Review
Sustainable Energy – without the hot air

Title:	Sustainable Energy – without the hot air
Author:	David JC MacKay
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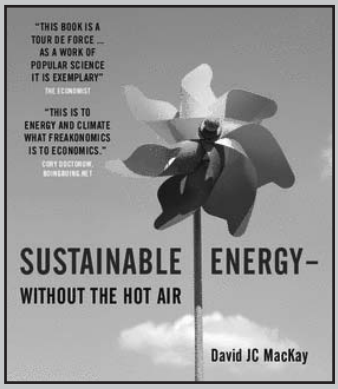

The fact of global climate change is, famously, contested but, as the scientific evidence has accumulated, a broad consensus has emerged that warming of the earth is indeed happening and that this is anthropogenic. Now the main debate (we will ignore here the minority of naysayers) has moved from 'whether' (it is happening) to 'what' (to do about it); this debate is not going well, if the measure of success is practical actions, globally agreed (or even agreed on a nation-by-nation basis), to reduce the rate of emissions of greenhouse gases with the aim, ultimately, of reducing the actual amount of such gases in the atmosphere.

There are however some points of agreement and one is that 'Sustainability' has become a key construct through which the debate is conducted, generally understood be linked to the idea of sustainable development as defined by the Bruntland Commission:

> Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.
> (Bruntland, 1987)

Although the concept of education for sustainable development (ESD) is also contested (Dillon & Huang, 2010), many countries, including the UK, have inserted sustainability into national curricula or standards. Teachers of D&T, amongst many others, are expected to embed thinking about sustainability into their teaching and my sense is that most do so gladly; given the focus in D&T on using materials to design and make products it would be strange if we didn't ask pupils to consider the environmental impact of both their material choices and their design intentions. A great deal of effort has been made to provide materials that can support sustainable thinking in D&T, some from commercial bodies, some from charities and some from industries. And therein lies a problem; how can teachers easily evaluate the accuracy of these materials? How robust are the claims they make, how influenced by commercial interest or political bias? This where MacKay's book makes its contribution powerfully, at least in the territory of sustainable energy and in the context of the UK. The best description of the book's aim, and an indication of its style, comes from it's own preface:

> I'm concerned about cutting UK emissions of twaddle – twaddle about sustainable energy. Everyone says getting off fossil fuels is important, and we're all encouraged to "make a difference," but many of the things that allegedly make a difference don't add up.
> Twaddle emissions are high at the moment because people get emotional (for example about wind farms or nuclear power) and no-one talks about numbers. Or if they do mention numbers, they select them to sound big, to make an impression, and to score points in arguments, rather than to aid thoughtful discussion.
> This is a straight-talking book about the numbers. The aim is to guide the reader around the claptrap to actions that really make a difference and to policies that add up.
> (p. viii)

After a discussion of some of the numbers surrounding nuclear power the author makes the point that:

> I'm not trying to be pro-nuclear. I'm just pro-arithmetic.
> (p.169)

So important does MacKay (a professor of Physics at Cambridge University) feel his mission to be that he has made his book free in two senses. Firstly, as well as being published as a physical book it also freely available as a series of electronic files at http://www.withouthotair.com/. Secondly MacKay has made the content (apart from some licensed images that he doesn't own) free to use under a Creative Commons licence and particularly encourages the use of the content for educational purposes; this is significantly aided by the fact that not only the text but also high quality versions of the many images in the book are available for download from the address above.

Sustainable Energy – without the hot air

The book is divided into 4 main sections:
1. Numbers not Adjectives.
2. Making a difference.
3. Technical Chapters.
4. Useful data.

The aim of the first section is to create a balance sheet of energy use and potential renewable production for the UK to establish just what the scale of the sustainable energy problem for the UK is. To do this, the author first creates a common unit for analysis; the amount of power used per person expressed as kilowatt hours per day [kWh/d]. Converting all power use and production into this form makes the subsequent comparisons much clearer for the reader.

The section goes on to create a kind of power profit and loss account for the UK by analysing the main sources and uses of power, taking a source and a use in alternate chapters. Two devices are used to keep these analyses accessible. Firstly, about half of the chapters (8 of 15) are accompanied by a technical chapter in section 3 into which more advanced mathematical analysis is placed, thus keeping the section 1 chapters both short and clear. Secondly the results of each chapter's analysis of energy sources and uses is displayed as a graphic made up of two stacks; the left-hand one displaying the accumulated energy consumption and the right-hand one showing the potential for sustainable energy production and this builds into a summary that can be quickly assimilated (figure 1).

This first section finishes by suggesting that the summary shown in figure 1 relies on rather too optimistic assumptions about the UK's ability and willingness to deploy renewable resources as well as rather too pessimistic assumptions about energy use. Figure 2 shows what the author believes the situation will be after a public consultation about renewables.

Section two faces up to the problem implied by figure 2; that, on the analysis provided, renewables sourced in the UK alone are not sufficient to meet the UK's energy needs. It makes the point that very large changes in both demand and supply are required to meet the demands of sustainability (and suggests that 'The mantra "Little changes can make a big difference" is bunkum, when applied to climate change and power.' (p.114)).

The section thus focuses on ways to reduce demand and increase supply that can make a big difference. In summary, the analysis points to demand reduction through the electrification of transport and of space heating and to increasing the supply of sustainable energy by some combination of UK-based renewables, clean coal, nuclear power and importing renewable energies – in particular from desert regions of North Africa.

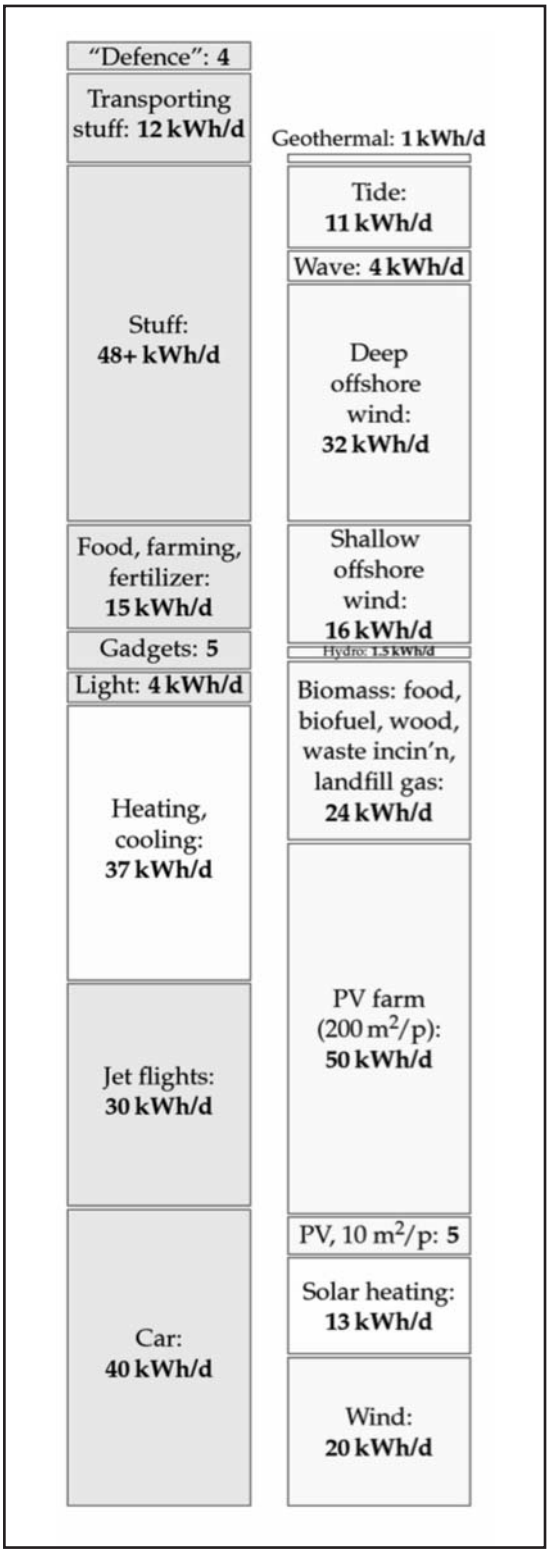

Figure 1. The final state at the end of section 1 (p103)

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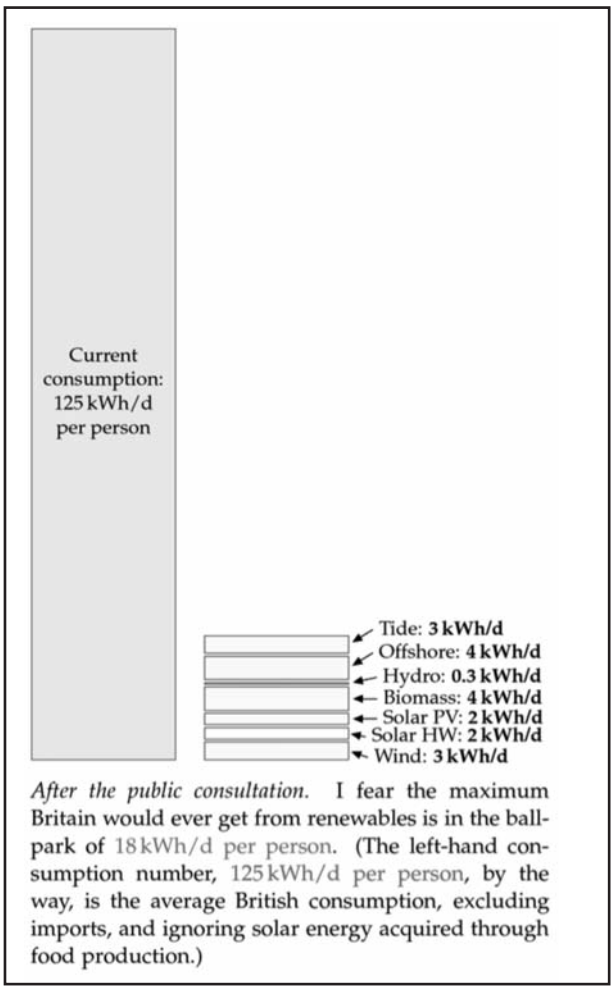

Figure 2. (p103)

To help exemplify the issues Mackay produces five possible energy plans that he believes are feasible to implement by 2050. These are based on consumption that is reduced from the current 125kWh/d to 68kWh/d with the vast majority of this demand being met by electrical power. These pans are summarised graphically in figure 3 but the author notes:

There are many plans that add up. In this chapter I will describe five. Please don't take any of the plans I present as "the author's recommended solution." My sole recommendation is this:
Make sure your policies include a plan that adds up!
Section 2 continues with some reflections on the likely costs of implementing these sustainable energy plans and the role of legislation, regulations and taxes in bringing about the required changes. It then briefly considers how the calculations applied in detail to UK energy supply could be applied to create 'Energy Plans Europe, America and the World'. The final chapter of the section suggests, with deliberate ambiguity, that "capturing carbon dioxide from thin air is the last thing we should talk about" and provides some background to the role of carbon dioxide in global warming and an overview of the potential of some carbon sequestration and geo-engineering technologies.

The third section, as noted above, provides technical annexes to some of the chapter in Section 2. The fourth section provides a range of technical data that will be invaluable to anyone wishing to explore or extend the calculations in the book.

Not everyone will agree with Mackay's conclusions (e.g. Kemp & Wexler, 2010) but that really isn't the point of his book; it's immense strength is its relentless focus on transparency in the assumptions, particularly numerical assumptions, that underlie the conclusions. One can only hope that this will significantly change the tone of sustainable energy debates.

For D&T teachers and lecturers (as well as those working in Science or on STEM projects) this is a valuable resource providing both a strategy for approaching discussions about sustainable energy and a wealth of data to support those discussions. Clearly sustainable energy is just a part of the sustainability discussion we want to have with pupils and students, but put this book together with those by, for example, Braungart & McDonough (2009) and Leonard (2010) and a very useful suite of resources to support ESD in D&T can be seen to be emerging.

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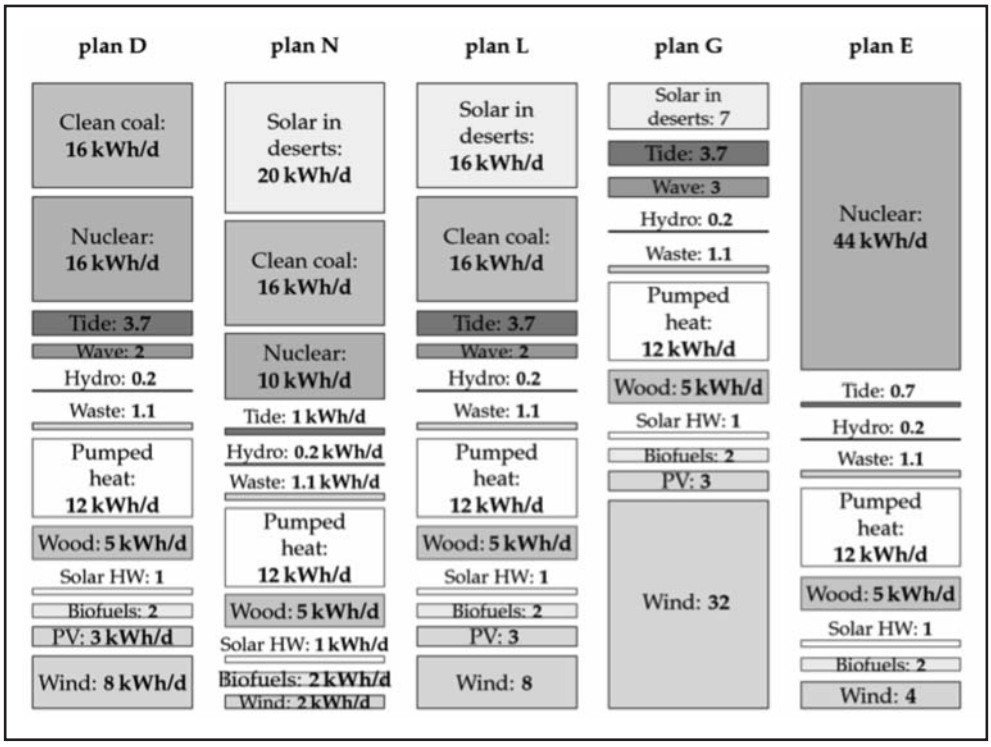

Figure 3. (p212)