the sustainable supply, processing, production, and consumption of primary and secondary raw materials in a circular economy, the potential impact of processes developed in WP4 and WP5 on the efficient supply, processing and use of raw materials will be quantified. Scenarios for industrial upscaling will be elaborated, including a thorough life cycle assessment compared to the LCA for primary production of NdFeB from mined sources of materials to clearly demonstrate the environmental benefits of the developed technologies. TEA will be performed and used to guide the most promising reprocessing routes in the project, with respect to performance and costs. In this context, the creation of by-products and waste, and their exiting/entering the circular system will be considered.	P2, P3, P4, P5	1, 1, 2, 13

WP/Task No.	WP Objectives + Description / Task Description	Partner (**strong** = Teamleader)	Person Month(s) (**strong** = Teamleader)
T6.1	Based on the comprehensive data already available from the FP7/HORIZON2020 projects “REMANENCE” (GA 310240), “REProMag” (GA 636881) and “ROMEO” (GA309729), an updated literature review of the environmental impact of RE magnets and recycling options, including the environmental impact of conventional coating removal methods for polymer bonded and sintered magnets, will help finetuning the project tasks and potential recycling options whilst also helping to identify where MaXycle’s LCA will sit within the existing literature. The approach will allow the identification of parameters that will be useful for the development of the LCA in Task 6.2.	**P5**	**3**
T6.2	By conducting an LCA, this task will focus on the assessment of the environmental impact of the suggested routes defined within the project compared to conventional methods. The task will focus on the labelling system and coating removal and upgrading routes for recycled magnets, that may be conducted towards the end of the project to utilise parameter measurements from produced magnets. However, state-of-the-art LCA will be developed earlier in the project to ensure that the workload is shared evenly across the whole timescale of the project.	P2, P4, **P5**	1, 1, **4**
T6.3	In order to consider the labelling system and the coating removal and upgrading routes for recycled magnets from a business perspective, the economic impact of the new approachs need to be considered with the help of a Life Cycle Cost approach, which takes into account the total cost of acquiring, owning, using, and disposing of the production line.	P3, **P5**	1, **4**
T6.4	The health and safety implications will be considered by investigating any potential safety considerations needed for working with RE magnets/powders, including all hazardous chemicals and substances. As basis for this assessment, respective data sheets will be collected from partners. The resulting report will establish guidelines for a controlled, safe working environment for the recycling and production of RE magnets according to the suggested methods.	P4, **P5**	1, **2**
WP7	**Objectives:** • Raising awareness of MaXycle’s aims and to give visibility to the project’s activities, progress, results, and benefits • To achieve the early and wide up-take of project results, resulting in a standardised, world-wide accepted grading and labelling system and an effective exploitation of the commercial and non-commercial project results • To manage and protect the consortium’s IPR in order to minimise the risk of patent, trademark, and IPR infringement **Description:** OTH This work package is dedicated to communication and exploitation of project results and achievements to identified target audiences to maximise active involvement and impact. In this context, the draft communication plan (CP) for promoting the project and its results includes an efficient and effective mix of both interpersonal and mass communication tools. The project will develop an Exploitation plan (EP) which will include team requirements, market analysis, product concept development materials, exploitation strategy (including IPR and standardisation issues) and actionable capitalisation strategy and financial models for sustainability of exploitation efforts. The EP will cover in detail analyses and potential cooperation with end-users, mediators, networks, competitors, suppliers, state regulators and policy makers and implementers. PM could not be devided appropriate because of the limitation of the online system.	P1, P2, P3, P4, P5	2, 1, 2, 2, 1
T7.1	Provision of information for target groups about project achievements through printed and digital materials. An appealing project corporate identity will be developed to promote the project, its results and its innovations on all internal and external documents. • A dedicated website will be developed and updated for for a minimum of two years after the project ends to providing information about the project for the different target groups. • At least 4 press releases to promote the project’s achievements will be published in different online and printed magazines and journals. • Three public electronic newsletters documenting project progress will be distributed amongst networks and platforms associated to eco-innovation and green-production. • Stakeholder communication activities including in-person visits. • Publishing of papers in top journals and conferences, and provision of open access. • Public outreach activities including visits to science fairs and local schools, placement of materials with the general science press, and production of a short (4 minute) public understanding video.	**P1**, P3, P5	**1**, 1, 1

WP/Task No.	WP Objectives + Description / Task Description	Partner (**strong** = Teamleader)	Person Month(s) (**strong** = Teamleader)
T7.2	Materials for training (pictures, presentations, tools) will be provided, targeting professionals and potential end-users specifically at the technical and commercial levels. Materials will be used for communication with key stakeholders in industry, trade groups and working groups, standard groups, environmental awareness groups and policy makers in Europe, and the U.S. and Asia. The task will raise awareness of the real costs of magnets and the rarity of the materials involved, introduce the development of the Eco-labelling system and classification system, describe it benefits and technical aspects in detail, and promote its fast implementation. The consortium will organise at least two training workshops (e.g. on the World Resources Forum and the European Raw Materials Week) to promote the grading and labelling system and other project results. It will publish at least four open access scientific/industrial publications in international peer-review journals and give five or more presentations of the project's achievements at relevant international fairs and conferences (e.g. Intermag, REPM workshop ...).	**P1**, P2	**1**, 1
T7.3	Technology and market watch activities will be performed by the means of IPR surveys and trademark research in specialised databases (Esp@cenet, WIPO...) to identify relevant patents or technologies and trademark infringements as well as their influence on project developments. A continuous technology watch on the state of the art and emergence of new scientific breakthroughs, industrial developments or new projects in the field will be carried out over the whole project period.	**P3**	**1**
T7.4	Two IPR exploitation workshops will be held during the partner meetings to identify exploitation strategies of project results e.g. direct exploitation by the project consortium or through technology transfer; indirect exploitation opportunities by disseminating and training and knowledge transfer, delivering important input for the exploitation plan in task 7.5	**P4**	**1**
T7.5	An initial draft exploitation plan will be prepared within M7, describing targeted exploitation activities as well as general exploitation strategy. It will entail an exploitation roadmap as well as a list of relevant stakeholders and networks/projects to be approached and will be updated every six months, compiling business models and business development strategies, including related IPR and standardisation strategies.	**P4**	**1**

Table of Milestones

Milestone No.	Month	Milestone Title + Description
M1.1	1	**Title:** Kick-Off Meeting **Description:** meeting
M1.2	19	**Title:** Mid-Term Project Review Meeting **Description:** Planned tasks successfully completed, progress according to gantt chart.
M1.3	36	**Title:** Project closure/final meeting **Description:** Planned tasks (WP 1-7) successfully completed.
M2.1	33	**Title:** Development of a classification system **Description:** Development of a classification system to access the data gathered in this project and to make it available to all interested parties with easy interfaces and search features.

Milestone No.	Month	Milestone Title + Description
M3.1	25	**Title:** Selection of a suitable labelling system **Description:** Selection of a suitable eco-labelling system for hard magnetic materials
M4.1	34	**Title:** Suitable coating removal technique **Description:** Establishment of suitable coating removals and recommendations for future use of eco-friendly coatings.
M5.1	34	**Title:** Optimised processing parameters **Description:** Optimised processing parameters for HPMS recyclates when used in polymer bonding, press-sintering, SDS processing and spark plasma sintering.
M6.1	34	**Title:** LCA/LCC completed **Description:** LCA/LCC completed
M6.2	36	**Title:** Health & Safety Report completed **Description:** Health & Safety Report completed
M7.1	25	**Title:** Final Exploitation plan **Description:** Delivering the exploitation plan for the project.
M7.2	28	**Title:** Workshop on Grading and Labelling System **Description:** First Workshop on Grading and Labelling System is being held.

Table of Deliverables

Deliverable No.	Month	Deliverable Title + Description
D1.1	2	**Title:** Set up of intranet and data repository **Description:** Set up of intranet and data repository

Deliverable No.	Month	Deliverable Title + Description
D1.2	2	**Title:** Set up of project management tool **Description:** Set up of project management tool
D1.3	7	**Title:** 6-months interim progress report **Description:** 6-months interim progress report.
D1.4	13	**Title:** 12-months progress report for the JCS **Description:** 12-month scientific and administrative report for the JCS.
D1.5	19	**Title:** Mid-term report **Description:** Mid-term report and presentations made by the coordinators at the mid-term Seminar with the participation of the CSC members and invited stakeholders.
D1.6	25	**Title:** 24-months progress report for the JCS **Description:** 24-month scientific and administrative report for the JCS.
D1.7	31	**Title:** 30-months interim progress report **Description:** 6-months interim progress report.
D1.8	36	**Title:** Final report **Description:** Submition of the final report.
D2.1	13	**Title:** Definition of classification data **Description:** Defining which data will be included in the classification system.
D2.2	25	**Title:** Recyclate grading chart **Description:** Producing a recyclate grading chart.

Deliverable No.	Month	Deliverable Title + Description
D2.3	33	**Title:** Classification system **Description:** Fully developed classification system for EOLM
D2.4	34	**Title:** Open access recyclate grading data base **Description:** Database available for public on the MaXycle website
D3.1	13	**Title:** Definition of data required **Description:** Deliver a data-set, translated in a code containing all required information for a labelling system for hard magnetic materials.
D3.2	20	**Title:** Report on labelling trials-subsurface **Description:** Submission of a report containing results for the suitability of the tested methods.
D3.3	21	**Title:** Report on labelling trials-surface **Description:** Submission of a report containing results for the suitability of the tested methods.
D3.4	25	**Title:** Report on life endurance trials **Description:** Submission of a report containing results of the life endurance trials.
D3.5	25	**Title:** Eco-labelling system **Description:** Report on the selected labelling system
D4.1	13	**Title:** Report on coating analysis **Description:** Delivery a comprehensive report about used coatings
D4.2	17	**Title:** Report on coating/residue removal **Description:** Compilation of a report of suitable techniques and recommendations for future use of eco-friendly coatings.

Deliverable No.	Month	Deliverable Title + Description
D4.3	20	**Title:** Report on analyses of coating residues **Description:** Delivery of a report about the maximum threshold for coating residues in HPMS powders.
D4.4	34	**Title:** Report on new coatings **Description:** Delivery of a report evaluating the possibilities for more eco-friendly magnet coatings.
D5.1	20	**Title:** Report on feedstock preparation **Description:** Compilation of a description of the suitable feedstock production for different recycling grades of HPMS powders for the respective production method.
D5.2	34	**Title:** Report on conventional/SDS production **Description:** Delivery of a report containing optimised processing parameters for the respective production methods.
D5.3	34	**Title:** Report on spark plasma sintering **Description:** Delivery of a report containing processing parameters for the spark plasma sintering production method.
D6.1	10	**Title:** LCA for conventional recycling **Description:** Benchmarking and report for conventional recycling and production
D6.2	34	**Title:** LCA for suggested recycling **Description:** Report for the proposed recycling and production method.
D6.3	34	**Title:** Life Cycle Cost report **Description:** Life Cycle Cost report
D6.4	36	**Title:** Health and safety report **Description:** Health and safety report

Deliverable No.	Month	Deliverable Title + Description
D7.1	4	**Title:** Communication Plan **Description:** Compilation of a report that describes the communication strategy and activities
D7.2	25	**Title:** Technology and knowledge transfer **Description:** Compilation of a report that describes the technology and knowledge transfer strategy and activities
D7.3	7	**Title:** Draft Exploitation Plan **Description:** Delivery of a plan that describes the targeted exploitation activities and strategy.
D7.4	25	**Title:** Final Exploitation Plan **Description:** Compilation of a comprehensive exploitation plan, defining the exploitation activities and strategies of the consortium members and the respective interactions, incl. IPR and standardisation strategies.
D7.5	36	**Title:** Final Communication/Exploitation plan **Description:** Delivery of a final plan for the exploitation of results and a summary of the project's communication activities

GANTT CHART

Name	Date	Duration	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Work package 1	Months 01 - 36	36 Months																																				
Task 1.1	Months 01 - 36	36 Months																																				
Task 1.2	Months 01 - 36	36 Months																																				
Task 1.3	Months 01 - 36	36 Months																																				
Task 1.4	Months 01 - 36	36 Months																																				
Milestone 1.1	Month 01	1 Month																																				
Milestone 1.2	Month 19	1 Month																																				
Milestone 1.3	Month 36	1 Month																																				
Deliverable 1.1	Month 02	1 Month																																				
Deliverable 1.2	Month 02	1 Month																																				
Deliverable 1.3	Month 07	1 Month																																				
Deliverable 1.4	Month 13	1 Month																																				
Deliverable 1.5	Month 19	1 Month																																				
Deliverable 1.6	Month 25	1 Month																																				
Deliverable 1.7	Month 31	1 Month																																				
Deliverable 1.8	Month 36	1 Month																																				
Work package 2	Months 01 - 34	34 Months																																				
Task 2.1	Months 01 - 12	12 Months																																				
Task 2.2	Months 08 - 19	12 Months																																				
Task 2.3	Months 13 - 24	12 Months																																				
Task 2.4	Months 16 - 32	17 Months																																				
Milestone 2.1	Month 33	1 Month																																				
Deliverable 2.1	Month 13	1 Month																																				
Deliverable 2.2	Month 25	1 Month																																				
Deliverable 2.3	Month 33	1 Month																																				

Deliverable 2.4	Month 34	1 Month
Work package 3	Months 01 - 25	25 Months
Task 3.1	Months 01 - 12	12 Months
Task 3.2	Months 08 - 19	12 Months
Task 3.3	Months 9 - 20	12 Months
Task 3.4	Months 13 - 24	12 Months
Milestone 3.1	Month 25	1 Month
Deliverable 3.1	Month 13	1 Month
Deliverable 3.2	Month 20	1 Month
Deliverable 3.3	Month 21	1 Month
Deliverable 3.4	Month 25	1 Month
Deliverable 3.5	Month 25	1 Month
Work package 4	Months 01 - 34	34 Months
Task 4.1	Months 01 - 12	12 Months
Task 4.2	Months 06 - 16	11 Months
Task 4.3	Months 07 - 19	13 Months
Task 4.4	Months 19 - 33	15 Months
Milestone 4.1	Month 34	1 Month
Deliverable 4.1	Month 13	1 Month
Deliverable 4.2	Month 17	1 Month
Deliverable 4.3	Month 20	1 Month
Deliverable 4.4	Month 34	1 Month
Work package 5	Months 07 - 34	28 Months
Task 5.1	Months 07 - 19	13 Months
Task 5.2	Months 9 - 33	25 Months
Task 5.3	Months 20 - 33	14 Months
Milestone 5.1	Month 34	1 Month
Deliverable 5.1	Month 20	1 Month
Deliverable 5.2	Month 34	1 Month

Deliverable 5.3	Month 34	1 Month
Work package 6	Months 01 - 36	36 Months
Task 6.1	Months 01 - 9	9 Months
Task 6.2	Months 06 - 33	28 Months
Task 6.3	Months 16 - 33	18 Months
Task 6.4	Months 26 - 36	11 Months
Milestone 6.1	Month 34	1 Month
Milestone 6.2	Month 36	1 Month
Deliverable 6.1	Month 10	1 Month
Deliverable 6.2	Month 34	1 Month
Deliverable 6.3	Month 34	1 Month
Deliverable 6.4	Month 36	1 Month
Work package 7	Months 01 - 36	36 Months
Task 7.1	Months 01 - 36	36 Months
Task 7.2	Months 04 - 33	30 Months
Task 7.3	Months 04 - 36	33 Months
Task 7.4	Months 13 - 36	24 Months
Task 7.5	Months 03 - 36	34 Months
Milestone 7.1	Month 25	1 Month
Milestone 7.2	Month 28	1 Month
Deliverable 7.1	Month 04	1 Month
Deliverable 7.2	Month 25	1 Month
Deliverable 7.3	Month 07	1 Month
Deliverable 7.4	Month 25	1 Month
Deliverable 7.5	Month 36	1 Month

MANAGEMENT

3.2.1. Structure and procedures

In order to ensure a management structure which provides full transparency and control of the entire project in terms of time, resources and cost monitoring, two management levels will be defined:

a)Coordination level

• ***The Steering Committee (SC)*** will decide high level management issues, as (i) all budget-related matters, (ii) acceptance/exclusion of partners, (iii) updating the work plan, (iv) alterations of the CA. It will comprise a senior management official from each partner and meet at least once every 6 months. SC will act as a board for review and assessment of the project implementation, being responsible for problem solving as the ultimate decision-making body of the consortium.

• ***The project coordinator (PC)*** will (i) co-ordinate, monitor the progress of all scientific and technological developments according to the work plan, (ii) direct all project modifications, (iii) execute the overall financial/administrative management, (iv) cover the legal, contractual and ethical management of the consortium, (v) communicate with the project responsibles on CSC/JCS/national level.

b)Operational level

• ***The Work Package leaders (WPL)*** will be in charge of coordination, monitoring and reporting of the respective WP and for coordination of the tasks with other WPs. They directly report to the PL, informing in case of unexpected outcomes or difficulties, contributing to a timely solution of the issue with help of the PC and the SC.

• ***The Task leaders (TL)*** provide successful implementation of the individual tasks.

3.2.2 Decision-making process and conflict resolution

The SC is the decision making authority for important issues related to budget changes, changes in the partner composition of the consortium, major changes in the work plan and legal and IP aspects. It decides with a $^{2}/_{3}$ majority of votes with one vote per partner present although unanimous decision will be sought. All other issues will be decided jointly by the project partners in general meetings. Further arrangements/responsibilities of different partners are defined in a CA. All disputes or differences which cannot be settled amicably will be resolved by mediation and finally settled by arbitration in Brussels under the rules of the International Chamber of Commerce.

3.2.3 Innovation and knowledge management

MaXycle will generate, share and use highly qualified knowledge, which will be collected, stored and transferred among the project partners as well as disseminated – after clarification of IPR – to external users. To foster an innovation friendly environment, (i) a secured electronic repository with all the documents will act as an internal knowledge pool, (ii) staff exchanges, mentoring schemes and visits will encourage the exchange experience on a personal bilateral level between its researchers and engineers, (iii) internal trainings to exchange knowledge will be organised. Thethis will be monitored by the SC.

3.2.4 Critical risks and risk mitigation measures

MaXycle is high risk high reward science, adopting research designs and methods not yet proven in application. As such the consortium is well aware that the project may face difficulties hindering the adequate implementation of foreseen activities. Thus, different strategies will be developed in parallel to ensure success if one path fails. In informal WP clusters, the partners will exchange daily information about WP progress via E-Mail and telephone, on a monthly basis via jour-fixe telcons and on a half year basis by attending project meetings. The project is organised into feedback loops promoting open and constant communication between different WPs and partners, with management being flexible and quick to respond to new results, developments and risks, and to maintain clear strategies to identify, protect, and exploit the results as they are generated. The table below provides an overview of main project risks and migitations.

Project risk	WP	Level of risk	Migitation
Loss of a project partner	WP1	LOW	The SC will make every effort to replace them or smoothly distribute the work other partners.
Lack of common consortium objectives	WP1	LOW	Objectives will be realigned if necessary through the SC.
Not enough data for a reliable classification system	WP2	MEDIUM	Obtain enough data from other magnet producers and recycling companies
Unsuitable labelling system	WP3	MEDIUM	Use of verified labelling system, labelling of devices
Poor coating removal with the new techniques	WP4	HIGH	Use coating removal techniques used till now.
New coatings for magnets	WP4	HIGH	Use of modified metallic coatings for easier removal and verified coatings.
Insufficient/poor quality feedstock	WP5	MEDIUM	Buy feedstock from other recycling company
Insufficient magnetic properties from SDS and SPS processes	WP5	HIGH	Use classical sintering techniques.
Insufficient data for reliable LCA and LCC simulation	WP6	MEDIUM	If the data supplied by the MaXycle work and the completed REMANENCE, ROMEO and REProMag projects will not be sufficient, more data will be collected.

Fig. 8: Risks and migitations

IMPLEMENTATION

The project research teams all have unique, but complementary, expertise in the areas necessary for the success of the project, forming a well-balanced consortium where all the partners will contribute and benefit. The consortium consists of partners from European academia, research institutes and industry, bringing together expertise in magnetic research, production and environment and economic impact. WP1 and WP7 will be equally distributed between partners, which could not be presented with PM in the WP, because of the limitations of the online system.

Jožef Stefan Institute (JSI) has many years of experience in the field of permanent magnets based on Rare-Earth and transition metals. It was involved in FP5, FP6, and FP7 European projects. JSI is fully equipped for the preparation and characterisation of all kinds of magnetic materials, being a member of Center for Electron Microscopy with the highly skilled experts in the field. JSI will be managing the project, develop coating removal techniques, SPS magnets, help with the classification system and do most of the microsturctural and magnetic analysis.

OBE Ohnmacht & Baumgärtner GmbH & Co. KG (OBE) is active in the areas of R&D, production of high precision metal components for a wide range of automotive, medical, aerospace and industrial applications. OBE has very well-equipped laboratories for performing work in metal injection moulding, 3D printing of green parts, mechanical and metallurgical analysis, equipment for characterisation of precision parts as well as a tool shop for injection moulding tools. As coordinator of the H2020 project REProMag, OBE has excellent expertise in the manufacturing of NdFeB type magnets via the SDS process. OBE will take over the task of press sintering, polymer bonding and SDS processing and help with test trials and analyses in other tasks.

The University of Applied Sciences Pforzheim (HSPF) is active in materials analyses and failure analyses of components for the precision industry, the development and characterisation of materials, coatings and manufacturing technologies and equipped with a state-of-the art metallographical lab, incl. SEM, XRD, optical microscopy, mechanical testing equipment and heat treatment facilities. A newly equipped lab for hydrogen processing is perfectly equipped for the HPMS of the scrap magnets and the investigation of different recyclate grades with a staff having 30+ years' experience in NdFeB-type materials. Additionally, it is well equipped with several laser machines for marking. HSPF will be the main task leader in WP2 and WP3 with help from other partners. Additionaly they will provide their expertise in other WP.

Magneti d.d. (MGI) is a manufacturer of Al-Ni-Co, Sm-Co and Nd-Fe-B permanent magnets. Magneti's products are used mostly in the automotive industry with customers like Continental, Bosch and Wabco. Magneti has a strong and well experienced research group making

continuous research and development on the material-quality as well as technology improvements. The company is also equipped with different measuring and analysing techniques; XRF, ICP-OS, Oxygen and Carbon content analysers, Particle size distribution analyser, FSSS, permagraphs, flux meters and 3D magnetic field mapper. Magnetis main taks will be providing the feedstock for the different production techniques. They will also help with their experies in other tasks.

IVL Swedish Environmental Research Institute (IVL) is an independent, non-profit organisation, owned by a foundation jointly established by the Swedish Government and Swedish industry. IVL works with applied research and contract assignments for an ecologically, economically, and socially sustainable growth within the business world and society at large. IVL has a broad and long experience of performing Life Cycle Assessments (LCA) on products and processes. IVL will be task leader in the LCA and LCC evaluation of the project, with the help of all other partners.

REFERENCE

[1] Kooroshy, J., Tiess, G., Tukker, A. and Walton, A.; Strengthening the European rare earths supply chain: Challenges and policy options, ERECON Final Report. https://ec.europa.eu/growth/sectors/raw-materials/specificinterest/erecon_en (2015)

[2] Shaw, S., Constantinides, S.; Permanent Magnets: the Demand for Rare Earths; 8th International Rare Earths Conference, Hong Kong (2012)

[3] Binnemans, K., et al.; Recycling of Rare Earths a Critical Review, Journal of Cleaner Production 51 p1-22. DOI: 10.1016/j.jclepro.2012.12.037 (2013)

[4] Schulze, R. and Buchert, M.; Estimates of global REE recycling potentials from NdFeB magnet material, Resources, Conservation and Recycling 113 p12-27. DOI: 10.1016/j.resconrec.2016.05.004 (2016)

[5] Sprecher, B., Kleijn, R., Kramer, G.J.; Recycling Potential of Neodymium: The Case of Computer Hard Disk Drives, Environmental Science and Technology 48 9506-9513. DOI: 10.1021/es501572z (2014)

[6] Sprecher, B., et. al; Life Cycle Inventory of the Production of Rare Earths and the Subsequent Production of NdFeB Rare Earth Permanent Magnets, Environmental Science and Technology 48(7) p3951-3958. DOI: 10.1021/es404596q (2014)

[7] Walton, A., Williams, A.J., Speight, J.D. and Harris, I.R.; US Patent No. US 13/169,839. “Magnet recycling” (Priority 2010, Application 2012, granted 2014) (2014)

[8] Walton, A., et al..; The Use of Hydrogen to Separate and Recycle Neodymium-Iron-Boron-type Magnets from Electronic Waste, Journal of Cleaner Production 104 p236-241. DOI: 10.1016/j.jclepro.2015.05.033 (2015)

[9] http://www.project-remanence.eu/

[10] http://www.repromag-project.eu/

[11] Herraiz, E., Bradshaw, A., Rowson, N.A., Onal, M.A.R., Franczak, A., Poenaru, I. and Walton, A.; Recycling of Nd-Fe-B magnets by hydrocyclone separation and re-sintering, Proceedings of the 24th International Workshop on Rare Earth Permanent Magnets and their Applications Darmstadt, Germany p498-503 (2016)

[12] Degri, M.J., The Processing and Characterisation of Recycled NdFeB-type Sintered Magnets, PhD thesis, The University of Birmingham (2014)

[13] Yang Y., Walton, A., Sheridan, R., Güth, K., Gauß, R., et al.; REE Recovery from End-of-Life NdFeB Permanent Magnet Scrap: A Critical Review, J. Sustain. Metall. 3:122-149 DOI 10.1007/s40831-016-0090-4 (2017)

[14] http://www.pannier.com/2d-data-matrix-codes/

[15] http://www.polysecure.eu/en/product-marker-solution/technology/

[16] Mann, V.S.J., et l.; Large scale production of sintered magnets from recycled hard disk drive scrap. Proceedings of the 24th International Workshop on Rare Earth Permanent Magnets and their Applications Darmstadt, Germany p564-569 (2016)

[17] Yu, N. J., Pan, M. X., Zhang, P.Y. and Ge, H.L., The Origin of Coercivity Enhancement of Sintered NdFeB Magnets Prepared by Dy Addition, Journal of Magnetics 18(3), p235-239 (2013)

[18] Choi, M., Cho, S., Song, Y., Kim, Y., Simultaneous enhancement in coercivity and remanence of Nd2Fe14B permanent magnet by grain boundary diffusion process using NdHx, Current Applied Physics 15(4) (2015)

[19] Burkhardt, C., Imgrund, P., Weber, O., Schlauf, T., Pischang, K., Gonzalez-Gutierrez, J., Kukla, C., Degri, M.J., Harris, I.R., Pickering, L. and Walton, A.; Metal Injection Moulding of NdFeB based on Recycled Powders, Proceedings of the 24th International Workshop on Rare Earth Permanent Magnets and their Applications Darmstadt, Germany p63-68 (2016)

PARTNER DATA

Partner 1 (Consortium Coordinator): Jozef Stefan Institute

FINANCE COMMENTS

Personnel	Project resources for the JSI team are mainly represented by 12 research months with costs of €63.720. JSI will include a senior scientist and two scientist.
Travel	6 Project meetings (7.200 €), 3 national conferences (1.500 €), 2 international conferences (2.400 €), 6 WP meetings (4.200 €)
Consumables / Equipment	Coating removal chemicals, High-purity argon, hydrogen, nitrogen; RE-Fe-B-type alloys, containing Dy; liquid nitrogen, filaments, thermocouples, milling balls, grinding materials, diamond paste, graphite paste, cutting wires, consumables for sintering and characterisation of produced and sintered magnets (total 33000€).
Subcontracts	
Other	

TASK(S)

• Work package leader WP1, WP4 and WP7
• management
• coating removal TRL 3-5
• SPS process TRL 3-5
• microstructural and magnetic characterization
Key personnel:
Spomenka Kobe
Benjamin Podmiljšak
Kristina Žagar Soderžnik

DECLARATION 2

In case of recommendation for funding, I hereby authorize the ERA-MIN Joint Call Secretariat to publish the information provided in the publishable abstract as well as the consortium partner organisations. I agree that the coordinator contact person details (name and e-mail address) will be published	yes

Partner 2: Magneti Ljubljana, d.d.

FINANCE COMMENTS

Personnel	Project resources for the Magneti team are mainly represented by 15 research months with costs of €35.400. Magneti will include a scientist.
Travel	6 Project meetings (7.200 €), 3 national conferences (1.500 €), 2 international conferences (2.400 €), 6 WP meetings (4.200 €)
Consumables / Equipment	NdFeB powder, Nd powder, lubricants, various gasses and material for microstructural preparation (11550€)
Subcontracts	
Other	

TASK(S)

• work package leader WP5
• feedstock development TRL 3-5
• feedstock enhancement TRL 3-5
• microstructural and magnetic characterization
Key personnel:
Irena Škulj

DECLARATION 2

In case of recommendation for funding, I hereby authorize the ERA-MIN Joint Call Secretariat to publish the information provided in the publishable abstract as well as the consortium partner organisations. I agree that the coordinator contact person details (name and e-mail address) will be published	yes

Partner 3: OBE Ohnmacht & Baumgärtner GmbH & Co. KG

FINANCE COMMENTS

Personnel	14,5 PM (8.300 Euro/PM) employing 2 R & D engineers
Travel	6 Project meetings (7.200 €), 3 national conferences (1.500 €), 2 international conferences (2.400 €), 6 WP meetings (4.200 €)
Consumables / Equipment	Injection mould adaption (20.000 €), powder and MIM feedstock (15.000 €), sintering furnace consumables, e.g. argon, nitrogen, hydrogen, tantalum plates (5.000 €), tools and spare parts for MIM production (5.000 €), workshop tools for mould adaption, e.g. electrodes for eroding (3.000 €)
Subcontracts	CT testing (3.000 €), IPR costs (2.500 €)
Other	

TASK(S)

• SDS process for different powder qualities TRL 4-6
• labelling trials (MDC) TRL 4-6
• Life endurance trials for marking system TRL 4-6
• development of test methods to classify powder grades TRL 4-6
• scenario development of upscaling the SDS process and labelling methods TRL 5-7
Key personnel:
• Oxana Weber

• Johannes Maurath

DECLARATION 2

In case of recommendation for funding, I hereby authorize the ERA-MIN Joint Call Secretariat to publish the information provided in the publishable abstract as well as the consortium partner organisations. I agree that the coordinator contact person details (name and e-mail address) will be published	yes

Partner 4: Pforzheim University of Applied Sciences

FINANCE COMMENTS

Personnel	40 PM (5.770 Euro/MM + 18,8% overhead 1084,76 Euro/PM), Employing a senior scientist and a PhD student.
Travel	6 Project meetings (7.200 €), 3 national conferences (1.500 €), 2 international conferences (2.400 €), 6 WP meetings (4.200 €)
Consumables / Equipment	Glove box (18.000 €), fume cupboard (12.000 €), lab debinding unit (8.000 €), Powder and MIM feedstock (10.000 €), sintering furnace consumables, e.g. argon, nitrogen, hydrogen, ceramic plates, tantalum plates (4.000 €), tools and spare parts for test equipment (3.000 €), sieves (5.000€), hydrogen storage equipment (2.000€).
Subcontracts	
Other	

TASK(S)

• Work package leader in WP2 and WP3
• development of a future Eco-labelling system for hard magnets TRL 4-6
• development of a classification system for recyclate grades of EOL NdFeB magnets TRL 4-6
• analysis of coating residue contents by various lab methods
• press sintering of magnets TRL 4-6
• microstructural analyses (Optical, SEM, EDX, WDX) carbon and oxygen content measurements
Key personnel:
• Carlo Burkhardt

DECLARATION 2

In case of recommendation for funding, I hereby authorize the ERA-MIN Joint Call Secretariat to publish the information provided in the publishable abstract as well as the consortium partner organisations. I agree that the coordinator contact person details (name and e-mail address) will be published	yes

Partner 5: IVL Swedish Environmental Research Institute

FINANCE COMMENTS

Personnel	14,5 PM (16.500 Euro/MM) which will include 2 project managers and a chemical engineer.
Travel	6 Project meetings (7.200 €), 2 national conferences (1.000 €), 2 international conferences (2.400 €), 4 WP meetings (2.800 €)
Consumables / Equipment	Software license (2000€)
Subcontracts	
Other	

TASK(S)

• Work package leader in WP6
• techno-economic assessment of the project
• create scenarios for industrial upscaling
Key personnel:
• Maria Wallenius Henriksson
• Mia Romare
• Christian Junestedt

DECLARATION 2

In case of recommendation for funding, I hereby authorize the ERA-MIN Joint Call Secretariat to publish the information provided in the publishable abstract as well as the consortium partner organisations. I agree that the coordinator contact person details (name and e-mail address) will be published	yes

FINANCES

Requested funding

Organisation name	Personnel	Travel	Consumables / Equipment	Subcontracts	Other	Requested Funding	Total Own Contribution	Total Costs
Jozef Stefan Institute	63720	15300	33000			134420	0	134420
Overhead	12740	3060	6600					
Magneti Ljubljana, d.d.	35400	15300	11550			74700	20750	95450
Overhead	7080	3060	2310					
OBE Ohnmacht & Baumgärtner GmbH & Co. KG	72210	9180	28800	3300		135528	69660	205188
Overhead	14442	1836	5760					
Pforzheim University of Applied Sciences	230800	15300	62000			365922	0	365922
Overhead	43390	2876	11556					
IVL Swedish Environmental Research Institute	240000	13400	2000			255400	0	255400
Overhead								
TOTAL	719782	79312	163576	3300	0	965970	90410	1056380

Own contribution

Organisation name	Personnel	Travel	Consumables / Equipment	Subcontracts	Other	Total Own Contribution
Jozef Stefan Institute						0
Magneti Ljubljana, d.d.	11800	5100	3850			20750
OBE Ohnmacht & Baumgärtner GmbH & Co. KG	48140	6120	13200	2200		69660
Pforzheim University of Applied Sciences						0
IVL Swedish Environmental Research Institute						0
TOTAL	59940	11220	17050	2200	0	90410

Institut "Jožef Stefan"

Curriculum Vitae

Key personnel:

Name: Spomenka
Surname: Kobe
Address: Jožef Stefan Institute
Jamova cesta 39
SI-1000 Ljubljana
Slovenia, Europe
Telephone: +38614773251
E-mail: spomenka.kobe@ijs.si

Prof. Dr. Spomenka Kobe is Scientific Advisor, Head of the Department for Nanostructured materials (http://nano.ijs.si) and a Member of the Scientific Council at the Jožef Stefan Institute (http://www.ijs.si). She is a professor at the International Postgraduate School "Jožef Stefan" (http://www.mps.si) where she is also a member of the Governing Board of the School. Prof. Spomenka Kobe is the Leader of the National Research Programme "Nanostructured Materials," until 2017 she was the Slovene director of The International Associated Laboratory "Push-Pull AlloyS And Complex CompoundS (PACS2): from bulk properties to surface functions" between CNRS, Nancy, France and Jožef Stefan Institute, Ljubljana, Slovenia (LIA PACS2). She initiated rare-earth magnet research activities in Slovenia and was the coordinator of the European project "Replacement and Original Magnet Engineering Option" - ROMEO (FP7-NMP). During her career she has been a principal investigator of many national and international projects. Prof. Kobe was the President of the Academic Society for Science and Engineering (SATENA) and in the year 2017, she became a Member of the Slovenian Academy of Engineering.

Prof. Kobe acts as the European Expert and Evaluator in the field of magnetism and magnetic materials. She is the recipient of two State Awards for Scientific Research and two Innovation Awards from industry for the successful transfer of technology. Her scientific work is documented in more than 160 refereed publications, seven chapters in a book and 30 invited talks at international conferences. Her applied research achievements include eight patents (4 EP), three innovations and five successful transfers of technology to the industrial production; in total 602 registered bibliographical units.

Job-related skills: processing of intermetallic alloys including Rare-Earth-Transition-Metals (RETM) Permanent Magnets, Hydrogen-storage materials, Quasicrystals, Magnetocaloric materials, Complex Metallic Alloys, Application of RETM permanent magnets in ecology, Effect of processing on microstructure and physical properties. Applied research has included the development and large-scale production of a large variety of magnetic materials, and in strong collaboration with industry; it has involved product development, quality control and troubleshooting at the factory-floor level.

Memberships: Slovenian Chemical society, Slovenian Material Society, MIDEM, European Ceramics Society, European Powder Metallurgy Association, Member of International Advisory Board of International Workshop on Rare-Earth Magnets and their Applications and International Symposium on Magnetic Anisotropy and Coercivity in Rare-Earth Transition Metal Alloys, Member of Magnetic Refrigeration Association, Member of TMS, and IEEE Magnetics.

Recent relevant publications:

- SODERŽNIK, Marko, KORENT, Matic, ŽAGAR, Kristina, KATTER, Matthias, ÜSTÜNER, Kaan, KOBE, Spomenka. High-coercivity Nd-Fe-B magnets obtained with the electrophoretic deposition of submicron TbF_3 followed by the grain-boundary diffusion process. *Acta materialia*, ISSN 1359-6454, 2016, vol. 115, pp. 278-284, doi: 10.1016/j.actamat.2016.06.003. [

- ŽAGAR, Kristina, KOCJAN, Andraž, KOBE, Spomenka. Magnetic and microstructural investigation of high-coercivity net-shape Nd-Fe-B-type magnets produced from spark-plasma-sintered melt-spun ribbons blended with DyF_3. *Journal of Magnetism and Magnetic Materials*, ISSN 0304-8853, 2016, vol. 403, pp. 90-96, doi: 10.1016/j.jmmm.2015.11.082.
- KELHAR, Luka, ZAVAŠNIK, Janez, MCGUINESS, Paul J., KOBE, Spomenka. The impact of processing parameters on the properties of Zn-bonded Nd-Fe-B magnet. *Journal of Magnetism and Magnetic Materials*, ISSN 0304-8853, 2016, vol. 419, pp. 171-175, doi: 10.1016/j.jmmm.2016.06.035.
- SAMARDŽIJA, Zoran, MCGUINESS, Paul J., SODERŽNIK, Marko, KOBE, Spomenka, SAGAWA, Masato. Microstructural and compositional characterization of terbium-doped Nd-Fe-B sintered magnets. *Materials characterization*, ISSN 1044-5803, 2012, vol. 67, no. 1, pp. 27-33, doi: 10.1016/j.matchar.2012.02.017.
- SODERŽNIK, Marko, ŽUŽEK ROŽMAN, Kristina, KOBE, Spomenka, MCGUINESS, Paul J. The grain-boundary diffusion process in Nd-Fe-B sintered magnets based on the electrophoretic deposition of DyF_3. *Intermetallics*, ISSN 0966-9795, 2012, vol. 23, str. 158-162, doi: 10.1016/j.intermet.2011.11.014.

Name: Benjamin
Surname: Podmiljšak
Address: Jožef Stefan Institute
Jamova cesta 39
SI-1000Ljubljana
Slovenia, Europe
Telephone: +38614773818
E-mail: benjamin.podmiljsak@ijs.si

Education and obtained academic degrees:

- 2004, B. Sc in Chemical Engineering, Univerza v Ljubljani, Slovenia, 2010,
- Ph.D. in Materials Science: MICROSTRUCTURAL INVESTIGATIONS OF RARE-EARTH TRANSITION-METAL-BASED MAGNETOCALORIC MATERIALS FOR NEAR-ROOM-TEMPERATURE APPLICATIONS, Jožef Stefan International Postgraduate School, Slovenia

Employment and professional appointments:

- 2004-2010, Technical advisor, Jožef Stefan Institute, Department for Nanostructured Materials, Ljubljana Slovenia
- 2010-2014 Research fellow, Institute Jožef Stefan, Department for Nanostructured Materials, Ljubljana Slovenia
- 2014- Researcher, Institute Jožef Stefan, Department for Nanostructured Materials, Ljubljana Slovenia
- 2010- Technical leader of K7 Laboratory, Institute Jožef Stefan, Department for Nanostructured Materials, Ljubljana Slovenia

Longer scientific visits:

- 2008-2009 Research associate in Leibnitz Institute for Solid State and Materials, Dresden, Germany (11 months)

Awards and prizes:

- 2005, Winning contribution of young scientists at the 13th Conference on Materials and Technologies, Portorož, Slovenia
- **2013, Exceptional scientific achievements,** Material Science, Slovenian Research Agency: Magnetic refrigeration, SAZU, 28.3. 2013

Other activities:

- 2008: Member of the local organizing committee for the Hot Nano Topics 2008, Portorož, Slovenia (May 2008)
- 2010: Member of the local organizing committee of the 21st Workshop on Rare-Earth Permanent Magnets and their Applications, Bled, Slovenia (August 2010).

Patents in Slovenia:

- *P-201000176:* Enhanced magnetocaloric material and its producing procedure; Authors: Podmiljšak Benjamin, McGuiness Paul J., Kobe Spomenka

Description of previous projects:

- 1.7.05-30.6.10: CMA: Complex metallic alloys, Description: Basic research project researching new complex metallic alloys on the basis of $Gd_5Si_2Ge_2Fe$ alloys.
- 1.3.08-28.2.11: Hy-nano-IM: Hydrogen-impermeable nano-material coatings for steels, Description: Producing hydrogen impermeable steel with TiAlN.
- 1.4.10-31.3.2014 Advanced materials and technologies for the future - Center of Excellence NAMASTE. Description: Developing a novel magnetocaloric material.

Current projects:

- 1.1.2015- REProMag (H2020): Resource Efficient Production of Magnets. Description: Development of a new manufacturing process for NdFeB magnets.

International Impact of Research Work:

A total of 22 publications in international scientific journals with 66 citations.
Additionally, he had over 30 presentations at international conferences.

Major research fields:

Synthesis and characterization of magnetocaloric materials (Gd(Si,Ge), La(Si,Fe) and amorphous alloys), synthesis and characterization NdFeB hard magnetic materials, magnetic measurements (VSM, permeameter), material synthesis (melt spinner, spark plasma sintering, arc melting)

Name: Kristina
Surname: Žagar
Address: Jožef Stefan Institute
Jamova cesta 39
SI-1000 Ljubljana
Slovenia, Europe
Telephone: +38614773898
E-mail: kristina.zagar@ijs.si

Education

2006 B.Sc. in Chemistry, Title: "Voltametric determination of bismuth based on self-assembled monolayers", Faculty of Chemistry and Chemical Technology, University of Ljubljana, Slovenia

2011 Ph.D. in Nanoscience and Nanotechnologies, Title: "Synthesis and characterization of perovskite nanostructures", Jožef Stefan International Postgraduate School, Ljubljana, Slovenia

Academic and research appointments

1999-2000 Internship (two months) at Blood Transfusion Centre of Slovenia (ZTM),

Ljubljana, Slovenia

2006-2011 Young research fellow, Department for Nanostructured Materials, Jožef Stefan Institute, Ljubljana, Slovenia

2011- Research fellow, Department for Nanostructured Materials, Jožef Stefan Institute, Ljubljana, Slovenia

Specializations

2008 IFW Dresden, Germany (one month)

2009 University of Cambridge, Department of Materials Science and Metallurgy, UK (one week)

2009 SuperSTEM Laboratory, Daresbury, UK (one month)

2010 SuperSTEM Laboratory, Daresbury, UK (one month)

2010 Catalonia Institute for Energy Research (IREC), Barcelona, Spain (one week)

2010 Ruđer Bosković Institute, Molecular Physics Laboratory , Zagreb, Croatia (one week)

Postdoctoral research March - August 2014

Vienna University of Technology (TUW), Institute of Solid State Physics, Advanced Magnetism Group, Vienna, Austria.

November 2014 - January 2015

Ernst Ruska-Centre (ER-C) for Microscopy and Spectroscopy with Electrons, Jülich, Germany in the frame of DAAD scholarship.

Awards

2007 Winner of the first prize among young researches at The 15th Conference on Materials and Technology, Portorož, Slovenia

2010 IFSM (International Federation of Societies for Microscopy) Scholarship award for IMC17 (International Microscopy Congres) held in Rio de Janeiro, Brazil

Invited lectures

2009 Title: "Template-assisted synthesis and characterization of perovskite nanostructures", Shanghai Institute of Ceramics, Shanghai, China (July, 2009)

2011 Title: "Synthesis and characterization of perovskite nanostructures", Croatian Microscopy Society, Zagreb, Croatia (July, 2011)

2012 Title: "Self-organized TiO_2 nanotube arrays : use in dye-sensitized solar cells", Sabanci University, Department of Materials Science and Engineering, Istanbul, Turkey (October, 2012)

2013 Title: »Anodic oxidation and coloring of alumina«, IMPOL, 9. Research simposium, Maribor, Slovenia (November 2013)

2013 Title: »Center for electron microscopy at the JSI - presentation«, 15. Slovenian meeting on application of physics, Bled, Slovenia (November 2013)

2015 Title: "Study of Dy diffusion in high-coercivity Nd–Fe–B-type magnets for electric- vehicle drive applications", 12th Multinational Congress on Microscopy, Eger, Hungary (August 2015)

Memberships in societies

- Member of the Slovene Society for Microscopy (SDM)
- Member of the European Microscopy Society (EMS)
- Member of the **International Federation of Societies for Microscopy (IFSM)**
- Member of the Academic Society for Science and Engineering (SATENA)

Other Activities

2007- Co-organiser of the visits at the Jožef Stefan Institute, Ljubljana, Slovenija (from October 2007)

2008 Member of the local organizing committee for the Hot Nano Topics 2008: incorporating SLONANO 2008 held in Portorož, Slovenia (May, 2008)

2009 Member of the local organizing committee for the Technology Transfer conference held in Ljubljana, Slovenia (October, 2009)

2009 Member of the local organizing committee for the Workshop on Quantitative HAADF-STEM imaging and EELS (AdSTEM2009) held in Piran, Slovenia (October, 2009)

2012 Member of the local organizing committee for the 6th Young Researchers Day 2012 held in Ljubljana, Slovenia (February, 2012)

2012- Secretary of the Slovene Society for Microscopy (SDM) (from December 2012-)

2013- Member of the local organizing committee of popular-science lectures "Science on the road, knowledge and ideas" is a series of popular-science lectures (from May 2013-)

2014 Member of the local organizing committee for the Workshop on Quantitative HAADF-STEM imaging and EELS (AdSTEM2014) held in Piran, Slovenia (October, 2014)

2015 Member of the local organizing committee of the 1st Slovene Microscopy Symposium held in Piran, Slovenia (May, 2014)

2017 Member of the local organizing committee of the 2st Slovene Microscopy Symposium held in Piran, Slovenia (May, 2017)

Major research fields

Synthesis and characterization of perovskite materials; template-assisted sol-gel electrophoretic deposition (EPD), synthesis of nanoporous alumina, titania and zirconia templates by electrochemical oxidation of Al and Ti metal foils. Synthesis of titania nanotubes for use in dye-sensitized solar cells (DSSC).

Analytical methods: scanning electron microscopy (SEM) and microanalysis (EDXS), conventional transmission electron microscopy (CTEM), analytical electron microscopy (AEM), high-resolution transmission electron microscopy (HRTEM), scanning transmission electron microscopy (STEM), HAADF-STEM imaging.

Dr. Irena Skulj, Magneti Ljubljana Ltd.

Role and Commitment

She is a head of Research and development including Rare-Earth research in Magneti Ljubljana. Magneti is a company with a strong and well experienced research group performing continuous research on quality of the materials, on processing routes and final designs of the products. In 1993 the company has established its own research group which is registered with Slovenian Research Agency (ARRS). The group works on the development of permanent metallic magnets. She has finished her BSc (2000) at the University of Ljubljana and PhD (2005) research in School of Metallurgy and Materials in Birmingham, UK both on NdFeB based magnetic materials. She has worked at Institute for Materials and Technologies in Ljubljana for 3.5 years as a researcher and gained experience. Since 2008, she works in Magneti Ljubljana. Employed by Magneti she is obtaining practical experience in production of REEs based magnets. She has also supervised PhD students working on NdFeB magnets prepared by sol-gel and BSc students researching the influence of microstructural changes on magnetic properties in NdFeB magnets. She has authored and co-authored several scientific papers in the field of REEs permanent magnets and her industrial port-folio includes the collaboration in many EU projects the recent dedicated to recycling of REEs in the field of REEs permanent magnets processing and economy. **In i-RHEME she participates with her expert knowledge in industrial permanent processing focusing on LCA analysis.**

Projects and Patents

- H2020-MSCA-ITN-2015_DEMETER, **Training Network for the Design and Recycling of Rare-Earth Permanent Magnet Motors and Generators in Hybrid and Full Electric Vehicles** [2015-present] http://etn-demeter.eu/
- ARRS L2 4099: Protected Permanent Magnets for Advanced High-Temperature Applications
- ARRS-Slovene national research agency ARRS L2-5486-0795: Biomedical shape memory alloys
- EU FP7 MC-ITN EREAN: European Rare Earth Magnet Recycling Network, http://erean.eu/
- FP7-MAG-DRIVE (JSI-Coordinators): New permanent magnets for electric-vehicle drive applications, with stronger, less expensive, and more corrosion-resistant magnets for smaller, more efficient and more reliable motors http://mag-drive-fp7.eu/
- EU FP7 REMANENCE: Rare Earth Magnet Recovery for Environmental and Resource Protection http://www.project-remanence.eu//
- EU FP7 NANOPYME: Nanocrystalline Permanent Magnets Based on Hybrid Metal-Ferrites, http://nanopyme-project.eu/ , improving the magnetic properties $(BH)_{max}$ of ferrite based permanent magnets.

Relevant Publications

The company is publishing through the external researchers working on different research projects. Some examples:

- D. Sojer, **I. Skulj**, S. Kobe et al., Protection of $Nd_2Fe_{14}B$-based melt-spun ribbons using nanoscale sol-gel derived films of SiO_2 and Al_2O_3, *Surface & Coatings Technology*, 232, 2013, 123-130.
- D. Sojer, **I. Skulj**, S. Kobe et al., Analysis of corrosion properties of melt spun Nd-Fe-B ribbons coated by alumina coatings, *Materiali in Technologije*, 47 (2), 2013, 223-228.
- M. Soderznik, et al., **I. Skulj**, A high-resolution field-emission-gun, scanning electron microscope investigation of anisotropic hydrogen decrepitation in Nd-Fe-B-based sintered magnets, *Journal of Applied Physics*, 107 (9), 2010, Article Number: 09A742.0.
- **I. Skulj,** H.E. Evans, I.R: HARRIS, Oxidation of NdFeB-type magnets modified with additions of Co, Dy, Zr and V. Journal of Materials Science, ISSN 0022-2461, 2008, vol. 43, no. 4, p. 1324-1333.
- **I. Skulj,** A.P. Douvalis, I.R. Harris, Characterisation of oxidation products of modified Nd-Fe-B type magnets. Journal of alloys and compounds, ISSN 0925-8388. [Print ed.], 2006, vol. 407, no. 1/2, p. 304-313.

RESUME

Personal Data

Surname, First Name:	Dr. Weber, Oxana	Nationality:	German
Date of Birth:	20/Sep/1980	Marital Status:	Married
Place of Birth :	Kisselewsk, Russia	E-mail:	oxana.weber@gmail.com

Education

Jul/2015 ↑ Jan/2015	PhD student at the department of Microsystems Engineering (IMTEK) at the Albert-Ludwigs-University Freiburg/ Germany, part-time continuing education; Subject of doctoral thesis: „Water-Soluble Binder Systems to Minimize Powder – Binder – Segregation Effects in Micro Powder Injection Moulding“; Degree: Dr. Sc (Eng) with the overall grade ”excellent”
Sep/2008 ↑ Oct/2003	Bavarian Julius-Maximilian University of Würzburg; Discipline: nanostructure technology with the main focuses on energy technology as well as nano- and optoelectronics; Subject of diploma thesis: „Structure and Densification of Thin Sol-Gel-Buffer Layers for Super Conductor Applications“; Degree: Dipl. Ing. (Univ) with the overall grade “excellent”
Jul/2003 ↑ Sep/2001	Bavaria College of Augsburg (national institute for obtaining higher education entrance qualifications); Degree: University-Entrance Diploma
Feb/2001 ↑ Sep/2000	Intensive German language course of the Otto Benecke Foundation e.V. at the VBA Nuremberg with the degree certification of the central German language examination
Jul/1999 ↑ Sep/1997	State University for Control Systems and Radio Communications of Tomsk/ Russia; Discipline: systems for automated designing
Aug/1997 ↑ Sep/1987	General School Nr.33 in Kisselewsk/ Russia; Degree: higher education entrance qualification with honours

Professional Experience

today ↑ Jul/2012	R & D engineer in the field of metal injection moulding at Ohnmacht & Baumgärtner GmbH & Co KG in Ispringen/ Germany
Jun/2012 ↑ Mar/2009	Research associate and project manager in the field of ceramic and metal injection moulding at the Karlsruhe Institute of Technology in Eggenstein-Leopoldshafen/ Germany
Feb/2009 ↑ Jul/2007	Graduate student and subsequently research associate in the fields physic and chemistry at Fraunhofer Institute for Silicate Research (ISC) in Würzburg/ Germany
Apr/2006 ↑ Feb/2006	Intern at the development department „New Businesses“ SMT - AG at Carl Zeiss SMT in Oberkochen/ Germany
Jul-Aug/2001 Jun-Aug/2000	Production assistant at Ulmer Zeitarbeit GmbH, Kempten/ Germany

Skills/ Interests

Languages	bilingual education in German and Russian technical English
EDV	MS-Office, Origin, EndNote, FiJi, Demand V3, format and design of Wikipedia pages
Hobbies	reading, good food, renovation of buildings, modern Korean culture

Gondelsheim, 2017-05-03

Johannes Maurath

Personal Details

Home: Buchtzigstrasse 52, 76275 Ettlingen, Germany
Mobile: +49 (0)157 78 79 3330
Office: OBE Ohnmacht & Baumgärtner GmbH & Co. KG, Turnstrasse 22, 75228 Ispringen, Germany
jMaurath@obe.de - Office: +49 (0) 7231 802-442

Work Experience

Mar 2017 – present **Research and development engineer:** OBE Ohnmacht & Baumgärtner GmbH & Co. KG (Ispringen Germany).

- Coordinating and executing research projects in the field of metal injection molding (MIM) and fused filament fabrication (FFF) of metal parts.
- Development of feedstocks for MIM processes.
- Assistance in coordination of process development for serial production of MIM parts.

Scientific Experience

Aug 2013 – Feb 2017 **Doctoral candidate:** Institute for Mechanical Process Engineering and Mechanics (KIT, Karlsruhe, Germany). Advisor: Prof. Dr. N. Willenbacher.

- Formulation of three-phase suspensions consisting of two immiscible fluid phases and one solid phase (so-called capillary suspensions) as precursors for highly porous sintered materials (used materials: ceramics, glasses, polymers).
- 3D printing of highly open-porous, hierarchically structured ceramics using capillary suspension based inks.
- Characterization of mechanical strength (compressive test, four point bending test, tensile test) and microstructure (mercury intrusion porosimetry, SEM image analysis) in porous bodies.
- Analysis and modelling of filtration behavior of capillary suspension based membranes.
- Rheology of capillary suspensions: Behavior in steady and oscillatory shear measurements.

Education

2013 **Diploma degree,** Karlsruhe Institute of Technology (KIT), Germany
Equivalent to Master of Science in Chemical Engineering,
Grade: 1.5 (approximate equivalent: A)

2007 **University-entrance diploma**, secondary school Bühl, Germany
Grade: 1.3 (approximate equivalent: A)

Languages

German:	Native language
English:	Excellent knowledge
French:	Basic knowledge

Interests and Activities

Swimming, running, rock climbing, travelling

Publications

1. Maurath,J.; Dittmann, J.; Schultz, N.; Willenbacher, N.; "Fabrication of Highly Porous Glass Filters using Capillary Suspension Processing", Separation and Purification Technology, 149 (2015) 470-478.

2. Dittmann, J.; Maurath, J.; Bitsch, B.; Willenbacher, N.; "Highly Porous Materials with Unique Mechanical Properties from Smart Capillary Suspensions", Advanced Materials, 28 (2016) 1689-1696.

3. Maurath, J.; Bitsch, B.; Schwegler, Y.; Willenbacher, N.; "Influence of Particle Shape on the Rheological Behavior of Three-phase Non-Brownian Suspensions", Colloids and Surfaces A: Physicochemical and Engineering Aspects 497 (2016) 316-326.

4. Schneider, M.; Maurath,J.; Fischer, S. B.; Weiß, M.; Willenbacher, N.; Koos, E.; "Suppressing Crack Formation in Particulate Systems by Utilizing Capillary Forces", ACS Applied Material Interfaces, 9 (2017) 11095-11105.

5. Maurath, J.; Willenbacher, N.; „3D Printing of Open-Porous Cellular Ceramics with High Specific Strength", submitted to Journal of the European Ceramic Society.

Pforzheim University

Prof. Dr. Carlo Burkhardt

Date of Birth: 15. December 1965

Nationality: German

Marital Status: Married;
One daughter, two sons

Address: Schönblickstr. 42
75331 Grunbach, Germany
Telephone: +49 7235 980256
Mobile: +49 162 2046 435
eMail: carlo.burkhardt@web.de

SCHOOL EDUCATION

1993-1996 *The University of Birmingham (GB), School of Metallurgy & Materials*

Ph.D. programme in Materials Science, funded by a Marie-Curie-Fellowship of the European Commission (Category 20)

Title: 'Production and Characterisation of HDDR Nd-Fe-B-Powders Based on Materials Produced by the Direct Reduction Process'

As part of the programme, I carried out research work and experiments at the Jozef-Stefan-Institute, Ljubljana (SLO) and the Max-Planck-Institut, Stuttgart (D)

1988-1992 *Hochschule Furtwangen (D), Fachbereich Maschinenbau*

BEng (hons) in Materials- and Surface Technology, first class degree

Winner of the ‚European Powder Metallurgy Thesis Competition 1994' (Masters Category) with the thesis 'Effect of heat treatments on dimensional changes in sintered parts'

I received a prize money of 1.000 ECUs (later named EURO) and I was allowed to present this work on the Powder Metallurgy World Congress 1994 in Paris and to publish the results in the Journal *Powder Metallurgy.*

1976-1985 *Theodor-Heuss Grammar School, Pforzheim (D)*

A-levels in Math, English, History, German, Physics and others

MANDATORY MILITARY SERVICE

1985-1986 *Air Force*

Ausbildungsregiment 3 in Roth (Basic Training) and Luftwaffen-unterstützungsgruppenkommando Süd Karlsruhe (Logistics Headquarter of the Air Force for Southern Germany); Last Grade: Private, First Class

PROFESSIONAL EXPERIENCE

Since 04/2017 *Professor for Materials & Manufacturing Technology, Head of the Institute for Materials (STI)*

- Reading materials science and manufacturing technology in Bachelor and Master courses
- R&D projects

2011-2017 *Managing Director of the OBE Ohnmacht & Baumgärtner GmbH & Co. KG, Ispringen (approx. 600 employees)*

- Responsible for technology-, market- and production strategy; including the responsibilities for budget and financial results
- Supervisor of the employees in R&D, project management, quality assurance and production

1997-2017 *Part-Time Lecturer at the University of Pforzheim*
(since 2008 Honorary Professor), School of Mechanical Engineering

2006-2011 *R&D Director Witzenmann GmbH, Pforzheim (approx. 3.000 employees)*

- Responsible for planning and coordination of the innovation process, development strategy and R&D budget,
- Supervisor of 55 Engineers and technicians in the departments Metal Forming, Welding, Joining and Materials Technology
- Head of the Material and Welding Labs
- Head of the Prototyping Department and the Technical Lab for Manufacturing Methods

2004-2006 *Head of Business Unit R&D Witzenmann GmbH, Pforzheim*

1998-2004 *Team Manager Product Development Automotive, Witzenmann GmbH, Pforzheim*

1996-1998 *Project Manager Product Development Automotive, Witzenmann GmbH, Pforzheim*

1992-1993 *Technical Sales Engineer, Witzenmann GmbH, Pforzheim*
Responsible for the French automotive market (customers: Renault, PSA etc.)

1986-1988 *Apprenticeship as a qualified bank clerk, Deutsche Bank AG, Pforzheim*

LANGUAGE SKILLS

English: fluent, Cambridge Certificate of Proficiency (European Language Level C2) Grade A
French: very good, 6 months internship at the Société Générale Alsacienne de Banque (one of the largest banks in France) in Thionville and Strasbourg (1989)

PERSONAL INFORMATION

Maria Wallenius Henriksson

Born 1963
PhD polymer chemistry: 1992
Title and position: Project manager and Materials and environmental expert, Environment and Chemistry
Affiliation: IVL Swedish Environmental Research Institute

Areas of expertise relevant for the proposed project

- More than 20 years of experience of performing Life Cycle Assessments on heavy duty trucks, hybrid drivelines, batteries as well as on polymer materials incl rubber materials, plastics, textiles and composites.
- Critical materials with focus on heavy-duty vehicles.
- Design for recycling with regard to polymer materials, especially composite materials

Relevant experiences

- Materials Engineering specialist at Volvo Group Trucks Technology, Gothenburg, Sweden with focus on environmental issues with regard to product development, product planning and purchasing
- LCA specialist at Volvo Group Trucks Technology, Gothenburg, Sweden with focus on methods and potential implementation in product development.
- PhD in polymer chemistry in 1992 at Chalmers University of Technology, Gothenburg, Sweden

Relevant EU-projects

EUROLIS contract 314515 (Oct 1, 20112- Sep 30, 2016)– Development of lithium sulphur batteries for automotive applications, Project manager for partner Volvo Technology AB's activities (LCA and safety aspects of batteries), www.eurolis.eu

- **THERMOMAG** Contract 263207 (May 1, 2011 – Oct 31, 2014) "Nanostructured energy- harvesting thermoelectrics based on Mg2Si". Performer of LCA on the thermoelectrics. http://cordis.europa.eu/project/rcn/98971_en.html
- **ELVA** contract 265898 (Dec 2010-May 2013) "Advanced Electric Vehicle Architectures". Project manager and performer of LCA for partner Volvo Technology AB. http://www.elva-project.eu/
- **EE-VERT** contract 218598 (Jan 1, 2009 – June 30, 2012) "Energy Efficient Vehicles for Road Transport". Performer of comparative LCA of current electric system in comparison to energy efficient system- http://www.ee-vert.net/
- **EURECOMP** contract 218609 (May 1, 2009 – July 1, 2012) "Recycling Thermoset Composites of the SST". Project manager and performer, for partner Volvo Technology, of Life Cycle Cost (LCC) of the recycling strategies incl using supercritical water as a solvent. http://cordis.europa.eu/result/rcn/54152_en.html

Examples of relevant publications

- Romare M., Wallenius Henriksson, M; (2016), D7.5 – Comparative study of Lithium sulphur cells for automotive applications incl safety aspects, Advanced European lithium sulphur cells for automotive applications (EUROLIS)
- Wallenius Henriksson, M.; (2012) D2.4.2 Comparative LCA of electrical systems for vehicles (EE-VERT)
- Wallenius Henriksson, M.; (2012) D4 Screening of Life Cycle Cost (EURECOMP)
- Wallenius Henriksson, M.; (2012) Screening of environmental impact of semiconductor materials for RENOTER project (phase 2 THERMOMAG)

Curriculum vitae for: Mia Romare

Born: 1988, **MSc:** 2013
Title and position: Project manager, Environment and Chemistry
Affiliation: IVL Swedish Environmental Research Institute

Areas of expertise relevant for the proposed programme

- Life cycle assessment of heavy duty vehicles, batteries and drivelines (conventional and electrified).
- Critical materials expert with specific focus on critical materials for heavy duty vehicles.

Relevant experiences

- Environmental engineer at Volvo group trucks technology, Gothenburg, Sweden with focus on environmental assessments in product development and product planning.
- Experience from life cycle assessments and critical materials assessments on whole heavy duty vehicles, heavy duty battery concepts, as well as diesel and electric engines and drivelines.
- Master thesis focused on life cycle assessment of lithium ion battery materials, including production.
- Swedish energy agency and the Swedish Transport Administration project focused on reviewing life cycle assessments for light duty vehicle lithium ion batteries. Focus on mining, material processing and manufacturing.

Examples of relevant publications

- Lisbeth Dahllöf, Mia Romare. The Life Cycle Energy Consumption and Greenhouse Gas Emissions from Lithium-ion Batteries - A Study with Focus on Current Technology and Batteries for Light-duty Vehicles (IVL report Draft 2017)
- Life Cycle Assessment of Lithium-ion Batteries for Plug-in Hybrid Buses (2013), Master of Science thesis, Chalmers University of Technology
- Romare, M., Wallenius Henriksson, M., (2016), D7.5 - Comparative LCA study of Lithium sulphur cells for automotive applications incl safety aspects, Advanced European lithium sulphur cells for automotive applications (EuroLiS)
- Romare, M., (2014), AP 2: BatMan - förberedelser för förbättrad återanvändning av batterisystem, project report for Swedish energy agency

Curriculum Vitae

Personal information

First name(s) / Surname(s)	Christian Junestedt
Born	1969
Affiliation	IVL Swedish Environmental Research Institute, Stockholm, Sweden

Occupational field

Environmental Technology, LCA, Waste water treatment

Relevant work experience

IVL Swedish Environmental Research Institute, Stockholm

Project leading, LCA, wastewater treatment, Clean tech, waste expertise, landfill, leachates, storm water chemicals

2017- ongoing Techno economic assessment of a technology used for recycling of rare earth element from apatite

2015 -ongoing Project leading and LCA expert – "Eco-UV project" LCA of conventional and newly developed UV technologies for water treatment

2015 - ongoing Project leading and LCA expert – LCA comparison of newly developed hydrometallurgic leaching routes aiming at recycling rare earth elements from HEV NiMH batteries

2014 -2016 LCA expert - "E4Water project" – Implementation new treatment technologies in the European chemical industries with the purpose to save water

Publications (peer-reviewed)

Innovative and Integrated Technologies for the Treatment of Industrial Wastewater, Antonio Lopez, Claudi Di Iaconi, Giuseppe Mascolo and Alfieri Pollice, 2011. Published as an IWA research report on 15 Dec 20 Christian Junestedt is a co-author of chapter 4 in the report.

Öman. C. and Junestedt. C. (2008) Chemical characterization of landfill leachates – 400 parameters and compounds. Waste Management 28 (2008) 1876-1891.

Svensson. A, Allard. A-S, Junestedt. C, Cerne, O and Ek. M. (2004) Assessment of androgenicity in Leachates from Swedish landfills and treatments for its elimination. Journal of Environmental science and health. Vol A39, Nos 11-12, pp. 2817-2825, 2004.

Jožef Stefan Institute, Ljubljana, Slovenia
Jamova cesta 39 / 1000 Ljubljana / Phone: +386 1 477 3 900 / Fax: +386 1 477 3189
E-mail: info@ijs.si / Homepage: www.ijs.si

Statement of commitment

As the legal representative of the Organization Jozef stefan Institute/Slovenia I support the submission of the transnational proposal A novel circular economy for sustainable RE-based magnets/MaXycle to the **ERA-MIN Joint Call 2017 on Raw Materials for Sustainable Development and the Circular Economy**, providing the essential conditions for the implementation of the project, according to the work programme presented.

As Lead Researcher[1] prof. dr. Spomenka Kobe/Head of the Department for Nanostructured Materials, I am aware of the ERA-MIN Call Text, the procedures and the national/regional rules and regulations, and confirm that the proposal fulfils our national/regional eligibility criteria in order to be eligible for the ERA-MIN Joint Call 2017.

In addition, the national/regional contact point Doroteja Zlobec of the funding organisation MIZS – Ministrstvo za izobrazevanje, znanost in sport (Ministry for Education, Science and Sport) [2] have been contacted on the national/regional eligibility rules and funding regulations.

Place, Date

Ljubljana, 18 Sept. 2017

Prof. dr. Jadran Lenarčič, Director

(Name of the legal representative of the Organisation)

Prof. dr. Spomenka Kobe

(Name of the Lead Researcher)

Institut "Jožef Stefan" Ljubljana, Slovenija 13

(Signature of the legal representative of the Organisation)

(Signature of the Lead Researcher)

[1] Lead researcher: the main responsible person of a legal entity who is the contact point with the corresponding national/regional Funding Organisation.
[2] The names of the contact persons of the funding organisation are inidcated in Table 1 of the "Guidelines for Applicants".

MAGNETI
LJUBLJANA, d.d.
Ljubljana, Stegne 37

Statement of commitment

As the legal representative of the Organization MAGNETI Ljubljana d.d./Slovenia I support the submission of the transnational proposal A novel circular economy for sustainable RE-based magnets/MaXycle to the **ERA-MIN Joint Call 2017 on Raw Materials for Sustainable Development and the Circular Economy**, providing the essential conditions for the implementation of the project, according to the work programme presented.

As Lead Researcher[1] Irena Škulj/Head of R&D, I am aware of the ERA-MIN Call Text, the procedures and the national/regional rules and regulations, and confirm that the proposal fulfils our national/regional eligibility criteria in order to be eligible for the ERA-MIN Joint Call 2017.

In addition, the national/regional contact point Doroteja Zlobec of the funding organisation MIZS – Ministrstvo za izobraževanje, znanost in sport (Ministry for Education, Science and Sport) [2] have been contacted on the national/regional eligibility rules and funding regulations.

Place, Date

Ljubljana, 15th Sep 2017

Albert Erman	Irena Škulj
(Name of the legal representative of the Organisation)	*(Name of the Lead Researcher)*
(Signature of the legal representative of the Organisation)	*(Signature of the Lead Researcher)*

[1] Lead researcher: the main responsible person of a legal entity who is the contact point with the corresponding national/regional Funding Organisation.
[2] The names of the contact persons of the funding organisation are inidcated in Table 1 of the "Guidelines for Applicants".

Statement of commitment

As the legal representative of the Organization OBE Ohnmacht & Baumgärtner GmbH & Co. KG, Ispringen, I support the submission of the transnational proposal MaXycle/A novel circular economy for sustainable RE-based magnets to the **ERA-MIN Joint Call 2017 on Raw Materials for Sustainable Development and the Circular Economy**, providing the essential conditions for the implementation of the project, according to the work programme presented.

As Lead Researcher Dr. Oxana Weber, of the Department MIM Entwicklung, I am aware of the ERA-MIN Call Text, the procedures and the national/regional rules and regulations, and confirm that the proposal fulfils our national/regional eligibility criteria in order to be eligible for the ERA-MIN Joint Call 2017.

In addition, the national/regional contact point Dr. Ing Holger Grünewald of the funding organisation PtJ (Project Management Jülich) has been contacted on the national/regional eligibility rules and funding regulations.

Place, Date

Ispringen, 18.09.2017

Peter Specht

(Name of the legal representative of the Organisation)

Dr. O. Weber

(Name of the Lead Researcher)

(Signature of the legal representative of the Organisation)

(Signature of the Lead Researcher)

HOCHSCHULE PFORZHEIM

Statement of commitment

As the legal representative of the Organization Pforzheim University, I support the submission of the transnational proposal MaXycle/A novel circular economy for sustainable RE-based magnets to the **ERA-MIN Joint Call 2017 on Raw Materials for Sustainable Development and the Circular Economy**, providing the essential conditions for the implementation of the project, according to the work programme presented.

As Lead Researcher Prof. Dr. Carlo Burkhardt, of the Department STI, Institute for Materials and Manufacturing Technology, I am aware of the ERA-MIN Call Text, the procedures and the national/regional rules and regulations, and confirm that the proposal fulfils our national/regional eligibility criteria in order to be eligible for the ERA-MIN Joint Call 2017.

In addition, the national/regional contact point Dr. Ing Holger Grünewald of the funding organisation PtJ (Project Management Jülich) has been contacted on the national/regional eligibility rules and funding regulations.

Place, Date

Pforzheim 15.09.2017

Prof. Dr. Ulrich Jautz

(Name of the legal representative of the Organisation)

Prof. Dr. Carlo Burkhardt

(Name of the Lead Researcher)

(Signature of the legal representative of the Organisation)

(Signature of the Lead Researcher)

ivl SVENSKA MILJÖINSTITUTET

Statement of commitment

As the legal representative of the Organization *IVL Swedish Environmental Research Institute/Sweden.* I support the submission of the transnational proposal A novel circular economy for sustainable RE-based magnets/MaXycle to the **ERA-MIN Joint Call 2017 on Raw Materials for Sustainable Development and the Circular Economy,** providing the essential conditions for the implementation of the project, according to the work programme presented.

As Lead Researcher[1] *Dr Maria Wallenius Henriksson/Project Manager and Materials and Environmental expert,* of the Department *Chemical & Environment (5070),* I am aware of the ERA-MIN Call Text, the procedures and the national/regional rules and regulations, and confirm that the proposal fulfils our national/regional eligibility criteria in order to be eligible for the ERA-MIN Joint Call 2017.

In addition, the national/regional contact point Susanne Gylesjö of the funding organisation VINNOVA have been contacted on the national/regional eligibility rules and funding regulations.

Göteborg, September 18, 2017

Tord Svedberg

Maria Wallenius Henriksson

(Signature of the legal representative of the Organisation)

(Signature of the Lead Researcher)

[1] Lead researcher: the main responsible person of a legal entity who is the contact point with the corresponding national/regional Funding Organisation.

School of Metallurgy and Materials
University of Birmingham
Edgbaston
Birmingham
B15 2TT
0121 414 5195

Letter of Intent

As the legal representative of the Birmingham Centre for Strategic Elements & Critical Materials at the University of Birmingham, United Kingdom, I support the submission of the transnational proposal MaXycle / A novel circular economy for sustainable RE-based magnets to the **ERA-MIN Joint Call 2017 on Raw Materials for Sustainable Development and the Circular Economy**. I state that the financial support is guaranteed to the Organisation Birmingham Centre for Strategic Elements & Critical Materials at the University of Birmingham, United Kingdom to participate as an associated partner,

- to participate in steering committee meetings
- to give advice and consulting on recycling procedures, the HPMS process and the development and implementation of the labelling and grading system
- to assist with the provision of recycling materials and
- to provide general support of the overall project aims, e.g. with the provision of LCA input data

The Lead researcher in charge is Dr. Allan Walton and is head of the Magnetic Materials Group at the University of Birmingham.

Place, Date 22/09/2017

Allan Walton

(Name of the legal representative of the Organisation)

A. Walton

(Signature of the legal representative of the Organisation)

Allan Walton

(Name of the Lead researcher)

A. Walton

(Signature of the Lead researcher)

RockLink
Rare Metals Recycling

Letter of Intent

As the legal representative of the Organisation Rocklink GmbH Germany, I support the submission of the transnational proposal MaXycle / A novel circular economy for sustainable RE-based magnets to the **ERA-MIN Joint Call 2017 on Raw Materials for Sustainable Development and the Circular Economy**. I state that the financial support is guaranteed to the Organisation Rocklink GmbH, Germany to participate as an associated partner,

- to participate in steering committee meetings
- to give advice and consulting on recycling procedures, and the development and implementation of the labelling and grading system
- to assist with the provision of recycling materials and
- to provide general support of the overall project aims, e.g. with the provision of LCA input data

The Lead researcher in charge is Mr. Leonard Ansorge and is part of the Department Executive Management.

Place, Date
Düsseldorf / 22/09/2022

ROCKLINK GMBH
DÜSSELDORF
GERMANY

ANSORGE, LEONARD

(Name of the legal representative of the Organisation)

(Name of the Lead researcher)

(Signature of the legal representative of the Organisation)

(Signature of the Lead researcher

Ethics issues table (to be uploaded as Annex 1 of full-proposal)

Full-Proposal includes H2020 "Ethics issues table" that must be filled in with yes/no.

Applicants should always describe any relevant ethical aspects in their research plans. If a research permit or a statement by an ethics committee is required for the implementation of the project, applicants shall provide information on the permits or permit proposals.

In case ethical issues apply (applicants mark respective issues in the table)

ERA-MIN 2 recommends that the national/regional organisations observe these issues (e.g. post-evaluation review) for their respective funded projects.

ETHICS ISSUES	**YES/No**	**Proposal section nº**
1.HUMAN EMBRYOS/FOETUSES		
Does your research involve Human Embryonic Stem Cells (hESCs)?	No	
Does your research involve the use of human embryos?	No	
Does your research involve the use of human foetal tissues / cells?	No	
2.HUMANS		
Does your research involve human participants?	No	
Does your research involve physical interventions on the study participants?	No	
Does it involve invasive techniques?	No	
3.HUMAN CELLS / TISSUES		
Does your research involve human cells or tissues? If your research involves human embryos/foetuses, please also complete the section "Human Embryos/Foetuses" [Box 1].	No	
4.PROTECTION OF PERSONAL DATA		
Does your research involve personal data collection and/or processing?	No	
Does your research involve further processing of previously collected personal data (secondary use)?	No	
5.ANIMALS		
Does your research involve animals?	No	
6.NON-EU COUNTRIES		
Does your research involve non-EU countries?	No	

Co-funded by the Horizon 2020 programme of the European Union

ETHICS ISSUES	YES/No	Proposal section nº
Do you plan to use local resources (e.g. animal and/or human tissue samples, genetic material, live animals, human remains, materials of historical value, endangered fauna or flora samples, etc.)?	No	
Do you plan to import any material - including personal data - from non-EU countries into the EU? If you consider importing data, please also complete the section "Protection of Personal Data" [Box 4].	No	
Do you plan to export any material - including personal data -from the EU to non-EU countries? If you consider exporting data, please also complete the section "Protection of Personal Data" [Box 4].	No	
If your research involves low and/or lower middle income countries, are benefits-sharing measures foreseen?	No	
Could the situation in the country put the individuals taking part in the research at risk?	No	
7.ENVIRONMENT PROTECTION		
Does your research involve the use of elements that may cause harm to the environment, to animals or plants?	No	
Does your research deal with endangered fauna and/or flora and/or protected areas?	No	
Does your research involve the use of elements that may cause harm to humans, including research staff?	No	
8.DUAL USE		
Does your research have the potential for military applications?	No	
9.MISUSE		
Does your research have the potential for malevolent/criminal/terrorist abuse?	No	
10.OTHER ETHICS ISSUES		
Are there any other ethics issues that should be taken into consideration? Please specify	No	
I CONFIRM THAT NONE OF THE ABOVE ISSUES APPLY TO MY PROPOSAL	Yes	

Co-funded by the Horizon 2020 programme of the European Union