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# Alternative Technology and Social Organisation in an Institutional Setting

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## Introduction

I grew up in the decades after the Second World War. There was a clear sense of new beginnings and of technological optimism, typified by the UK's 1951 Festival of Britain, which I visited as a wide-eyed schoolboy. In retrospect, this very period experienced a step-change in many standard indicators of human activity, later labelled 'The Great Acceleration' (Steffen *et al*., 2015).

The sense of ineluctable progress has continued to be the dominant narrative, and it is as well to acknowledge it. But this essay explores particular veins of radical doubt regarding the trajectory of modern socio-technical development, which led to the emergence of the so-called Alternative Technology (AT) movement in the 1970s (Harper and Eriksson, 1972; Dickson, 1975; Winner, 1979; Smith, 2005).[1]

In retrospect we can distinguish two critical streams of thought. One was a *social and cultural* critique of technology, arguably going back to Ruskin, followed by (for example) William Morris, M.K.Gandhi, Lewis Mumford, Herbert Marcuse, E.F. Schumacher and Ivan Illich. The other was a physical/environmental critique commonly associated with Carson (1962), followed by (for example) Commoner (1966, 1971), Ehrlich (1969), Goldsmith (1972), and Meadows *et al*. (1972). The AT movement attempted to combine these two streams and follow through their implications. It also drew strongly on a wider pool of dissident ideas, summarised in Box 1.

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**BOX 1**

**Utopian socialism** (Morris, 1970; LeGuin, 1974)
**Anarchism** (Kroptkin, 1974; Ward, 1973)
**Deviant Marxism** (Cohn-Bendit, 1969; Debord 1971);
**Decentralist political theory** (Kohr, 1957; Goodman, 1968);
**Community living** (Kanter, 1972; Gaskin, 1974)
**Deliberately anti-modern communities** such as North American Anabaptists (Hostetler, 1970);
**Pre-modern societies** (Schumacher, 1968; Sahlins, 1968);
**Steady-state economic**s (Boulding, 1966; Daly, 1977)
**Low-income lifestyles** (Nearing and Nearing, 1960; Seymour and Seymour, 1973);
**Metaphysical perspectives** (Pirsig, 1974; Castaneda, 1968);
**Fringe science** (Reich, 1960; Watson, 1974).

But why the emphasis on technology? A core view was that uncontrolled technical innovation was a principal driver of growth and change for both good and ill. From the physical/environmental perspective, it was suspected that catastrophic risks were plausible and were strongly related to the scale and complexity of human activity. Unexpected, emergent properties of complex systems were widely noted (Platt, 1969; Forrester, 1969) and catalogues of malign counter-intuitive effects were common (Rattray-Taylor, 1970; Harper, 1971; Farvar and Milton, 1972; Davis and Pedler, 1974). And of course, the process had hardly begun. If the root of such effects was indeed technology and innovation, evidently a completely different approach to technology was required to safeguard the future.

At the same time, from the social and cultural perspective, it was thought that deliberate changes in technology could also help escape the sense of alienation widely experienced by younger people at the time (Roszak, 1970). A contemporary text sums it up:

> We have to break through the political, economic, social and psychological forces that constrain and oppress us. The trouble is these forces hold one another together in a web of reinforcement so consistent that it's hard to know where to begin loosening their grip: patterns of ownership, status-games, the way you work, what you learned at school, what the neighbours think, who gives the orders, what turns you on, what you see on TV, what you can or cannot buy … . Technology is one of these also, but we think it's a good place to get your fingers in the crack. (Boyle and Harper, 1976, p. 6)

The net result was a militantly precautionary anti-modernism, favouring simple, locally generated craft-based technologies, often of a deliberately archaic kind. This approach contrasted sharply with that of moderate critics such as Beck, Giddens and Lash (1994), but it represented a serious attempt to follow through the implications of the theoretical and empirical critiques. And of course it remained at odds with the prevailing culture, with extremely limited take-up, as observed by Seyfang and Smith (2007).

Essential were special places where the prevailing rules were different and a new 'socio-technical culture' could be developed in what would be later termed a 'protected niche' (Smith, 2000). There it would be possible to explore the expected synergies between all the technologies working together, and their interactions with appropriate skills and lifestyles. Hence the rise of institutions in specific locations dedicated to the development of AT, for which a satisfactory generic label has never been agreed, although 'ecocentres' is often used by default (Harper, 2002; Ecolink, 2003). Several such foci had emerged in the USA in the early 1970s, and one in the Netherlands. These inspired the foundation of the National Centre for the Development of Alternative Technology, UK in 1974, later simply the Centre for Alternative Technology or CAT. In what follows I shall describe some ways in which CAT pursued a changing vision of an alternative socio-technical culture in the subsequent decades.

## AT practice at the Centre for Alternative Technology (CAT)

I should declare my own involvement in CAT. I worked there from 1983 to 2013 in various roles, latterly as Head of Research. I was an early theorist of AT (Harper and Eriksson, 1972; Harper, 1973; Boyle and Harper, 1976) and my work was part of a large corpus initially drawn on by CAT's founders to define its terms of reference. While at CAT I had frequent occasion to analyse and comment on its activities, successes and failures (e.g. Harper, 1995, 2002).

True to its founding spirit, CAT attempted to combine both political and environmental critiques of modern technology, and to pursue its technological agenda in a socially 'alternative' manner. That is, it tried to create a sustainable system for providing essential needs within a collectivist living-and-working organisation, along with classic radical features such as consensus decision-making, needs-based wages and rotation of tasks. Much of spirit is captured in Allan Shepherd's recent work on CAT's oral history (Shepherd, 2015).

I want to illustrate the nature and evolution of CAT's socio-technical culture in two areas: electricity supply and research. These demonstrate distinctive features that might be difficult to achieve outside this special context. They also illustrate conflicts, both internal and in terms of deviations from conventional norms. Over time we can observe a gradual pattern of reconciliation with mainstream technology and indeed a retreat from many of the more radical social practices. Nevertheless, a reasoned critical stance was maintained, and arguably became more cogent as the organisation becomes recognisably aligned with mainstream institutional structures.

## Electricity system

*Living with very little electricity*

The electricity system at CAT evolved slowly. It was initially assumed that in some sense independence from the mains grid was a good thing, even though some of the generation systems used conventional energy sources. For example there was a de-tuned car engine running on propane gas. A sceptic would say this is no different from a gas-fired power-station and rather less efficient. The critical factor is that *output is modest and intrinsically limited*, and everybody has to operate within these strict limits. Electricity is expensive in terms of cost per kWh because there are few economies of scale and there is a high cost in labour input. On the other hand, the absolute cost is low, simply because so little is being used. As a former colleague once put it, your first 100 Watts is the most valuable (P. Raine in Shepherd, 2015: 93). Viewed in historical perspective, even this amount is already the equivalent of having a personal 'energy slave' that can in fact do several things a real human servant could not do. Speaking from experience, you learn to appreciate that 100 W, especially when you know you can have a further 1000 W or more for a short time if you really need it.

Did self-generated electricity release us from dependence on the mainstream system? At first sight it looks like that. You do not suffer from mains power-cuts. You do not pay electricity bills. On the other hand, you have power-cuts of your own, and severe limitations relative to life in the Outside World. And of course all the electrical components are produced by the mainstream industrial system.

In the long run, this semi-independence is in a strict sense no independence at all. It could be argued however that it is more 'resilient' in that the mainstream has become rather excessively complex and interconnected and is therefore vulnerable to breakdowns of various kinds. At the extreme case of a generalised collapse (e.g. Źiźek, 2010; Orlov, 2013), groups that had emphasised redundancy and resilience—rather than efficiencies of volume and speed—might last a little longer.

The key difference is the sense of ownership. The generation and control-systems were right there all around; you could touch them; at least one-third of the staff were directly involved in power management of one kind or another, and the rest were actively enfolded in the delicate balances of supply and demand. This collective ownership was curiously *empowering*.

*Intercom: a simple socio-technical system*

The intercom is an example of a 'community technology' (Boyle, 1978), using readily available components. At that time in the late 1970s and 80s, there were no mobile telephones, and only one single land line connected CAT to the 'outside world'. The site consisted of a dozen or so buildings with various functions scattered over several hectares, and communication was problematic. The answer was a simple hard-wired two-way 'intercom' in each building, consisting of a small hand-made hardboard box on the wall with a button and speaker grille (Figure 1). You would press the button and speak, and your voice would emerge from all the other boxes like a quiet Tannoy. Its most common use was simply to find where someone was, and arrange to meet face-to-face to complete any required business. It was also very useful of course for public announcements regarding meals, meetings, appeals for help on urgent tasks, emergencies etc.

The intercom was crucial for scheduling the use of high-demand electrical appliances. Recall that total electricity generation was rarely more than 2 kW, which had to be used for all purposes. Routine lighting, sound systems and radios under 20 W, even small TVs, were rarely a problem, but high-consumption devices such as washing machines and photocopiers consumed so much that they could only be used one at a time. It became part of site etiquette to request (via the intercom) the use of a high-consumption appliance so that 'slots' could be scheduled. Two at once would simply crash the system.

During a working day, routine electricity would be provided by a small hydro set, perhaps supplemented by electricity from the gas-powered car engine. At night, demand was much lower so did not justify either propane consumption or loss of water from the reservoir. Instead the system relied on lead–acid batteries providing up to 800 W. In battery mode, the system was designed to shut down completely if demand exceeded this level. For those who lived on the site, this provided a nightly ritual as the Duty Engineer prepared to switch off the generators. Meters in the control room would provide information on what was being used.

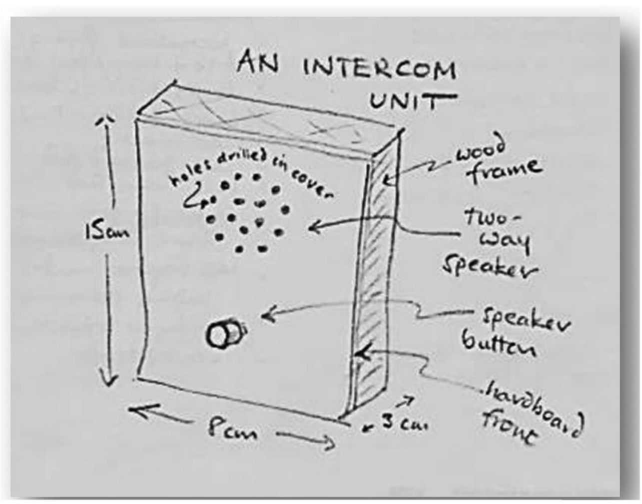


**Figure 1.** Sketch of an intercom unit, one in every building. It is indicative of the sheer normality of these items that nobody ever thought to take a photograph of one. Very basic electrical technology. Credit: Peter Harper.

The voice would crackle over the intercom, ‘OK everybody, let’s start turning things off’, and gradually demand would reduce until below the magic 800 W, leaving just lights and radios. ‘Thank you, that should hold. Good night everyone’. Better than a mug of cocoa.

I should add that after this moment in the day, if anybody inadvertently turned on enough heavy loads to go above 800 W, the system would respond by switching *everything* off, and in the blackness the intercoms (that operated independently on a 24-volt DC system) would hiss with dire imprecations. Such processes simultaneously encouraged and enforced solidarity and awareness of the needs of others.

Of course, it will be objected such patterns could not possibly operate in mainstream life. But the case is worth pondering: the site residents had to engage with this kind of system in order to operate lights, sound systems, computers, battery chargers and washing machines. At the same time, it created a high degree of conviviality (Illich, 1971). Is this win–win effect possible in mainstream society?

It is illuminating to compare this level of electricity provision with freshly electrified neighbourhoods of developing countries. Winther (2015) for example describes the new patterns of life made possible by the same few 100 W in rural Zanzibar. This comes close to the notion of AT as a happy medium between destitution and luxury, much as Schumacher called for in 1973, and resonating strongly with Hans Rosling’s statistical demonstrations of the ‘global middle’ (Rosling, 2011). It has been seriously proposed that prosperous modern societies could be run on an average of 2 kW per head (Jochem, 2006). At CAT we did just that.

### *Electronics and miniaturisation*

At the very beginning, in the very labile first year, there were few if any strict regulations—only numerous ‘heuristics’ or rules of thumb (Polya, 1945; Gigerenza and Gaissmaier, 2011). One heuristic was ‘keep it simple’, leading to a preference for early-modern or pre-modern technologies. So for example candles, and hurricane and Tilley lamps running on paraffin were preferred to electric lights. It seemed more robust, and lent a romantic air to group evenings. Nobody remarked that even an old-fashioned incandescent light bulb was 50 times more efficient in turning energy into light and one hundred times cheaper for the same amount of light (Nordhaus, 1998).

Only wealthy modern people can afford to play at being primitive, and we were far from wealthy. Eventually economic gravity forced us as least partially into the modern world, and the matter of electricity. Electricity is remarkably versatile, but CAT had no connection to the mains supply and was obliged to generate its own. This was consistent with the local-supply ethos and the Centre was extremely fortunate to recruit a professional electrical engineer, Dr Robert Todd, from the University of Southampton. One of the reasons for choosing the site was the existence of a nineteenth-century reservoir, formerly used to provide power for water wheels and belt drives for the machinery on what had been an industrial site. So hydro-power was an obvious first choice.

There was no shortage of small-scale hydro equipment in the local area. Many farmers had installed their own in the pre-grid era, but now the grid was ubiquitous; water turbines and generators could be picked up for a song. Farmers could not believe anyone would really want this old stuff when grid electricity was so cheap and reliable. But to the CAT pioneers it was heaven-sent, making use of unwanted and somewhat ‘old’ mechanical technology. A photo of the time shows the manoeuvring of an enormous old generator that in another era could well have been a woolly mammoth (Figure 2).

But what then? What *kind* of electricity system? High-voltage AC or low-voltage DC? After much wrangling and debate it was decided to have *both* AC and DC for different purposes. AC would emerge directly from regulated alternators. But how to regulate the voltage and frequency as loads came and went? How technically sophisticated did we wish to be? A lot of the old equipment was regulated mechanically, but Bob Todd was able to replace much of this with electronic systems. Quickly it was realised that solid-state electronics could do more with a few grams of material than the old mechanical system could with many kilograms—much more cheaply and reliably.

Which then, is the ‘alternative technology’? The large, coarse, erratic mechanical system that the blacksmith and the local electrician might have made with ubiquitous materials? or else the compact, deft, reliable electronic system that depends on components made in the most advanced factories with arcane materials, probably overseas, under horrible conditions?

**Figure 2.** Installing CAT’s first AC generator onto its operating platform. Credit: Centre for Alternative Technology.

Many an argument raged long into the night, but in the end it had to be acknowledged that the much-derided notions of efficiency and cost had to be taken into account. The shoe starts to pinch, and this is a key difference between AT activists actually doing it, and castles-in-the-air theorists (such as I had myself previously been) merely writing about it.

It has now become conventional to contrast efficiency and resilience, with an optimal compromise between those aims. The diagram (from Lietaer *et al.*, 2010) sums up this view. It became clear that the CAT approach pursued resilience too vigorously to fall inside the window of viability (Figure 3).

Economists and technological optimists have long heralded the 'dematerialisation' of modern economies through miniaturisation of components, and here we could see it in action in our electrical systems. We went on to establish a flourishing in-house electronic control-systems workshop that eventually spun off two high-tech enterprises. Were these AT? One (Dulas Engineering, 2015) specialised in renewable energy systems so we could say that it was a logical extension of the founding principles. The other (Aber Instruments, 2015) created some extraordinary devices for precise electrical measurement of microbial biomass. Initially it was imagined these would have their main applications in medicine and anaerobic biogas production. As it turned out however, they have become indispensable in the brewing industry for monitoring the fermentation of beer (Figure 4). Any glass of Kirin or Budweiser will have been produced using used an advanced model of a device original invented at CAT. Is *that* AT?

## *Beyond Moore's Law*

Some further comments are due on the subject of miniaturisation. The notion has been endlessly celebrated in the form of 'Moore's Law', where the operational

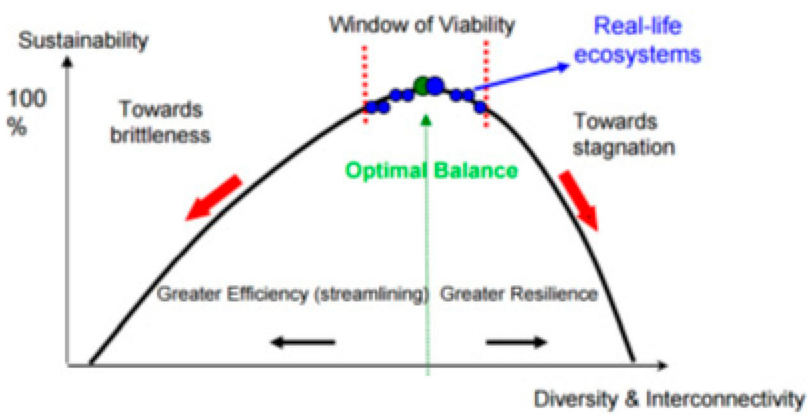


**Figure 3.** Sustainability as a trade-off between efficiency and resilience. CAT's critique of mainstream technology for an obsession with efficiency often drove it towards the opposite pathology. Credit: Bernard Lietaer *et al.* (2010).

**Figure 4.** The Biomass Monitor, affectionately known as 'the Bug Meter', invented at CAT. Used to electrically measure the volume of respiring biomass in a solution. Undisputably high-tech, and principally used in the brewing industry. Is this AT? Credit: Centre for Alternative Technology.

efficiency of microprocessors doubles about every 18 months. This is an incredible rate of Technical change, maintained for at least 30 years (Moore, 2006). Has it brought a massive reduction of energy consumption and resource use? No, it has not: the extra efficiency is invariably used to expand functionality in congenial but ultimately unnecessary directions. This is probably a key distinction between the mainstream and the AT approach. At CAT there was an intuitive notion of what was a reasonable range and level of functionalities; these were held roughly constant, and efficiency increases used to reduce environmental and other impacts. This could be one working definition of AT, shared with steady-state or de-growth proposals for modern economies as a whole (Victor, 2008; D'Alisa *et al.*, 2014)

Moore's Law has been so dramatic and inexorable that it has persuaded many that its underlying mechanisms can be applied to the whole of an economy. This is clearly false because most human needs are tied to the scale of human beings. One can indeed be moderate and frugal. But you cannot indefinitely miniaturise meals, or roads, or hospitals, or houses, or vehicles, or football pitches, or reservoirs, or clothes or national parks.

To render such items sustainable, different, *non-miniaturisation*, approaches are required; many rehearsed in the 'sustainable consumption' literature (e.g. Jackson, 2009; Syse and Mueller, 2015). At CAT, a frequent strategy has been to maximise low-impact components of a structure or process, while minimising high-impact components that might nevertheless be necessary for effective functioning. For example, in buildings one might find that 80% of the mass consists of earth, timber, reclaimed stone, hemp, straw, clay, lime plasters and such materials, while the other 20%—sometimes dubbed 'industrial vitamins'—will be plastics, metals, glass, Portland cement, wiring, plumbing. Such a building meets modern standards but reverses the customary ratio of these two classes of materials (Borer, 2010).

This 80:20 reversal principle might be applied elsewhere: journeys, holidays, medicine, diets .... Try your own speculations. In the future it could become an operational definition for AT.

## Unconventional research

Mainstream innovation strives to improve functionality or reduce cost with little regard for environmental impacts. In contrast, CAT has generated innovations that attempt to reduce environmental impacts, while maintaining an agreed level of functionality. Examples have already been cited with respect to energy and building systems; others include

- A water-balanced cable railway with compressed-gas regenerative braking (STEP, n.d.)
- Developments of the Walter Segal system for self-builders (Borer and Harris, 1998)
- Waterless and composting toilets (Harper and Halestrap, 1999; see also commercial spinoff, Natsol, 2015)
- Waste-water treatment systems using only plants and plumbing (Grant, 2008)
- District heating system with 24-hour storage combining complementary solar and biomass contributions
- Improved methods and simple equipment for home composting (Harper, 2001)
- Novel uses of industrial and domestic waste products that are hard to commercialise.

Alongside these practical innovations, it was thought that CAT should investigate gaps in knowledge and understanding that it was well-placed to fill. Institutional and market biases in the mainstream world combine to over-research some areas and under-research others. What follows are the results of ‘alternative’ thinking applied to potentially useful knowledge, using simple eighteenth-century levels of equipment that Benjamin Franklin or Erasmus Darwin would have found familiar (Uglow, 2002).

### *Cinderella topics*

Some areas of knowledge and practice are neglected (like Cinderella) because official knowledge thinks it already knows the answers, or finds the matter irrelevant or disagreeable. Research tends to follow the money, leaving many important topics moping by the fireside.

Consider old-fashioned garden lore, commonly derided as ‘old wives tales’. Such lore is widely used to guide horticultural practice, and is propagated by

Chinese whispers, repeated in garden books while everybody assumes that somebody somewhere must have done the original research. But have they? Who is going to check these things out? The results could be genuinely useful, whether confirmed or—even more so—if disconfirmed. Here are two among many we thought helpful to investigate:

> "A layer of black plastic sheeting warms the soil". For most people, this simply stands to reason and must be true. But has anybody actually measured it? We did, and it doesn't. *Clear* plastic sheeting has quite a strong effect, but black plastic has only a very small effect. So the warming was an urban myth.
>
> "Always plant brassicas (cabbage family) in firm ground". Why? It does not help most plants, which prefer a looser texture. But this one is easy to test, especially if you have some ground that has been compacted for some time. And yes, there is a very strong effect. All it needed was a control, and we always try to encourage those who attend garden courses at CAT to make sure they design control samples whenever trying anything new. In principle, any gardener could contribute useful new knowledge.

There are some cases where potentially useful areas are not only neglected but positively rejected. An example is the use of human urine as a fertiliser. Extensive trials at CAT over many years have shown it to be a versatile and complete source of plant fertility, a microbially sterile fluid safer than (say) bath-water (Figure 5). And using (or 'recycling') it of course minimises the widely-recognised problems in its release to the wider environment (OECD, 2007).Yet despite, a considerable range of positive reports (Richert *et al*., 2010) in the UK at least it remains a 'Cinderella' area of research.

Urine might not be cool, but other topics are positively taboo. There are many subjects where there exists a large constituency who would like to know more, but there is no reliable information because the topic is simply off the scientific radar. A case in point is the influence of the moon on plant growth. No university researchers would engage with this because they 'know' it would be a waste of time and that they would be ridiculed by colleagues, or worse.

Yet out there in the world are thousands, perhaps millions, who *do* believe the moon influences plant growth, and operate their farms and gardens according to elaborate lunar calendars. And many people really do want to know whether it is true. This is a gap, and a job for CAT because we are not subject to academic peer-pressure. Actually it is quite difficult to create an experiment that will test all the claimed systems, but we tried our best. You might be relieved to hear there was no indication of any lunar effects. Was this then a waste of time? No, because in its rough and ready eighteenth-century way it was a controlled study and generated a clear result, and is ready to be replicated with larger sample sizes. It does not

**Figure 5.** Representative result of an experiment using diluted human urine as a general fertiliser in a low-fertility industrial-waste medium, control on right. A dramatic result, and 'classic' low-tech AT. Credit: Peter Harper.

disprove any lunar influence, but it should have picked up any effects large enough to be concerned with. My view of all these things is: if the effects exist but are very small, then why bother?

All the preceding examples are forms of 'science for the people' where we are investigating matters people really want to know about, which the orthodox research community cannot tell them, except on the basis of *ex cathedra* Higher Knowledge. We have investigated a fair range of 'weird' claims and never observed any really surprising effects. The point is that we investigated these matters in good faith, with open minds, gaining results that helped others to avoid false pathways. Nobody else would do it.

## Energy policy interventions

'Ecocentres' such as CAT are generally known for promotion and execution of small-scale 'bottom-up' processes, and historically CAT has shared this inclination. From time to time however, the organisation has attempted to analyse national or even international measures that would be required to deliver physical sustainability at a global scale. This arises from an extension of the basic egalitarian ethic across time, to include future generations. As ever, the question arises: Are the measures implied also AT, or actually a departure from it?

We can reasonably ask whether there are distinctive contributions that ecocentres can make to public policy. I would like to suggest one respect in which they could do so, because they are not trammelled by the requirement to be 'politically realistic'. Most official, governmental, academic or business reports are aware that they will be heavily censured, or simply ignored, if they make proposals outside the realm of what is currently politically plausible. As we see in UK climate change policy, one result is that elaborate proposals clearly do not match the physical requirements (Harper, forthcoming).

As a principle that CAT and a few others have adopted, it is more rational first to design policies that are *physically* realistic, and only afterwards work out what technical, political and economic measures are needed to deliver them. Naturally this means that the CAT reports, rigorously physical, tend to be ignored as politically implausible, but not entirely. And they often serve indirectly to change the terms of the debate.

An important early example was *An Alternative Energy Strategy for the United Kingdom* (AESUK), produced by Bob Todd and others in the 1970s (Todd, 1977). It was so far ahead of its time that it was readily dubbed 'unrealistic'; but subsequent events have been much closer to its prescriptions than the official projections of the late 1970s (Harper and Todd, 2004). Indeed the Energy Minister of the incoming UK government of 1997 was heard to cite it as having influenced his thinking.

AESUK inspired a further series of reports, *Zero-Carbon Britain* (CAT, 2013), moving very far from the low-tech bricolage of the early years. Remarkably, there is no embarrassment with economies of scale, huge machinery, grids, complete makeovers of agricultural policy, wartime-scale investments—all implying 'creative destruction' on a gargantuan scale (Figure 6). The whole analysis is driven by basic ethics and arrays of numbers that specify the physical timetable. The results are simply a following-through of the physical constraints with minimal regard for politics. The subsequent political choices must follow the relatively few physically viable transition pathways, and are largely left for others to explore, but clearly the process cannot be left to liberalised global markets.

One striking feature of the ZCB reports is that for entirely pragmatic reasons they emphasise *technical* solutions, and try to avoid the need for lifestyle changes. There is no doubt that changes of customary practice will be essential, and that the recent historic period of rapid growth is over. Nevertheless the reports' abandonment of lifestyle change as *the* key component is a considerable shift. This distances CAT from the 'deep green' parts of the environment movement, who usually cleave to the doctrine that Small is (always) Beautiful.

This shift warrants comment. For some it is a betrayal of hard-fought ideals. For others it signifies a welcome return to the real world. Many at CAT would say it is

**Figure 6.** A floating 3 MW wind turbine. The ZCB reports envisage up to 100 GW of capacity in such machines in the deeper parts of UK territorial waters. Is this still AT? Credit: Statoil.

simply a recognition that we are running out of time. Had the long slow cultural changes called for in the 1970s taken hold and become widespread, all could have been achieved with 'alternative' systems. But of course these changes have not spread, and as various global thresholds loom, the responses have to be more rapid, drastic, infrastructural and 'one-size-fits-all'. By analogy, an accident victim with severe blood-loss needs a tourniquet, a blood transfusion and emergency surgery—not an improved diet, plenty of exercise and co-counselling. Thus the *Zero-Carbon Britain* studies are aimed at a rapid global and national emergency transition.

At the same time, the studies do not deny the value of millions of small, local and particular processes. Back on the CAT site, experiments continue in the search for functional local systems with minimal environmental impacts. CAT continues to provide tools and inspiration for people who want to make a greater personal contribution to general sustainability.

But today there is much more concern for whether new systems can be generalised and applied on a wider national scale. The basic principle of 'fairness and physics', extended in time (Schellnhuber and Klingenfeld, 2011), dictates that the transition to a sustainable world be extremely rapid. It seems unavoidable that 'high-tech' must do the heavy lifting, at least in the short term. Thus two different forms of socio-technical transition need to run in parallel.

## Disclosure statement

No potential conflict of interest was reported by the author.

## Note

[1]An explanatory aside is needed with respect to the parallel term 'Appropriate Technology', often used as a synonym and with the same abbreviation AT. 'Appropriate Technology' was originally applied to situations in developing countries and was derived from Schumacher's earlier notion of 'Intermediate Technology' (Schumacher, 1968, 1973). Later the terms were often used interchangeably (Rybczynski, 1980; McRobie, 1981).

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