

Embracing Systems Thinking and Complexity

A supporting article to 'Changing Systems, Not Just Lightbulbs: Building Pathways to Zero Carbon in Higher Education – a Guide to What Works', written and produced by the Carbon Neutral University Network (Sheffield).

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In our Guide for universities on building low carbon pathways, we introduce systems thinking.¹ Our contention is that systems approaches are vital to meeting the scale of the challenge which climate change presents. We agree with Peter Senge, as quoted in the Guide; *“human beings are natural systems thinkers.... but this talent must be understood and cultivated”*.²

Roles for systems thinking skills in universities

How can our universities develop systems thinking skills in students and staff members, and at the same time develop systems intelligence as an organisation? There are two key concepts in systems thinking that help us begin to frame answers to that question - double-loop learning and leverage points. Firstly, let's briefly introduce what we mean by “a system”.

At their most basic, systems can be seen as interacting stocks and flows. Examples of stocks include the amount of wealth in the economy; the amount of physical infrastructure such as houses, industrial plant, gas-fired power stations and wind turbines; the amount of land on which we grow crops and graze animals. New wealth is created by adding value to raw materials or providing services, which is an inflow; depreciation and spending is an outflow. New wind turbines coming on-stream represent an inflow into the stock of generating capacity; the closure of a coal-fired power station represents an outflow. Stocks can also be non-material, such as the level of trust in the Government to manage the economy; or the level of public concern about action on climate change.

Social systems usually include large numbers of players, whose goals and motivations differ to some extent. In a well-functioning system, there is sufficient agreement about common goals to avoid excessive conflict and allow the system to perform vital functions. Most people are provided with shelter and food, albeit of widely varying standard; millions of journeys are made daily, with remarkably few collisions. Feedback loops in the system have the potential

¹ Carbon Neutral University Network, *Changing Systems, Not Just Lightbulbs*, 2018, pp. 19-23.

² Peter Senge and others, *The Necessary Revolution: How Individuals and Organizations are Working Together to Create a Sustainable World*, (London: Nicholas Brealey, 2008), p.167.

to correct imbalances; if you speed, you may get a speeding ticket. Some feedback loops tend to accelerate behaviour – your friend buys an e-bike, you have a ride and like it, you buy one and tell your friends about it, and so on. These forms of feedback are described as negative and positive feedback loops respectively.

For example, there is a clear and strong positive feedback loop in our present society linking personal income and carbon emissions. The more we earn, the more we can gain access to better housing and a better car, more consumer goods, more travel and holidays abroad, more costly entertainment and sports activities. Our experience of these ‘good things in life’ tends, naturally, to lead us to wanting more of them due to the positive feedback of enjoyment and pleasure. This is not to mention complex issues of social status, which generally strengthen this positive feedback loop further. However, all these purchases and activities increase our carbon footprint – as our society is presently structured.

Double-loop learning

This example of a positive feedback loop in consumer behaviour gives a brief taste of levels of complexity in our social and economic system. It highlights the value of one of the features of systems thinking - double-loop learning. With this kind of learning, what is discovered concerns not only the details of the challenge the system is presented with, in this case climate change; but also, the assumptions, values and beliefs that lie behind the situation.^{3 4} In a well-structured learning environment, we can begin collectively to develop a sense of not just the “what”, but also of the “why”.

Leverage points and systems behaviour

Gaining a sense of the “why” leads us to the question, “*What can we do?*” What can we change? What interventions might make a real difference? This brings us to look at leverage points. Leverage points in the system are places where a relatively small amount of effort can result in a large change. The concept is introduced in Donella Meadows’ paper ‘[Leverage Points: Places to intervene in a system](#)’.⁵ It is quite possible that the super-tanker of carbon emissions, whether of an institution or of our society, is easier to turn than it first appears.

However – a cautionary note is in order here. One of the characteristics of systems is that they often behave in counter-intuitive ways. It’s as well to recognise this sooner rather than later. It can be all-too-easy to find a leverage point – and then, to our surprise, find that the system moves in the wrong direction. The introduction of energy-saving LED lightbulbs could

³ Mark K. Smith, ‘Chris Argyris: Theories of action, double-loop learning and organizational learning’, [infed](#), 2013.

⁴ Richard Culatta, ‘Double Loop Learning (C. Argyris)’, [InstructionalDesign.org](#), 2018.

⁵ Donella Meadows, ‘Leverage Points: Places to Intervene in a System’, *The Solutions Journal*, 1.1 (2010), pp. 41-49.

prove to be a classic example of this – the result may be that the system as a whole [uses more energy](#).⁶

In their 2013 book ‘The Burning Question’, Mike Berners-Lee and Duncan Clark explore how the rise of renewable energy generation has allowed us to use more energy, whilst the level of fossil fuel consumption remains roughly the same. Hence emissions have not fallen substantially.⁷

This is not to say that renewable energy technologies or LED lights are not important in the fight for a stable climate, of course – they are very important developments. They need, however, to be looked at in the context of systems behaviour, if they are to become part of the solution on a wider scale.

Let us take the goal of creating a zero carbon society in twenty years. How might we go about designing interventions based on systems thinking? There can be large differences in how much leverage particular interventions will exert. The interventions listed here are roughly in reverse order of effectiveness, according to Donella Meadows’ guide to leverage points; that is, we introduce the *least* effective first.⁸

1. Increase low-carbon inflows to the system

For example, increase renewable energy generating capacity, which delivers higher amounts of energy per tonne of CO_{2e} emitted in its construction and operation, compared to oil-fired or gas-fired power stations. However, as discussed above, this may not by itself bring down emissions.

2. Decrease outflows of CO_{2e} per unit of consumption in the system

For example, substitute LED lights for older compact fluorescent or halogen bulbs, thereby using less electricity per unit of light. Again, as mentioned above, this too on its own may not bring down emissions. When lighting becomes both cheap and energy-efficient, we are tempted it seems to install more of it – ultimately using the same amount of energy as before, if not more.⁶

3. Speed up positive feedback loops about low-carbon initiatives

For example, develop a national “emissions barometer” which shows very clearly whether emissions are going up or down. Show this weekly on the national weather forecast.

The issue here may be about delays in the system responding to our actions, that are not easy to change. New renewable energy plants take time to build – it can appear that much effort is

⁶ Phil McKenna, ‘The Lighting Paradox: Cheaper efficient LEDs save energy, and people use more’, *Inside Climate News*, 20 August 2015.

⁷ Mike Berners-Lee and Duncan Clark, *The Burning Question*, (London: Profile Books, 2013).

⁸ Donella Meadows, ‘Leverage Points’.

being made, and money spent, for little result. Could there be potential for such an initiative to have the opposite effect to that intended?

4. Strengthen negative feedback loops about high-carbon activities

The aim here is to discourage high-carbon activities; and encourage low-carbon ones. One approach could be to introduce a national '[Carbon Fee and Dividend](#)',⁹ such as that being proposed in the USA by the [Citizens' Climate Lobby](#).¹⁰

This is potentially the most powerful of the steps considered so far – it provides a direct economic incentive to change behaviour, both for individuals and for organisations. Could it have unintended consequences? Perhaps – a systems perspective suggests we run a small pilot project to investigate this, before making a big commitment.

5. Weaken system-reinforcing loops - introduce measures that build a more equal distribution of resources

Now we move into territory that can make a big difference – and that governments of all complexions tend to shy away from. However, the pressure for change may be growing.

At present in Western economies, economic growth brings the greatest benefits to the already well-off, and only very slowly – if at all – benefits people on low incomes. This is a reinforcing feedback loop – which makes it both dangerous, and difficult to change. It reinforces “success to the successful”, in economic terms, and propels continuing growth.¹¹ Economic growth is a fundamental driver behind continuing high levels of emissions. The idea of “de-coupling” growth from emissions has been convincingly demonstrated by [Tim Jackson](#) and others to be unrealistic, barring some major technical or scientific breakthrough.¹²

Rather than work on the assumption that the only way forward is further growth, what effects could a more shared distribution of resources have? For example, [Land Value Tax](#) could be used as a source of public revenue, rather than taxes on income or purchases.¹³ A [Basic Income Scheme](#) could offer a degree of economic security through periods of economic turbulence and change.¹⁴ These kinds of measures begin to share more evenly the abundant wealth already present in the UK, opening up possibilities for evolving an economy not based on growth.

A further system-reinforcing loop in the global economy is subsidies which encourage the exploitation of fossil fuel reserves. Whilst the perverse effects of such subsidies are

⁹ Citizens' Climate Lobby, *Carbon Fee and Dividend Policy* (n.d.).

¹⁰ <https://citizensclimatelobby.org/>

¹¹ Donella Meadows, *Leverage Points*, Point 7 – Reinforcing Feedback Loops.

¹² Tim Jackson, *Prosperity without Growth: Foundations for the Economy of Tomorrow*, 2nd edn (London: Routledge, 2017).

¹³ Land Value Taxation Campaign, *What is Land Value Taxation?* (n.d.).

¹⁴ Dr Luke Martinell, *Assessing the Case for a Universal Basic Income in the UK*, IPR Policy Brief, University of Bath, September 2017.

recognised, [they have continued to grow](#), dwarfing support for the development of renewable energy sources.¹⁵ Changes to such measures have the potential to significantly change the system in the direction of reducing emissions.

6. Make information accessible and clear

Where information is missing, distorted or misunderstood, systems can behave in perverse ways. For example, declining fish stocks in themselves don't necessarily lead to a reduction in fishing activity – as the fish become scarcer, the price rises.¹⁶ As certain animals become rarer, the price paid for them as either pets or body parts for “medicine” goes up to sometimes astronomical figures. The price doesn't provide the feedback that's needed – it's population figures that do.

How many students or staff members know what their university's annual CO₂ emissions are? And whether these emissions are going up or down? How many citizens know such figures for the town or city where they live?

Making such information readily accessible, and put into clear context, could introduce a feedback loop which is typically missing from public discourse. As always, though – we need to be careful about perverse, unintended effects. Could such information be misinterpreted? Could these figures be taken as an indication of the health and growth of an institution, or a city – and hence lead us in the opposite direction? Once again – tests and research are needed early on, to avoid costly mistakes.

7. Change the rules

Incentives, punishments and constraints often have profound effects on behaviour. Consider how the atmosphere in a university changes as exam time approaches. The risk of plagiarism, for example, galvanises institutions to go to considerable lengths to detect it. Recent examples of cheating in sport demonstrate how unacceptable we find it for the rules to be broken, when they are intended to create a level playing field.

What would happen if clear incentives were introduced to reduce carbon emissions? For example, linking emissions levels inversely to a university vice-chancellor's pay....? What about fines for companies who fail to meet mandated emissions reductions, together with compulsory public disclosure of such failure?

Where rule changes are introduced, it starts to feel like the pressure is on to change behaviour.

¹⁵ Kevin Watkins, 'Why We Need to Abolish Fossil Fuel Subsidies', *World Economic Forum*, 11 November 2014.

¹⁶ An example discussed in Donella Meadows' *Leverage Points: Places to Intervene in the System*, Point 6 – Information Flows.

8. Encourage systems innovation

Large institutional cultures, such as universities, local authorities, the civil service and governmental departments, all tend to resist change. We get used to doing things a certain way - changing things means more work, perhaps learning new skills, and potentially a threat to some key people's positions and authority.

However - evolution is a process fundamental to the health of systems. In a study of "the successful habits of visionary companies", Collins and Porras found that outstanding companies consistently behaved in ways that prompted them to change *before* the surrounding environment demanded that they do so.¹⁷ These companies deliberately created a culture of improvement and innovation and set their sights on what Collins and Porras describe as "BHAGs – Big Hairy Audacious Goals".¹⁸

To become a leader in the field, these innovations need to go beyond existing "good practice" and move into new territory; what Paul Hobcraft describes as "*next practice*".¹⁹ The Scottish Government, for example, has recognised [the need for cultural change](#) in the way it interacts with the people it serves.²⁰

We need to welcome new people into the conversations, to listen to new ideas, and to find how to embrace new ways of doing things. In chapters 5 - 8 of the Guide we explore ways in which universities can develop an enabling, innovative culture.²¹

9. Change the system goals

Shared goals can be powerful drivers of systems behaviour.

What are the current goals of UK society? One that is apparent, as we write in summer 2018, is to accomplish Brexit with the minimum of pain and the maximum of gain. A goal which, of course, was never agreed on by anything like consensus in the first place, and still seems to divide British society roughly down the middle. There is little question, though, that the introduction of this goal has focused minds, continues to absorb an enormous amount of political energy, and regularly occupies the daily news headlines. This illustrates something of the power that goals can have.

What could happen if an ambitious zero carbon goal was introduced in the UK, with a clear rationale, firm and graspable timelines, and a concerted effort to build public consensus around this goal? Whilst the introduction of such a goal might seem a remote possibility at present, social orientation around new goals can change – sometimes remarkably quickly,

¹⁷ James C Collins and Jerry I Porras, *Built to Last: Successful Habits of Visionary Companies* (London: Random House, 2000).

¹⁸ Collins and Porras, *ibid.*, p.187; p.94.

¹⁹ Paul Hobcraft, 'Forget about Best Practice, It Is All About Next Practice', *Hype Innovation Blog*, 23 November 2016.

²⁰ Workforce Scotland, *Theory U*, Blogs June – December 2015.

²¹ Carbon Neutral University Network, *Changing Systems, Not Just Lightbulbs*, 2018, pp. 25-55.

once the urgency of the situation is grasped. The legendary transition of Britain's economy from peace-time to war-time production, at the start of WWII, is one example.

This period of transition has valuable lessons for us today, which are examined in detail in Paul Gilding's book 'The Great Disruption: how the climate crisis will transform the global economy'.²² Gilding explores how just such a mobilisation could occur around addressing climate change, once the urgency is truly understood by enough people.

10. Change the system paradigms

Paradigms are the "deep, unstated beliefs" about how the world works. From these, the system's goals, rules, feedback loops, flows and stocks arise.²³

For example, a deeply held paradigm is that prosperity depends on growth, as we discussed earlier (see pp. 4-5). Whilst such paradigms may be notoriously difficult to change for a society, they clearly can change for individuals – and even for institutions. David Somervell discusses this in the context of the University of Edinburgh, in his [presentation and interview](#) for the 'Lightbulbs' event.²⁴

What kind of priority is currently given to addressing climate change, when compared to other issues in the UK? In a list of concerns which UK voters were weighing up in deciding how to vote in the 2017 elections, "the environment" came 10th on the list.²⁵ For young people considering which university to study at, "how seriously the university takes environmental issues" scored an equal 11th in priority; the same score as "nightlife".²⁶

What these survey results suggest – a result that emerges consistently – is that there are quite a number of other concerns that rank higher than addressing climate change. It can certainly be argued that we are only able to hold in mind, and work with, a small number of priorities at any one time. All too easily, climate change moves out of immediate sight.

What could happen if addressing climate change came to be seen as intrinsically linked to addressing issues of prosperity and equity? Which in turn leads to increasing the chances of having a safe city centre and an enjoyable nightlife? Greater equity is [correlated with reduced crime rates](#).²⁷

Work which begins to shift paradigms can potentially have large impacts. We've already referred to Tim Jackson's work on 'Prosperity without Growth' (see p.4). Other work in this

²² Paul Gilding, *The Great Disruption: how the climate crisis will transform the global economy* (London: Bloomsbury, 2011); see for example pp. 110-111, pp. 256-258.

²³ Donella Meadows, *Leverage Points*, Point 2 – Paradigms.

²⁴ David Somervell, presentation at *Changing Systems, Not Just Lightbulbs* event, 13 May 2017.

²⁵ YouGov, *Top Issues Tracker*, June 2016 – June 2017.

²⁶ National Union of Students, *Sustainability Skills 2016-17*, March 2018, p. 12.

²⁷ The Equality Trust, *Crime*, 2017; drawing on the work of Kate Pickett and Richard Wilkinson, *The Spirit Level: Why Equality is Better for Everyone* (London: Penguin, 2009).

field includes Kate Raworth's '[Doughnut Economics](#)',^{28 29} and Rob Dietz and Dan O'Neill's 'Enough is Enough'³⁰.

Promoting, discussing, teaching this kind of work could be contributing to the kind of paradigm shift that's needed, if we are to truly address climate change in the timeframe we have available. What's more, there could be greater social receptivity to new ideas than it may appear, as George Monbiot is urging in his call for a new '[Restoration Story](#)'.³¹

Leadership in time

In our Guide we have emphasised that we have but little time to make big changes. The graph on page 13 brings this home.³² Where is such leadership going to come from? Our final point is to draw on another of Collins and Porras' findings. In the "*visionary companies*" they found a clear, conscious effort to "*build for the future*" – planning and investing with a long time-frame in mind. For these companies, "*long-term*" means "*not five or ten years – it means multiple decades – fifty years is more like it.*" At the same time, they pay careful attention to "*doing well today*".³³

Looking ahead fifty years from now, it seems certain that the changes brought about in response to climate change – in terms of both mitigation and adaptation – will be dramatic, and in many ways extremely difficult to predict. We are going to need systems thinking *par excellence*, and institutions willing to take dynamic and flexible leadership roles. Our aim in 'Changing Systems, Not Just Lightbulbs: Building Pathways to Zero Carbon in Higher Education – a Guide to What Works' is to introduce some practical approaches to building such institutions.

Further perspectives on systems and complexity

What you have just read is, of necessity, an extremely brief and incomplete introduction to this field. The focus has deliberately been on ways to intervene in a system, and there are many other aspects of systems that can be explored. These include 'emergent properties', that is properties the system has which the individual elements within it don't have; the all-important role of the 'observer' of a system; where 'system boundaries' are drawn; and different ways of modelling, drawing and representing a system. Overleaf is just a small selection of further reading about systems and complexity.

²⁸ Kate Raworth, 'What on Earth is the Doughnut?', *Exploring Doughnut Economics* (n.d.).

²⁹ Kate Raworth, *Doughnut Economics: Seven Ways to Think like a 21st Century Economist* (London: Cornerstone, 2018).

³⁰ Rob Dietz and Dan O'Neill, *Enough is Enough: Building a Sustainable Economy in a World of Finite Resources* (Abingdon: Routledge, 2013)

³¹ George Monbiot, 'How Do We Get Out of This Mess?', *George Monbiot*, 11 September 2017.

³² Carbon Neutral University Network, *Changing Systems, Not Just Lightbulbs*, 2018, p.13.

³³ James C Collins and Jerry I Porras, *Built to Last: Successful Habits of Visionary Companies* (London: Random House, 2000), pp. 190 -191.

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