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Electrify everything to save energy.

A new book published today (2 December 2008) describes the profound changes necessary to achieve the Committee on Climate Change's carbon targets (announced yesterday, 1 December 2008).

Sustainable Energy – without the hot air, by scientist Professor David MacKay from Cambridge University, offers detailed recipes to transform Britain from its fossil-fuel habit.

In these 'energy plans that add up',

- Britain must replace all its petrol and diesel cars by electric transport; and
- All building-heating systems must be replaced by heat pumps. [Heat pumps work like back-to-front refrigerators, using a little electricity to move a lot of heat into the building from the air or ground outside the building.]

These electric technologies are much more efficient than today's fossil fuel systems; of course to power these electric cars and heat pumps will require extra electricity which has to come from new zero-carbon sources.

Sustainable Energy – without the hot air describes the scale of building required to provide *all* Britain's energy from zero-carbon sources. For renewables to make a significant contribution, country-sized renewable facilities are required, either in our country or in someone else's. The other options that could contribute to the zero-carbon energy mix are not easy either: nuclear power, and coal with carbon-capture and storage. *[How to end this bit?]* MacKay's message is "it's not going to be easy to make an energy plan that adds up – but it is possible."

A few headline-ideas

Initiative to cut twaddle emissions

Energy book goes where few have gone before: to a thorough discussion of numbers.

Energy book gets cross-party support. Industry leaders, scientists, environmentalists, and politicians of all colours have praised David MacKay's new book,

Sustainable Energy – without the hot air, for its clear and objective presentation of energy arithmetic.

Tony Juniper, former Executive Director of Friends of the Earth, said "For anyone with influence on energy policy, whether in government, business or a campaign group, this book should be compulsory reading."

Robert Sansom, Director of Strategy and Sustainable Development, EDF Energy, said "At last a book that comprehensively reveals the true facts about sustainable energy in a form that is both highly readable and entertaining."

Peter Ainsworth MP, Shadow Secretary of State for Environment, Food, and Rural Affairs, said *Sustainable Energy – without the hot air*, is "engagingly written, packed with useful information, and refreshingly factual."

David Howarth MP, Shadow Solicitor General, Liberal Democrats, said "David MacKay's book sets the standard for all future debate on energy policy and climate change."

Michael Meacher MP, Former Environment Minister, said "This hugely important book ... should be a 'must read' not only at home and in industry, but on each Government Minister's desk, and not just in the UK."

More endorsements

... a really valuable contribution ... uses a potent mixture of arithmetic and common sense to dispel some myths and slay some sacred cows.

Lord Oxburgh KBE FRS
Former Chairman, Royal Dutch Shell

Energy policy is crucial for the world, and a wide public should be engaged in debate and decisions on these issues. But such debate must be grounded in realistic numbers and good physics. All the key principles are clearly and accessibly explained in this book. David MacKay has performed a great service by writing it.

Prof Martin Rees FRS
President of the Royal Society

This remarkable book sets out, with enormous clarity and objectivity, the various alternative low-carbon pathways that are open to us.

Sir David King FRS
Chief Scientific Adviser to the UK Government, 2000–08

Fascinating, provocative, and realistic, this book lives up to its name and gives us the tools for straight thinking about climate change.

Sir John Sulston FRS
Nobel laureate; Chair, Institute of Science, Ethics and Innovation, University of Manchester

This book is what has been needed for a long time. This is a book which tackles energy from first principles, which demystifies the overwhelming array of information

that is published, and which does so accessibly. This should be the starting point for anyone trying to understand the issues surrounding sustainable energy.

Peter Guthrie OBE FRAE

Professor of Engineering for Sustainable Development; Trustee/Director of Engineers Without Borders

A few quotes from the book

Motivations [p2]

I recently read two books, one by a physicist, and one by an economist. In *Out of Gas*, Caltech physicist David Goodstein describes an impending energy crisis brought on by The End of the Age of Oil. This crisis is coming soon, he predicts: the crisis will bite, not when the last drop of oil is extracted, but when oil extraction can't meet demand – perhaps as soon as 2015 or 2025. Moreover, even if we magically switched all our energy-guzzling to nuclear power right away, Goodstein says, the oil crisis would simply be replaced by a *nuclear* crisis in just twenty years or so, as uranium reserves also became depleted.

In *The Skeptical Environmentalist*, Bjørn Lomborg paints a completely different picture. "Everything is fine." Indeed, "everything is getting better." Furthermore, "we are not headed for a major energy crisis," and "there is plenty of energy."

How could two smart people come to such different conclusions? I had to get to the bottom of this.

On "Wind or nuclear?" [p3]

"Wind or nuclear?"... Greater polarization of views among smart people is hard to imagine.

This heated debate is fundamentally about numbers. How much energy could each source deliver, at what economic and social cost, and with what risks? But actual numbers are rarely mentioned. In public debates, people just say "Nuclear is a money pit" or "We have a *huge* amount of wave and wind." The trouble with this sort of language is that it's not sufficient to know that something is huge: we need to know how the one "huge" compares with another "huge," namely *our huge energy consumption*. To make this comparison, we need numbers, not adjectives.

Where numbers are used, their meaning is often obfuscated by enormousness. Numbers are chosen to impress, to score points in arguments, rather than to inform. "Los Angeles residents drive 142 million miles – the distance from Earth to Mars – every single day." "Each year, 27 million acres of tropical rainforest are destroyed." "14 billion pounds of trash are dumped into the sea every year." "British people throw away 2.6 billion slices of bread per year." "The waste paper buried each year in the UK could fill 103 448 double-decker buses."

If all the ineffective ideas for solving the energy crisis were laid end to end, they would reach to the moon and back.... I digress.

The result of this lack of meaningful numbers and facts? We are inundated with a flood of crazy innumerate codswallop. The BBC doles out advice on how we can do our bit to save the planet – for example "switch off your mobile phone charger when it's not in use;" if anyone objects that mobile phone chargers are not *actually* our number one form of energy consumption, the mantra "every little helps" is wheeled out. Every little helps? A more realistic mantra is:

if everyone does a little, we'll achieve only a little.

The truth about chargers [p68]

> Modern phone chargers, when left plugged in with no phone attached, use about half a watt. In our preferred units, this is a power consumption of about 0.01 kWh per day. For anyone whose consumption stack is over 100 kWh per day, the BBC's advice, *always unplug the phone charger*, could potentially reduce their energy consumption by one hundredth of one percent (if only they would do it).
>
> *Every little helps!*
>
> I don't think so. Obsessively switching off the phone-charger is like bailing the Titanic with a teaspoon. Do switch it off, but please be aware how tiny a gesture it is. Let me put it this way:
>
> > All the energy saved in switching off your charger for one day is used up in *one second* of car-driving.
> >
> > The energy saved in switching off the charger for *one year* is equal to the energy in a single hot bath.

On planes

Imagine that you make one intercontinental trip per year by plane. How much energy does that cost?

[*A calculation follows, and concludes...*]

... your average energy consumption is 29 kWh per day.

Let's make clear what this means. Flying once per year has an energy cost slightly bigger than leaving a 1 kW electric fire on, non-stop, 24 hours a day, all year.

Some questions and answers

What's this book about?

Sustainable Energy – without the hot air looks carefully at all the technologies that can contribute to a sustainable energy solution. There are just three main options for

getting off fossil fuels: efficiency measures; renewables; and nuclear power. *Sustainable Energy – without the hot air* shows, from first principles, how much each of these options can contribute. Then it describes six solutions for the UK, six building plans with different balances between the options. And what has to be emphasized is, whatever plan you choose, if it adds up, it requires building of new energy systems on an enormous scale, a scale far bigger than most politicians ever discuss.

Hasn't government already committed to a big expansion of renewables and nuclear?

Yes, but these plans don't go far enough, and today's building rates of new energy systems are nowhere near big enough to achieve the targets set by the Committee on Climate Change. John Hutton announced permission a year ago for 33 GW of new wind farm capacity, which corresponds to roughly 11 000 turbines. If these wind farms were built they would generate **4 kWh per day per person**. [In *Sustainable Energy – without the hot air*, I express all forms of energy consumption and production *per person*.] There's also been discussion of building 10 new nuclear power stations. With an average output of 10 GW, these would generate **4 kWh per day per person**, just the same as the proposed wind farms. In contrast, Britain's total energy consumption today is **125 kWh per day per person**. **[That's *all* forms of energy consumption: transport, heating, electricity, for example.] Now, 4 plus 4 is 8, so these wind farms and nuclear plants would contribute only about 8% of our current consumption. We need to be realistic about the scale of what's required to make an energy plan that adds up.**

You emphasize that heat pumps are an efficient way to do heating. What about combined heat and power?

If we are serious about getting off fossil fuels, combined heat and power using natural gas is nonsense. Combined heat and power means carrying on burning natural gas in order to make heat and electricity *together*. Yes, it's very slightly more efficient than burning natural gas to make heat and electricity separately. But *it still uses natural gas!* That's a fossil fuel. Britain's natural gas is running out. And burning natural gas causes climate change. Thankfully, as *Sustainable Energy – without the hot air* explains, heat pumps are a significantly more efficient way to heat buildings and to make hot water.

How come you don't mention hydrogen-powered cars?

Today's electric cars are more than ten times more energy-efficient than hydrogen-powered cars. The BMW Hydrogen 7 car uses three times more energy than the average British fossil-fuel car. [Powering the BMW uses 254 kWh per 100 km; the average British car uses 80 kWh per 100 km.] In the European trials of hydrogen buses, the energy consumption of the hydrogen buses was between 80% and 200% greater than that of the baseline diesel bus. Meanwhile, electric vehicles such as the Tesla car, the Th!nk Ox, and the Lightning use far less energy than the average car [between 11 kWh and 20 kWh per 100 km; and there are prototype cars such as the

Loremo that use as little as 6 kWh per 100 km]. If hydrogen cars turn out to beat electric cars, all well and good. But it seems very unlikely!

You don't seem very keen on decentralized microgeneration?

I am keen on anything that works. I'm pro-arithmetic. Some forms of decentralized microgeneration *do* work – for example, solar panels on roofs for making hot water: they work, they can generate roughly half of your home's hot water. The data's displayed on page 39 of *Sustainable Energy – without the hot air*. Every south-facing roof should have a hot-water panel.

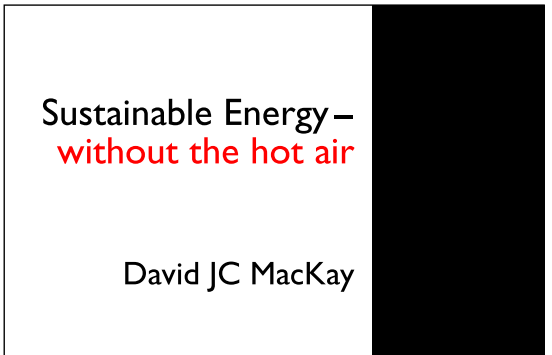
However, some microgenerators simply do not work. Microturbines, for example, on typical roofs in Britain, generate so little energy, they will never pay for the energy cost of their own manufacture. Perhaps if these useless windmills make people think about their energy consumption, they may have some useful side-effects. But as energy generators, they are worse than useless.

Why did you write this book?

I wrote *Sustainable Energy – without the hot air* to try to help everyone to have constructive conversations about energy, instead of the perpetual Punch-and-Judy show of pro-wind versus anti-wind, pro-nuclear versus anti-nuclear. We need to get off fossil fuels, and we need an energy plan that adds up. We need to talk about facts and numbers, and cut UK twaddle emissions. Twaddle emissions have been high recently because people have been debating energy policy without talking about numbers – or if people do use numbers, they select them to sound big, to make an impression, and to score points in arguments, rather than to aid thoughtful discussion. *Sustainable Energy – without the hot air* is intended to be an honest, balanced, straight-talking book about the numbers.

I heard that the book is available free online. Is that right?

Yes, the whole book is available for free download. Obviously, I want my nice publisher to be happy, so I hope lots of people buy the book. But sustainable energy is really important. I want everyone to understand the energy challenge, and to know how the facts and the numbers add up. So *Sustainable Energy – without the hot air* is available in full at `www.withouthotair.com`.



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Sustainable Energy – without the hot air

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At last a book that comprehensively reveals the true facts about sustainable energy in a form that is both highly readable and entertaining.

Robert Sansom
Director of Strategy and Sustainable Development EDF Energy

A new book published by a Cambridge scientist lays out the numbers required for constructive energy discussions. The energy debate is notorious for generating acrimonious argument and confrontation, but the honest, fact-based approach of "Sustainable Energy - without the hot air," by physics professor David MacKay, has won remarkable support from across the political parties, from industry, and from environmentalists.

How much energy do we use, per person? How much energy could we produce from renewables, per person? How big will renewable facilities need to be, in order for renewables to make a sizeable contribution? What are our other sustainable energy options, apart from renewables, and how much could they produce?

How easy is it to get off our fossil fuel habit? Could Britain live on its own renewables? How does our current energy consumption compare with our sustainable energy options? David MacKay will offer a straight-talking assessment of the numbers, and discuss how to make energy plans

that add up.

explores current consumption of energy, what could conceivably be generated by renewables in a country like Britain, and the potential of efficiency measures and new technologies to reduce consumption.

All expressed in a single consistent set of user friendly units.

Catch-phrases: Numbers not adjectives

Discusses All energy-generating technologies that could claim to be called 'sustainable', not only renewables – including 'clean coal' nuclear fission, and nuclear fusion.

Not pro-nuclear - pro-arithmetic

Scale of building required

Possible details:

1) examples of some numbers from the book. Phone charger 0.01 kWh per day Driving a car for one second 0.01 kWh.

2) examples of things that don't come out well under the book's scrutiny, and things that do: a) Hydrogen car / electric car

b) combined heat and power / heat pumps

c)

3) Scale of wind to make a difference; scale of wave to make a difference.

More quotes.

Sustainable Energy – without the hot air.

The author – **David MacKay** is a Professor in the Department of Physics at the University of Cambridge. He is a member of the World Economic Forum Global Agenda Council on Climate Change. He studied Natural Sciences at Cambridge then obtained his PhD in Computation and Neural Systems at the California Institute of Technology. He is internationally known for his research in machine learning, information theory, and communication systems. He has taught Physics in Cambridge since 1995. Since 2005, he has devoted increasing amounts of time to public teaching about energy.