Measurement Priorities for Sustainable Production & Consumption Issue 1.0

IfM

Report of a workshop facilitated by Institute for Manufacturing for DTI & NMS

UNIVERSITY OF CAMBRIDGE

Contents

1.1 Executive Summary

This report results from a one-day road-mapping workshop to identify priorities for the development of the measurement knowledge base within the theme of sustainable production & consumption. The workshop took place at NPL in Teddington on 6th June 2006. The roadmapping process involves building a layered view of the theme, starting with trends and drivers, and moving on through applications to identify needs in the underpinning knowledge base. The graphics on the following pages illustrate these priority areas, linkages and timescales. The process is explained in more detail in Appendix 1.

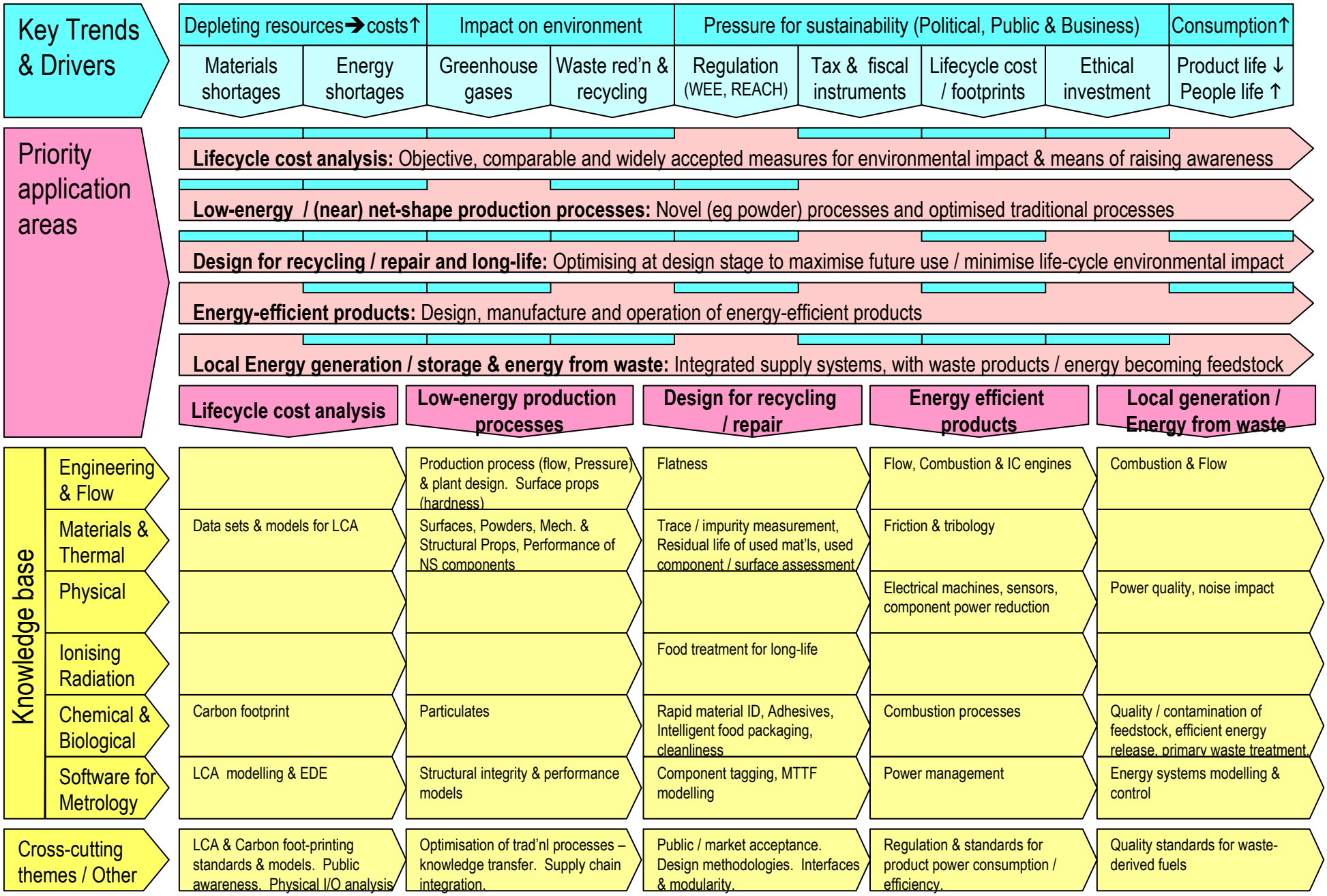
Participants were invited from across industry, academia and the NMIs, based on their understanding of the market and their insight into a number of pre-scoped focus areas. These covered energy efficiency, waste management, industrial bio-technology and design, materials and manufacturing processes for low-waste.

In summary, the workshop found that there is growing pressure from government, public and the investment community for a more sustainable approach, driven by the need to balance increasing demands from global consumers against the diminishing finite materials and energy resources and the environmental impact of their use. Regulation at the product and enterprise levels are playing an increasing role in driving changed behaviours.

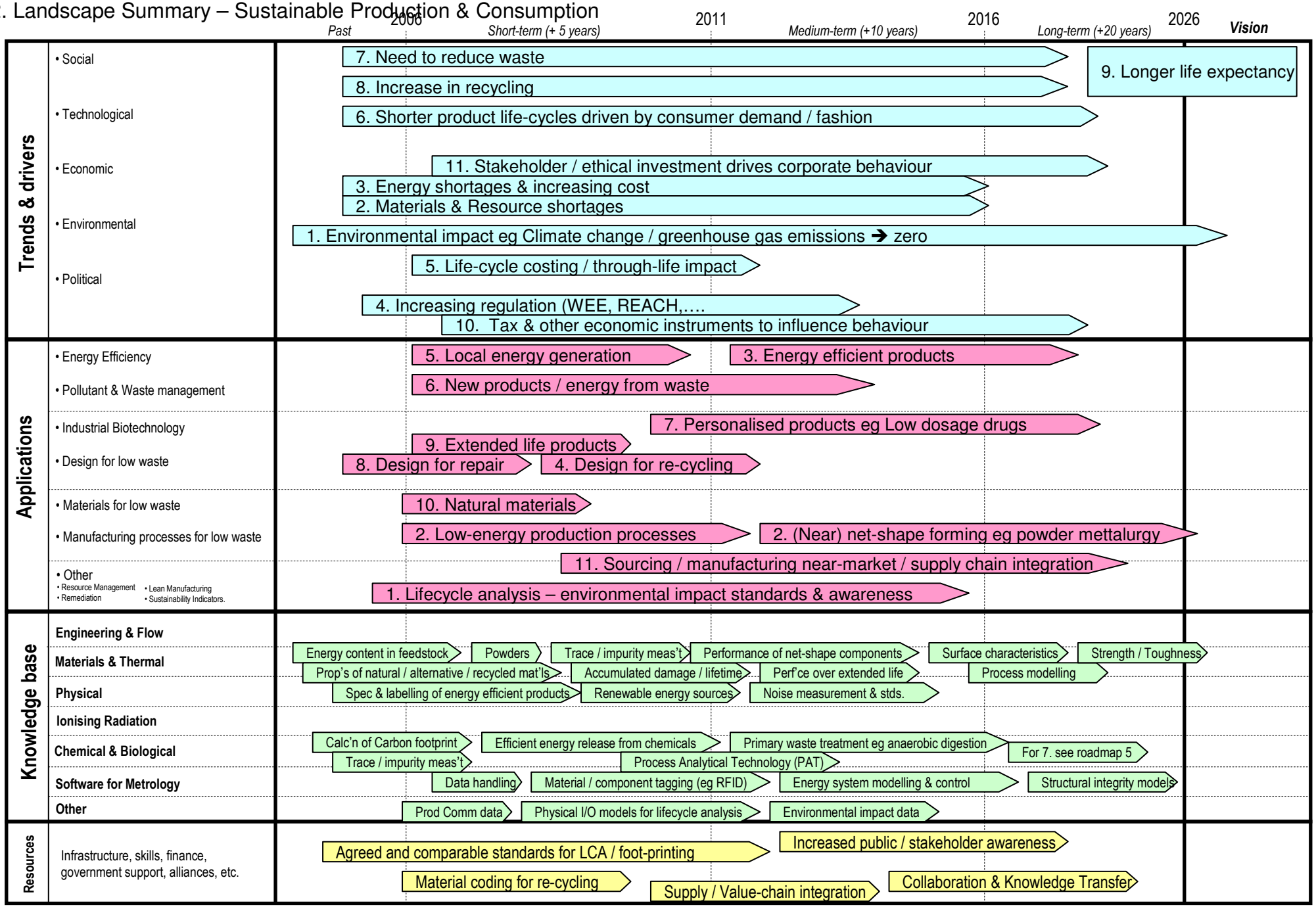
The workshop identified a number of the key supporting application areas to assist in prioritising future developments in the measurement and standards knowledge base. The highest priority areas were identified as the ability to analyse the full life-cycle impact of a product or service; energy efficient products and processes; generation of energy from waste and design for improved recycling and repair.

The report identifies a number of the key developments in the measurement knowledge base which will be needed to underpin these applications. Whilst by no means definitive, these development areas provide some clear indicators for future research focus. As well as knowledge base developments which underpin specific applications, there are a number of common themes which emerge. These include life-cycle analysis and carbon foot-printing; standards for product modularity, power consumption and bio-fuels. The need for effective means to raise public awareness was also highlighted.

1.2 Executive Summary Roadmap - Sustainable Production & Consumption



2. Landscape Summary – Sustainable Production & Consumption



3. Sustainable Production & Consumption focus areas

The following topic areas were evaluated according to their overall importance to the theme of sustainable consumption & production, and the impact that measurement was likely to make in advancing the topic area. Topic areas that score highly on both criteria were viewed as being the most likely sources for priority developments in the knowledge base. These were then used to focus recruitment of workshop participants.

Theme: Sustainable Production & Consumption	Importance	Impact	Overall
Energy efficiency	10.86	8.33	13.69
Pollutant monitoring & control / Performance monitoring	9.71	8.71	13.05
Industrial Biotechnology (including bio-mass & Catalysis)	8.86	7.86	11.84
Design for low waste (resources, energy) – high yield	9.14	6.71	11.34
Recycling of materials / Design for re-use	9.29	6.29	11.21
Flexible / Lean manufacturing	8.86	6.71	11.11
Low waste materials and processes	9.00	6.00	10.82
Waste management & disposal (inc incineration)	9.43	5.29	10.81
Sustainability indicators	8.67	6.33	10.73
Resource management & treatment / remediation (eg water, minerals, land)	8.71	5.86	10.50
Supply chain optimisation / logistics	9.17	5.00	10.44
Sustainable agriculture (food & non-food)	8.43	5.00	9.80

4. Landscape

4.1 Trends & Drivers
4.2 Priority trends & drivers
4.3 Application areas
4.4 Priority application areas
4.5 Knowledge base
4.6 Linkages

4.1 SUSTAINABLE P&C TRENDS & DRIVERS	Past	Short Term 2006 2011	Medium Term 2012 2016	Long Term 2017 2026	Vision
SOCIAL	Expectation of instant consumer gratification	Procurement based on full life-cycle costing Consumerism & fashion drive short product lifecycles	Growing customer acceptance of re-use / re-processing Growing leisure	Longer life expectancy	Public demands low environmental impact measures
		Growing demand for goods & services	Public pressure to understand REAL product cost		
TECHNOLOGICAL		Increasing use of natural materials eg in composites Personalised products (eg pharmaceuticals)	Reduce / manage contamination in recycled materials Increasing electronics content ➔ recycling harder	Stability of IT products? Alternative / replacement materials	
		Reducing product life cycles / fashion	Design optimisation for material & energy resources		
			Digital evolution of documents ➔ reduced paper		
ECONOMIC	Growth of "Ethical" investment & reports	Higher resource & Energy costs	Trend to purchasing service not product	Escalation of resource & energy costs	Ethical investment drives business
	"triple bottom line"	Global sourcing driven by competitive pressures	Resource and Energy shortages emerging Domestic trading quota		
ENVIRONMENTAL	Climate Change		Reduce waste at source Noise pollution	Increasing remote pollution measurement	Even "renewables" are finite
	Water shortages	Waste minimisation	Serious resource & energy shortages	Re-USE rather than re-CYCLE	Landfill ➔ zero
		Increasing Energy Conservation		Extreme Environmental challenges	Zero environmental impact
POLITICAL & LEGAL	Comply with EU, ROHAS & WEE legislation	Growing waste & resource regulation Government embedding SP&C in £125Bn spend	Realisation to not "gold plate" regulation standards Local council impact through business rates & planning	Impact of overly pessimistic design rules	
		Increasing role of fiscal measures			

4.2 Sustainable Production & Consumption - *Priority trends & drivers*

Rank	Trend and Driver	Score
1.	Environmental impact eg. Climate change ➔ zero impact	15
2.	Material and resource shortages	13
3.	Energy shortage and increasing costs	13
4.	Increasing regulation (WEE, REACH, …)	12
5.	Life cycle costing – through life environmental impact	9
6.	Shorter product life-cycles / Consumer demand / “buy new”	9
7.	Reduction in waste	7
8.	Increase in recycling	6
9.	Longer life expectancy	3
10.	Tax & other economic instruments to encourage sustainability	3
11.	Stakeholder / ethical investment driving company behaviour	2

4.3 SUSTAINABLE P&C APPLICATIONS	Past	Short Term 2006 – 2011	Medium Term 2012 – 2016	Long Term 2017 – 2026	Vision
ENERGY EFFICIENCY		Product design for energy efficiency Energy storage	Local energy generation		
		Increased sub-metering & energy mgmt	Energy from Waste		
POLLUTANT & WASTE MANAGEMENT		Environmental monitoring	Reduced / re-cycleable product packaging New products from "waste"	Monitoring capability (atmosphere / ground water…..)	
		Noise mapping of products			
INDUSTRIAL BIOTECHNOLOGY		Scale out rather than scale up Product / materials redesign to use waste feedstock	Genetic engineering for non-food products Energy from Waste	Extended-life food & food products (smart packaging?)	
		Natural v synthetic products / materials			
DESIGN & MATERIALS FOR LOW WASTE	Design for environmental complaince	New application-specific composite materials Design for re-manufacturing / conditioning	Lightweight / high-performance engineering Modular design for long-life products	Long-life buildings	Recycling composite products
		Extended-life products Design for re-use D.F. low material usage	Design for re-cycling (avoid mixed matls / contamination) Ability to predict residual life of components	Low-water product Design for long-life	
MANUFACTURING PROCESSES FOR LOW WASTE		Low energy / Resource-efficient processing Design & joining for disassembly	Intelligent repair based on remaining life Waste as feed-stock	Surface engineering for extended life	
		Increased re-manufacturing / conditioning Faster process es	Component re-use warehouses / supply chain (near) Net-shape processes eg powder mettall'gy		Move from owning products to consuming services
OTHER SP&C • Resource mg'mt • Remediation • Lean manu'f • Sustainability indic'ts		Water leakage measurement	Re-use of grey water	Catalytic processes for land / water treatment	
	Awareness programmes	Lifecycle impact analysis prodedures Supply chain integration / co-location	Manufacturing on demand / at point of use Life-cycle cost / impact analysis / footprinting	Public awareness of sustainability indicators	
OTHER THEMES: • Security / IC World • Energy / Transport • Health / Built environ't • Design & Manuf		Software upgrade rather than buy new	Energy from Waste	Monitoring consumer product safety	
		Better Gov't procurement eg NHS Energy efficient buildings	Lightweight / high-performance engineering Design for durability	Long-life buildings	

4.4 Sustainable Production & Consumption - *Priority applications*

Rank	Application	Score
1.	Life cycle analysis – environmental impact stds + awareness	25
2.	Low energy / (Near-) Net shape manufacturing processes	15
3.	Energy Efficient Products	8
4.	Design for recycling	7
5.	Local Energy generation	6
6.	New products / Energy from waste / waste minimisation	5
7.	Low-dosage / personalised drugs	4
8.	Design for repair	3
9.	Extended-life products	3
10.	Natural (rather than synthetic) materials	2
11.	Sourcing near-market / smart procurement / supply chain integr'n	2

4.5 SUSTAINABLE P&C KNOWLEDGE BASE	Past	Short Term 2006 2016	Medium Term 2017 2026	Long Term 2027 2036	Vision 2040+
ENGINEERING & FLOW		Production process flow, pressure	Plant design optimisation	Flow	Combustion in IC engines
			Surface properties	Surface assessment of used components (flatness, wear cleanliness	
MATERIALS & THERMAL	Mat'l props of Net shape components	Energy content in feedstock	Trace / impurity measurement for recycling	Mat'l properties of recycled materials	Surface characterisation
	Data sets & models for LCA	Powders for Powder mettalurgy	Material properties for replacement / natural mat'ls	Accumulated damage / remaining life	Performance of materials over extended prod life
PHYSICAL		Specification & labelling for energy efficient products		Noise measurement & Stds	Component power optimisation
			Renewable energy sources	Sensors	
IONISING RADIATION		Standards for treatment of foods for extended shelf-life			
CHEMICAL & BIOLOGICAL	Rapid material ID	Carbon foot-printing – standards & methods	Efficient energy release from chemicals	Primary waste treatment eg anaerobic digestion	
	Particulates		Trace / impurity measurement	Process analytical testing (PAT)	Adhesives
SOFTWARE FOR METROLOGY		Data handling	Materials / component tagging eg RFID	Energy system modelling & control	Structural integrity models
		LCA modelling & EDE	MTTF modelling	ISO/STEP for data exchange	
OTHER INCLUDING REGULATORY		Prod Con data	Physical I/O models for Life Cycle Analysis	Environmental impact data	

Long Term 2027 2036	Vision 2040+
Strength & Toughness	Tribology & friction
Process modelling for low-energy prod processes	
Power quality	
Microbial contamination	Quality & contamination of feedstock
Intelligent food packaging	Primary waste treatment

4.6 SUSTAIABLE P&C LINKAGES		**Trends & Drivers**										
Application areas		1. Environmental impact / climate change	2. Materials & resource shortages	3. Energy shortages and increasing cost	4. Increasing regulation (WEE, REACH)	5. Life-cycle costing	6. Shorter product life-cycles	7. Reduction in waste	8. Increase in recycling	9. Longer life-expectancy	10. Tax and other economic instruments	11. Stakeholder / ethical investment
	1. Lifecycle Analysis											
	2. Low-energy production processes / near net-shape											
	3. Energy efficient products											
	4. Design for recycling											
	5. Local energy generation											
	6. New products / energy from waste											
	7. Personalised products eg drugs											
	8. Design for repair											
	9. Extended life products											
	10. Natural materials											
	11. Sourcing / production near-market											

5. Contributors

Expert	Affiliation
Raymond Boyle	NEL
Andrew Bullmore	Hoare Lea
Nicky Chambers	Best Foot Forward
Mark Gee	NPL
Peter Lyne	LGC
Mike Kennedy	GKN
Martin Marples	Namtec
Fred Mead	World Business Council for Sustainable Development
David Nettleton	NPL
Prof Asim Ray	Queen Mary College London
Bryan Roebuck	NPL
Andrew Rowley	Resource efficiency KTN
Graham Sims	NPL
Maggie Statham	DTI
Ton Van Esch	Xerox
Elizabeth Warham	DTI

Appendix 1. Road-mapping workshop process

Measurement and Knowledge Base Priorities for NMS
Description of Roadmapping Process and Report

This process is aimed at establishing the future knowledge base priorities for the National Measurement System. A wide range of external participants combined with NMS staff to follow a roadmapping process facilitated by the Institute for Manufacturing. Eight subject-based one day roadmapping workshops were run plus a cross cutting themes session.

Roadmap Subject areas

- Environmentally Friendly Transport
- A More Secure Environment
- Sustainable Production and Consumption
- Renewable and Sustainable Energy
- Bioscience and Healthcare
- Intelligent Connected World
- Design Engineering and Advanced Manufacture
- The Built Environment

Roadmapping Process Description

Participants

An initial view is taken of likely major topic areas within the roadmap subject based on importance and impact and used to structure an invitee list. This ensures a good coverage of topics and defines the subject more closely but it is not used to limit discussion on the day. The intent is to capture the input of external NMS 'customers' to guide future development although NMS staff also contribute on the day.

Profiles

Each participant was asked to complete a Profiles form to capture views across three time periods prior to the workshop and as a way of sharing rapidly (5 mins presentation per roadmap) information on the roadmapping day.

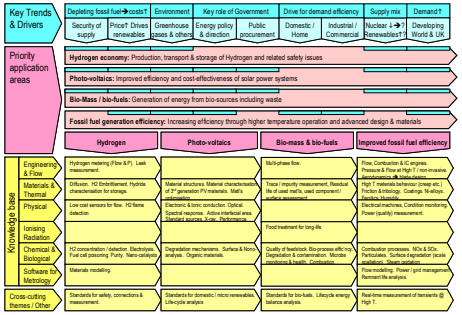
	Short term (2006 - 2011)	*Medium term (2011 - 2016)*	*Long term (2016-2026)*
Trends & drivers	• Rising energy costs • Increased public awareness of global warming and possible solutions (nuclear, renewables, CO_2 sequestration) • Early market adoption of local power generation	• Security of energy supply • Improved efficiency in use of energy • Maintenance of lifestyle expectations ie acceptable energy solutions will be demanded	• Reduction in reserves of fossil fuel • Awareness of total energy and total environmental impact (life cycle accounting)
Applications	• Growth in microgeneration systems (small wind, microCHP, solar thermal etc) • Development of CO_2 sequestration • Continued development and adoption of wind and marine renewables	• Increased energy efficiency in buildings • Growth in CHP and recovery of heat from thermal plant • Contribution from marine power systems giving both cyclic (tidal) and variable (wave) outputs	• Development of H_2 economy and fuel cell CHP systems • Baseload power generation adjacent to big users • Possible adoption of some new nuclear power
Knowledge base	• Electrical power measurement for distributed generation • New flow metrology challenges for renewables and other systems (wind – remote sensing, marine – wave energy and tidal flow characterisation, H_2 and CO_2 flow issues) • Measurements to support EIA requirements, eg marine acoustics	• Integrated systems for energy management – will require low cost sensors • Comprehensive integration of microgeneration systems in national power supply • Metrology and standards to support novel energy storage technology (H_2 supercapacitors, novel batteries)	• Measurement systems to support the distribution and use of H_2 • Measurement systems to monitor materials and component durability in marine and wind systems • New metrology challenges in support of enhanced nuclear power safety

Report Format

The report captures and structures output from the day in summary and detailed format to enable 'drill down'. All the original input is captured including Profiles Sheets.

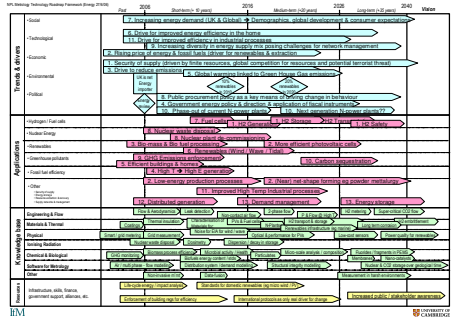
Executive Summary Roadmap

This picture is intended to provide a quick overview of output and does not include a time dimension. It groups and captures the key trends and drivers and links them to priority application areas. Linkages are shown by the blue bars in the application section. Each priority application is linked to knowledge base requirements by category and cross cutting subjects identified. A certain amount of grouping and consolidation has been carried out to allow representation of this view.



Landscape Summary

This view is intended to reintroduce the time dimension to the roadmap and although linkages cannot be seen, priority trends, applications and associated knowledge base and resource issues are illustrated. This map is intended to assist in the prioritisation by NMS of their planning based on time until requirement.



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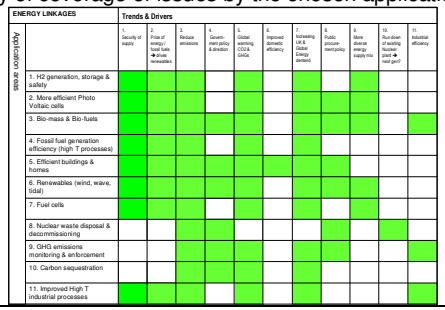
Core Roadmapping Session

This session consists of capture of issues and ideas for three linked time-based 'layers' with prioritisation between each layer. Time intervals are agreed for the topic in hand to represent, the short, medium and long terms

- Layer 1: Trends and drivers – Capture of political, environmental, economic , technological, social issues followed by grouping and prioritisation to provide a focus for Layer 2
- Layer 2: Brainstorm of application related to key trends followed by prioritisation based on potential knowledge base impact to provide basis for Layer 3
- Layer 3 Measurement and knowledge base issues related to priority applications categorised into standard NMS taxonomy

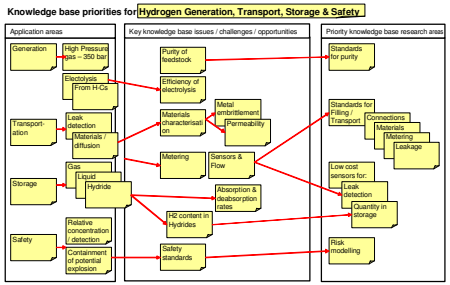
Linkages

A matrix captures the relationship between key trends and drivers and priority application areas as a means of illustrating linkages and adequacy of coverage of issues by the chosen applications.



In-Depth Breakout

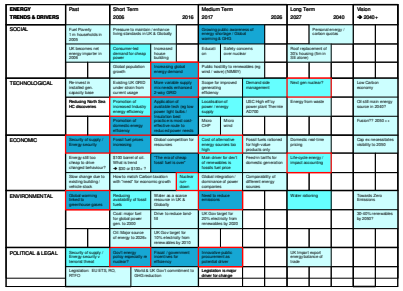
A breakout session examines three key applications as chosen by the group to examine related knowledge base issues in more depth and to recommend priority development areas. Breakout participants are chosen for their specialist knowledge wherever possible.



Group Feedback

The roadmapping participants are asked for their feedback and final input on the day before the workshop report is written

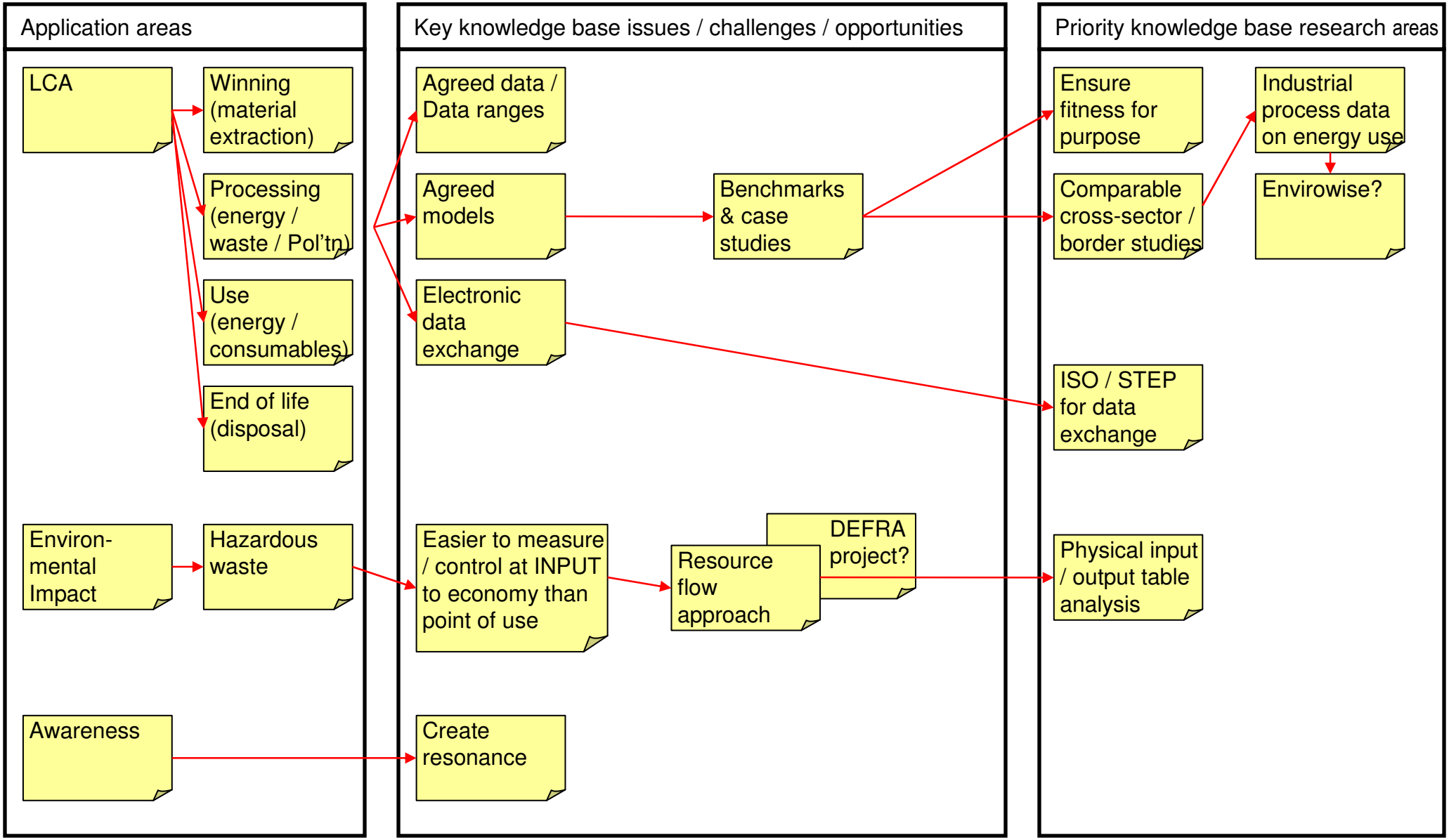
Detailed Input Capture



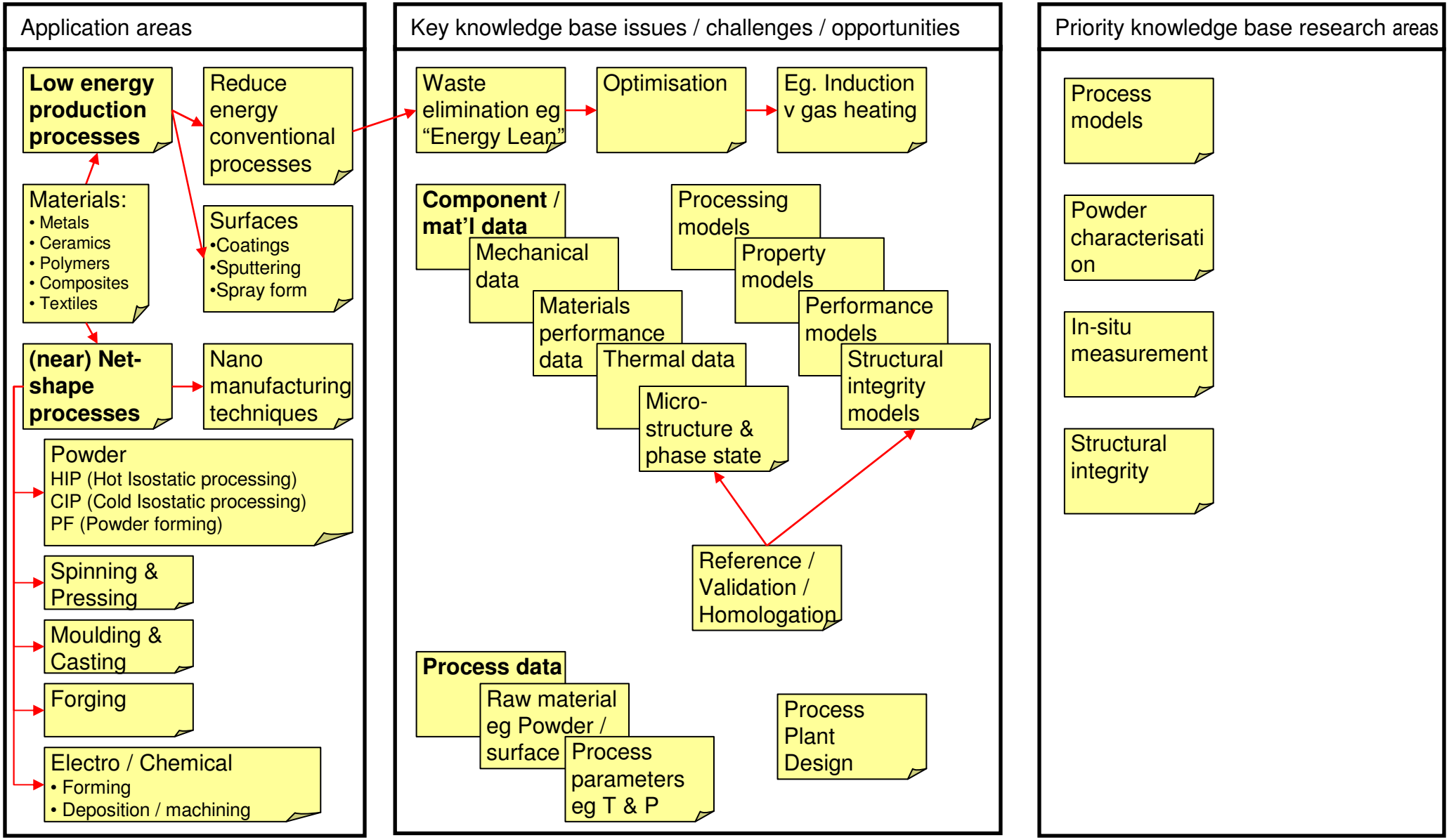
All input from the roadmapping session is capture across three matrices representing each layer. Each matrix includes time interval and categorisation. Prioritised issues are identified with darker shading.

Appendix 2. Knowledge base

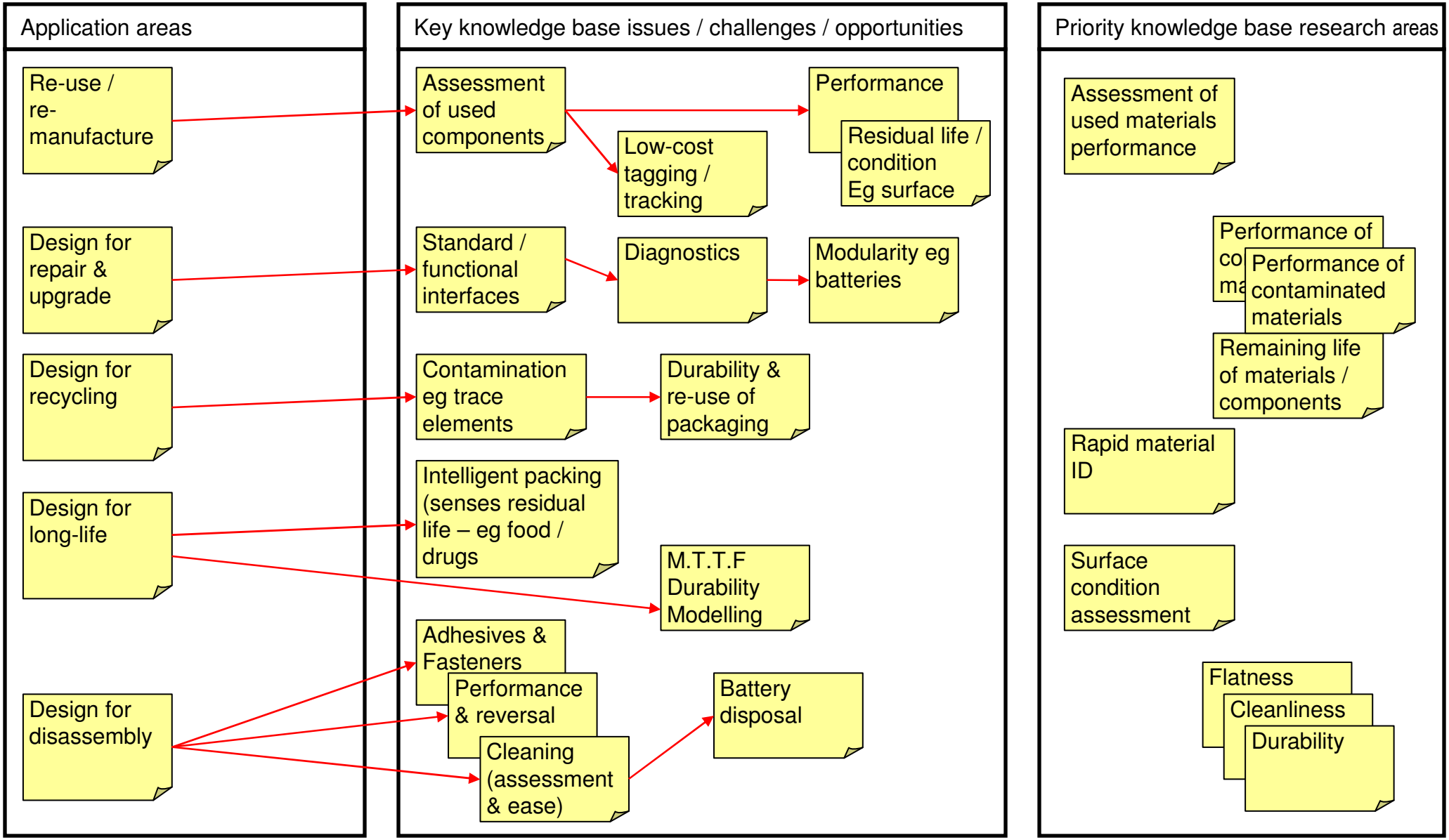
Knowledge base priorities for Life Cycle Analysis



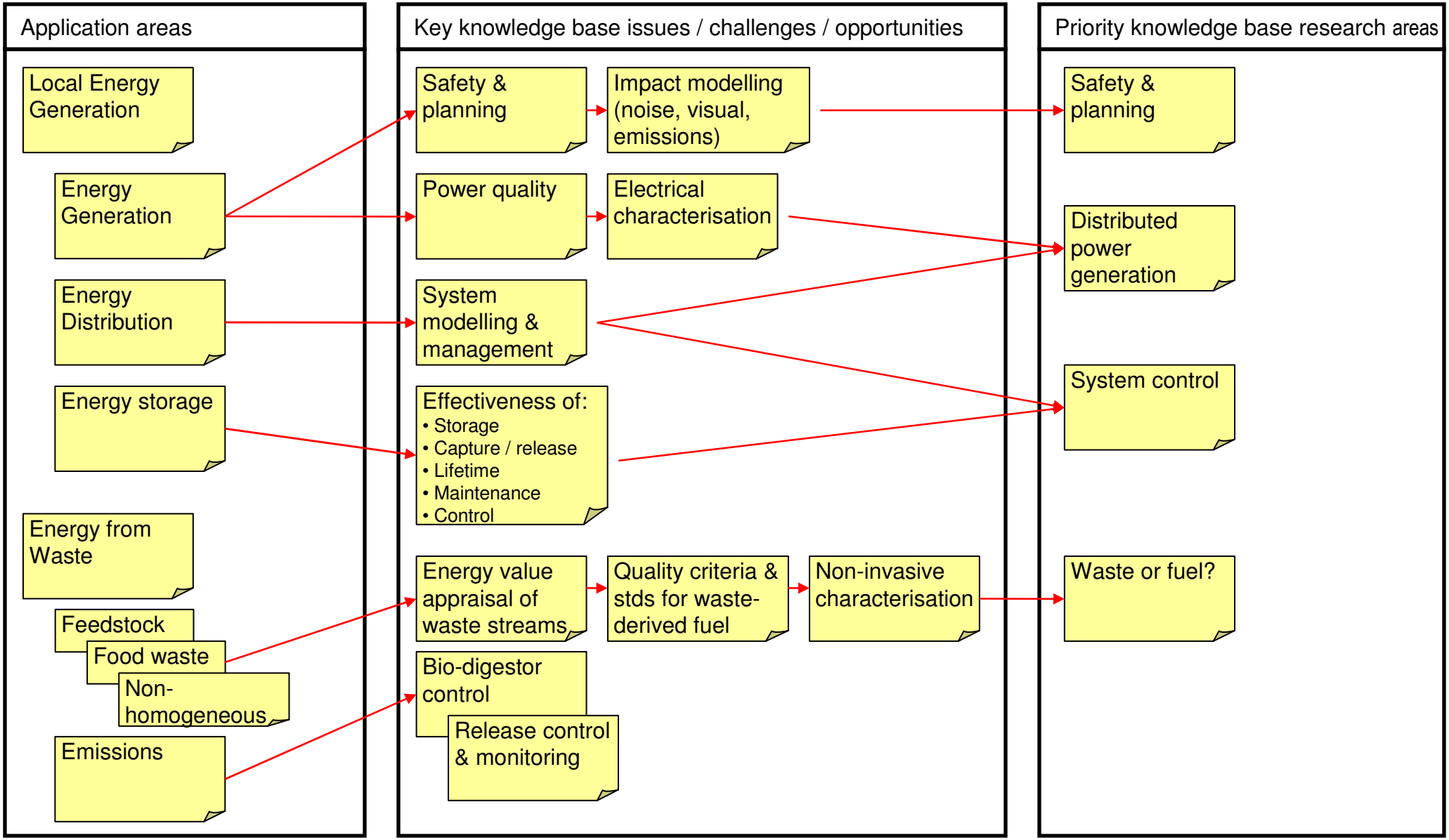
Knowledge base priorities for Low energy & resource / net-shape production processes



Knowledge base priorities for **Design for…** *reuse, recycling, disassembly, repair, long-life*



Knowledge base priorities for Local Energy Generation & Energy from Waste



Perspectives

DTI National Measurement System Roadmap

Workshop:
6th June 2006

Perspectives

Sustainable Production & Consumption

Fred Mead
Projects Manager
World Business Council for Sustainable Development

	Short term (2006 - 2011)	*Medium term (2011 - 2016)*	*Long term (2016-2026)*
Trends & drivers	• Rising costs and scarcity of resources •Legislative e.g. Regulations on end of life recycling –e.g automotive and WEEE directive •Govt commitment to SC&P – embedding SD in the annual £125b UK Public sector spend	• x	• x
Applications	• Awareness programmes such as Resource Efficiency Clubs, Enviroinnovate •Recycling and Recovery processes. •Company measurement and Audit procedures	• x	• x
Knowledge base	•Demanufacturing technologies e.g. WEEE •Primary Treatment opportunities e.g Anaerobic digestion •New materials with new properties and longer life–e.g.Nanotechnology	• x	• x

DTI National Measurement System Roadmap

Workshop:
6th June 2006

Perspectives

Sustainable Production & Consumption

Andrew Rowley
Network Director
The Resource Efficiency KTN

	Short term (2006 - 2011)	*Medium term (2011 - 2016)*	*Long term (2016-2026)*
Trends & drivers	• Higher resource & energy costs • Growing demand for goods and services • Increasing waste & resource regulation and fiscal constraints	• Some resource and energy shortages/ increasing resource costs • Continuing demand for goods & services • Significant regulation and use of fiscal instruments	• Serious resource and energy shortages/ substantial costs • Stringent environmental regulation • Substantial fiscal waste and resource use measures
Applications	• Increased use of re-manufacturing/re-conditioning • New products that are specifically designed for de-manufacturing and re-use • Resource-efficient processing	• Reduced use of primary resources – new products from "waste" • New "low impact materials" – reduced energy manufacturing • Modular design – long life components and products	• Long life buildings. Limited new-build and demolition. • Extended-life foods & food products • Low-"water" products
Knowledge base	• Improved quality control – advanced process measurement systems/sensors • Resource "tagging", resource flow modelling	• Measurement of impurities. Advanced separation technologies. Advanced re-forming technologies. • Accelerated long-life property testing • Advanced design technologies	• Modular building design. Re-useable sections. Material tracking and monitoring technology. Automatic material property monitoring. • Intelligent packaging, built-in sensors – predictive/adaptive "use-by" dates • All materials, components have a low-water "factor"

DTI National Measurement System Roadmap

Workshop:
6th June 2006

Perspectives

Sustainable Production & Consumption

Graham Sims
Knowledge Leader
National Physical Laboratory

	Short term (2006 - 2011)	*Medium term (2011 - 2016)*	*Long term (2016-2026)*
Trends & drivers	• Increased realisation of importance of procurement based on full life costing (Materials Innovation and Growth Report) • Increased use of natural n •And self reinforcements in composites •Increased energy conservation	• Increased effort to reduce waste at source in manufacturing and process industries • Reduced contamination in recycling of materials • Design optimisation for material and energy resources	• Increased remote pollution measurement • Extreme environmental challenges
Applications	• Life-cycle-analysis procedures • New composite materials validated for use in specific applications •Insulation products for ambient and above-ambient applications	• Design for recycling – avoidance of mixed materials and contaminated materials. • Light-weight high performance engineering	• Monitoring capability for atmosphere, ground-water etc. • Catalytic type processes for reducing or cleaning water/ environment
Knowledge base	• Validation of LCA procedures / standards and provision of reference data. • Reference test methods and data, particularly for above ambient conditions	• Measurement of low-level contaminates in recyclate • Design data for new “green” materials , particularly for durability aspects	• Validation and traceability of measurements to internationally agreed standards

DTI National Measurement System Roadmap

Workshop:
6th June 2006

Perspectives

Sustainable Production & Consumption

Ton van Esch
Lean SixSigma Master Blackbelt
Xerox Europe, Manufacturing & Supply Chain

	Short term (2006 - 2011)	*Medium term (2011 - 2016)*	*Long term (2016-2026)*
Trends & drivers	• Comply with EU legislation: ROHAS, WEEE • Waste minimisation • Globalisation of sourcing driven by competitive pressures	• Further reduce waste • Changes in customer perception of re-processing • Digital evolution of the document, reduced product lifecycle	•
Applications	• Product design for compliance • Design for recycling • Stimulate partnerships between manufacturers, raw material suppliers, logistics service providers, recyclers.	• Design for durability, serviceability (RIC) • Ability to predict residual life of components • Customer training, purchase of service rather than ownership of product	•
Knowledge base	• Materials knowledge • Life Cycle assessment • Web enabled supply chain solutions	• Develop technologies to predict residual component life • Influence legislation and market acceptance of reprocessing concepts • Global knowledge of design, manufacturing and distribution capabilities	•