Materials Security, Productivity and New Business Models

Nicholas Morley

Bonn, 29th October 2012

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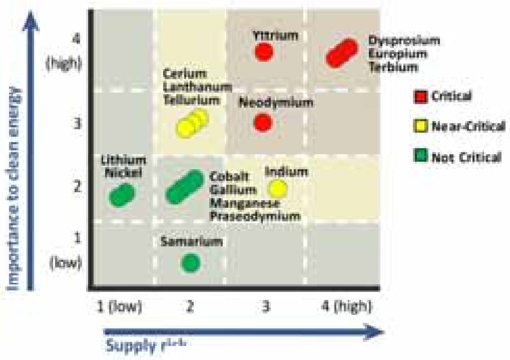
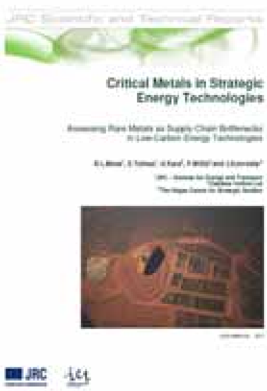
Policy Context





Sources: KITECH, US Dept. of Energy, EU RMI, EC JRC IET

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Materials Criticality across all Strategic Energy Technologies

Element	Rating
Rare Earths: Dy, Eu, Tb, Y	High
Rare Earths: Pr, Nd	High
Gallium	High
Tellurium	High
Graphite	High-Medium
Rhenium	High-Medium
Indium	High-Medium
Platinum	High-Medium
Rare Earths: La, Ce, Sm, Gd	Medium
Cobalt	Medium
Tantalum	Medium
Niobium	Medium
Vanadium	Medium
Tin	Medium
Chromium	Medium
Selenium	Medium-Low
Lithium	Medium-Low
Hafnium	Medium-Low
Molybdenum	Medium-Low
Silver	Medium-Low
Nickel	Low
Gold	Low
Copper	Low
Cadmium	Low

Source: Oakdene Hollins Estimates

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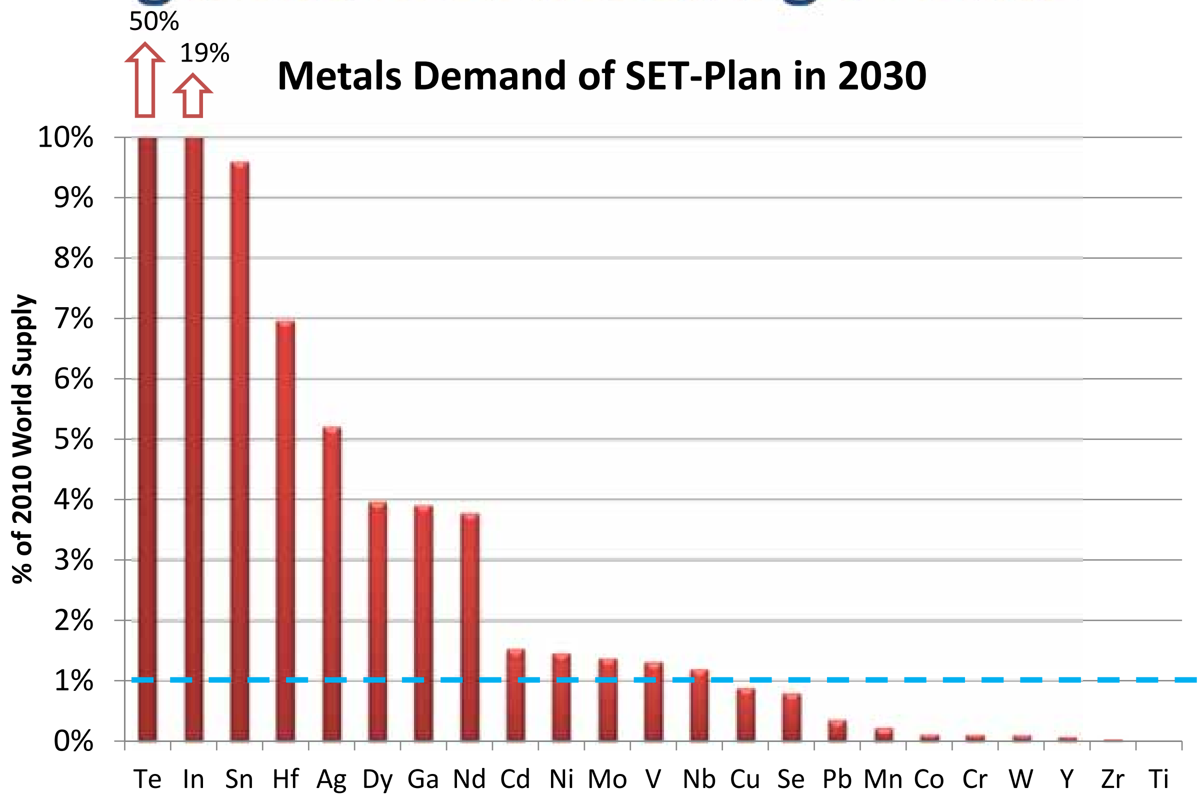
Significance Screening Results



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Source: Oakdene Hollins/HCSS for EC JRC

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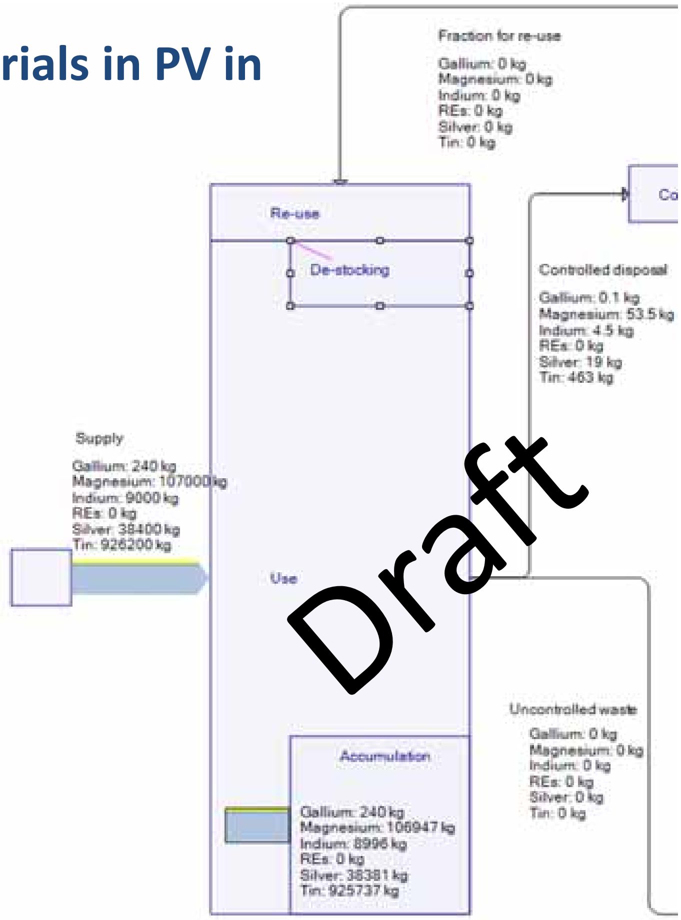
Critical Materials in PV in the UK, 2011



Source: Oakdene Hollins

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Responses to Materials Criticality

Data collection and dissemination

Procurement and stockpiling

Trade and international co-operation

Primary production

Design and innovation

Resource efficiency strategies (e.g. recycling)

Source: Oakdene Hollins

Policies for the recovery of strategic materials

- Improved collection
- Advanced sorting techniques
- Implementation of new recycling technology
- Linking agents within the supply chain
- Design for disassembly
- More sophisticated waste recovery targets
- Alignment and enforcement of regulations
- Remanufacturing and reuse

Key product groups for the "EU Critical 14"

	Antimony	Beryllium	Cobalt	Fluorspar	Gallium	Germanium	Graphite	Indium	Magnesium	Niobium	PGMs	REEs	Tantalum	Tungsten
Auto/aero components		■	■				■		■	■			■	
Batteries			■				■					■		
Catalysts			■			■					■	■		
Cemented carbide tools			■											■
Chemicals				■										
Construction									■					
Electrical equipment					■		■	■	■			■		
Electronics/IT	■	■			■	■		■			■	■	■	
Flame retardants	■													
Optics					■	■								
Packaging									■					
Steel & steel alloys				■			■		■			■		

Source: Oakdene Hollins

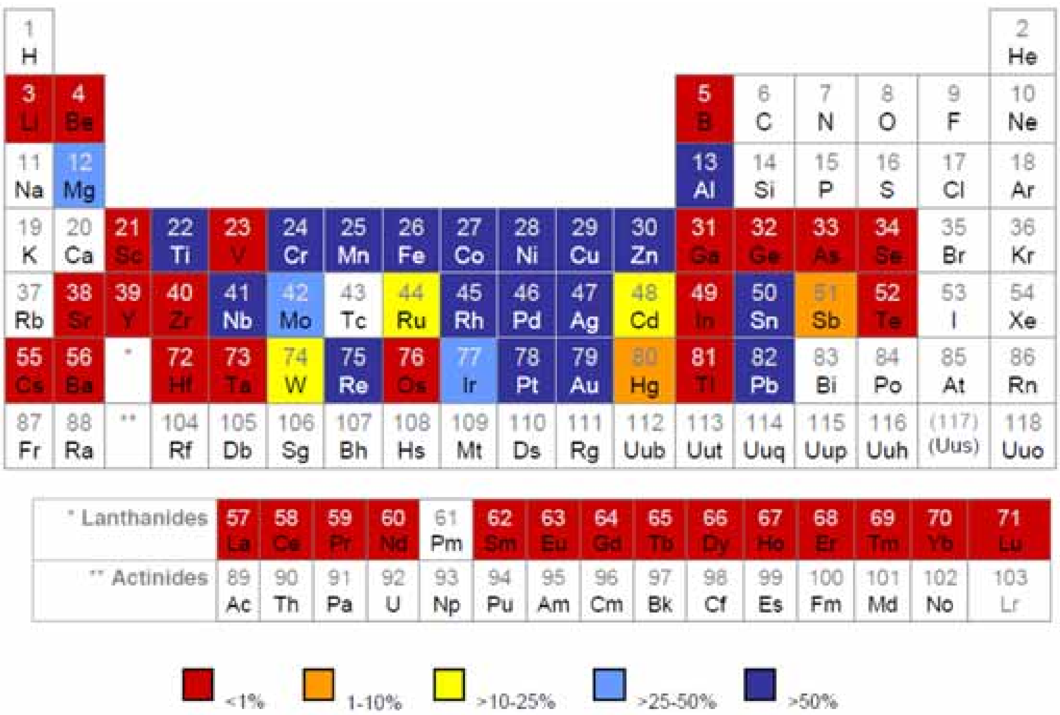
Red = product life extension practices in use

Which metals and where?

Component	Element	Global recycling rate
Printed Circuit Boards	Antimony	1-10%
	Beryllium	<1%
	Copper	>50%
	Gallium	<1%
	Germanium	<1%
	Gold	>50%
	Silver	>50%
	Platinum Group Metals	>50%
	Tantalum	<1%
Flat Panel Displays	Indium	<1%
Hard Disk Drives	Ruthenium (PGM)	10-25%
	Rare Earth Elements	<1%

Source: Oakdene Hollins for

Recycling



Source: UNEP/EU Working document

Metal Content?

- Example of mobile phone (excluding batteries):
  - 12.6% Copper
  - 0.35% Silver
  - 340g/t Gold
  - 144g/t Palladium
  - Also Iron, Aluminium, Nickel, Tin, Zinc…
- Far richer than conventional ores
- Need for improved collection

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Source: OECD

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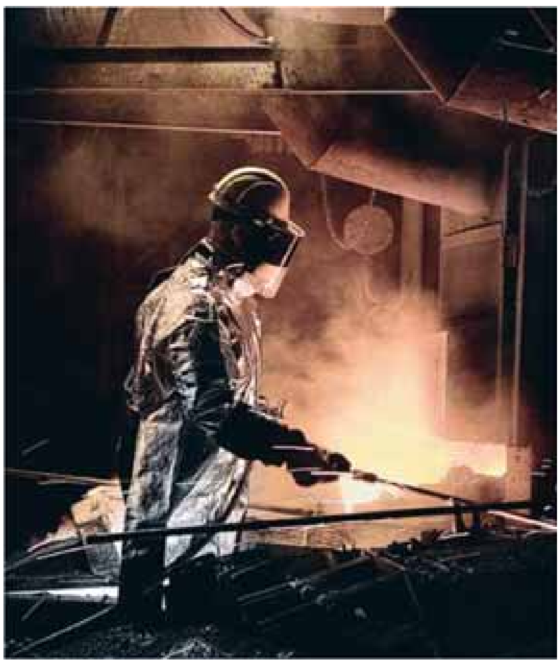
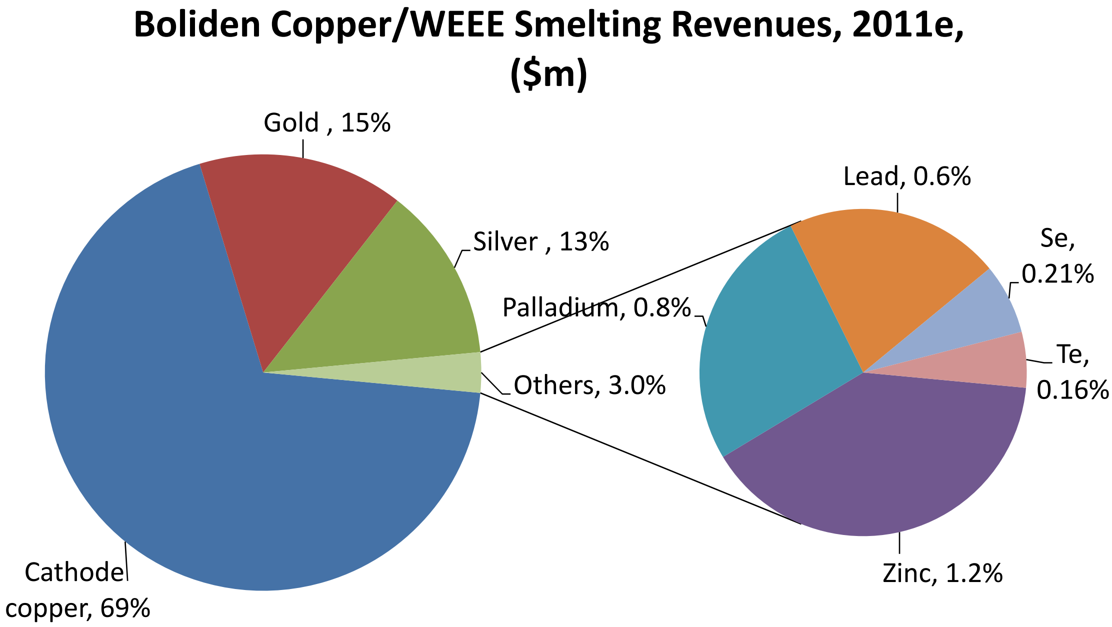
Precious Metals: Example of Boliden

- Copper Smelters:
  - Rönnskär (Sweden)
  - Harjavalta (Finland)
- Rönnskär processed 60kt electronic scrap in 2011
- Expanding to 120kt capacity – become world's largest
- Focus on copper and precious metal recovery



Source: Boliden Annual Report 2011

Precious Metals: Example of Boliden



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Source: Oakdene Hollins for ILZSG/ICSG/INSG

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Analysis of WEEE Recovery Opportunities

- Many metals used in very small quantities on a PCB
- Current practice of shredding for recovery:
  - Copper and precious metals already recovered
  - Rare earths lost in ferrous fraction
  - Others are quite reactive – lost in slag
- Some niche opportunities are possible:
  - Rare earth magnets in hard disk drives
  - Rare earth phosphor lighting
  - Indium in flat panel displays

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Source: Oakdene Hollins for EPOW

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Rare Earth Magnet Recovery

- Hard disk drives (HDD) account for 1/3 of RE magnet demand
- Processes to cut HDD & remove RE magnets for recycling
- Need to segregate, not shred with WEEE to recover RE
- Data security as economic incentive for collection & sorting
- Wind Turbines & (H)EVs in long term due to length of lifetimes

Source: Oakdene Hollins for EPOW

Indium Recovery from Flat Panel Displays

- Over half of primary Indium used to make FPDs
- Recycling of Indium process waste common and efficient
- Easy to separate FPDs from WEEE as easily recognisable and need to remove mercury
- Pilot scale technologies being developed to remove ITO – dismantling and dissolution
- Medium timeframe for FPDs in waste; solar PV for long term

Source: Oakdene Hollins for EPOW

Beyond Recovery to Reuse

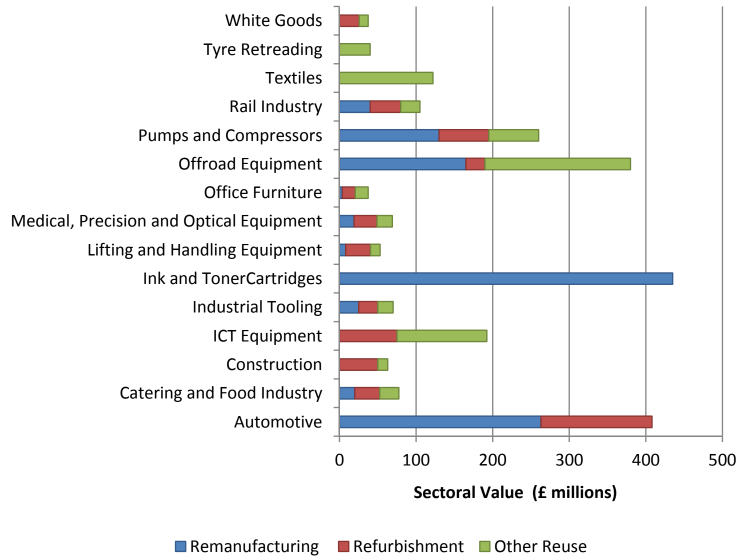
- Resource opportunities:
  - Use of others' waste & typically low cost feedstock
  - Protect against fluctuating resource markets
  - Utilise difficult to recover materials
- Whole life service:
  - Encourages long term customer base
  - Value added business model
- Environmental / Social benefits:
  - Energy, material and water costs reduced
  - Cost reduction for procurers
  - Carbon savings
  - Green growth and skilled job creation

Remanufacturing

"The practice of taking an end-of-life artefact and returning it to as-new condition, with warranty to match" Ijomah

- A long industrial history
- Origins in the military
- Worth c. £5bn, 50,000 people in UK
- Policy drivers in waste prevention

Value of remanufacturing and reuse in the UK



Source: Oakdene Hollins, 2010

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Reuse of ICT equipment in the UK, 2009

Type	Units sold (000)	Refurbished (000)	Reused (000)
Desktops	**2,750**	**49.5**	**764****
Home Users	917		
Business Users	1,833		
Laptops	**8,250**	**148.5**	**382**
Home Users	4,950		
Business Users	3,300		
Servers	**3,678**		**183**
Total	**11,000**	**220**	**1,150**

Source: ONS Product sales and trade, 2009
*** this number includes monitors and base units sold separately*

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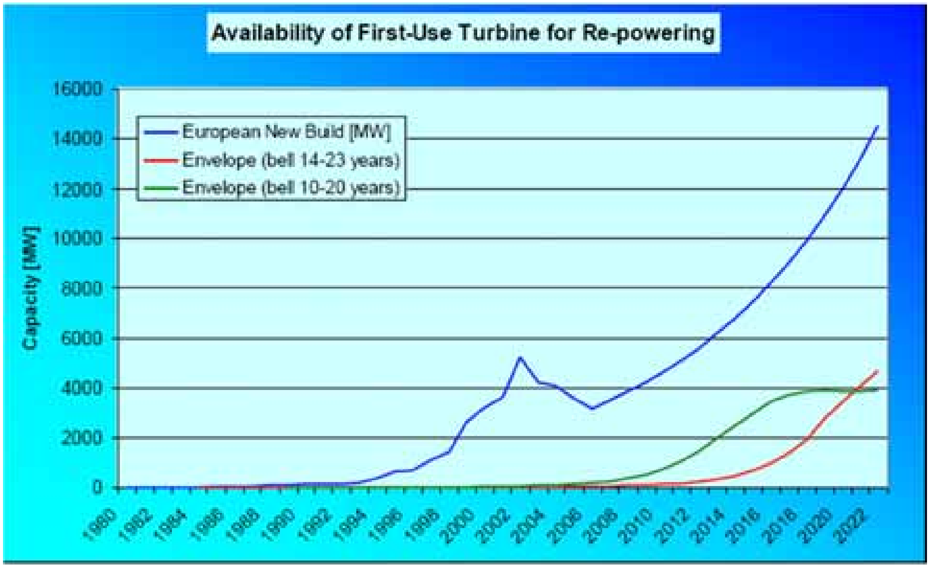
Remanufacturing potential in wind power



Source: CRR 2008

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Potential for remanufacture

Beneficial Features	Detrimental Features
High intrinsic value	Poor design for assembly/disassembly
Good durability	Proliferation of materials in construction
Low to moderate technological evolution	Status-dependant, fashionable items
Cores readily available	Poor perception of standards/branding
Integrated sales/service/upgrade options	Low price of new goods
Design information available	Craft skill shortage

"Four Golden Rules of Remanufacturing"

- Determine optimal mix of: rate of product evolution, value, and re-constructability
- Remanufacturing is at its most successful when most hidden
- Reduce customer risk e.g. use standards
- Recovery of core is key to growth

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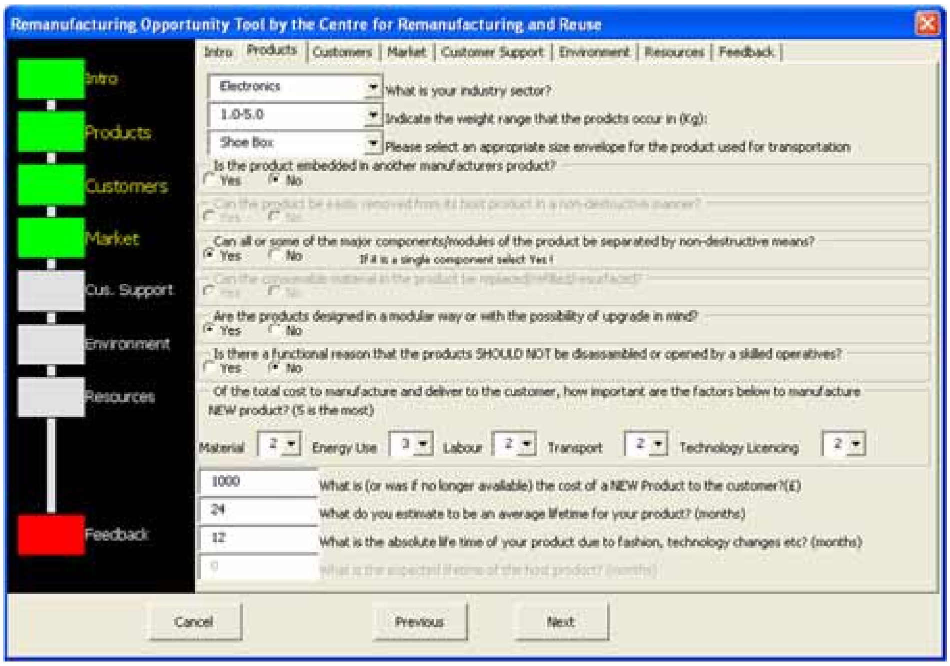
Remanufacturing decision tool



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Conclusions

- Raw material concerns will remain part of the policy mix, extending to biotic as well as abiotic materials
- These concerns will give increased impetus to traceability/provenance innovations and to closed loop business models close to country markets
- Recycling methods for some critical materials exist but are often underdeveloped
- Many product groups using critical materials are suitable for product life extension and remanufacturing/reuse
- Remanufactured products are often best embedded in service business models and use standards to encourage reuse whilst help conserve resources and create green growth

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