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Opportunities for reprocessing neodymium

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Contents

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About Us

Useful Simple Projects is a consultancy who specialise in the delivery of a sustainable built environment. We work with clients across the sector providing a wide range of traditional and innovative consultancy and design services.

This includes:

- Technical advice in relation to the sustainability agenda,
- Sustainable infrastructure and building design,
- Stakeholder engagement and community consultation strategies,
- Development of decision-making tools and processes; and,
- Engagement with supply chains to influence product development.

Useful Simple Projects is part of the Useful Simple Trust.

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The Useful Simple Projects team who worked on this project were Judith Sykes, Mark Shayler, Sophie Thomas, Dan Epstein, Jo Carris and Andy Carrera. Thank you also to Sam Marriott from Ticketey-Boo for additional research and to The Great Recovery for the use of materials to facilitate workshops.

Graphic design by thomasmatthews.com

1.0 Background

Resource security and price volatility is an increasing concern for global businesses. Many organisations now rank security of supply of raw materials as one of their most significant business risks. Whilst past fluctuations and shareholder value have driven resource efficiency through the global supply chain, some 90% of material still ends up in the waste stream within 6 months[1]. Through this fast moving linear process of extract, use and dispose, we are throwing away valuable materials including many at risk elements.

In 2012, the EU published its report on Critical Raw Materials in which it identified 14 elements it believes are at risk due to demand outstripping supply and geopolitical risk. The authors also called for policies to promote recycling and more research into recycling these 'technically challenging' products.

Neodymium is on this list as one of the rare earth elements. It is predominantly produced by China, with Russia and Brazil also having some production capacity[2]. The massive reliance on China as the main producer has recently caused a significant geopolitical supply risk. In 2011 China reduced the amount of rare earths exported by 40% in order to ensure processing occurred within its borders[3], the price consequences are illustrated in Figure 1.

The impact of this artificial restriction further serves to illustrate the risks of neodymium supply constriction and the need to use the material more efficiently. China has stock-piled the material to meet its own growth projections. Furthermore it wants to reap the additional value from exporting converted product rather than raw materials. The challenge is that due to price manipulation mines have closed and will only reopen when price stabilises. Hence China has a near monopoly despite owning only a third of world reserves.

Once extracted, neodymium is predominantly used in magnets that then find their way into hard disk drives (HDDs), automotive and renewable energy technologies. The magnets themselves will last 10,000 years and yet current methods of disposal mean they are lost to the waste stream. Given the increasing pace of consumption within the PC market, this value is not insignificant.

Useful Simple Projects have therefore been investigating potential for neodymium recovery particularly from hard disk drives. Through this feasibility study we worked with the supply chain to investigate the market opportunity for recovery and potential opportunities for holding onto the value of this material. This report sets out our findings.

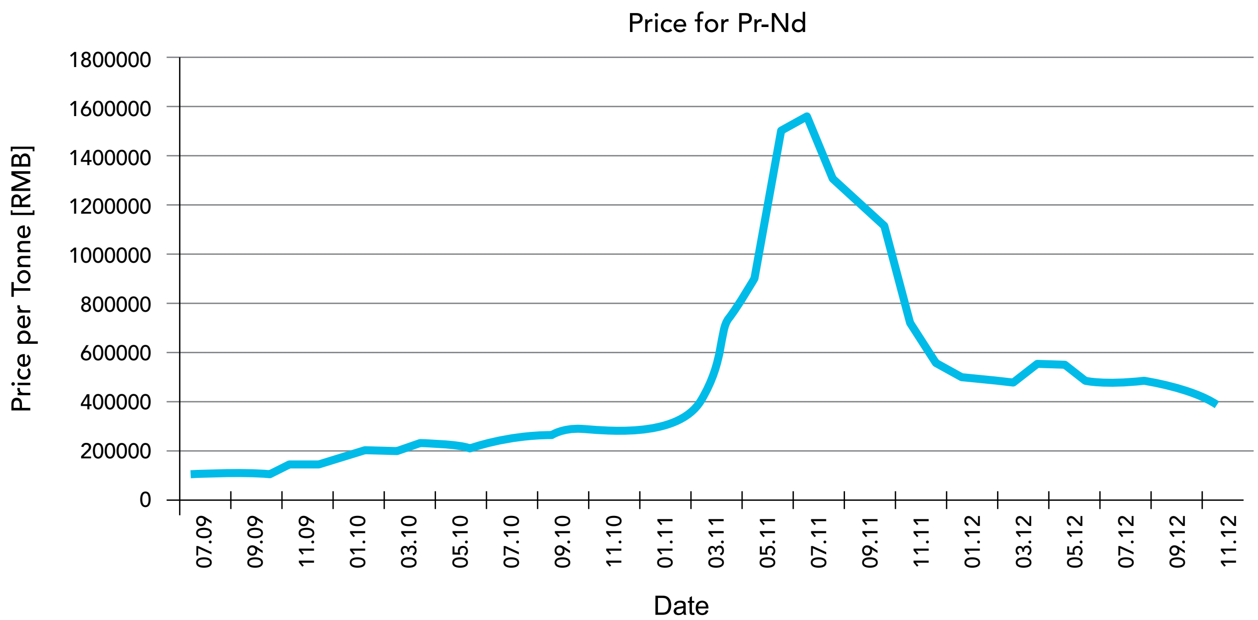

Figure 1: Neodymium pricing illustrating 2011 price hike (source: supermagnete.com).

2.0 What We Did

This is a business led, collaborative project bringing together the supply chain, subject matter expertise and experience in the design and delivery of closed loop products and business models. The project components include research into new business models, design for disassembly and reuse and supply chain innovation.

We pulled together a group of companies actively involved in the supply chain of one product that uses neodymium as illustrated in Box 1. We looked at the supply chain of HDDs as these pose a number of specific challenges:

- They are used widely in every PC or laptop in the world.
- Despite the advent of solid state drives, their use is expected to increase [4].
- The magnets are very difficult to extract and hence they are left in the HDDs.
- The HDDs are shredded and the neodymium magnets are recycled as ferrous materials and therefore lost in terms of their original function and in terms of their financial value. Any subsequent recycling will be into steel rather than magnets.
- There are only a handful of HDD manufacturers hence there may be opportunity to work with producers on design.

We undertook focused research and then developed a workshop to explore the barriers, issues and opportunities to developing new design strategies and business models. We focused on extraction during the recycling process of old/used (HDDs).

We undertook the following specific work packages:

- Research and product baseline assessment,
- Investigation of redesign options in supply chain workshop,
- Evaluation of options,
- Exploration of the barriers to implementation; and,
- Development of recommendations.

The experts we worked with

Reprocessing expert – S2S
S2S are a recycling and data destruction specialist. They take HDDs, de-gauze them, shred them and send them for material recovery.

Materials chemist – Professor Martin Goosey
Martin is an independent materials expert in the electronics sector and a Professor at the University of Loughborough.

PC manufacturer – Novatech
Novatech are one of the UK's largest PC manufacturers and work closely with HDD manufacturers on product specification.

Box 1: The experts we worked with.

3.0 Research and Product Baseline Assessment

Tearing apart the HDD

In order to establish the potential cost benefit of extraction we needed to establish a baseline understanding of HDDs by taking them apart. We were interested in how easy it would be and the value of the components.

The initial HDD breakdown is shown in Figure 2. The results are based on scrap values of metals from the LME and printed circuit board values from S2S, along with an estimated value based on the price of neodymium per tonne.

This showed that, as suspected, the neodymium magnet inside is the most valuable component. To ensure a good data set, we repeated the exercise for a broad range of HDDs. These were a mix of laptop HDDs, server HDDs and tower type HDDs with a wide variation of data capacities.

One of the key observations from taking apart the HDDs was the difficulty of getting into the drive itself. Take for example a fairly standard Western Digital tower computer HDD. From the outside it looks as though there may be as few as three points where the HDD is screwed shut. However, hidden under security stickers a further seven screws were found, all of which were covered by small black stickers and countersunk into the casing tofinish flush.

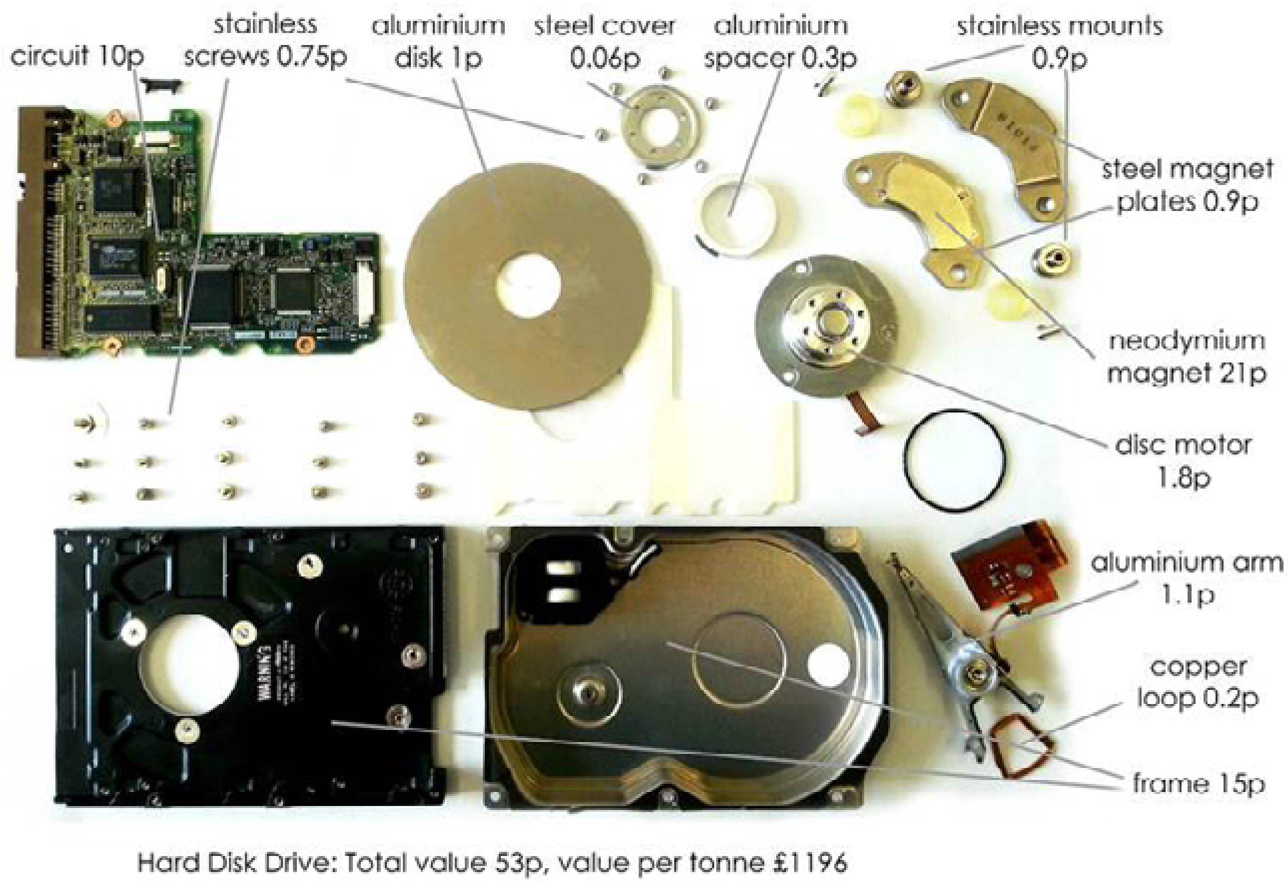

Figure 2: Component value of an HDD.

3.0 Research and Product Baseline Assessment

The data set produced from this exploration of HDDs is presented in Table 1. This details weights of the separated components.

The data tells us two important things: The first is that there is no correlation between brand and magnet shape, i.e. modularity or weight, and there is no correlation between HDD capacity and magnet size as illustrated in Figure 3. Secondly, we noted any difficulties in disassembly or any pieces that were easy; this showed the lack of modularity across HDDs in general, making a quick disassembly almost impossible.

The second most valuable component, the PCB, sits on the outside of most HDDs and is fastened down with 4 or 5 screws. A well-directed hit with a hammer and pry allows the extraction of the PCB, potentially creating additional value in a separate supply chain in the order of 10p per unit.

Typically the HDD is simply shredded at this point in a conventional recovery facility, after which the material is segregated by magnet and the ferrous elements are recycled. The neodymium is recycled as ferrous. The neodymium ends up crushed into small pieces and mixed in with all the other HDD components. This is typically then fed into a metals reprocessing stream.

Unlocking the value

The financial validity of recovery of both PCBs and HDDs can be put in simple terms: Paying someone £12 per hour would mean removing 120 PCBs per hour to break even. It takes roughly 10 seconds to remove a PCB from an HDD. This results in 360 PCBs being removed per hour or circa £36 in value which makes for a viable process.

The labour costs for the magnets will be higher as they are much more difficult to extract. They are protected by a metal casing with hidden security screws and gaskets, sitting inside a screwed down housing that they are then glued to. It is almost impossible to remove them by hand in less than five minutes and requires a plethora of screwdriver bits for each drive. The same £12 per hour analogy would mean removing a minimum of 60 per hour to balance cost and reward. This shows that the time window for disassembly simply doesn't add up.

Figure 3: Magnets removed from hard drives relating to data sets in Table 1.

3.0 Research and Product Baseline Assessment

Component	HP 146GB DG146ABAB4 Laptop mass (g)	Samsung 160GB HMI6HI Laptop mass (g)	Toshiba 250GB HDD2E62 Laptop mass (g)	Hitachi 320Gb 5K500 Laptop mass (g)	Western Digital WD500YS 500GB PC mass (g)	Seagate 500GB 7200.11 PC mass (g)	Seagate 200 GB 7200.7 PC mass (g)	Seagate 80GB 7200.9 PC mass (g)
Cover Screws	1.5g (8)	0.6 (7)	0.4 (7)	0.7 (7)	3.1 (10)	2.9 (8)	2.6 (7)	2.5 (7)
Cover	45.3	10.3	8.35	8.3	153.6	93.45	102.2	87.5
PCB Screws	0.65 (7)	0.3 (7)	0.3 (6)	0.3 (9)	0.9 (5)	1.3 (3)	1.7 (5)	0.8 (4)
PCB	16.2	11.55	12.9	11.25	31.4	19.1	31.6	17.4
Foam under PCB	0.9	0.6	0.25		1.5	1.2	1.05	
Disk Screws	0.4 (4)	0.2	0.15	0.1	1.1 (6)	0.8 (5)	1.05 (6)	1.1 (6)
Disk Plate	2.15	1.55	1.05	2.1	3	4.65	2	2.95 31.5
Disk(s)	19.7 (2)	4.8	4.7	11.7 (2)	92.2 (4)	45.85 (2)	45.8 (2)	4
Disk Spacing rings	0.9	1.6	0.8	10.3	6.35 (3)	1.3	1.5	
Disk Spacing blocks					23.4 (3)	13.3		
Plastic disk spacers		0.25					1.5	
Disk Spacer screw					0.3	1.2 (5)	0.6	
Reader arm screw		0.25 (2)	0.25 (2)			0.6	0.7	0.6
Reader arm	7.35	6.55	7.25	7.2	23.4	19.35	21.75	12.7
Magnet screws	0.25	0.3 (2)	0.5 (5)	0.25		1.55	0.85	1.1
Magnet casing	14.3	12	8.45	7.95	59.45	37.55	28.1	37.65
Magnets	5	3.2	3.3	2.55	16.55	10.25	13.4	8.1
Cover with Motor	66.8	39.75	39.7	42.3	276.2	284.6		275.2
Cover without Motor							253.3	
Motor				1.95			60.2	
Stickers	0.45	0.7	1.55		0.45	0.9	0.9	0.9
Total								
Notes	Two Screw heads, fairly simple.	Philips and Torques Moderate to difficult, struggled to separate one magnet.	3 different bits, magnets separated from casing easily. Lots of extra screws.	3 different bits, loads of PCB screws. Magnets held with 3 screws. Magnets come off easily	Two different bits. All screws covered with stickers and lots of them	Fairly easy to disassemble. Screws holding down magnets and hidden screw under main sticker	Fairly easy to disassemble. Screws holding down magnets and hidden screw under main sticker	Fairly easy to disassemble. Screws holding down magnets and hidden screw under main sticker

Table 1: Summary of data sets from HDD teardown.

3.0 Research and Product Baseline Assessment

We then took a sample hard drive, Hitachi 320GB HDD from a laptop, and carried out a life cycle assessment on it using Sustainable Minds LCA cloud software illustrated in Figure 4.

On the surface the CO_2e figure looks like it's not telling us much. But actually it shows that the value is not in the energy used to process these materials, as with aluminium, but purely in the actual material cost and rarity itself.

So just how rare is neodymium and how critical is it to extract it from our waste stream here in the UK? In accordance with the British Geological Surveys 2012 risk list, rare earth elements sit at the very top of the league [5]. Neodymium has a scarcity factor of 8.0 according to the Royal Society of Chemistry, showing that it sits just short of the top 10.

According to The U.S. Congressional Research Service, global production of all 17 rare earth materials combined amounts to an estimated 114,500 tonnes annually, with China owning 97% of this. We are using an estimated 163,000 tonnes annually (2012) with the short fall made up by previously mined material. Of this, 20% is thought to be neodymium, that's 32,600 tonnes.

The material flow from east to west has been illustrated in the U.S., again by the Congressional Research document, shown in Figure 5.

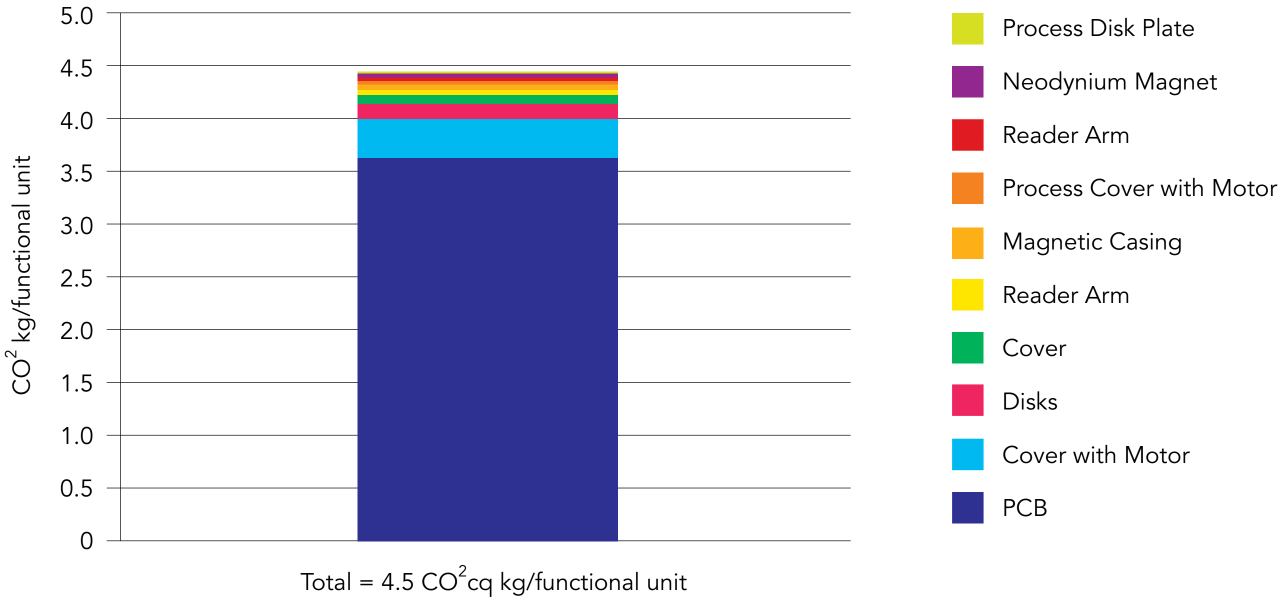

Figure 4: Life cycle assessment of an HDD.

3.0 Research and Product Baseline Assessment

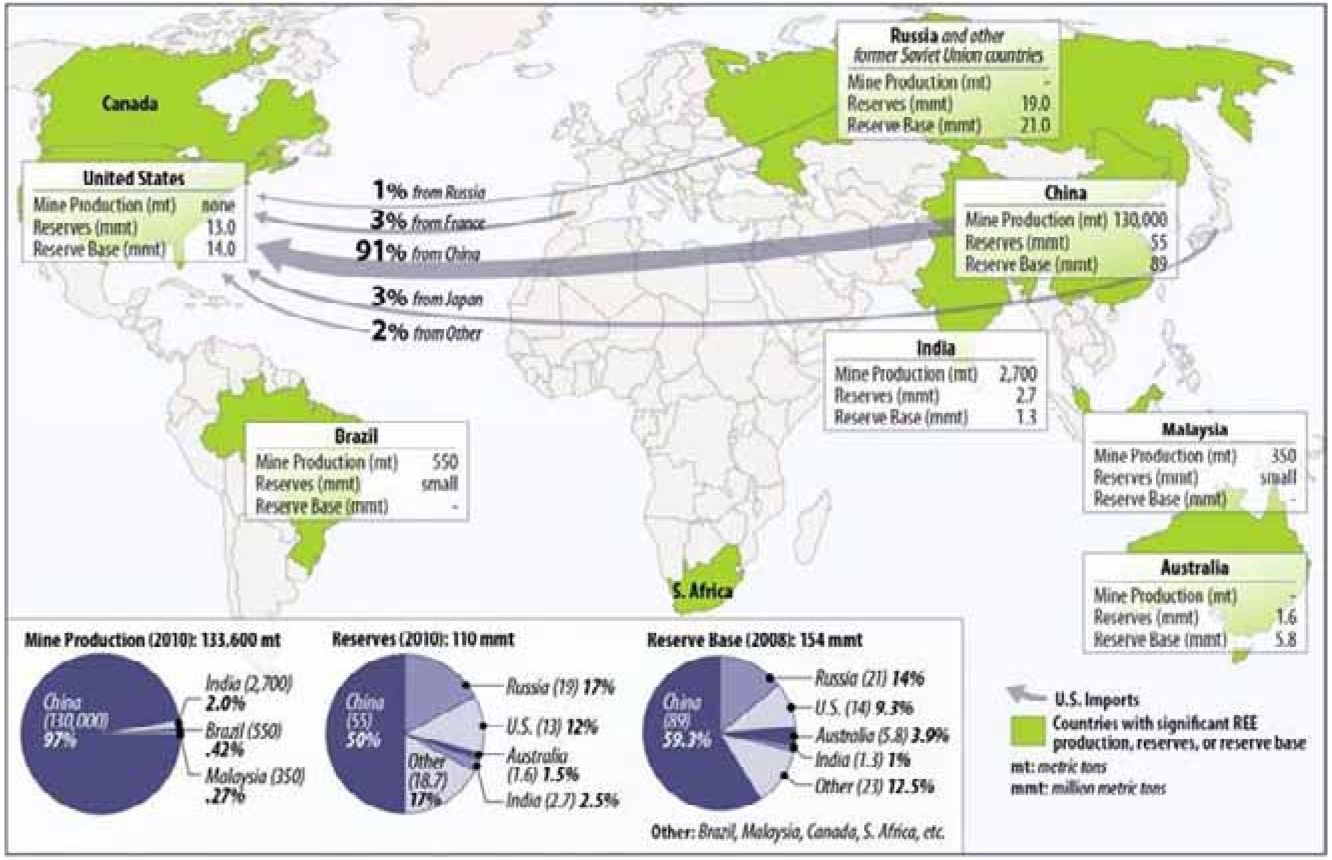

Figure 5: Rare earth elements: world production reserves and U.S. imports
(source: U.S. Geological survey, mineral commodity summaries, 2008–2011).

3.0 Research and Product Baseline Assessment

It's not just HDDs that contain this element. Neodymium is found in a huge array of the world's products including electric cars, wind turbines and power tools. Because of this, demand is only set to increase. With this increase in demand neodymium resources are only set to deplete whilst China retain control of what's left. This is why it is strategically important to look at the need and opportunity for retaining the material in the UK.

Hence the problem needs to be considered as both a supply and demand opportunity. In terms of supply there are 54 million PCs in the UK[6], each with around 7g of magnets which equates to 120 tonnes of neodymium (assuming a 30% concentration in magnets). This has a value of $5 million at today's prices[7]. Scale this up to the EU, the opportunity could be valued around $150 million.

On the demand side, there is a desire to grow our electric vehicle and turbine capacity. The UK are among the leaders in these technologies, particularly in terms of tidal power where we lead the way with a number of Marine Energy Technology Parks whose aim is to maintain our international lead in this sector[8].

We have less presence in the finished wind turbine market but are one of the top five markets for wind turbines[9]. In terms of electric vehicle technology we are home to significant investment and production capacity in the form of the Nissan EV activity that has seen investment of £420 million and the creation of 2000 jobs[10]. Many commentators believe this, and our engineering and design background, leave us well-placed to lead the market[11].

Having a UK supply of neodymium will reduce the risk of supply instability and price fluctuations. Furthermore, developing recovery technologies in the UK will draw other materials in from around the world.

Additionally, the above analysis is based on the current historic low price of neodymium at £35,000 per tonne rather than the historic high price of £65,000 per tonne on 2011[12].

The conclusion of the baseline assessment:

- To be economically viable, we need to be able to recover neodymium magnets much more quickly, in less than 30 seconds.
- Whilst the economics may not stack up right now, history illustrates that rising prices could tip the balance in favour of recovery.
- If we develop recovery expertise for neodymium there are likely to be a number of ripple benefits for the UK in stabilising materials supply for emerging green technology markets and becoming a hub for high value materials reprocessing.

4.0 The Redesign Workshop

Following the baseline assessment, Useful Simple Projects hosted a workshop with the supply chain, specifically representatives from Novatech, S2S and materials specialist Martin Goosey.

At the workshop we presented the baseline assessment, explored the issues facing all parties across product life and then took apart a number of HDDs.

We then ran a redesign session discussing and mapping of what could be done and highlighting potential barriers.

Observations from the workshop

A key part of the workshop was undertaking a teardown of a number of HDDs by the supply chain to understand the time required to remove the magnets. This also gave a great insight into the design attributes of the HDDs.

There were a number of general observations made by the team of specialists, these are summarised below:

- The market is ignorant of the value of neodymium within the products that it makes. Yet neodymium use in HDDs is not a dead issue. Solid State Drives (SSDs) will take time to take over as the main storage media. This is particularly the case for the rapidly growing emerging markets.
- There is considerable paranoia regarding the security of HDDs at end of life, even though techniques such as degaussing are safe consumers want drives shredded as well.
- Scrap revenue from shredded ferrous items is circa £900/tonne. This is only 10% less than the scrap value for neodymium magnets and hence the extra work to recover magnets only brings a marginal gain.
- Current reprocessors dismantle 12 HDDs per hour, which equates to one every 5 minutes. In order to ensure that the process is cost effective the magnets would need to be removable within 30 seconds.
- During shredding the neodymium sticks to the side of the shredding barrel so there is potential for collection at this point but the material is contaminated and diluted by other parts of the drive.
- 80% of PC failures are due to the hard drive failing.

Additionally there were a number of specific observations that are discussed below.

The workshop was an interactive and practical exercise. The photographs on the following page show the disassembly of HDDs from their position in the PC.

4.0 The Redesign Workshop

Figure 6: Images from workshop.

4.0 The Redesign Workshop

Redesign Options

There are a number of design strategies that the supply chain could adopt to enhance the recovery of these materials. The four most promising options we investigated following the disassembly included:

- Redesigning the HDD to allow removal of the magnets,
- Redesigning the magnets to standardise them and allow re-use in other HDDs or other products,
- Designing for re-use; and,
- Redesigning the recovery process to allow more effective removal of the magnetic material post-recycling.

The workshop was incredibly useful to contextualise the scale and scope of intervention strategies. The small scale of production of HDDs would not allow the redesign of the magnets along modular lines due to cost barriers of re-engineering the process. There are significant differences in HDD design and magnet design even from the same brand, this is because the main brands use a number of suppliers and contract sub-assemblers to produce the final product. It was felt by the expert team that the opportunities to affect change at the design stage were overly ambitious for a project of this scale. However, there are significant opportunities to redesign the recovery and recycling process to maximise magnet content in the recovered fraction.

There is also a significant opportunity to develop a re-use system for the HDDs. Whilst HDD memory was falling in price and our desire for it was increasing exponentially, HDD replacement has been increasing. There are signs that this is now slowing (particularly in the external HDD market)[13] but replacement over recent years produced a glut of HDDs for reprocessing. Indeed, although PC sales fell in Q1 2013 HDD sales held firm [14]. Furthermore, analysts at the same source expect that this represents the bottom of the market and that HDD sales will now increase.

Concern regarding safe and secure destruction of data on old HDDs has driven the entire industry towards fine particle shredding. This ensures that the entire HDD and enclosures are shredded down to pieces that are 6mm in size. This is seen by our industry panel as overkill. Technologies such as degaussing are deemed secure methods of data destruction by data destruction companies, yet customers often require the physical destruction of the HDD as well. There is a significant opportunity to work with large-scale users of HDDs to educate them to degauss rather than shred. This would allow the HDD to be disassembled for recovery. However, this has a cost implication which is discussed in further detail below.

The preferred redesign option was to re-engineer the recovery process. Currently the entire HDD is shredded and the neodymium within the magnet is lost in small pieces mixed in with the rest of the drive. Hence removal of the magnet and then the neodymium within the magnet is impossible.

4.0 The Redesign Workshop

To increase the efficacy of recovery, we investigated whether the neodymium could be recovered by simply guillotining the corner of the HDD as illustrated in Figure 7. We estimated that this would give us a four-fold increase in neodymium concentration compared with scrap/shredded HDDs. This process was tested at bench-scale on a Fujitsu MPG3204AT, randomly selected for the trial.

The increase in concentration is achieved by removing the corner of the HDD where the magnets are situated and then reprocessing this in a separate waste stream. This is an area percentage as shown below.

The total weight of the HDD was 472g. The cut corner weighed 131g (28% by weight) and once opened; the magnets were separated and weighed at 11.2g.

The percentage of total weight that the magnets represented within the device as a whole was 2.4%. After cutting the corner off, the concentration of neodymium in this separate piece of material represents 8.7% of the weight, this shows a four-fold increase. It is important to note that this particular HDD is a very robust unit. The base plate is thick aluminium and the steel brackets that the magnets sit on are a much heavier gauge than that usually found in HDDs. This would imply that in an 'average' HDD the percentage increase of neodymium concentration would be much higher.

To be certain this would be the case, we repeated the process with an HP DG146ABAB4 laptop HDD. The percentage value of neodymium is 2.7% as a complete unit, but increases to 15.4% if the corner is cut and processed separately.

The time to remove the corner piece was a matter of seconds. This would not hamper the existing recovery process or add any significant process complications.

Figure 7: Testing the guillotine method.

5.0 Redesign Options

Out of the redesign workshops, we developed the following four approaches and recommendations for neodymium reprocessing.

Design approach 1:
Design for reduced impact

Starting at the beginning is a good place to start. There are significant differences in the size of magnets performing the same function.

There is no exact correlation between drive capacity and magnet size, as illustrated in Figure 8.

Some drives have a single magnet whilst others have two. Some are attached to two separate plates whilst others utilize more complex plates (see above).

Hence, the first approach must be to minimize the materials used to deliver the same functionality. Hence we have identified that the smallest magnets used for a 3.5 inch HDD are 2.55g and the largest are 16.55g. Therefore there is an obvious lean design opportunity.

Recommendation 1: Communicate the 'lean' opportunities to the HDD industry.

The major barrier to rolling out a lean design approach to HDDs is the dispersed supply chain of the HDD manufacturers. As part of a proposed second project we will approach a handful of HDD manufacturers and show our 'best in class' research.

A second barrier is the advent of solid state drives. These will, in time, replace HDDs; however, HDD sales are projected to remain strong over the next few years due to growth in middle-class consumption worldwide.

Figure 8: Magnets and drive capacity.

5.0 Redesign Options

Design approach 2: Refurbishment of hard drives

HDDs do occasionally fail, however the majority of units passed to S2S are not broken, they are being replaced with larger capacity drives and new drives. Consequently there is an opportunity to erase and refurbish drives for second use. As the use of Cloud services grows and as thin-client technology is adopted by large organisations the need for large local storage will reduce. Consequently there may be an opportunity to use smaller capacity drives in some applications. There may be an opportunity to cascade drives through emerging markets.

However, there are a number of barriers here. The most significant is perceived security. There is a great deal of concern relating to data loss and theft from HDD and computer recycling. However existing non-destructive technology removes all data from drives. Therefore there is a need to reassure customers about data security.

There are a number of services that refurbish and sell-on PCs. These include Wastecare, ICTR, S2S and many, many more. However, many companies that pass on their ICT equipment still insist on removal and destruction of HDDs and replacement with a new one.

Recommendation 2: TSB to work with WRAP to stimulate markets for refurbished drives. Also work with WRAP to incentivise HDD return via retailers such as Amazon.

Design Approach 3: Designing the product and system to get the magnet out whole

In an ideal world the magnet would be removed whole. In order to do this the HDD would need to be easily open-able and the magnets quickly accessible. However there is also a need to have a robustly constructed HDD case. Consequently the supply chain group felt that this was not feasible. Furthermore, the magnets are incredibly strong and glued to the armature. This of course hinders removal.

A half way house would be to guillotine off the corner of the drive with the magnets in it and remove the magnets from the guillotined corners at a later date.

The barriers to removing the magnets whole are:

1. The time required to do so.
2. The fact that the magnets are glued to the armatures.

Recommendation 3: Guillotine the corners off a sample of drives and disassemble a selection in order to calculate the time required to remove the magnets.

Design Approach 4: Redesigning the system to recover the shredded magnet

When the HDDs are shredded the magnets are also shredded and these are spread around the recycling vessel and stuck to ferrous objects. Due to the relatively small amount of magnet relative to the rest the HDD and the fact that it is all mixed together, separating the valuable magnet is impossible.

However, if a degree of pre-separation can be undertaken this would significantly increase the concentration of neodymium and therefore the cost effectiveness recovery. As discussed earlier in this report the mechanical removal of the relevant corner of the HDD increases the concentration of magnet as a proportion other materials. It could lift the concentration from 2.7% to 15.4%. This increases concentration by over 500%. A further option is to thermally de-magnify the guillotined corners and then possibly remove the magnets in one piece. However, the magnet is glued to the armature with very, very strong glue and hence removal is likely to be faster, cheaper and easier in pieces than whole. There is an opportunity to use thermally reactive glue that auto-disassembles.

There is great potential to redesign the shredding and recovery system in order to maximize recovery. If it is not possible to change the product we can redesign the way we process them.

Recommendation 4: Trial this mechanical separation and recovery of magnet fragments. Partner with The Universities of Birmingham and Loughborough.

6.0 Some Potential Barriers

General

Not one of the companies had full visibility of the supply chain. The supply chain is by nature fractured and this means coordinating a sector wide re-design programme is impossible. There is also a significant information gap in terms of consumer motivation and behaviour around disposal and security. Further research is required here.

Specific barriers from the supply chain.

In addition to the supply chain visibility issues there are a number of specific barriers that S2S and Novatech have highlighted. Specifically:

- Concentration of neodymium too small for viable extraction in current system.
- HDDs too complex for disassembly.
- HDDs and neodymium magnets mainly manufactured in China.

Furthermore it was noted that most SMEs simply take electronics to council tips, rather than for secure data destruction.

7.0 Conclusions and Next Steps

There is a growing demand for neodymium across the globe and at the same time a tightening of supply. Therefore there is a strong case for businesses in terms of criticality for neodymium recovery. The economic case is less strong due to the difficulties in material extraction. Implementing a broad design solution to this problem is incredibly difficult and complex due to the splintered and geographically dispersed nature of the supply chain.

The much-heralded solid state drive revolution is not yet in full flow and hence the use of neodymium magnets is set to continue. The perfect storm of poor material recovery, worldwide and UK growth in higher-value markets such as renewables, reduced availability of materials due to China's export caps, and absolute scarcity mean that control of rare earths will determine the ability of nation states to make product and therefore make money.

Neodymium recovery from HDDs is currently unviable economically due to a combination of design barriers, splintered supply chains, and the relatively low current value of the material. The projected demand for the material and the projected growth of the renewables industries is likely to push prices higher in the future. At some point, this will unlock the viability of neodymium recovery. It is not possible to guess the point when economic viability will be reached with out further investigation into reprocessing costs. It is recommended that further work be undertaken now in order to reduce costs of disassembly and prepare the ground for when enhanced recovery can be exploited.

Therefore we recommend the following actions:

Recommendation 1: Given the opportunity to reduce the size of the magnet in each HDD it is recommended that TSB or WRAP develop a number of case studies highlighting the resource efficiency opportunities in terms of lean design. Base this on a 'best in class' approach that results in a league table of lean designed HDDs. As part of this develop best-practice design guides for the HDD industry.

Recommendation 2: There is a need to develop the market for refurbished drives, whether this be in machines for the social housing market, into security camera recording units, into the thin-client terminal market, or into the market for entry-level machines for developing nations. It is recommended that the TSB work with WRAP to stimulate markets for refurbished drives (distinct from refurbished IT where drives are often replaced). There is also a significant opportunity to work with WRAP and the retailers to incentivise HDD return.

Recommendation 3: Undertake a trial with reprocessors and recyclers to partially disassemble the HDDs in order to test the principle and speed of partial recovery.

Recommendation 4: Trial the approach of mechanical separation and recovery of magnet fragments. Build in a reprocessing trial to ascertain the best method of separation, the appropriate fraction and how this varies by HDD design. Partner with The Universities of Birmingham and Loughborough.

Recommendation 5: Undertake a detailed mass-balance of neodymium use in the UK. How much is used in each industry? Where does it come from? How much is imported in product? Can the supply risk be quantified? How much is in our waste streams?

Recommendation 6: Develop an industry-wide action group to coordinate the design, use, recovery and reuse of neodymium. In fact, this should be widened to embrace all rare earth materials in IT. Partners to include Intellect, ECA, EEF, RARE3, Envirophone.

Recommendation 7: investigate the potential for holding or stockpiling: There may be an opportunity to part-disassemble the HDDs and stockpile for future reprocessing.

The scale of opportunity is significant but the greatest benefit comes in securing raw materials for a growing and strategically vital sector of the UK economy at a time when supply is being restricted and demand is set to rise.

7.0 Footnotes

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