We have an addiction to fossil fuels, and it’s not sustainable. How can we replace fossil fuels? How can we ensure security of energy supply? How can we solve climate change?

We’re often told that “huge” amounts of renewable power are available – wind, wave, tide, and so forth. But our current power consumption is also huge! To understand our sustainable energy crisis, we need to know how the one “huge” compares with the other. We need numbers, not adjectives.

This book shows how to estimate the numbers, and what those numbers depend on. Taking the United Kingdom as an example, it asks first “could Britain live on renewable energy resources along?” and second “how can a country like Britain make a realistic post-fossil-fuel energy plan that adds up?” It answers these questions in detail, bringing home the size of the changes that society must undergo if sustainable living is to be achieved. It’s not going to be easy to make an energy plan that adds up – but it is possible.

David MacKay is a Professor in the Department of Physics at the University of Cambridge.
Sustainable Energy – without the hot air
David JC MacKay

4 Wind

The UK has the best wind resources in Europe. Sustainable Development Commission.

Wind farms are distributed across the country

James Lovelock

How much wind power could we realistically generate?
We can make an estimate of the potential of on-shore (land-based) wind in the United Kingdom by multiplying the average power per unit land area of a wind farm by the area per person in the UK:

\[
\text{power per person} = \text{wind power per unit area} \times \text{area per person.}
\]

Chapter 8 (p168) explains how to estimate the power per unit area of a wind farm in the UK. If the UK wind map is in a 12 by 12 miles per hour, the power per unit area of wind farm is about 24/1000.

The figure of 6 m/s is probably an over-estimate for many locations in Britain. For example, figure 4.1 shows daily mean wind speeds in Cornwall during 2006. The daily average speed reached 3 m/s, only about 60% of the 6 m/s quoted at 30 km/h. That gives an approximate figure of 3 m/s. The average of 6 m/s in Scotland figure 4.2.

Figure 4.2. The British population density: 250 people per square kilometre in 400 square metres per person, we find that wind power could

We start with a square 100 m by 100 m area of roughly 0.001 by 0.001 at 1 m/s average wind, the power delivered would be

\[
\text{power per person} = \frac{0.001 \times 1}{0.001} = 1 \text{W/m}^2.
\]

The power delivered by the wind farm is

\[
\text{wind power per unit land area} = \frac{0.001 \times 1}{0.001} = 1 \text{W/m}^2.
\]

Figure 4.3. Cambridge wind farm (source: Cambridge Photovoltaics). Stirling engine. 2007. Shear stress 5000. PV farm 1995.

The average wind power delivered in the UK is 3 m/s, so that the power per unit area of a wind farm is about 24/1000.

The average Brit throws away 400 g of packaging per day.

In 1995, Britain invented the first commercially available wind farm. The power station is

\[
\text{power} = \frac{1}{100} \times 100 \times 1 = 1 \text{W}.
\]

The mass of one can is 15 g. Estimating wind power per unit area.

Source: Hammond and

From Swedish Steel, “The consumption of coal and coke is 700 kg per ton of finished steel, equal to

48 kWh per day per person

for the transport of the stuff by sea, by road,

and by rail. The mass of steel is

150 MJ per kg of aluminium (40

\[
\text{wind power per unit land area} = \frac{48}{700} = 0.068 \text{W/m}^2.
\]

Wind power per unit area

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\]

The consumption of oil, LPG and electrical power is 710 kWh per ton finished product.

Note that both of these approaches are underestimates of the true area. The corrected area is

\[
\text{wind power per unit area} = \frac{48}{700} = 0.068 \text{W/m}^2.
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