ELLEN MACARTHUR FOUNDATION
Rethink the future

Rethinking the Economy

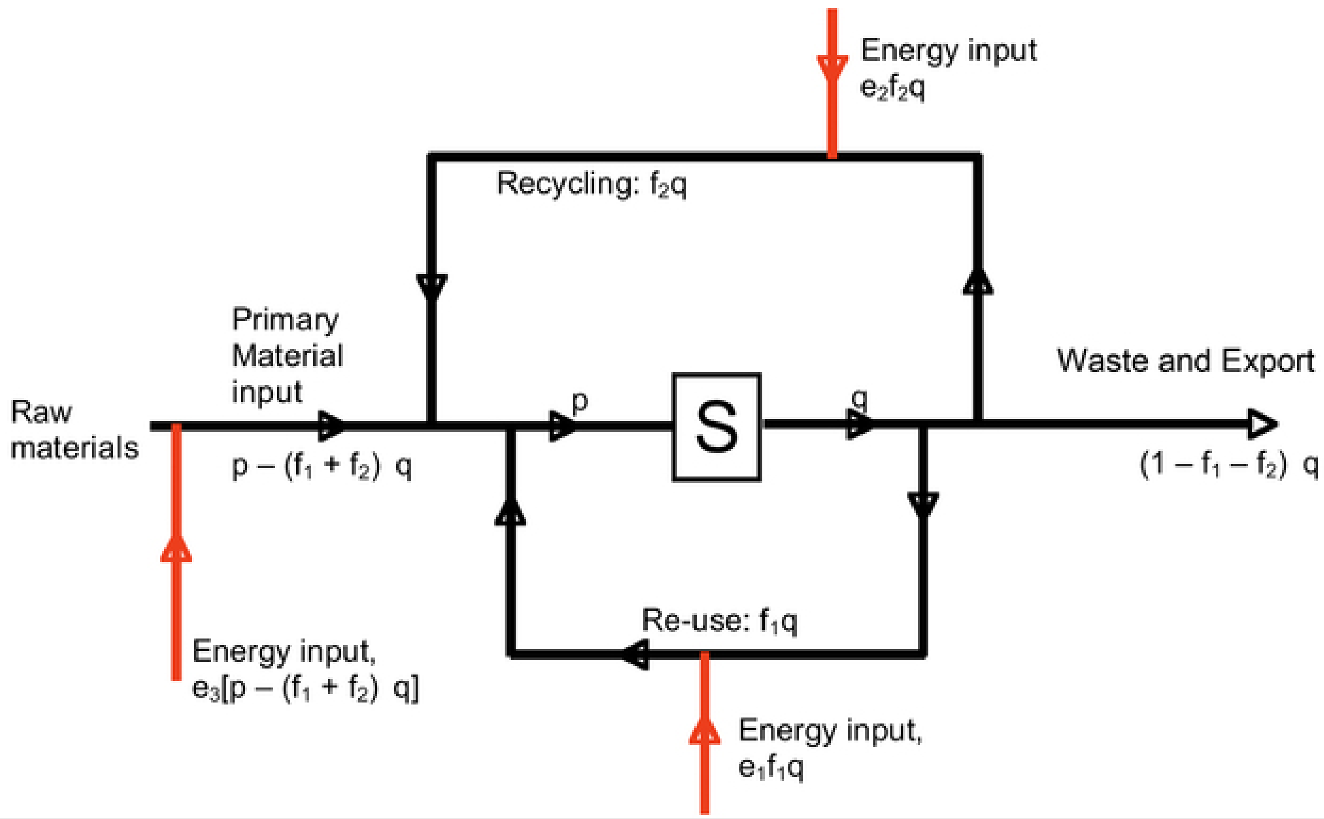
Roland Clift and Julian Allwood outline how industrial ecology, applying chemical engineering thinking to the management of material flows in the economy, can point the way to an economy that can work long-term.

Initially published on The Chemical Engineer

If we accept the need to reduce our emissions of greenhouse gases, decarbonising the energy system is a high priority, along with reducing energy use. Policy in the UK, as in many other countries, has so far focussed on improving the energy efficiency of industrial processes which provide materials and products. However, the scope for improving industrial energy efficiency is limited: industrial processes have always been subject to cost pressures to optimise performance. So we need to approach the problem differently, focussing on how to reduce flows of materials through the economy. This does not necessarily mean having less material goods in use; rather, it means managing materials more intelligently. The ideal model is the “closed-loop economy”, an idea which governments (including the European Commission and China) are now supporting. However the idea of closed-loop material use is by no means new: it is at the heart of the concept and approach known as industrial ecology.

Re-engineering Performance

Part of industrial ecology involves analysing the flows and stocks of materials in the economy – “chemical engineering outside the pipe” (TCE, July 2007, pp.21-22). A completely closed-loop zero-waste economy is, of course, thermodynamically impossible. However, a very simple (and simplified) example shows how elementary material balances can yield useful conclusions, in this case that serious reductions in energy use, far outweighing potential savings from improving the energy efficiency of industrial processes, can be realised by focussing on product design and use.



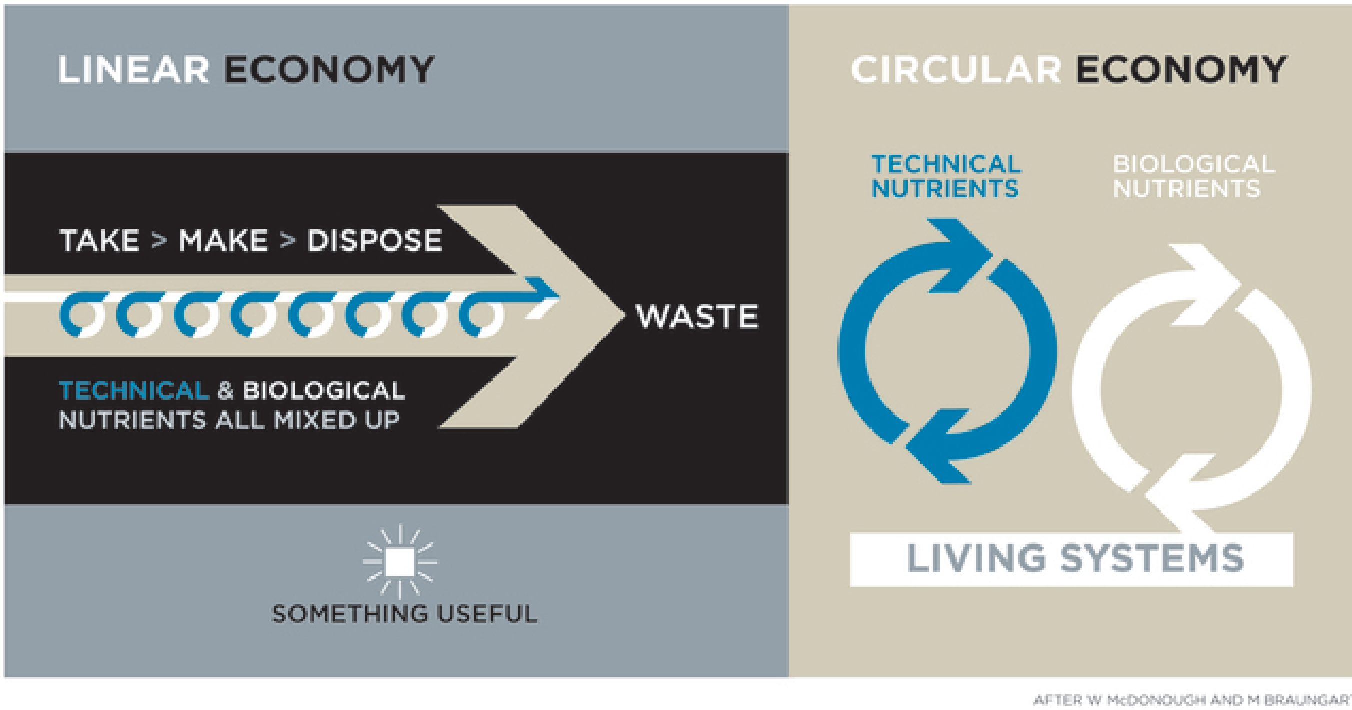
See "Figure A1" caption below

The focus should be on design to reduce embodied materials; on using goods more intensively (e.g. car-pooling); on extending service lives and repairing or upgrading used products; and on designing products to be dismantled and the components re-used or, failing re-use, so that the materials can be separated and recycled.

The implications of extending product and component life have been explored in detail by Walter Stahel of the Product Life Institute in Geneva, with the maxim (1,p.195):

> **Do not repair what is not broken, do not remanufacture something that can be repaired, do not recycle a product that can be remanufactured.**

Stahel, amongst others, has gone further to explore how the shift from disposable products to service delivery could lead to restructuring of a post-industrial economy. His simple maxim implies a major shift in economic activity: energy use would to a large extent be substituted by labour, mainly skilled labour, as re-engineering substitutes for primary material demand. Activities which are labour- rather than capital-intensive are less subject to the economies of scale which characterise the chemical and material industries. Thus Stahel's concept of the performance economy also embraces more localisation of economic activity.



© Graham Pritchard / Ellen MacArthur Foundation

Foresighting and Back-casting

While it is possible to envisage an economy with high material efficiency, the path to get there is less evident. Extending product life represents a reversal of current trends; it requires behavioural change even more than changes in technology or product design. For many product groups, ranging from manufactured products like mobile telephones to clothing, service life is commonly limited by fashion rather than obsolescence or loss of functionality. As a specific example, the quantities of used clothing in the municipal waste stream have risen markedly in recent years, a trend which the House of Commons Science and Technology Committee has dubbed the Primark effect

Reversing the current trend will require a combination of economic pressures and fashion. Some economic pressure is starting to come from the increasing cost and scarcity of critical materials such as the Rare Earth Elements (REEs) (see TCE Dec. 2010/Jan.2011, pp.33-35), heightened by China's limitations on exports of REEs. Manufacturers of products dependent on scarce elements have an increasing incentive to recover materials when their products reach the end of their service lives. This goes beyond the approach of mandating return or "take-back" of used products, embodied in European Directives such as those covering Waste Electrical and Electronic Equipment (WEEE) and End-of-Life Vehicles (ELVs), introduced at a time when economic pressures encouraging take-back were missing. Increasing material scarcity will drive the move towards providing products on a lease or sale-and-return basis, moving towards one of the holy grails of industrial ecology: providing services rather than selling products.

Free-market economists argue that resource pricing via "the market" must be the driver or else the shift in business models will not succeed. Those who are less convinced of the virtue of a free market, maybe even thinking that a globalised market is one of the main processes which has brought the human economy into conflict with the environment, point out that one of the things Governments can do is intervene in the market, most obviously by fiscal measures – i.e. taxation. The current approach, not just in the UK, is to tax labour rather than use of non-renewable resources, representing economic pressure in diametrically the wrong direction. Measures like the European Emission Trading System (ETS) represent hesitant moves towards taxing resources (in this case, the carrying capacity of the atmosphere and biosphere) and have arguably been too weak to have any serious effect in driving restructuring. An area of current debate among economists is ecological tax reform – shifting the tax base to resource use and environmental impact rather than labour. Such measures are generally opposed by established industries but need not be politically unthinkable if it is made clear that the changes should be revenue-neutral, i.e. not increasing total tax revenues.

Where would this leave developing economies? From a global perspective, everybody would benefit if they developed in ways which embed material efficiency. Closed-loop material use along with industrial symbiosis – co-locating or connecting industries so that a waste or co-product from one becomes an input to another – are established bases for planning development in, for example, China and South Korea. Economic development based on exploiting primary resources will be helped if greater value is attached to those resources, but only if the added value accrues to the developing economy rather than a multinational developer; this implies further questions about the role of a globalised market.

A more closed-loop economy is a necessary part of sustainability but will need both political will and changes in popular fashion.

About the authors

• Roland Clift _is Emeritus Professor of Environmental Technology in the Centre for Environmental Strategy at the University of Surrey, UK and Executive Director of the International Society for Industrial Ecology; he gave the 2010 Danckwerts Memorial lecture on “Chemical Engineering outside the pipe: Industrial Ecology and Sustainability”._

• Julian Allwood _is Senior Lecturer in Engineering at the University of Cambridge where he leads the Low Carbon and Materials Processing group; he is currently an EPSRC Leadership Fellow, and has been appointed Lead Author for work on mitigation in industry for the 5th Assessment Report of the Intergovernmental Panel on Climate Change, due in 2014._

Figure A.1
Re-use and recycling
e1 Energy input per tonne of material re-used.
e2 Energy input per tonne of material recycled.
e3 Energy input per tonne of primary material

f1 Fraction of post-use material recovered and re-used
f2 Fraction of post-use material recovered and recycled
p Annual flow of material entering use
q Annual flow of post-use waste. (Note: for a mature sector, q _ p)
S Stock of material in use

Further reading

1. Stahel, W.R. “The Performance Economy”, Palgrave-MacMillan, 2nd edition, 2010
2. Clift, R. “Clean Technology and Industrial Ecology”, in Pollution – Causes, Effects and Control, ed. R.M.Harrison, Royal Society of Chemistry, pp. 411-444, 2001.
3. Allwood, J.M., Cullen, J.M. & Milford, R.L., “Options for achieving a 50% cut in industrial carbon emissions by 2050”, Environ. Sci. Technol. 44, 1888-1894, 2010
4. Allwood, J.M., Ashby, M.F., Gutowski, T.G. & Worrell, E., “Material efficiency: a white paper”, Resources, Conservation & Recycling 55, 362-381, 2011