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ANNUAL REVIEW 2013-14

EPSRC Centre for Innovative Manufacturing in INDUSTRIAL SUSTAINABILITY

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CPM – the Swedish Life Cycle Centre

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DIN, The German Institute for Standardization

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ELCON Solution Oy

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Forum for the Future

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Members

The Foresight Report on the Future of Manufacturing in the UK to 2050 was published in October 2013. This Annual Report of the EPSRC Centre for Industrial Sustainability is an exemplar of the thought and practical analysis required to make the difference the Foresight Report concluded was necessary to shake the UK out of its complacency over fixing its inadequacies for achieving a long term enduring competitive performance. In my Forward to that Report I wrote:

"Manufacturing in 2050 will look very different from today, and will be virtually unrecognisable from that of 30 years ago. Successful firms will be capable of rapidly adapting their physical and intellectual infrastructures to exploit changes in technology as manufacturing becomes faster, more responsive to changing global markets and closer to customers. Successful firms will also harness a wider skills base, with highly qualified leaders and managers whose expertise combines both commercial and technical acumen.

Constant adaptability will pervade all aspects of manufacturing, from research and development to innovation, production processes, supplier and customer interdependencies, and lifetime product maintenance and repair. Products and processes will be sustainable, with built-in reuse, remanufacturing and recycling for products reaching the end of their useful lives. Closed loop systems will be used to eliminate energy and water waste and to recycle physical waste.

These developments will further emphasise the key role of physical production in unlocking innovative new revenue streams, particularly as firms embrace 'servitisation' and manufacturers make use of the increasing pervasiveness of 'Big Data' to enhance their competitiveness. And it will be important that flows of highly skilled workers, patient capital, and support to promote critical mass in small and medium sized enterprises are all internationally competitive. The implications for UK manufacturing firms and the UK Government are substantial. Some businesses are already adapting and are world class, but many are not positioned to succeed in a future world where greater opportunities will be balanced by greater competition. The UK needs to radically change its approach to providing a constant and consistent framework within which all firms aspire to prosper.

A business-as-usual approach will not deliver that outcome. Other economies are already ahead, and catching up will require an adaptive capacity that the UK has not yet demonstrated. Achieving this is essential, as the future competitiveness and health of UK manufacturing will affect many other parts of the economy through its numerous linkages."

This EPSRC Report demonstrates the pace required to address these issues. It highlights admirably the practical issues. Industry cannot and does not lie still. We all have to solve today's problems and condition ourselves to grabbing tomorrow's opportunities. It is clear that sustainability in all its forms must be embraced as an opportunity rather than passively allowing it to become a burden both to individual firms and to whole nations. The Report demonstrates that the EPSRC Centre for Industrial Sustainability has positioned itself at the heart of this movement, uncovering new knowledge and technology to apply in helping industry. Throughout this Report are examples of the new ideas that may become regarded as normal in just a few years; ideas that keep industry at the heart of a modern economy rather than it being marginalised. It is also wonderful to learn about how the many young people involved that are staying close to industry while tackling big problems, ranging from making todays industry rapidly more efficient in using scarce resources to finding new value creating logic that helps deliver system change. The work of the Centre offers hope for a positive industrial future that can be successful and sustainable over the long term. Future generations depend on this.

Sir Richard Lapthorne, CBE
Chairman, Cable and Wireless Communications PLC
Chairman, Project Lead Expert Group, Foresight Future of Manufacturing

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Executive summary

2013-14 has been the year in which the Centre has moved into a more consistent and effective mode of operation which I like to think of as the “drumbeat”.

Sustain Value, the first of our main Grand Challenge projects has concluded very successfully with a range of Tools, Quick Guides and Cases studies. Many of these have been taken up by industry and our distribution partners starting to use and build upon them in interesting ways. All of our other major projects are well underway as are most of our PhD’s; and as a result we are seeing other interesting tools and guides emerging with increasing regularity – these tools are our primary drumbeat.

The 2013 annual conference was very well received. There was a constant buzz of debate and discussion driven from both the challenging speakers and the range and quality of research on show.

Our mid term review ran in March and we have set up 5 action teams to ensure that the valuable advice and insights that the reviewers provided can be incorporated into the future operation of the Centre. There was a strong message that the Centres work is vital for the UK economy and society and that we should look to significantly expand the size and scope of our work to be a more inclusive UK National Centre.

As part of our “course and correction” approach we carried out a review of strategy in November. This review gathered input from all of our stakeholders and looked hard at our performance to date. We identified that in quantitative terms we were broadly in alignment with the top level objectives we set out in our initial proposal. However, the more detailed shape of our revenues, resources, activities was often quite different as certain activities bloomed while others did not take root.

Based on our internal strategy review and the external mid term review it is clear that the Centre has built a strong foundation of good research, good researchers and great partners. Over the next year we will be accelerating our impact – helping industry, building leaders, informing policy and disseminating our new knowledge – as well as reaching out to other researchers across the UK.

As the year has ended we have embarked on our plans for growing the Centre and our impact, and ensuring that the Centre has the momentum, funding and structure to take it through 2020. I can see exciting new research challenges emerging from our roundtable event last June. These, together with opportunities for new developments in education and training, knowledge exchange, dissemination and policy influence, are all being pulled by our industry partnerships and collaborations and signal another exciting 12 months ahead of us.

Professor Steve Evans
Centre Director, University of Cambridge

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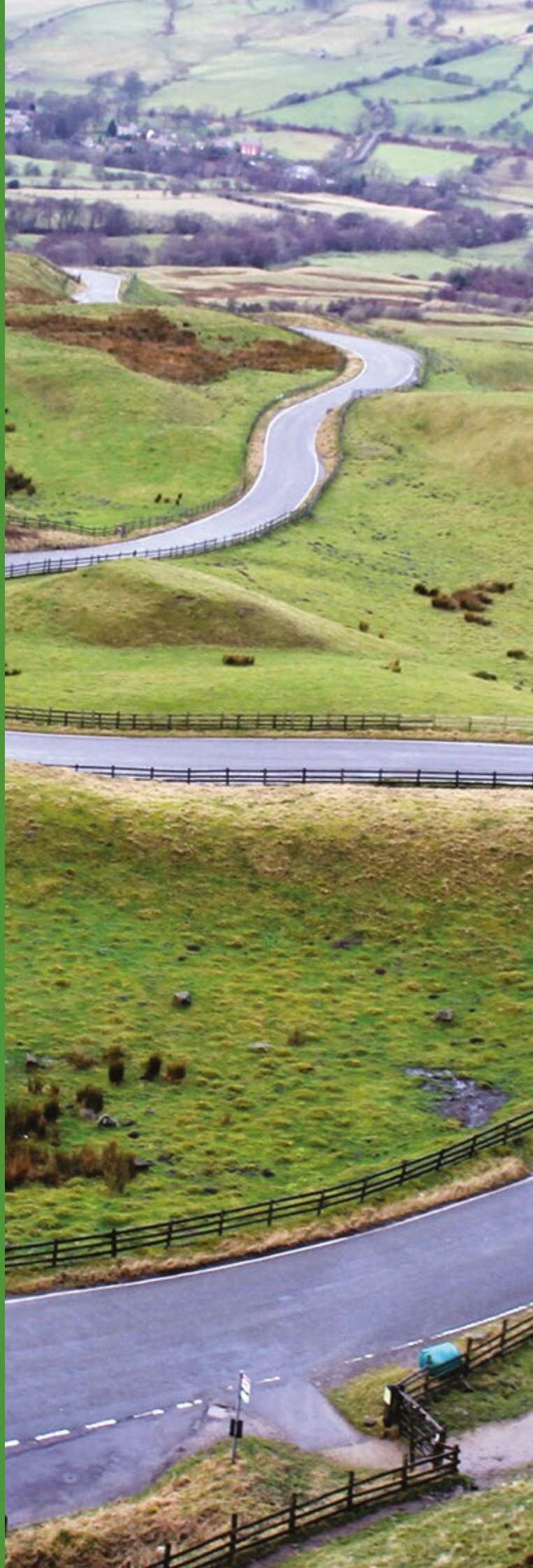
Challenge and vision

"The work of the Centre offers hope for a positive industrial future that can be successful and sustainable over the long term. Future generations depend on this."

Sir Richard Lapthorne, CBE
Chairman, Cable and Wireless Communications PLC
Chairman, Project Lead Expert Group,
Foresight Future of Manufacturing



Welcome to our Annual Report for 2014. The EPSRC Centre for Industrial Sustainability conducts research that helps move industry to a sustainable future. A sustainable future is one which delivers shared and long-term success economically, environmentally and socially.

Industry is often perceived as a key part of environmental and social problems but our research shows a different path, a path where technology, management and policy combine to build a healthy and thriving future. Industry is a key player in the use and flow of energy, water and resources and holds great competence in co-ordination of people, money, machines and materials and in the use of technology at scale. Industry is increasingly seeing itself as a major part of the transformation of our wider systems toward sustainability.

The Centre is lucky enough to work with some of the companies who lead the way in this thinking, which ensures that our research is at the leading edge of practice. But we are equally interested in the challenge of bringing the bulk of industry into this transformation – where we add greater value while using less energy, water and materials. These are sensible goals for all industry and our research and the tools we build are already helping leading edge manufacturers and those who are new to the subject.

We do research into how manufacturers can improve now (and with limited budget), we try to build the tools and technologies that industry will need over the next 10 years, and we study the future shape of sustainable making. This 3 part research agenda is based on our view that all our research should be both practical and systemic – having a route to practice while understanding that all manufacturing occurs within a complex system. We aim to improve industrial practice, to create future leaders and to inform policy. This report provides examples of research and cases where that research delivers into practice, people and policy. In our third year of operation we have been busy turning our research into tools and using them, and you can read about some of that later.

It has been a busy, exciting year.
We have also observed some significant changes, with ever more companies and organisations setting out to become more sustainable in their making, with a deeply nuanced understanding of industrial sustainability being shown by our leading companies, and with a significantly increased understanding of the inter-connection between industry and sustainability in the policy process. The debate has moved on from viewing sustainability as a challenge to sustainability as an opportunity.

We have had to follow this fundamental shift by re-visiting our research agenda – through an internal strategy review, through a mid-term review of the Centre by a leading international panel and through convening a Roundtable of leading thinkers in industrial sustainability. We will soon reveal the new research agenda that is emerging from this, but to take one example, the importance of an innovative value creation logic (or 'new business models') has become increasingly apparent and we can already demonstrate that increasing importance from industry through our multiple new projects in this field.

The Centre had key roles to play in the UK Governments Foresight exercise, setting out a vision for manufacturing in 2050. Sustainability, and many associated topics such as resilience, on-shoring and resource efficiency, are prominent in the report which is now informing the detail policy process. The Foresight report also started a number of debates across the UK (and wider) which is bringing a better understanding of industrial sustainability to many who had not taken it seriously.

The report offers up some of our successes – just read the case study or the tools sections – but others must be left out for brevity, or occasionally for confidentiality. That broad success is complemented by many individual successes- in winning lectureships or promotions, in best paper awards, in the increasing requests we get to bring our insights to new audiences.

Our Centre continues to grow – new researchers have arrived from around the world, new manufacturers have joined the Centre as members, new projects have started with new collaborators, and ever more academics are increasing the importance of sustainability in their own research and joining in conversations and activities with the Centre.

Our next challenge is to embrace the evolving subject and increasing attention, to learn how to utilise the widening and deepening subject interest from industry and academia, and to increase the depth and speed of progress in helping the UK move to a sustainable industrial system.

UNIVERSITY OF CAMBRIDGE Cranfield UNIVERSITY Imperial College London Loughborough University

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Leadership team

Professor Steve Evans
Centre Director, University of Cambridge

Professor Evans has a 23 year record of research and leadership in Industrial Sustainability. This spans the launch of the first UK Masters in sustainable design to the leadership of this Centre. He has worked with many leading businesses such as Jaguar-Landover, Toyota, Airbus Industries, Unilever and is instrumental in the creation and development of many ground breaking SME's such as Riversimple & Vitsoe. In the field of Government policy Evans has been an expert contributor in several Parliamentary Inquiries, the recent Future of Manufacturing Report, and several UN reports on Industrial Strategy.

High level group

Barry Sheerman MP
Chair
Member of Parliament for Huddersfield

Prof Adisa Azapagic
University of Manchester

Dr Stephan Biller
Chief Scientist for Advanced Manufacturing
GE Global Research

Andrew Buckley
Membership & Marketing Director
EEF

Paul Calver
Global Value Chain Specialist
UK Trade and Investment

Andrew Churchill
Managing Director
JJ Churchill, Ltd

Prof Steve Evans
Centre Director
University of Cambridge

Steven Fawkes
Founder and Principal
EnergyPro Ltd

Richard Miller
Head of Sustainability
Technology Strategy Board

Tim Page
Senior Policy Officer
Trades Union Congress

Lynva Russell
Board Member and former Chief Exec
Policy Connect

Prof Günther Seliger
TUBerlin

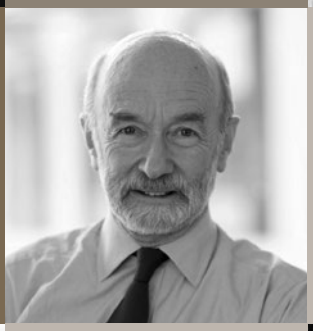
Ian Bamford
Secretary
Commercial Director
Centre for Industrial Sustainability

Executive group

Dr Jorge Arinez
Group Manager
Manufacturing Systems R&D
General Motors

Dr Peter Ball
Co-Investigator
Cranfield University

Ian Bamford
Commercial Director
Centre for Industrial Sustainability



Professor Sir Mike Gregory
Co-Investigator
University of Cambridge

Steve Hope
General Manager
Environmental Affairs and Corporate Citizenship
Toyota Motor Europe

Dr Derek Pedley
Associate Director for Business Development
Knowledge Transfer Network

Professor Shahin Rahimifard
Deputy Director and Co-Investigator
Loughborough University

Hugo Spowers
Company Architect and Technical Director
Riversimple Ltd.

Dr Mike Tennant
Co-Investigator
Imperial College London

Roy Willey
Environmental Care Manager
Unilever

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Research projects in practice

Research projects are the foundation of Centre activity, delivering the new understanding and insight that can solve real-life problems. The research projects are all different – ranging from 20+ man-years to single PhDs, from recycling technology to policy, from near-term to long-term in focus. Our flagship programmes – the Grand Challenge Projects are typically staffed by a combination of the Centre leadership, lead researchers, and doctoral researchers. The doctoral researches will typically be associated with one or more grand challenge projects and also pursue an independent but related research theme. Please dip into this great mix by reading the brief introductions below and seeking out the named contacts, who love to talk about their research and love to help people.

Automated robotic disassembly

The car industry is facing a large challenge as new legislation is forcing more stringent rules on end-of-life (EOL) vehicle recycling.

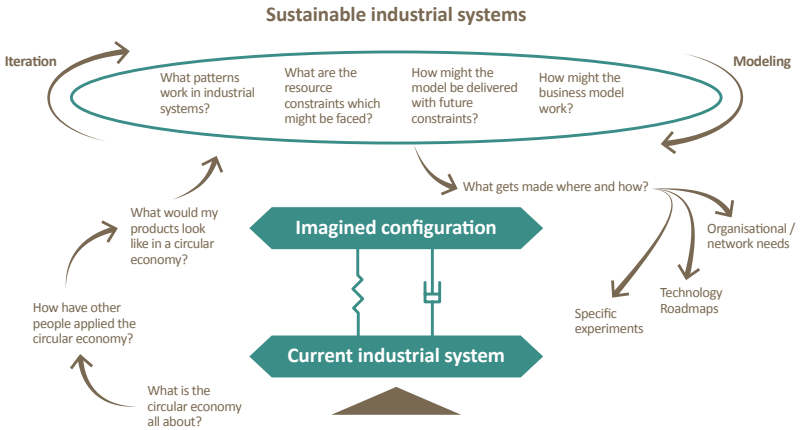
Hybrid vehicles present a much greater challenge compared to traditional vehicles as most of the EOL value is contained within precious metals and strategically important materials. As such, the goal of this project is to expand the capability of current recycling procedures to deal with EOL hybrid vehicles, and to explore platforms for the design and recycling of our future electric vehicles. The automated robotic disassembly project has been approached in a 3 stage methodology 1) manual, non-destructive disassembly, 2) automated semi-destructive disassembly, and 3) validation and optimisation. Stage 1 has been completed with the results informing the strategies implemented during stage 2. Stage 2 is currently ongoing focusing on tool development, tool capabilities, component fixturing design and assessment of optimal component orientation for dismantling with several successful disassembly procedures being developed. Further work will focus on stage 3 where validation and optimisation of the stage 2 disassembly procedures will be carried out. If you are interested in engaging with this project please contact Dr Michael Barwood (M.Barwood@lboro.ac.uk or smart@lboro.ac.uk).

Configurations for Sustainable Industrial Systems

We are seeking to understand the challenges of planning manufacturing for an uncertain and increasingly volatile future.

The aim of this research is to develop knowledge and tools that will help manufacturers, and those interested in manufacturing, explore how manufacturing might be configured in the future and how they can actively prepare for those challenges today. From understanding the ideas behind the circular economy and how they might be applied, to considering the future constraints and systemic enablers, we identify what manufacturers will need to be good at in order to deliver a more sustainable and prosperous future.

We seek to make the knowledge developed by the researchers accessible to practitioners. If you are interested in how your firm could be engaging with the future of manufacturing, please contact the project leader Dr Dai Morgan (dcm32@cam.ac.uk).



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BUSINESS MODELS

Business Models for Sustainable Industrial Systems

Business Models for Sustainable Industrial Systems is a three-year project funded by the EPSRC which kicked off on 1 July 2014.

The project is looking to advance the research and practice on business model innovations that support industrial sustainability with partners Toyota and Riversimple. The aim of the project is to develop a novel way of helping companies find and visualise opportunities for business model innovations that result in more sustainable businesses. Agent-based modelling techniques will be applied to unravel complex behavioural characteristics and contexts that have the potential to disrupt the current business model. If your organisation is interested in experimenting with new more sustainable business models please contact the lead researcher on the project Dr Doroteya Vladimirova (dkv21@cam.ac.uk).

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BUSINESS MODELS

REDRESS

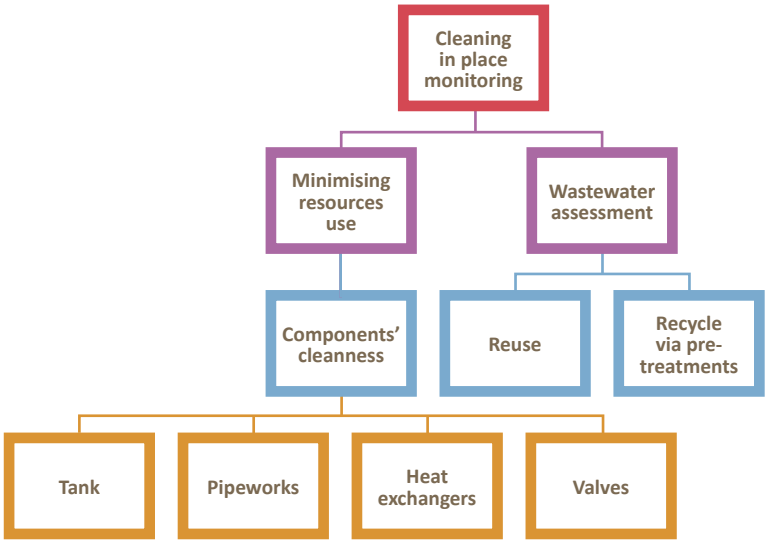
REDRESS is a collaborative project between M&S and Cambridge and funded by the TSB competition 'Supply Chain Innovation Towards A Circular Economy'.

This is a 2-year project to drive garment recovery and retained value through business model and supply chain innovation. This project seeks to accelerate M&S Plan A commitments around reducing waste. The focus for this project will be to reduce the environmental impact of raw materials in M&S' clothing supply chain. The team will apply circular economy thinking to drive greater garment recovery and retained value.
The outcomes of the project can be applied to textile and other industries. To find out more about this project, contact lead researcher Dr Nancy Bocken (nmpb2@cam.ac.uk).

Cleaning-in-place

Cleaning-in-place (CIP) is a widely used technique applied to clean industrial equipment without disassembly. Best practices are currently adopted in order to optimise the process.

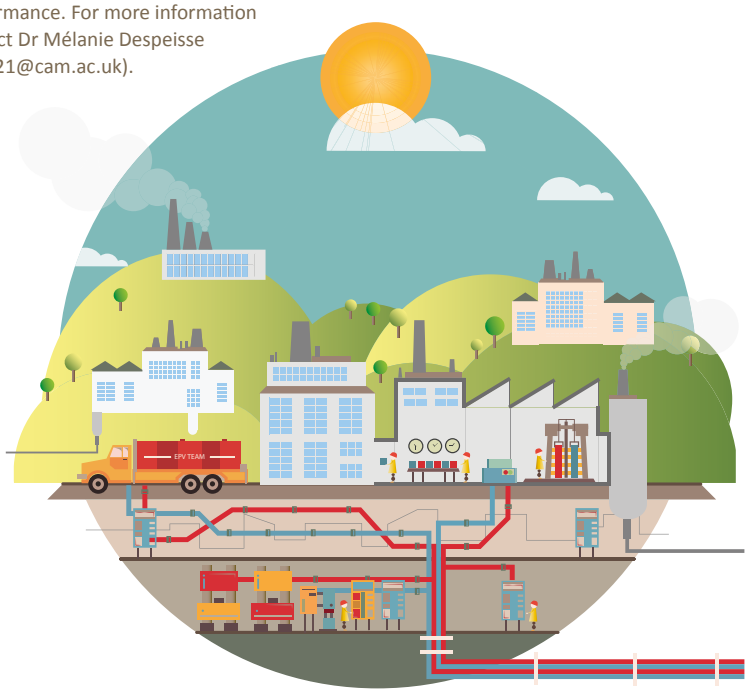
However, the excessive amount of water, energy, time and resources represent a very common issue due to the lack of monitoring tools. In this work an image-based sensor monitoring system was developed in order to minimise energy, water and time utilised in the process. The system is made of an image acquisition system consisting of a camera and the lighting is provided by an UV lamp. The fouling removal detection was carried out by acquiring digital images inside the tank during all the phases of cleaning process. Data and image processing techniques were adopted to retrieve information useful to be fed into an intelligent decision making support system for the automatic cleaning assessment throughout all the stages of cleaning-in-place process. If you are interested in engaging with this project please contact Dr Elliot Woolley (e.b.woolley@lboro.ac.uk).



Environmental Performance Variation (EPV)

A variation of up to 500% in energy, water or waste performance was observed between worst and best performing factories (making similar products with similar technology).

We are uncovering the reasons for this performance variation and using the knowledge to build tools that help manufacturers. The reasons may be technical, managerial or behavioural, and originate from individual, organisational or industrial histories and scales. The EPV project aims to improve the overall sustainability of UK and global manufacturing through the development of a toolkit to help reduce environmental performance variation between factories and elevate (future) factory sustainability performance. For more information contact Dr Mélanie Despeisse (md621@cam.ac.uk).



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RESEARCH PROJECTS IN PRACTICE

Doctoral research projects

How to understand and use ‘circularity’ as a basis for innovation

Fenna Blomsma

This research seeks to understand the influence of perceptions and beliefs on innovation projects aimed at closing material loops and how these shape the direction and outcomes of such projects. The aim is to develop better processes for ‘circularity’ driven innovation projects.

Business models for sustainability informed by ecosystem concepts

Geraldine Brennan

Extending the concept of “loops” or material and energy flows to social systems, this research explores symbolic flows between organizations. An in-depth case study exploring stakeholder relationships within Adnams business ecosystem highlights the impact of organizational dynamics on value creation opportunities.

Exploring ways to develop the sustainable design process: using ‘up-design’ thinking

Jee-Yeon Choi

This research is concerned with design thinking and the associated skills needed to bring ‘up-design’ to practical reality. The aim is to develop a guide for product makers to help them implement design thinking in their development processes.

Factory environmental-performance modelling

Aanand Davé

By developing methods for data composition to simulate factory building, utility and manufacturing assets and resources this research supports progress towards more sustainable factories. The aim is to improve decision-making, focussing on the efficiency of energy, material, and waste resource flows contributing to factory environmental.

Exploring transformation to a sustainable industrial system

Lloyd Fernando

It is not clear what sustainable industrial systems will look like or how they will be delivered. This research develops planning tools for organisations that are beginning to explore what the new shapes of the industrial system may be. It helps users determine relevant variables, and identify key enablers and barriers.

Increasing the resilience of manufacturing to resource shocks (Rare Earths)

Liam Gardner

The aim of this research is to develop a framework for companies to identify the vulnerability of their business to restrictions in resource availability (Primarily Rare Earths), and support the selection and development of REM and risk management strategies to increase the resilience of the business.

Gaining manufacturing flexibility, while improving sustainability through eco-effective changeovers

Ergun Gungor

Changeovers in manufacturing can be costly in economic and environmental terms. This research investigates ways to improve the performance of changeover operations in manufacturing by capturing a range of strategies and tactics while providing the capability to quantify the “true cost” of changeover operations to the company and the environment.

Searching for sustainability-led innovation: reconciling the unintended consequences of conflicting organizational logics

Stefan Hemel

This research explores how distinct organizational logics impact the search for sustainability-led innovations. Using a paradox perspective, the research will aim to identify strategies for reconciliation of paradoxical tensions to help companies resolve social, environmental and economic trade-offs and deliver innovations for sustainability.

Long term planning for sustainable manufacturing using systems thinking

Sotirios Levakos

This research aims to enable manufacturing businesses to contribute to and improve the transition towards sustainable industrial systems. Drawing insights from systems theory and theories of change, a scenario based method is being developed to support long term strategic planning in manufacturing businesses.

Energy and resource efficiency in production facilities

Lampros Litos

Case studies on energy and resource efficiency in factories reveal wide opportunities for improvement that go beyond technical solutions. To better understand and control the underlying conditions, this research maps and characterizes the practices and techniques that affect environmental performance in production facilities.

Reducing the environmental impact of wind turbine blades

Jacky Liu

How can the environmental impact of wind turbine blades be reduced? This research will identify strategies that have the potential to improve the energy consumption, material consumption and CO2 emissions of turbine blade manufacturing processes. Transportation, installation, operation and end of life processes will also be investigated.

Sustainable life cycle management

Ioannis Mastoris

Sustainability is often considered as an add-on dimension of decision-making in organisations. This project is increasing our understanding of how sustainability aspects can be integrated into decision making across the organisation. This helps manufacturers to identify opportunities for improving and ease the processes of integration of sustainability aspects in decision making.

Examining strategic roadmapping in a resource constrained world

Elliott More

This research explores the challenge manufacturing firms face in devising strategy, as resources become ever more constrained. The potential for technology roadmapping to encourage more sustainable strategy development is examined, informed by case studies in both UK and China. The outcome of the research is a revised roadmapping process to help firms face this growing challenge.

Influencing factors for sustainable design implementation in the front-end of new product development process within the Fast-Moving-Consumer-Goods sector

Curie Park

This research examines the factors that influence the successful implementation of sustainable design within the Fast-Moving-Consumer-Goods sector. 11 factors and 32 elements have been identified through investigating the front-end of the new product development process, and a conceptual framework is used to explain the relationship between them.

Diffusion framework – environmental and social sustainability practices across supply chains

Handson Pimenta

This research studies the best practices and conditions for the diffusion of sustainability through a supply chain network. Expected outcomes include a checklist for suppliers to improve their sustainability performance, and a summary that helps the diffusion of sustainability practices.

Practicing doing more with less environmental impact in factories

Simon Roberts

By understanding good practice in factories, this research aims to develop the tools and techniques that foster improvement programmes. Investigating the dynamics of improvement activities, and comparing how teams routinely assess environmental performance in different factories, will uncover how manufacturers are doing more with less environmental impact.

What is the impact of sustainability marketing communications on pro-environmental behaviour change?

Zoe Rowe

This research will identify key characteristics or principles required for successful sustainability marketing communications that aim to encourage pro-environmental behaviour change. Tests will be carried out and findings will aid sustainability professionals implement successful communications to encourage individuals to act in a more environmentally conscious manner.

The effect of language on sustainability performance

Jules Saunderson

Focusing on metaphors used in discussing issues relating to sustainable development, this research is exploring whether different metaphoric frames can be deployed in order to inspire a more positive, proactive and productive conversation.

CO^2 emissions from the cement industry

Daniel Summerbell

This research seeks to examine the main sources of CO^2 emissions from the cement industry and identify opportunities to reduce them. We are now collaborating closely with a local cement manufacturer to perform an in-depth analysis of their factory.

Policy support mechanisms for industrial symbiosis: a comparative study between UK and China

Yuan Tao

This project seeks to understand how policies act as driving mechanisms in promoting industrial symbiosis. Through comparing different policy supportiveness to develop industrial symbiosis between UK and China, this research aims to find out what policy works well under what conditions and what policy does not.

What are the attributes of the individuals who change the status quo of business as usual through radical sustainability-oriented innovation?

Ilka Weißbrod

This research explores key concepts that link the individual and the systemic level, including emergence, sense-making and experimentation. Entrepreneurs and intrapreneurs are at the centre of the research.

Sustainable value creation for servitizing manufacturers

Miying Yang

This research seeks to help servitizing manufacturers create sustainable value. A Sustainable Value Analysis Tool (SVAT) has been developed to identify and analyse the uncaptured value throughout the product life cycle. The tool was used in a number of studies, helping identify patterns of creating value from previously uncaptured sources.

Assessing the environmental impact of single-use medical device disposal

Madeleine Yates

This study explores the environmental impacts of single-use medical device (SUD) disposal and compares the different routes these can take. It demonstrates how disposal behaviours in healthcare settings can affect these environmental impacts and identifies how this information can be used to reduce these.

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RESEARCH PROJECTS IN PRACTICE

Completed doctoral research projects

A framework for the integration of informal waste management sector with the formal sector in developing countries

Dr Maryam Masood

The work is focused on building waste management profiles for two cities in Pakistan i.e. Lahore and Faisalabad. The focus is on exploring and quantifying the role of informal sector in solid waste management in the city of Lahore and possible routes for its integration with the formal waste management sector are assessed. A framework is presented based on possibilities of integration, constraints, public attitudes, relationships and limitations of the process. The methodology adopted is multiple case studies, surveys, focus group discussions and interviews.

Sustainable value creation: alignment of stakeholder interests through business model innovation

Dr Samuel Short

Sustainable Business Models (SBMs) are increasingly suggested as a key to delivering more holistic system-level change, offering the potential to better align the interests of industry with wider stakeholder groups including society and the environment. However, there is still a relatively limited understanding of the potential of SBMs, what they should look like, and how firms might develop new SBMs in practice. This thesis therefore seeks to extend the understanding of how business model innovation might deliver sustainability. A multiple case study approach to theory building is applied to the exploration of emerging exemplars of SBMs, drawing on empirical evidence from fourteen in-depth industrial case studies in the UK and Italy. The findings of this research will be of interest to academic researchers seeking to further develop theory in the areas of business model innovation, value networks, and industrial sustainability, and for practitioners and policymakers seeking to integrate sustainability more fully into industrial systems.

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Sustainable business tools

Tools are at the heart of our impact plan; tools are where 'the wheels hit the road'. Researchers improve our understanding of the current situation and imagine a better future.
That understanding is then carefully turned into pilot tools that we use with our members. After this assisted testing, we re-build the tools so that they can be used as widely as possible.
Tool-building is an additional skill that we demand of our researchers, but it can only be successful if the feedback is honest and rich. Do check these tools out – you may already be using some, or want to use one, and your comments are always welcome.

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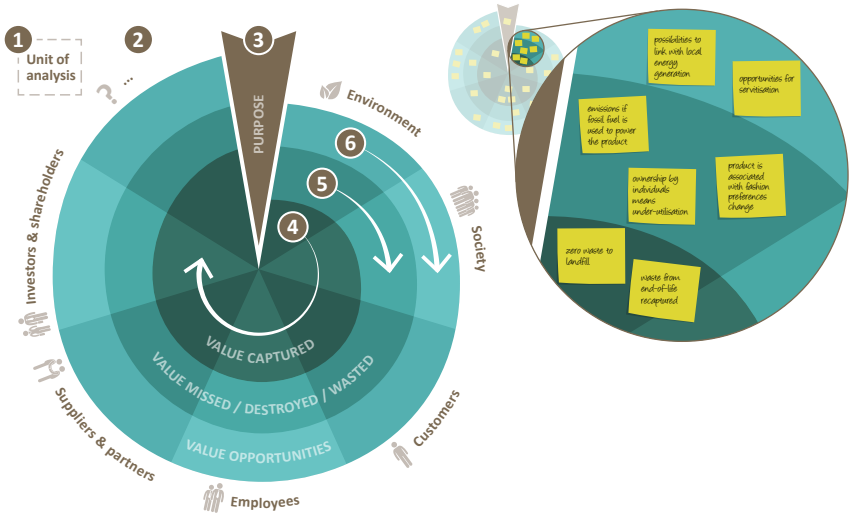
BUSINESS MODELS

Value Mapping Tool

Understanding what kind of value is created, destroyed and/or missed and captured is important for finding areas to innovate and improve businesses and for scoping out opportunities.

The Value Mapping Tool assists in systematically assessing various forms of value (positive and negative) in the business and its network. It adopts a multi-stakeholder perspective, through which value exchanges (financial, infrastructure, social benefits) can be analysed and potential stakeholder conflicts identified for positive value creation in the network. It stimulates innovation and encourages stakeholder collaboration for sustainable value creation. This tool provides a structured and visual approach for academics and practitioners (such as entrepreneurs, business managers, researchers) to understand and create new value propositions that support business model design for sustainability. The value mapping tool has been used in industry (practitioners at start-ups, SMEs, multinationals, PrISMS program) and with academic institutions (teaching material) through 30 workshops with participation ranging from 2 to 50 people.
For more information please contact Dr Padmakshi Rana (pr296@cam.ac.uk) or Dr Doroteya Vladimirova (dkv21@cam.ac.uk)



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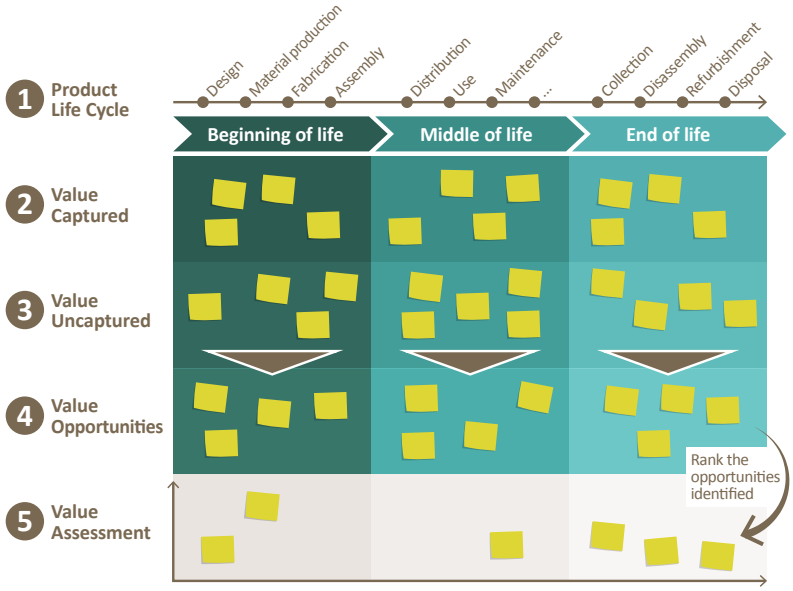
BUSINESS MODELS

Sustainable Value Analysis Tool (SVAT)

Sustainable Value Analysis Tool (SVAT) is designed to help manufacturing companies identify opportunities to create sustainable value by analysing the captured and uncaptured value throughout the entire life cycle of products.

Uncaptured value exists in almost all companies. Some uncaptured value is visible, e.g. waste streams in production, co-products, under-utilised resources, and reusable components of broken products; some is invisible, e.g. over capacity of labour, insufficient use of expertise and knowledge. Reducing any form of the uncaptured value would create sustainable value. However, identifying the uncaptured value and creating value from it is not always easy. The tool supports this process, providing companies with a scheme to systematically look for each form of uncaptured value at the beginning, middle and end of the product life cycle, and with a method to help create sustainable value from the identified uncaptured value. During its development, the SVAT has been used and well received in 15 manufacturing companies across various sectors and of various sizes. It has helped them find opportunities to create value and helped companies to discover the potential of a collaboration to create mutual value. Contact doctoral researcher Miying Yang (my306@cam.ac.uk) to find out how you could use SVAT to find opportunities to create value in your business.



Sustainable business model archetypes and the Business Model Innovation Grid

Sustainable business model archetypes are groupings of mechanisms and solutions that contribute to building up the business model for sustainability.

The archetypes were developed based on collaborative research as part of the EU project Sustain Value. The aim is to develop a common language that can be used to accelerate the development of sustainable business models in research and practice.

The sustainable business model archetypes are:

1. Optimise material and energy efficiency
2. Closing resource loops
3. Substitute with renewables and natural processes
4. Deliver functionality rather than ownership
5. Adopt a stewardship role
6. Encourage sufficiency
7. Seek inclusive value creation
8. Re-purpose the business for society/environment

Plan C, a non-profit organisation in Belgium are using the archetypes as part of their future strategy focused on tackling resource scarcity. A blog was developed to introduce the BMIX – a business model innovation grid with a multitude of approaches and 100 real life business cases to inspire businesses to reconceive their businesses and make them future proof. There is an ongoing collaboration with Plan C to use the archetypes and BMIX as part of workshops and source more innovative cases to inspire businesses. For more information contact Dr Nancy Bocken (nmpb2@cam.ac.uk) or visit the Plan-C BMIX website at www.plan-c.eu/bmix/.

Better Models in Business Models - BM²

The BM² tool is being developed to help companies identify opportunities for disruption and innovation.

The BM² tool is being developed to help companies identify opportunities for disruption and innovation of their business models which will lead to more economically, socially and environmentally sustainable businesses. In a 3-year project funded by the EPSRC, we are developing a computer-based tool to help companies identify and visualise opportunities for business model innovations that result in creating and capturing more value in the wider system of the firm. The tool is applying agent-based modelling techniques to unravel complex behavioural characteristics and contexts that have the potential to disrupt and transform the current business model. The purpose of the tool is to identify key leverage points for intervention in the system, and reduce the uncertainty and risk of changing a firm's business model.
If your organisation is looking to experiment with new more sustainable business models please contact Dr Doroteya Vladimirova (dkv21@cam.ac.uk).

Eco-ideation

The eco-ideation tool was developed to facilitate the generation of product and process ideas giving step change reductions in CO2 emissions.

To develop the tool, the features of products and processes, which drive product life cycle carbon emissions, were characterized with a set of indicators. A visual traffic-light tool shows these indicators on a sliding scale between best (''green'') and worst (''red'') conceivable performance. A leading question is linked to each slider to stimulate eco-ideation. The aim of each leading question and slider is to stimulate a separate 'mini-eco-ideation' session. The eco- ideation method consists of the following steps: (1) For each question and slider, envisage current performance (which is often still in the 'red' areas), (2) Generate ideas, which move the slider to the green side (i.e. lowest carbon emissions), (3) List ideas and follow up with an idea selection process. The eco-ideation method is being used by several companies. In particular, it is now part of the early stage venture toolkit used by the ECS PrISMS project at the IfM, University of Cambridge.
To find out more contact Dr Nancy Bocken (nmpb2@cam.ac.uk).

PRODUCT DESIGN	3 **COMPACTING:** How compact is the product? Can the product be sized up or diluted at a later stage of the product life cycle?	Compact / Dense	Medium compactness and density	Outsized / Dilute
	4 **COMPONENTS/ INGREDIENTS:** How energy intensive are components and ingredients? For example, plastic is less energy intensive than steel, and paper is less energy intensive than plastic. Animal-based is more energy intensive than vegetable based, keeping weight and distance travelled equal	Non-energy-intensive	Room for improvement	Energy-intensive
	5 **RAW MATERIAL EFFICIENCY:** How efficiently are raw materials used?	Efficient: Low use and loss. Reusable, Recyclable	Room for improvement	Inefficient: High use/loss. Disposable, Non-Recyclable
	6 **DURABILITY/ EFFECT/ EXPERIENCE:** Is the product durable? Is the effect or experience long-lasting? Can the product be used in a targetted way to fulfil the required functions?	Durable / Long-lasting / Can be used in a targetted way	Medium effect, not very targetted	Short-lifetime / Short-lived effect / Unfocused
	7 **END OF LIFE:** Can the product be entirely used up, or is it endlessly reusable?	0% waste at end of life / Endlessly reusable	Some recycle, repair, disassembly, reuse issues	100% waste / Not reusable, repairable or recyclable
	8 **INTERMEDIATE PACKAGING:** How often is the product repacked throughout the supply chain?	One shelf ready pack	2-3 repackings	4 or more repackings

E

EFFICIENCY

Environmental Performance Variation Toolkit

This EPV Toolkit aims to guide manufacturing companies on the eco-efficiency journey with 5 questions:

1. Can you see waste? Decide to take the journey towards eco-efficiency (shift mindset) and learn to identify waste.
2. How can you remedy it? Find solutions, from quick wins to more advanced tactics for resource efficiency.
3. What's the size of the prize? Understand potential benefits and set targets.
4. Where are you now? Assess your current performance and benchmark yourself.
5. Where to from here? Identify improvements in a systematic way, take action and make it a routine activity.

The toolkit is intended for manufacturers on the first steps of an industrial sustainability journey by seeing waste more clearly. It can be used internally or across supply chains. The toolkit contains a range of tools and methods to guide you through this journey and integrate eco-efficiency in day-to-day activities in a practical (and entertaining!) manner. It will help you understand what eco-efficiency means for your company, give examples of best practices, and help you to implement them in your own factory. For more information contact Dr Melanie Despeisse (md621@cam.ac.uk).

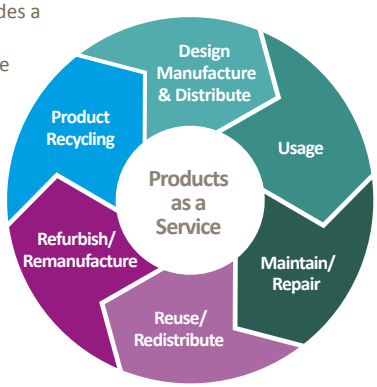
C

CIRCULARITY

Circulareconomy toolkit.org

The traditional linear take-make-dispose supply chain is placing pressure on our resources and material costs.

In a more 'circular' economy, materials are continuously reused to minimise resource depletion. With a vast number of possibilities for creating value out of the Circular Economy, it can be challenging to assess all the options. Building on literature, industry surveys and case examples, a Circular Economy Toolkit was developed to assist companies in their move to a circular economy. The website includes benefits, guidelines, examples and key challenges. It includes a 5-minute opportunity assessment tool and the materials to run your own workshop. The website has been accessed by people in over 75 countries. The toolkit was developed on the ISMM course at IfM, University of Cambridge in 2013 by Jamie Evans and supervised by Dr Nancy Bocken. The toolkit will continue to run and develop going forward. At present a collaborative project has started with WRAP to develop the toolkit further, and expand its content and usage. For more information contact Dr Nancy Bocken (nmpb2@cam.ac.uk). www.circulareconomytoolkit.org/



CircularEconomy Toolkit
Resources for an Evolving World

C

CIRCULARITY

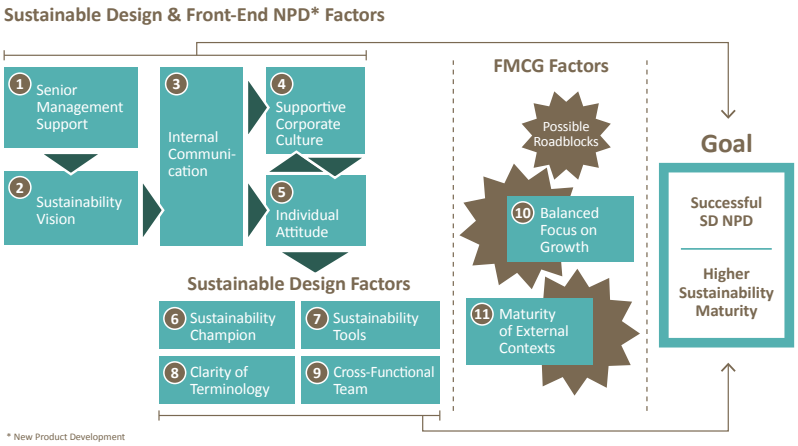
Circularity Thinking Toolbox

A multitude of collections of principles have sprung up around the ideas of 'closing loops' and 'waste = food' over the last 15 years, such as Circular Economy (EMF, 2012), Blue Economy (Pauli, 2010) and Cradle to Cradle (McDonough and Braungart, 2002). However, these collections put forward different interpretations of 'circularity' and have distinct underlying assumptions and departure points, making it difficult to determine what 'going circular' means for your business. The Centre's 'Circularity Thinking' toolbox can help with this: tools unpack different forms of circularity, give an overview of the implications of various ways of organising it and finally zoom in on how to develop strategies for implementing circularity within your production processes, co- and by product generation and/or on the level of components and products. For more information contact doctoral researchers Fenna Blomsma (f.blomsma12@imperial.ac.uk) or Geraldine Brennan (geraldine.brennan09@imperial.ac.uk).

Relationship of FMCG sustainable design influencing factors framework

This conceptual framework explains the relationship of 11 factors that inter-relatedly influence the successful implementation of sustainable design at the front-end of new product development process within the fast-moving-consumer-goods (FMCG) sector.

This framework explains which factors should precede others, how some factors are reinforcing. The framework also presents two potential roadblocks that may fundamentally inhibit the entire practice. The roadblocks are particularly conspicuous within the FMCG industry, where its principal orientation is on consumers' needs. This framework guides FMCG industry practitioners with steps to follow in order to be more successful in implementing sustainable design, and to achieve higher sustainability maturity level. For more information contact Curie Park (c.park@cranfield.ac.uk).

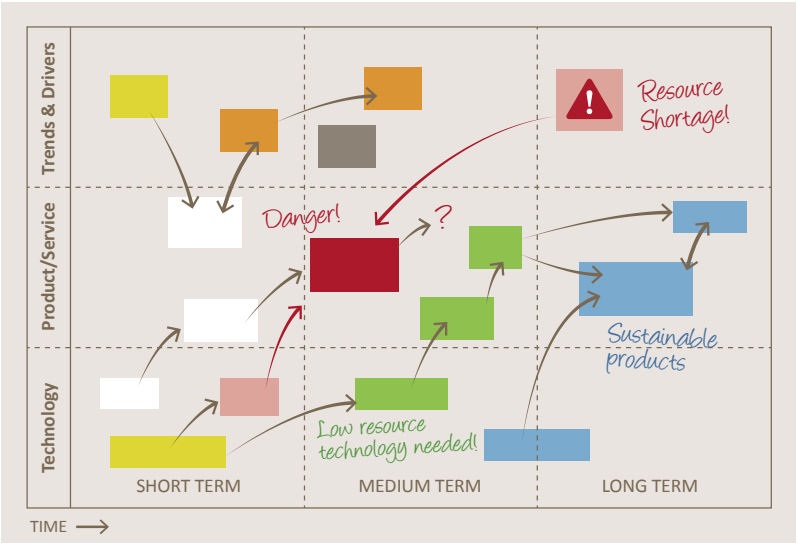


Resource aware roadmapping

Technology roadmapping is a strategic planning tool used widely in the manufacturing sector for aligning commercial and technology functions in firms.

Developed in the 1970s by Motorola, technology roadmapping was developed when firms faced different challenges to the present resource constrained world. As such, this research has focused on identifying how the tool can be updated to help firms recognise and manage the impact of future resource constraints on their business.

The revised tool guides participants through a series of simple activities to help them recognise how the availability of vital resources will impact their current product lines. The simple visual structure of the roadmap encourages participants to recognise how future resource shortages will place particular product lines at risk, encouraging them to reconsider their strategic vision. This could involve investing in alternative or low-resource technologies. In essence, the tool helps manufacturing firms devise more sustainable business strategy for a resource-constrained world. Contact Elliott More (egm27@cam.ac.uk) for queries and the chance to pilot the tool in your firm.



FoM

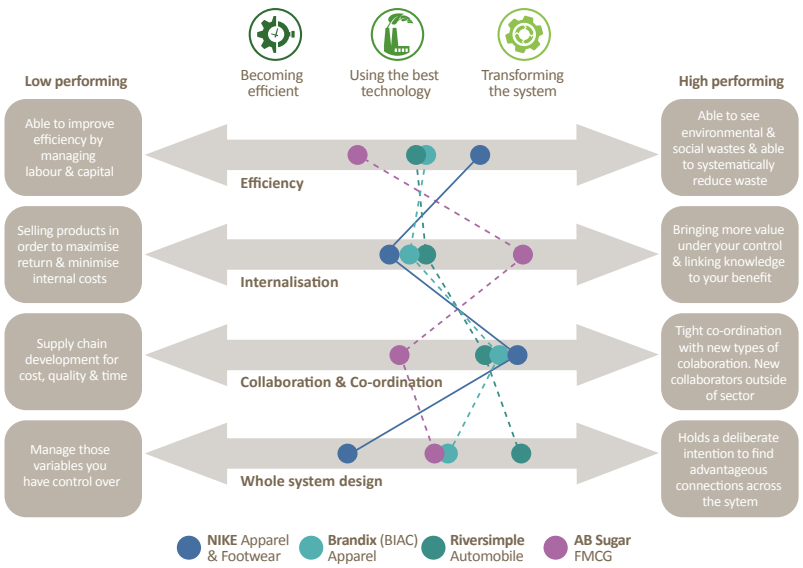
FUTURE OF MANUFACTURING

Systems Mapping and Capability Assessment Toolkit

The toolkit supports businesses and individuals in exploring possible future industrial systems and identifying priorities and actions that can be taken to move towards sustainable industrial systems.

Systems mapping provides a structured approach to planning and exploring the transition to future industrial systems. Through a participatory process, the tool helps develop a collective understanding of the current system, explore possible future configurations and identify what needs to change about the current system to enable progress. Capability assessment then helps companies understand what they need to be good at in order to support the transition to a sustainable industrial system. Existing capabilities in efficiency, internalisation, collaboration & coordination, and whole system design are explored and compared with the performance of other organisations. Areas for improvement can then be identified and prioritised. For more information please contact Lloyd Fernando (ldf21@cam.ac.uk) and Steve Evans (se321@cam.ac.uk).

Industrial Sustainability Capability Assessment
Improving the short to long term performance of industry



BT

B USINESS TRANSFORMATION

Transformation to product-service systems

The Transformation tool is being developed to guide companies through the change of a product-centric business model towards a more service-oriented one.

In a 3.5-year study, we found that industry practitioners looking to innovate their firm's business model through the addition of services face a transformation which is multidimensional and resource intensive, and expose the organisation to new risks. Moreover, the transformation permeates beyond the boundaries of the firm into the sphere of its customers and suppliers. The purpose of the Transformation tool is to help reduce the disruption that is currently observed in companies which move from products to product-service systems. The tool will help organisations overcome the challenges and manage their journey towards effective delivery of integrated products and services. The tool has been used with a global sports apparel company to synthesise and structure change management efforts in the organisation. If your company is considering a large scale organisational change or a shift towards a new business model, please contact Dr Doroteya Vladimirova (dkv21@cam.ac.uk).

Tools dissemination and impact

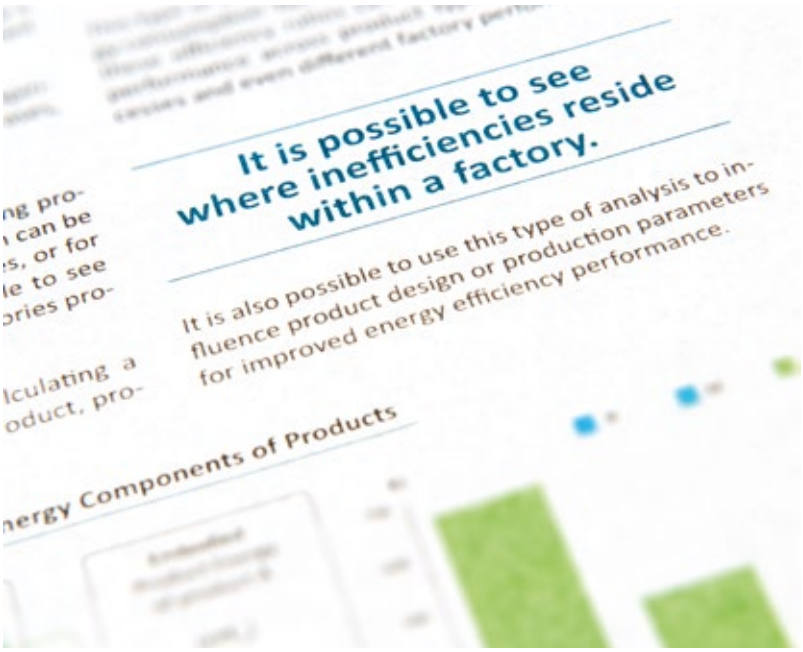
Tools have the capacity for impact, both during the research projects and beyond, through our members and their networks.

We are developing a series of industry focused Quick Guides designed to make the Centre's research outputs accessible to business. Another mechanism that helps disseminate tools and deliver more impact, involves IfM-ECS, a company embedded in the University of Cambridge. IfM-ECS is designed to take research outputs and deliver them into practice – working with SMEs, large companies and governments – through a range of programmes. Their flagship sustainability programme - the PrISMS project - is introduced below.

Quick Guides

'Quick Guides' are a series of Industry guides aimed at taking the ideas, concepts and tools generated by Centre researchers and presenting them in short, straightforward, engaging 2 page documents that allow manufacturers to easily establish if and how an idea could work in their situation. At present there are 16 completed guides with another 6 in production. In all over 40 are identified and planned for production. Completed Quick Guides can be downloaded from the publication page of our website.

If you have any questions or would like further information about Quick Guides please contact Ian Bamford (imb31@cam.ac.uk).



PrISMS

The Practical and Innovative Solutions for Manufacturing Sustainability (PrISMS) programme is a three-year activity which aims to transform the growth prospects of start-ups and SMEs across the Eastern Region – creating and safeguarding jobs, while helping companies make their products and operations more sustainable. Research from Centre projects is fed into the programme to help integrate sustainability considerations into interventions. Already, tools for eco-ideation, value mapping and paingain evaluation have been delivered into companies, with many more interventions planned and tools being developed. The PrISMS programme is delivered by experienced facilitators all of whom have worked in manufacturing at a senior level for many years and have supported hundreds of startups and SMEs.

It is designed to require as little time as possible from the company's management and to ensure that knowledge and skills are transferred to the companies involved, enabling them to build capabilities in key areas of the business. To find out more about participating in the programme contact prisms-enquiries@eng.cam.ac.uk.

ANNUAL REVIEW **2013-14**

Case studies

As an industry oriented research centre we seek to improve real life performance. These case studies are a selection drawn from the many projects we do. They show how research can be used in real life, and how using our research in practice, informs the research and increases our quality of understanding. The variety of case studies is an exciting part of our world, ranging from dis-assembly technology robotics to value creation logic, from batteries to beer. This is only a partial view of our work, if you have a challenge that you think we should be tackling then do tell us – we may already be researching it, or it might inform our future plans.

Beyond material loops: exploring organizational influence and value creation in Adnams' business ecosystem

Established in 1872, Adnams Plc. is an East Anglian regional brewery with a turnover of c. £60 million who directly employ 400 people. They have three distinct but interconnected aspects of their business – a brewery and distillery, pub estate, hotels and retail stores. Adnams are viewed as a pioneer in sustainability having won the Queen's Enterprise Award for Sustainable Development for a second time in 2012 and the Investor in People Gold Award (2012). Since 2007 they have applied industrial ecology concepts "closing-loops" or "circularity" to their production and operation systems. Examples include cycling waste-heat from their brewing process into the next brew, building an eco-distribution centre that requires no mechanical heating or cooling, mitigating the need for energy inputs in the first instance and cycling harvested rainwater back into the local ecosystem via septic tanks and reed beds. They have also set up Adnams BioEnergy Ltd., a joint venture, for a anaerobic digestion plant which uses brewery and food waste from a 25mile radius to produce bio-methane creating energy for other processes (For further information see their case study in (Zokaei et al., 2013).

The Challenge

Whilst closing these material loops has led to significant reductions in Adnams' environmental impact they recognise that the remainder of their impact is beyond their immediate sphere of control and situated in their business ecosystem (Moore, 1993), the system in which they interact with other stakeholders. This has warranted an exploration of their organizational influence and stakeholder dynamics which influence the material flows within their business ecosystem.

An explorative qualitative case study

To gain an understanding of Adnams organizational influence and identify further opportunities for creating environmental, social and financial value with their stakeholders, an in-depth qualitative case study exploring key relationships in their business ecosystem has been developed. This on-going collaboration forms the basis of a PhD project and over the last 18 months data has been collected from 40 interviews relating to 25 external relationships.

Preliminary impact & intended outcomes

Data analysis is currently on-going however the preliminary impact of this project has been the space it has provided both internal and external stakeholders in Adnams' business ecosystem to reflect on their respective relationships. Engaging with a qualitative approach to exploring their business ecosystem has highlighted examples where Adnams' organizational influence has resulted in value creation within their business ecosystem they were unaware of, as well as examples of value creation potential not yet realised with their stakeholders. Furthermore, this approach has created an additional feedback loop between their stakeholders and them. Ultimately the intended outcome of this research is to provide Adnams with an in-depth diagnosis on the current status of the stakeholder relationships explored based on both their internal perspective of these relationships and the respective external stakeholder's perspective.

References:

Moore, J. F. 1993. Predators and Prey: A New Ecology of Competition. *Harvard Business Review*, May-June.
Zokaei, K., Lovins, H., Wood, A., Hines, P. 2013. *Creating a Lean and Green Business System*. CRC Press, USA.

EoLT

Automated robotic disassembly

Toyota is a Japanese automotive manufacturer which has long been recognized as an industry leader in manufacturing and production. Toyota, similar to other automotive manufacturers relies on pre-existing automotive recycling processes to achieve legislative targets; However, as a leading sustainable company, Toyota is continuously exploring alternative recycling and recovery processes and technologies so that they can improve the environmental impact of their vehicles when they reach end-of-life (EOL).

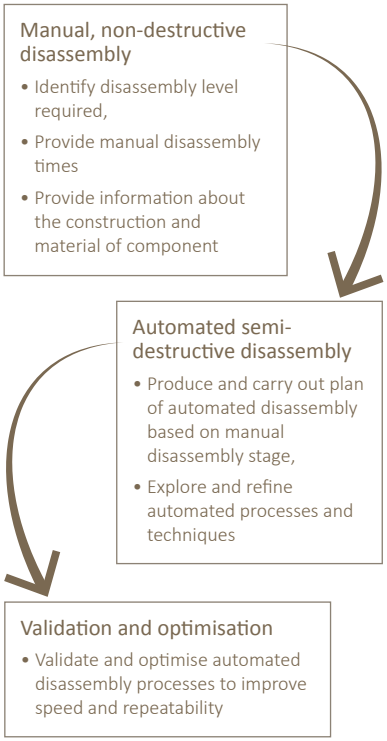


Figure 1: Three stage procedure for automated robotic disassembly of hybrid/ electrical vehicle components

The challenge

Due to large volumes and various sizes of waste, current recycling technologies often rely on fragmentation techniques and processes; this is especially the case with the automotive recycling and recovery industry. These existing processes were developed for recuperating mainly large amounts of ferrous and non-ferrous metals, not taking into consideration the recycling of other Strategic Important Materials (SIM). As the automotive industry has moved to more resource efficient strategies, securing reliable, sustainable and undistorted access to certain raw materials is of growing concern. In order to contribute to its continuous search for raw materials, special focus is given on turning waste into a resource. In order to achieve this future recycling methods and processes need to be adapted to be capable of dealing with the above-mentioned challenges.

Approach

We are exploring the potential use of robots for pre-concentrating SIM from selected automotive components before they enter traditional automotive recycling and recovery processes. This will create greater value recycling streams and improve recyclate quality. The approach has been carried out in three stages, display in Figure 1.

Outcomes

The first stage of manual, non-destructive disassembly has been completed, with a subset of the results displayed in Table 1. For each component the disassembly times were assessed, the material contents were explored, and the levels of disassembly were recorded. This allowed the components to be classified into four categories, 1) Simple, high value, 2) Simple, low value, 3) Complex, high value, and 4) Complex, low value.

Major progress has also been made in the second stage, namely the automated semi-destructive disassembly, based on the first stage results. Using linear robotic algorithms the initial focus has concentrated on the simple, high value components. Currently several trial robotic setups have been designed and implemented to experiment with the various tools and techniques used to dismantle the components e.g. angle of cuts, depth of drilling, angle of drill bit heads, type of cutting blades etc.., with further work continuing.

Component Identifier	Component Description	Key Materials	Approx. Disassembly Time (min)
T01	Powersteering ECU	Au and Ag	25
T02	Engine ECU	Cu and Al	25
T03	A/C unit and ECU	Cu and Al	15 (ECU only)
T04	Driving Support ECU	Au and Ag	15 (ECU only)
T05	Power mgmt ECU	Au and Ag	5
T06	Airbag ECU	Au and Ag	5
T07	Window regulator	REE	30
T08	Radio/GPS	Au and Ag	75
T09	Combi-meter	Au and Ag	55

Table 1: First stage manual, non-destructive disassembly key results

Future work

The future focus in this project will be on development of linear robotic disassembly algorithms for the four component types, before moving onto the 3rd stage, validation and optimisation, which will aim to improve all processes developed in the second stage. The future work will also include the investigation of new methods to further separate valuable materials (e.g. SIM) from waste through specially designed post-fragmentation technologies (e.g. novel air classification processes and solid dense media separation).

Sustainable value analysis: from 'selling gas generators' to 'selling gases'

A traditional air separation unit (also called gas generators) manufacturing company located in China, has in recent years been shifting its main business from making and selling gas generators to 'selling gases'. Selling gases creates a continuous income stream whereas selling a gas generator usually entails a one-time payment. The business which employs around 3000 people has successfully established 27 gas sub-companies in China since 2010.

The challenge

The transformation extends the manufacturer's business from only making and selling machines to also producing and selling gases by using their own machines. When undertaking such a transformation, value uncaptured can be left in the product life cycle. Some of the value uncaptured is visible, e.g. waste streams in production, co-products, under-utilised resources; and some is invisible, e.g. over capacity of labour, or service. We helped the manufacturer to identify the hidden uncaptured value in the life cycle and finds ways to create sustainable value from it.

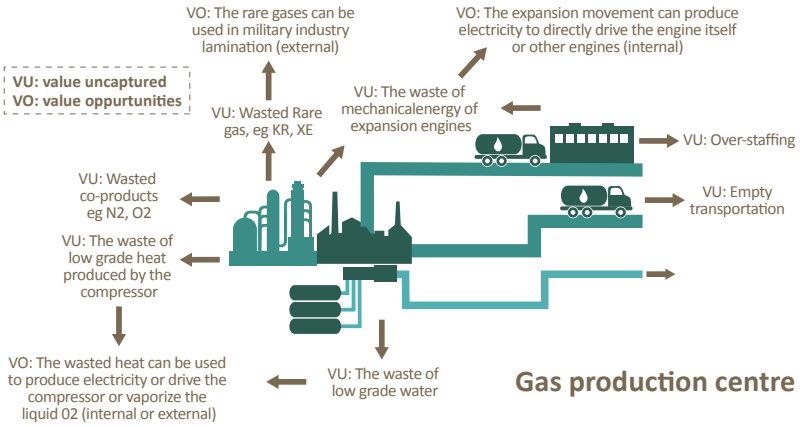
Approach and process

We used the Sustainable Value Analysis Tool (SVAT) with managers and designers from the manufacturer in order to identify the opportunities of creating sustainable value. The first step was to specify the life cycle of air separation units under the business model of 'selling gases' and then to describe the current value captured in each stage of life cycle. Then, the potential value that has not been captured previously (i.e. value uncaptured) is identified in each stage of life cycle. Finally, the identified value uncaptured is analysed and opportunities for sustainable value creation are explored.

This process was facilitated with step-by-step guidance and inspiring examples provide by the SVAT. The life cycle thinking, and the consideration of economic, social and environmental sustainability were naturally embedded into the process.

Outcomes

The manufacturer developed a better understanding of both positive and negative aspects of the current business model, and gained a systematic picture of the business relationship with stakeholders along the entire life cycle. Using SVAT, the manufacturer successfully identified some value uncaptured and the opportunities for creating sustainable value from it as shown in the diagram below.



Wider lessons

Value uncaptured (e.g. waste) exists in almost all companies, especially in servitizing companies. The identification of value uncaptured is difficult because they are usually invisible and hidden. The SVAT provides a systematic way to look for different forms of value uncaptured in each stage of life cycle: value missed, value destroyed, value surplus, value absence. Several patterns of creating value from value uncaptured can be summarised to guide future use of SVAT. For example, matching value absence and value surplus, reducing value destroyed and missed, internal value creation and external value creation.

BM

BUSINESS MODELS

Generating sustainable business solutions

Elcon Solutions Oy of Paimo, Finland develops, markets and produces uninterrupted AC and DC power systems, customised DC power supplies, DC/DC converters, custom tailored electronics and wireless solutions, while importing components for green power systems. The company's main focus is on solutions for energy and industrial plants.
Their battery back-up systems are necessary for guaranteeing the 24/7 operation of critical devices. Battery backed up DC power supply system solutions are being used in many power plants and stations, substations, and many other locations including e.g. uninterrupted power supply of process automation.

The challenge

Elcon was looking at exploring potential business models and understanding the impact of their business activities to help deliver social, environmental and economic benefits. Their participation in the Sustain Value project provided access to tools designed or identified for generating sustainable solutions, which resulted in their extensive involvement in the use of the tools for generating opportunities to change their business.

Approach

Sustainable business modelling tools developed in the Sustain Value project and two tools that already exist were used with Elcon to assist their business modelling approach. The tools were used for exploring the service model for Elcon – such as new offerings in monitoring facilities and equipment, new revenue streams through lease, and revenue through reuse, and configuring the new value proposition with the potential new business model.

Outcomes

The team at Elcon developed a new understanding about sustainable business models and assessment of sustainability of their own products through the application of the sustainable business modelling tools. Based on this information there has been concrete operational arrangements and also changes in ways to think about and discuss the sustainability of products. The use of the various tools resulted in following:

- Broaden thinking and formalise ideas and pathways for the new offering
- Revaluation of the existing business – vision, corporate strategy
- Generating cross organisational views and change, while encouraging openness amongst employees
- The positive impact of using shared infrastructure and resources for improving communication of production and delivery stages and being cost effective

Recommendations

The implementation of the new business model also brings new challenges to Elcon's every-day operations. In order to respond to its value proposition, operational arrangements were made and new requirements for product development were identified. In this case operational changes were accomplished by networking with another manufacturing company. In this new setting Elcon's responsibilities are in operations related to sales, services, product and service design and development while their partner is responsible for the manufacturing of the products.

Wider lessons

The development and implementation of sustainable business models is a temporal process made up of a series of incremental activities building progressively towards a more completely integrated solution. It requires a long term vision and redesigning business models for sustainability. Assisting companies in understanding the true scope of the impact of their activities on a broad range of stakeholders and identifying possible pathways to change is only part of the challenge.

New methodology for sustainable industrial development in ASEAN countries

The United Nations Industrial Development Organisations (UNIDO) is the agency of the United Nations that promotes industrial development for poverty reduction, inclusive globalization and environmental sustainability. As part of UNIDOs work the Centre was asked to help build a tool for policy makers in developing countries that would help them to select which specific industrial sectors to locate there, but to analyse this in such a way that industrial development also maximised environmental and social development. The main objective of this project is to provide policy recommendations to the Association of Southeast Asian Nations (ASEAN) governing body as part of their Green Growth plan to facilitate the pursuit of a long-term sustainable development path.

The challenge

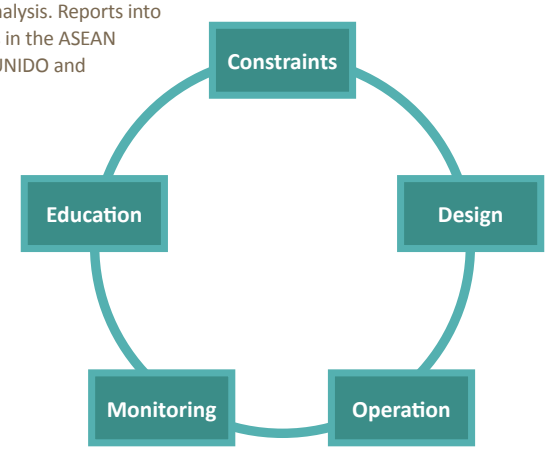
Many economies are undertaking the challenge to grow their industrial sectors and thereby improve the quality of life of the people, while still taking into account long term societal and environmental needs. Which sectors have the potential to increase the national economy without causing environmental and societal issues? The answer to this question requires a consideration of local strengths and constraints, a countries competitive position globally and the performance characteristics of the sectors under consideration. To date, approaches have focused on the economic dimension of industrial development. New methods are needed to assess industrial development options more comprehensively.

Approach and process

Building on an existing UNIDO approach, methodologies were developed to independently conduct analysis of the economic, environmental and social aspects of an industrial subsector. A method to combine the two analyses was devised in order to derive appropriate policy recommendations for green growth. The technique aimed to identify not only the negative constraints on economic growth, but also areas of national or sectoral strength where natural capacity or resources could be safely exploited.

Outcomes

The method was applied in the context of ASEAN region countries. The scarcity of data regarding economic, environmental and societal impacts necessitated a largely qualitative approach to the analysis. Reports into chemical and metal industries in the ASEAN region were developed with UNIDO and are publically available.



Recommendations

In the absence of extensive data sets – robust and transparent qualitative methods are required in order to support industrial policy development which better account for environmental and social factors. It is envisaged that government officials, primarily from the ministry of industry or the environment, will use the method developed. The complexity of the method has been necessarily limited to encourage early adoption and so extended use is recommended to build up the repository of existing data available to the policy maker, and to highlight areas in which data needs to be developed. In this way policy making capacity can be increased.

Wider lessons

While improved data collection is a core part of monitoring and managing a nation's health and wealth, alternative methods are needed in order to support and improve industrial policy development until data repositories develop sufficiently. Qualitative indicators will never be perfect proxies of what they intend to measure, however they can provide a solid foundation for inter-country analyses, when drawing from carefully selected and properly contextualised data. For example, when considering industrial policy it is important to recognise the interconnectedness of sectors, rather than taking a narrow and isolated view of sectors impacts.

Factory environmental performance variation analysis

A European high-volume consumer goods manufacturer with net sales of over and 7.3 billion and more than 70,000 employees, is committed to continuously monitoring and reducing their environmental impact. To help them achieve their goals the manufacturer has been working with Centre researchers to find new ways to improve their environmental performance.

The challenge

The manufacturer aims to improve their environmental performance with a 20% reduction in their CO2 footprint across their manufacturing supply chain by 2015. This includes implementing resource efficiency measures for energy, materials and waste within company owned factories. Corrective action requires cognizant, conscientious employees cooperating with energy-minded leaders to identify areas of waste and suggest conservation practices. “We know from life cycle assessment that energy use in our factories is a major source of CO2 emissions – focus on the factory system’s use of energy resources is therefore a logical priority.” - Head of Zero Waste Programme at the manufacturer (2013).

Approach

An array of factory facility, utility and manufacturing asset data has been collected with the goal of comparing energy efficiency to identify potential savings across 6 of their factories. Specific analysis targets include a comparison of ‘power factors’ (the ratio of the real power that is used to do work and the apparent power that is supplied) to identify energy consumption patterns, the use of a power factor correction tool to suggest potential savings, and a detailed comparison of selected high-energy consuming factories from data gathered hourly for the duration of a year. Process data for the 6 factories was composed (figure 1) to define a credible data set, then used to measure and compare power factors (figure 2), and detailed factory environmental performance.

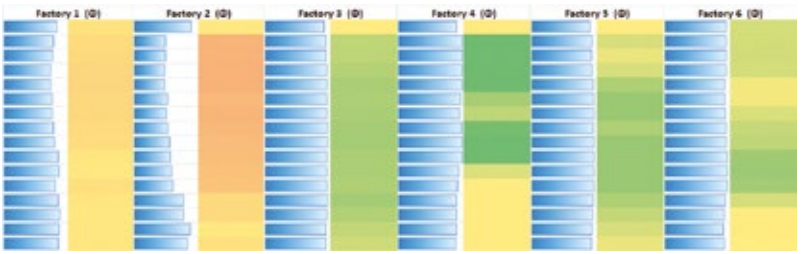


Figure 1. Sample of composed measurements used for analysis

Outcomes

Data composition identified patterns in electricity, gas and water consumption.
A comparison of electrical power factors (figure 2) across factories shows factory 6 to be the most energy efficient, operating at an mean power factor 0.96 Φ, well above the target of >0.9 Φ. Regular monitoring and measurement against this specified target is helping the manufacturer to mitigate against energy losses and avoid financial penalties from electricity suppliers. However, Factory 5 has a mean power factor of 0.46 Φ. This low mean indicates that a more detailed study, is required. Additionally, a comparison across the factories highlights a performance variation of 50%.

			[P] 33.33%	[P] 29.59%		[Q] 54.31%	[Q] 45.69%	
Date	Time	Active Energy (P) [kW]	Process 1	Process 2	Reactive Energy (Q) [kVA]	Transformers	Motors & Coils	Power Factor (Φ)
01/07/2013	00:00:00	1612.80	48.38	112.90	886.40	70.91	44.32	0.88
01/07/2013	01:00:00	1915.20	57.46	134.06	885.60	70.85	44.28	0.91
01/07/2013	02:00:00	1944.00	58.32	136.08	915.20	73.22	45.76	0.90
01/07/2013	03:00:00	1985.60	59.57	138.99	983.20	78.66	49.16	0.90
01/07/2013	04:00:00	1953.60	58.61	136.75	1019.20	81.54	50.96	0.89
01/07/2013	05:00:00	2036.00	61.08	142.52	1144.80	91.58	57.24	0.87
01/07/2013	06:00:00	3515.20	105.46	246.06	1810.40	144.83	90.52	0.89

Figure 2. Sample of Power factor analysis, highlighting time-step and operational efficiency

Recommendations

Power factor analysis for each factory has shown that operating efficiency improvements can result in corrections of up to 105kVA in reactive energy for the largest producer.
The estimated net reduction in CO2 is equivalent to 62,800Kgs per annum. To reduce on-going costs, improve environmental performance and help meet CO2 targets specified, the manufacturer could do the following:

- Consult with its supplier to make corrective changes in system capacitance.
- Sites could change to low-loss transformers with a typical payback period is 18-28th months.
- Work motors, pumps and compressors at lower speeds, in order to minimise electrical power consumption. Installation of Variable Speed Drives on high-energy consumers such as building HVAC systems and energy intensive equipment (e.g. motors) can provide better control, performance and reduce energy consumption.

Wider lessons

Top-down analysis can be a helpful way of revealing high-energy consumers and patterns when comparing multi-level assets and resources across factories. In addition, The analysis of power factors (an often forgotten energy variable) is a useful indicator to potential energy saving opportunities.

Cutting energy use and costs at a Cambridgeshire SME

Photofabrication (www.photofab.co.uk) is a specialist photochemical machining company that employs around 50 people and produces intricately shaped metal components. Services include chemical etching, plating, laser cutting and metal stamping. Its operations range from prototype to production in aerospace, automotive, communications, defence, life sciences, medical and security. IfM ECS worked with the firm through the part ERDF-funded PrISMS programme which is supported by the Centre for Industrial Sustainability. PrISMS aims to transform the growth prospects of manufacturing start-ups and SMEs in the East of England by helping firms grow revenues and profitability, make products and operations more sustainable, and create and safeguard jobs. Read more information on the PrISMS program in the Sustainable Business Tools section of this report.

PHOTOFABRICATION
Component Chemical Etching, Precisely.

The challenge

The company wanted to explore the potential to cut their energy bill by: reducing energy use for the etching tanks; reducing lighting bills; moving away from using compressed air; and implementing a formalised energy management policy.

Approach

IfM ECS and Ecopare, a company that specialises in practical energy management solutions for businesses, worked with Photofabrication to create an energy use report that identified potential savings. Energy use was then monitored to assess the savings made.
Actions included:

- Etching tanks: rebalancing the weekly start-up cycle for more efficient heating of the tanks; reducing liquid in the tanks to reduce energy consumption; replacing heater elements to bring tanks to the required temperature more quickly; lagging tanks to reduce heat loss
- Lighting: a new lighting strategy was introduced
- Compressed air use: exploring more efficient processes
- Formalised environmental management systems: potential adoption of ISO14001 standard.

Outcomes

Implementation of energy-saving measures is expected to save the firm around £30,000 a year. Measures include: eliminating the need to heat the etching tanks; reducing lighting bills by about 60% with the introduction of LEDs; and, purchasing a new compressor resulting in a recurring energy savings of £8,000 per annum (the capital cost was recovered in eight months). As a result of all these actions, the power consumption per sheet etched has fallen from 12.5 kWh to 8.4 kWh in the last 12 months – this is an improvement of 32.7%.
In addition, water usage has become more efficient, including using recycled water, and a large investment in effluent treatment means a reduction in metals (nickel, copper, chromium and zinc) in the discharge from 7 part per million to just trace elements. Crucially, all of these improvements can be sustained or enhanced.

Recommendations

Additional energy savings could be realised with continuous electrical consumption monitoring via a dashboard/portal which would allow for a programme of continuous optimisation of energy. Further energy savings could potentially be achieved by reusing waste heat from existing processes or adding a combined heat and power system which could produce 'free heat' to further reduce the electricity bill by up to 30%.

Wider lessons

IfM ECS helped Photofabrication establish strategic priorities for the medium term; ensured senior management's direction was focused; prioritised issues and created action plans.
The firm is reducing its lead time to offer a 3-day premium turn-around to all customers, it has set targets for key performance indicators and runs quarterly projects to achieve them, and it has invested in improving staff development, customer service and new processes.
Paul Rea, operations director, says: "We have worked closely with IfM ECS and we see the benefits. It allows us to tap into resources we don't have, to see things in a different way and to make decisions on that basis."

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Policy

The shift to a sustainable industrial system can only happen at a system level that includes governments and policies. Our research both informs policy-making and actively studies the policy-making process. This research ranges from UK policy-making within a mature industrial structure to policy-making in newly industrialising countries with much less mature industrial and policy-making systems. This section highlights some of the main policy projects which the Centre has been involved in.

Next Manufacturing Revolution

The launch of the NMR report into non-labour resource productivity last July has been a catalyst for businesses and policy makers to engage with the opportunities it identified for improvements in the UK economy. It was the first report to explain environmental performance in an accessible language of non-labour resource productivity providing strong evidence for a critical productivity gap in the UK. There has been activity with businesses such as Nestle and Kyocera, policy inputs such as the Conservative parties report on 2020 Productivity and Efficiency and sectoral work commencing with the Food and beverage sector. The value of this work is reflected in the commendation for NMR in the 2degrees Sustainability Champions Awards in June. Other authors and influential commentators have frequently referenced the original report.
Dr Greg Lavery CEO of Lavery Pennel commented, “The NMR’s fact-based approach combined with extensive outreach plan seems to be at the forefront of a new wave of sustainability communications based on transparency and engagement.” For more www.nextmanufacturingrevolution.org.

Foresight

In October 2013, the Government Office of Science published the Future of Manufacturing Foresight report, looking at the future of manufacturing between now and 2050. With evidence collected from industry workgroups, international workshops and freshly commissioned evidence from leading academics, the report is the largest and most extensively researched pieces of work on the future of manufacturing in recent times.

The Centre had a strong influencing hand in the development of the report - Prof Sir Mike Gregory acted as a reviewer, whilst Dr Mike Tennant lead the key evidence paper on sustainability and manufacturing, with support from Dr Nancy Bocken, Geraldine Brennan and Dr Dai Morgan. Prof Steve Evans had the most prominent role, being part of the lead expert group that commissioned the research papers, attended workshops and sifted through the evidence to write the report.

The main findings of the report suggest that manufacturing will become faster, more responsive and closer to the customer, exposed to new markets, staffed by increasingly skilled workers and of course, more sustainable. Whilst it was not surprising that sustainability was one of the key themes, the consistent global consensus amongst leading manufacturing nations such as the US, Germany and Japan that sustainability was one of the most important shaping forces was striking.
To find out more you can download the full report and evidence papers from the government office of science website and/or contact Steve Evans (se321@cam.ac.uk) or Mike Tennant (m.tennant@imperial.ac.uk).

UNIDO

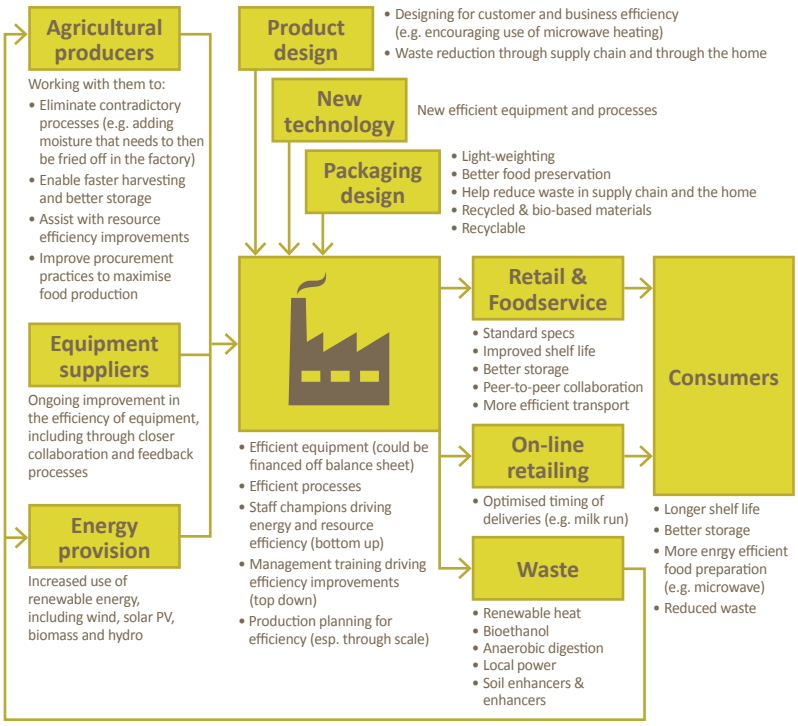
This research developed an integrated methodology for measuring economic, environment and social dimensions of manufacturing industries in the countries of the ASEAN region. After creating an initial methodology, five countries were visited (Thailand, Indonesia, Malaysia, Philippines and Vietnam) to interview government officials, industry leaders, NGOs and local people to understand their current situations. Quantitative data was collected from the national statistics office and other relevant authorities. From this research, we developed a new policy frame leading to national strategies for manufacturing industry based on the measurement of economic, social and environment dimensions and suggested a new integrated methodology for assessing economic, social and environmental changes. For more information contact Dr Jae-Hwan Park (jhp37@cam.ac.uk).

UN ESCAP

This research developed alternative policies for industry's role in integrated energy and water management in Ulaanbaatar, the capital city of Mongolia. Desk research was combined with a visit to Mongolia to interview central and local government officials, industry experts and local people to understand their opinions, positions and concerns. Focusing on the demand aspects of energy and water, we developed new policy recommendations based on two manufacturing industries (textile and construction) demonstrating how to improve the energy and water efficiency of Ulaanbaatar city by innovating on the demand side. For more information contact Dr Jae-Hwan Park (jhp37@cam.ac.uk).

Resource Efficiency Road-mapping

Understanding the future direction and challenges of moving to sustainable operation is a challenge for key sectors of the UK economy. The Centre in conjunction with NMR started a program to build roadmaps to understand what these are and how they might be overcome. Food and Beverage was the first sector in early 2014, with Automotive, Apparel and Aerospace planned for late 2014 and early 2015. The first event drew 25 high-level participants from industry, government and academia.
The concluding report identified 4 major areas for attention; Energy Efficiency, Production Waste, Transport Efficiency and Packaging Optimisation.
The participants identified 6 key enablers (all are examined in detail in the report at www.nextmanufacturingrevolution.org). These include: Collaboration along the supply chain; Learning how to make more compelling business cases; Including resource efficiency as part of integrated design of production processes; products; packaging and distribution; Improved and expanded CEO leadership. Fifteen actions were agreed which 5 groups took away to build upon. For more information contact Ian Bamford (imb31@cam.ac.uk).



2023 Vison for Waste, Energy and Transport Efficiency in the Food and Beverage Sector

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Cohort development program

None of this happens without people. We are particularly proud of the quality of our team – both the researchers and the back-office supports – but we do not rest on this.

We work hard to offer individual support and development paths for researchers, and the success is clear with researchers from across the UK, and indeed the globe, clamouring to join the programme! Having built a strong base the next year will see us further increase our capacity and our ability to bring in other UK researchers.

During the first gathering of the Centre it was discussed that one version of success would be that if in 5 years, the current Centre staff were re-applying for their jobs against the new recruits, we would struggle to get in – such was the quality of those who we had taken on in the Centre. In March, members of the cohort were heavily involved in the Centre Mid Term Review, with the cohort reps past and present sharing their experience of the Centre and many of the cohort also involved when the projects were scrutinised. The review committee complimented the integration across the various institutions and the quality of the individual researchers. At the halfway point, therefore, the quality of the researchers recruited and involved in the Centre cohort programme is looking very strong.

The events this year have ranged from tool workshops, to discussion groups on the role of the private sectors in industrial sustainability, to how research can be done most effectively, and how to get your story across to different audiences.
Tools are a core part of how the centre delivers impact through projects, and so the cohort year started early with a session on tools and how they are developed – how they can be part of a PhD in data collection and contribute to solving industrial problems. With sessions from tools developers, and those who deliver tools into industry, there was also a chance to get first-hand experience with home grown tools as well as those from further afield.

The annual cohort retreat in Losehill saw its largest ever attendance with almost 50 people from the UK and Europe joining to learn from each other, reflect on their progress individually and plan for the future. Sessions were run on routes to academia and industry, pitching and communicating ideas as well as pop-up sessions on subjects as varied as systems modelling and schools outreach activities. The week culminated with an extended session between members and the cohort sharing knowledge and experiences

During a busy spring period the cohort has a chance to further flex their communication muscles with a 20 strong group engaging in a discussion around the role of the private sector in sustainability. Finally, Claire Wyatt, an actress and sustainability communications professional, ran a session which aimed to help the cohort find ways to tell stories, in a compelling way, so they can engage others better and help their ideas become more impactful.

Members of the cohort continue to play a central role in projects, developing their own research and contributing to activities across the Centre and beyond including playing a key role in developing and curating quick guides and designing outreach activities.
The cohort development programme is there to support research students from across the Centre institutions and beyond and welcomes members from across the research community. We look forward to welcoming PhD researchers who will join our cohort programme from the new EPSRC Centre for Doctoral Training (DTC) in Sustainable Materials and Manufacturing. This new DTC under the direction of the Universities of Cranfield, Exeter and Warwick will be recruiting Research Engineers to start the new Engineering Doctorate programme in October 2014. If you would like to join the cohort please contact the programme coordinator Dr Dai Morgan (dcm32@cam.ac.uk).

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Outreach

Communicating the Centre's research and policy outputs to industry, academia, and the public is another key part of our activity. This includes events such as our Annual Conference, Sustainability Road-mapping workshops, and Sustainability Roundtable series, as well as materials such as our Quick Guide series, quarterly newsletters, website and much more. We seek out opportunities to communicate with and look for areas for collaboration with other organisations - a recent visit of Centre researchers to the Stockholm Resilience Centre and a visit by academics from the University of Malaya are examples of this, as well regular visitors to the Centre from other institutions who stay anywhere from 2-months to a year.
A few activities from this past year are highlighted below.

Outreach to industry and the sustainability community

Annual conference

The Centre held its 2nd Annual Conference, 'Integrating Industrial Sustainability', at Magdelene College, Cambridge in September 2013. The two day event included keynote talks from Dr John Ehrenfeld, author of 'Sustainability by Design' and 'Flourishing', and Peter Price Thomas, Senior Associate and former CEO of the Natural Step. Over 120 delegates from around the world attended the conference representing industry and academia. Talks from the conference can be viewed from the Centre's website. The 3rd Annual Conference on 16-17 September 2014, 'Delivering Impact – knowledge into action', will focus on research outputs from the Centre including an exhibition of Sustainable Business Tools and conceptual models developed by Centre researchers. Speakers from Toyota, Airbus, General Motors, M&S and others will join Keynote speakers Hugo Spowers of Riversimple and Dr Heinz Leuenberger of UNIDO for a stimulating conference emphasizing tools and solutions for industry designed to create impact.

Member meetings

Centre industrial members were invited to join Centre researchers for the last day of the Cohort Retreat in January. Researchers listened to very interesting presentations by industrial partners Riversimple and Extremis and by the ESKTN on what is currently happening within their businesses and organisations and, where we could help. Riversimple then spent a very productive afternoon meeting and discussing ideas with researchers and this has led to a number of follow up discussions which are already influencing

their thinking, while new member Extremis Technology, left with a stream of potential projects to conduct with the Centre which led Operations Director Andrew Gowan to say, “When I retire, this will be one of those days that I look back on as a game changer”.

Industrial members gathered again for an All Stakeholders meeting in May 2014 which also included members of the Executive and High Level Groups as well as Centre researchers and staff. Attendees were invited to review the Mid-term Review recommendation reports and implementation plans and contribute to them.

First Industrial Sustainability Roundtable

The beginning of June saw the successful completion of the 1st Industrial Sustainability Roundtable. Hosted by the Centre for Industrial Sustainability, the roundtable series seeks to engage thought leaders in strategic issues within the field of industrial sustainability. This first roundtable was set up to gather the latest thinking on industrial sustainability to assess the research priorities for the decade ahead. This gathering brought together select leaders from academic, industry and related organisations from Australia, China, Europe and USA together for an intensive discussion of the future agenda on industrial sustainability. 2020 is a key date in many industrial, academic and government communications but this event sought to explore well beyond that date. A white paper is currently being developed by the group with the expectation of a discussion draft available in the autumn.

Sustainability Road-mapping Workshop

In January the Centre organised, sponsored and participated in a UK Food and Beverage Industry Sustainability Road-mapping Workshop through the Next Manufacturing Revolution (NMR). The workshop brought together leading companies, industry associations, relevant government departments and subject matter experts to discuss resource efficiency barriers and enablers in the UK Food and Beverage Industry. Outcomes from the workshop are published in the report ‘Food and Beverage Sector Non-Labour Resource Efficiency: Unlocking Cost Savings, Jobs and Environmental Improvements’ on the NMR website www.nextmanufacturingrevolution.org. Similar road-mapping workshop in other sectors will take place in late 2014 and 2015.

Sustainability and Manufacturing Summer Workshop

Twenty PhD and Masters students from the Graduate School of Management of Technology at Hanyang University in Korea attended the Centre’s first ‘Sustainability and Manufacturing’ Summer Workshop at the Institute for Manufacturing in Cambridge in June 2014. The 5-day workshop included lectures on Industrial Sustainability from a Systems Perspective, Sustainable Business Models, Open Innovation, Nantechnology, Laser Technology, International Supply Management as well as many other topics. ‘I am very pleased that I can have some idea how I can connect what I have learnt in the class to real industry problems..... not only from an environmental perspective, but also economic and social aspects’, said one student after attending the workshop. Hangyang does not currently offer a course in sustainable manufacturing but hopes to extend its research theme into sustainability. They are eager to establish a long term relationship with the Centre and the IfM as they move towards developing this research theme and hope the Summer Workshop will be a regular event. For more information on the Centre’s summer workshop programme please contact Dr Jae-Hwan Park (jhp37@cam.ac.uk).

Outreach to the wider public

Cambridge Science Festival

Staff from the Centre for Industrial Sustainability entertained children and young people with their ‘Sustainability Games’ during the Cambridge Science Festival at the Institute for Manufacturing in March 2014. The Games included an interactive online activity and quiz and hands-on puzzle as well as a ‘community space’ where children could try our word search, crossword, and colouring sheet, read a book about sustainability or just sit and have a break from the crowds!

Online presence

The Centre has grown its online presence with new sections of the website including publication of our Quick Guide series, conference presentations, and academic publications. An online quarterly newsletter was introduced in November and has been well received. A YouTube channel was also created during the autumn of 2012. There are currently ten video presentations available for viewing and another 6 will be added in September 2014.

Recent publications
since September 2013

Journal Papers

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Bocken, N., Rana, P., Short, S. 2014. *Using the value mapping tool for sustainable business thinking. International Conference on Sustainable Design and Manufacturing, 28-30 April 2014, Cardiff, Wales, UK*

Chertow, M., Bocken, N. 2014. *Industrial Symbiosis as a Sustainable Business Model: theoretical and empirical findings. Resilience 2014, 4-8 May 2014, Montpelier, France.*

Davé A., Ball, P.B., 2013. *Factory Modelling: Data Guidance for Analysing Production, Utility and Building Architecture Systems. Proceedings of the 11th International Conference on Manufacturing Research (ICMR2013), September 2013, Cranfield, UK.*

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Sustain Value Reports

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Our people

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