

# The shape of things to come

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Factory. Credit: The District

Researchers are providing a vision for creatively rethinking how the manufacturing industry can perform sustainably in a changing world.

In the late 18th and early 19th centuries, industrialisation swept the globe and changed it forever: humanity mastered the art of transforming the world's [raw materials](#) into the 'stuff of the world'. Today, everything around us, from the cars we drive, to the goods we own and the clothes we wear is largely the product of industrial [manufacturing](#).

But industrialisation also had an unintended effect on the [global environment](#) – contributing to the increasing burden of [carbon emissions](#)

, pollution and waste – and it's widely accepted that a new 'green' [industrial revolution](#) is urgently needed.

"It's clear that current processes cannot be sustained indefinitely," said Professor Steve Evans. "As well as the environmental effects, the world has a finite amount of natural resources, and current processes are probably only 10% efficient at converting them into usable product."

Evans leads the EPSRC Centre for Innovative Manufacturing, which connects systems engineers and business analysts at Cambridge's EPSRC Centre for Industrial Sustainability with researchers at Cranfield University, Imperial College and Loughborough University. The Centre is funded with £5.7 million from the Engineering and Physical Sciences Research Council.

Centre researchers work with multinational businesses such as Toyota, Unilever and M&S to develop the knowledge and tools that will help manufacturers navigate their way through the complexities of designing sustainable industrial processes in the long term.

"To live well, experts think that we must be able to manufacture what we need using less than a quarter of the current bio-capacity. What this means is a reduction of 75–90% in how much carbon-based energy and resources our industrial systems currently use," said Evans. "And to achieve this will mean a complete reshaping of how we manufacture."

His vision extends all the way to a future in which factories could have a net positive effect on the environment: "Part of the work we are doing on configurations would suggest that by the 2050s the air and water leaving factories might be cleaner than what's going in. A greater number will either use local materials or grow the materials they use – perhaps as nanostructures or using green chemistry. This will fundamentally change scale and location decisions for factories to the

point where they will be so advantageous that people will want them at the end of their street."

Developing ideas of how eco-factories could look in the future is one aspect of the research carried out by the Centre. However, these are long-term visions, and the researchers recognise not only the complexities of change but also that the "window of opportunity for action is rapidly closing." One key focus of their research agenda, therefore, is to understand how industries can improve their efficiency and environmental performance now, without changing current products and processes.

"How can you find out how efficient a factory can be? You just ask common sense questions," said Evans. "We go into the factories to collect examples of sustainable industrial activity, identify new courses of action, and then publish these as case study reports." A database of over 1,000 effective practices in industrial sustainability has been compiled and will be generally available later this year.

For Toyota, for example, the researchers discovered that significantly better industrial performance is possible through innovative thinking and careful planning without relying on the development of a 'step change'.

Toyota operate nine manufacturing sites in Europe ranging from engine manufacture through to vehicle assembly. "Toyota took the route of developing action plans with challenging targets to reduce environmental impact – recycling waste water, sending zero waste to landfill and so on – and focused on individual aspects of manufacturing to develop best practice. By adopting these principles, they reduced the energy needed to make cars across their European factories by 44% in five years."

"Some factories are noticeably more efficient than others," Evans added. "We want to know why, and whether they are squeezing every last drop

from best practice. If not, how much further can they go and what can competitor factories learn from this?"

Other companies studied by the team have focused their steps on improving environmental performance on packaging reduction (Philips), shifting operations from a product-based system to one in which it provides a service (Xerox), and building a new energy-efficient production facility (Adnams brewery).

"Understanding how far you can push current systems is the most urgently needed step. But technological development is also essential to achieve the significant changes in efficiency that we need," said Evans. To help this agenda, the Centre is also looking at the technology needed to manage factories. One software tool they have built – THERM (for THrough-life Energy and Resource Modelling) – models the way that energy, materials and water can flow around factories. "Traditionally, these processes are considered as secondary to modelling production of the product and yet they are integral to approaching sustainability at a factory level."

The THERM project, funded by the Technology Strategy Board, gathered a team of practitioners (Toyota and Airbus), academics (Cranfield University and De Montfort University) and software developers (Integrated Environmental Solutions) to create the software tool, now available to industry. The tool integrates the modelling of manufacturing processes within their environment – the factory building – to identify system-wide opportunities to reduce resource consumption, carbon emissions and waste generated.

"The greatest opportunity to reduce the environmental impact of an industrial system comes about when we consider the system as a whole, because the optimisation of any one part is ultimately constrained by other aspects," explained Evans, who is a member of the Foresight lead

expert group that is combining the latest scientific evidence with futures analysis to help policy makers consider the Future of Manufacturing for the Government Office for Science.

Evans and his team believe that this 'systems thinking' approach is crucial. "The evidence we have seen from case studies shows that sub-system approaches can dramatically improve sustainability. But to help future generations meet the needs of humanity within the carrying capacity of the planet it will be important to develop the know-how to enable changes across the whole industrial system. Such a system is likely to look very different to today's global industry. We believe that manufacturing will change its shape."

Provided by University of Cambridge

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