Tools are at the heart of our impact plan and tool-building is an additional skill that we demand of our researchers. Our research outputs are 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. Read more about some of our tools below.

Factory Resource and Energy Efficiency (FREE) toolkit

The FREE toolkit guides manufacturers through their eco-efficiency journey with simple tools and games which are engaging and easy to use as they require little (if any) data to get started.

This helps overcome the first barriers to implementation and gain momentum for more advanced activities. The toolkit helps identify improvements, strengths and weaknesses through examples of good practices and sustainable manufacturing models, assess current practice maturity (qualitative) and develop performance indicators (quantitative).

The FREE toolkit also provides a strong framework on which companies can develop their own approach to eco-efficiency: as companies understand how eco-efficiency fits into their operations, they can customise their use of the FREE toolkit to match their specific needs. It can be used internally or across supply chains.

The tools are mapped against five key elements for eco-efficiency:

1) See waste. What is your waste worth? Learn to identify waste in your factory.
2) Find solutions. How can you remedy it? Quick wins to more advanced tactics for resource efficiency.
3) Set targets. What’s the size of the prize? Determine potential benefits and set targets.
4) Assess yourself. Where are you now? Establish current performance and benchmarking.
5) Create good habits. Where to from here? Identify improvements in a systematic way, and make it a routine activity.

For more information contact Dr Mélanie Despeisse, md621@cam.ac.uk.
Factory Eco-efficiency Modelling (FEEM) Framework

As progress is made in eco-efficiency, further advances become more challenging.

An expansion of scope, integrating resources across functional boundaries of manufacturing, utilities and facilities assets, is necessary to accommodate further efficiency opportunities. This can be achieved with the FEEM framework, an operational resource modelling framework for managing assets and making informed decisions as well as an aid in practical implementation and paybacks.

The framework is used to analyse asset resource consumption and improve operational eco-efficiency from the factory site boundary to machine processes. Each subdivision of the framework considers assets at greater detail by progressively modelling finer data granularities. All model subdivisions focus on the dynamic behaviour of system inputs, outputs, controllers and losses to show asset eco-efficiency, based upon resource magnitude and time-step granularity factors. Framework models provide users with the ability to compose, model and analyse the eco-efficiency of their factory assets within and across available data granularities. To date the FEEM framework has been successfully trialled with 7 companies from different industry sectors.

For more information contact doctoral researcher Aanand Davé, a.dave@cranfield.ac.uk.

The Capability Assessment Grid for Eco-efficiency (CAGE)

The capability assessment grid for eco-efficiency (CAGE) is a maturity-based framework that describes how manufacturing systems evolve towards achieving sustainability goals such as eco-efficiency.

The grid develops visualisations about the maturity of manufacturing practices in factories and potentially generates recommendations for improvements at various organizational levels. As a tool it can be used in various industrial settings and help practitioners break down and convert complex sustainability challenges into manageable work-packages for wider workforce engagement. In more detail, as a management tool it can be used to reduce variability of perceptions about environmental performance and help practitioners develop a common language about eco-efficiency improvement projects. The tool has been trialled with industry at many levels, either in peer-to-peer workshops with environmental managers from various companies or with practitioners from industries with multi-site manufacturing configuration (i.e. aerospace) or single-site process facilities (construction materials). The graph demonstrates how maturity of practice (vertical axis) guides improvements in eco-efficiency (curve turns green). The two aspects of eco-efficiency (i.e. economic performance and environmental performance) become equally important in decision making at high-maturity levels.

For more information on CAGE contact doctoral researcher Lampros Litos, ll443@cam.ac.uk.

Energy Efficiency Card Game

This tool uses a card game format to engage staff in varied roles in eco-efficiency activities and enable them learn about good practices for energy saving improvements in a factory environment.

As well as highlighting how energy can be saved, it also highlights the potential barriers to change and how they can be overcome. The game has been piloted with Airbus SAS at their factory in Broughton. It was played with 4 different groups of Airbus staff and the feedback provided positive support for the value of the game and some insight into how it might be adapted to suit specific manufacturing scenarios. If you would like to find out more about the game and how it might be applied in your business please contact Dr Mélanie Despeisse, md621@cam.ac.uk.
Designing Ubiquitous Sustainability into Product Design Processes

A framework has been developed to help companies embed sustainability considerations within their established product development processes.

This is achieved through a systematic investigative method that can be used to assess existing design practices and identify both the critical features of the business and products that need to be improved, as well as any available opportunities already used within the design processes that can be employed to readily, and efficiently include consideration of sustainability.

By using this framework a company can therefore identify targeted and customised opportunities for improvement of sustainable design, expand understanding of their processes and products, and evolve towards a situation in the future where sustainability considerations are an embedded part of their design process – towards ‘Ubiquitous Sustainability’ in design.

For more information contact Dr Leila Sheldrick, L.Sheldrick@lboro.ac.uk.

Framework of Relationship of FMCG Sustainable Design Factors

The conceptual framework explains the iterative relationship of 11 factors that 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 shows what factors precede others, how factors reinforce the others. It 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. The framework guides FMCG practitioners with steps to follow in order to diagnose their sustainable design implementation practice and to develop more holistic sustainability strategy in a long-term view.

For more information contact Dr Curie Park, curieous@gmail.com.
Material Flow Assessment in Manufacturing (MFAM) Framework

The MFAM framework is used as a basis for investigation of the material efficiency in the manufacture of products.

The assessment of material efficiency is based on the objectives of using less material processing to produce a unit product, to improve production yield, and to reduce the environmental impact of material processing. The framework uses a combined quantitative and qualitative approach to give structure to the investigation of complex systems, with the aim of uncovering innovative opportunities for improvement. The framework consists of five distinct phases: 1) production system scope, 2) material flow inventory, 3) material flow assessment, 4) improvement scenario modeling, and 5) interpretation. These phases are largely interdependent, with phases 1–4 following a largely sequential but potentially iterative progression. The fifth phase meanwhile runs in parallel with the other phases as an iterative and reflective mechanism, interpreting the results and applying suitable decision-making process. MFAM has been used to improve material flow and resource efficiency at a Unilever factory.

For more information please contact Dr Oliver Gould, O.J.Gould@lboro.ac.uk.

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**Phase 1: Production system scope**
- Define production system function
- Define production system boundary and processes within
- Define products being manufactured within system

**Phase 2: Material flow inventory**
- Determine and characterise required materials for products that are manufactured
- Define material flow - inputs and outputs to each connecting process unit within the system
- Establish qualitative and quantitative consequences of processes (transformation, transport and storage) on material flow

**Phase 3: Material flow assessment**
- Determine appropriate definitions of material efficiency relevant to system
- Measure performance of material flow efficiency

**Phase 4: Improvement strategy model**
- Address point sources of inefficiency
- Determine alternative production scenarios
- Dynamic modelling of alternative scenarios

**Phase 5: Interpretation**
Sustainable Business Models Suite: Transforming businesses to deliver uncaptured and sustainable value

Is your business getting the full benefit of the value you are creating for customers and other stakeholders? Could your current business model be actively destroying value for others, ultimately affecting the organisation’s ability to capture value in the long run? Answers to these questions and more are explored using three powerful innovation tools which make up the Sustainable Business Models Suite: Cambridge Value Mapping Tool, Sustainable Value Analysis Tool, and Business Transformation Tool. Together these tools enable new perspectives on value forms - missed, destroyed, surplus and absence and provide a structured approach to discover failed value exchanges among stakeholders and an organised method for implementing sustainable change in a business. The Sustainable Business Model Suite is used through workshops to help practitioners who want to gain a more complete understanding of the economic, social, and environmental value created by a business, and to explore opportunities for transforming the current business model towards a more sustainable one. The tools can be adapted to the size and complexity of the business from new start-ups to established multinationals. More information on the individual tools can be found in this section of the report.

For more information please contact Dr Doroteya Vladimirova, dkv21@cam.ac.uk.

Business Transformation Tool

The Business Transformation Tool has been developed to support a business in turning a new value opportunity into a new business model.

It helps design change programmes to implement business model innovations and develop action plans. The tool provides a structured approach to understanding and managing complex multi-dimensional change and long-term sustainable business transformation. The tool has been used in workshops with 16 companies.

For more information please contact Dr Doroteya Vladimirova (dkv21@cam.ac.uk).

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 SustainValue. The aim is to develop a common language that can be used to accelerate the development of sustainable business models in research and practice. 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 http://www.plan-c.eu/bmix/.
The Sustainable Value Analysis Tool

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 kind 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 value uncaptured (i.e. value surplus, value absence, value destroyed and value missed) at the beginning, middle and end of the product life cycle, and with a method to turn the identified value uncaptured into value opportunities. The SVAT has been well received in 25 manufacturing companies across various sectors and of various sizes. It helped them find opportunities to create value internally and to discover the potential of creating mutual value externally. The tool has also been used for other purposes such as research, consultancy, business education and university education.

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.

Better Models in Business Models - BM²

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 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, dlv21@cam.ac.uk.
The Cambridge Value Mapping Tool

The Cambridge Value Mapping Tool has been developed to elicit failed value exchanges among multiple stakeholders in the network of the firm and uncover new value opportunities through a structured and visual approach.

Sustainability-oriented innovation: The search for variety in hybrid organizational forms

Sustainability-oriented innovation (SOI) involves a search for variety-creating opportunities in hybrid organizational forms which share potentially conflicting logics - that is, between public, non-profit and for-profit partners.

SOI does this by identifying responses to tensions that arise in such engagements. This tool provides a systematic approach for appraising opportunities in searching for sustainability-oriented innovations. It adopts a multi-stakeholder perspective, through which the exchange of value can be analysed and potential stakeholder conflicts identified to create positive value in the network. It provides a new perspective for practitioners to understand and create new economic, social, and environmental value from their business. The Cambridge Value Mapping Tool has been used in industry through a multitude of group workshops or in-house bespoke workshops. The tool is also used as teaching material at the University of Cambridge other academic institutions.

For more information please contact Prof Steve Evans, se321@cam.ac.uk.

SUSTAINABLE BUSINESS TOOLS

Systems and Innovation

Sustainability-oriented innovation: The search for variety in hybrid organizational forms

The tool assists in systematically analysing various forms of value in a business and network and stimulate innovation in sustainable value creation. The tool adopts a multi-stakeholder perspective, through which the exchange of value can be analysed and potential stakeholder conflicts identified to create positive value in the network. It provides a new perspective for practitioners to understand and create new economic, social, and environmental value from their business. The Cambridge Value Mapping Tool has been used in industry through a multitude of group workshops or in-house bespoke workshops. The tool is also used as teaching material at the University of Cambridge other academic institutions.

For more information please contact doctoral researcher Stefan Hemel, Stefan.hemel@cranfield.ac.uk or Dr Palie Smart, palie.smart@cranfield.ac.uk.
**Principles – Pattern – Practice**

Principle-Pattern-Practice is a design language for discussing a specific industrial system of a business with its partners, and for collectively envisioning future sustainable industrial systems.

The purpose of this tool is to create a shared understanding among the diverse participants and decision makers involved in designing a sustainable industrial system. An industrial system can be collectively described and coherently understood in terms of its pattern, its set of principles, and the associated practice decisions. This tool helps identify the underlying principles of an industrial system based on manufacturing decisions. Through this tool, practitioners can discuss the manufacturing decisions (practice) and underlying principles of their current industrial system. They can then use this terminology to ideate about future sustainable industrial systems. The tool’s ability to describe sustainable industrial systems is demonstrated for Industrial Symbiosis as an example in the accompanying figure.

For more information, please contact doctoral researcher Sudhir Rama Murthy, ssrr3@cam.ac.uk.

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**Industrial Sustainability Competency Development Toolkit**

The Industrial sustainability competency 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.

The toolkit can be used by organisations to diagnose current performance, identify potential areas of action which can deliver substantial performance improvements, and develop a collaborative plan for long-term competency development.

**The dimensions of performance proposed are:**

1) **Efficiency** – how well are current operations operated? (Focus on energy, water, materials input and waste and water output)
2) **Internalisation** – what is the approach to business model innovation? (Seek value from its waste)
3) **Coordination and collaboration** – how effective is the business at identifying and working with unusually valuable partners?
4) **Whole system design** – how effective is the firm in conceptualising and implementing radically improved new system designs?

Competency assessment helps companies understand what they need to be good at in order to support the transition to a sustainable industrial system. Existing competency in efficiency, internalisation, collaboration & co-ordination, 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 doctoral researcher Lloyd Fernando, ldf21@cam.ac.uk, or Prof Steve Evans, se321@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.

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, the tool 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 doctoral researcher Elliott More (egm27@cam.ac.uk) for more information.
Circularity Toolkit

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 Toolkit 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. Showcased at Resource 2015, the Circularity Toolkit is evolving based on insights from practice.

If you are interested in trialling the current prototype contact doctoral researchers Fenna Blomsma at f.blomsma12@imperial.ac.uk or Geraldine Brennan at geraldine.brennan09@imperial.ac.uk.

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 IFIM, 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).

http://www.circulareconomytoolkit.org/