In December 2007 I was motivated, by something I had read relating to the environment, to submit to the editor of a long established Scottish newspaper, namely the Herald, a letter making some comments on global warming, which at the time I felt needed to be expressed. It contained the following paragraph:

It troubles me that the news media, politicians, industrialists, economists and even some scientists continue to ‘green-wash’ the situation by propagating the lie that renewable sources of power will allow 6.5 billion people, growing rapidly to 10 billion, to pursue Western style energy wasteful modes of living, while at the same time protecting the planet. I suspect that even if every suitable pocket of land on the surface of the planet were covered with windmills, solar panels and bio-fuel crops, and if every suitable sea shelf, estuary and strait were furnished with windmills, wave machines and barrage systems, we would still have insufficient power from renewables to accomplish this.

Since submitting it, I have been exercised by niggling doubts as to the extent to which this statement is fully supported by the scientific and engineering evidence. My ‘gut feeling’ – not an instinct I like to rely on too much as an engineer – on the basis of my long acquaintance with electrical systems, and of wide reading on the subject of global warming, is that it probably expresses a grain of truth about the exaggerated claims for ‘renewables’, not by those ‘at the sharp end’ developing these renewable systems, I hasten to add, but by those with a vested interested in unimpeded economic growth. The ‘spin’, which largely amounts to unsubstantiated assertions made repeatedly in certain organs of the ‘media’, in effect suggests that renewable resources can provide a complete replacement for fossil fuels, when they eventually run out, or preferably, are locked below ground before they do. If we assume that a post fossil fuel era will arrive, sooner or later, the implication is that for the foreseeable future energy supply will not be constrained, and hence that ‘business as usual’, particularly in the industrialised world, is possible. I should note that here, and throughout the book, the term renewable energy implies energy diverted to human use, which is endlessly available as a result of daily solar radiation passing through the atmosphere and striking the surface of the
planet. This diversion does not add to or subtract from the Earth’s energy balance and is thus sustainable.

Some well established global warming arguments, which suggest that business-as-usual is not an option for mankind, are revisited in Chap. 1. The exhortations emanating from these arguments urging the global community to drastically cut fossil fuel usage, and to expand energy supply from the so called ‘renewables’, are also reconsidered from an electrical engineer’s perspective. However, despite the expressed fears, the commonplace presumption appears to have developed, for whatever reason, that the amount of power that mankind can potentially harness from hydro, wind, wave, sun and other renewable resources, is more than large enough to assuage future demand levels. While the levels of potential global power consumption, which are well documented, usually in official reports, are generally accepted as being reliable, the presumption of unlimited power from renewables is like saying that since we have enough land to grow all the wheat we need, the future global consumption of bread will be satisfied. Just because enough land may be available it does not necessarily mean that it will be allocated to the growing of wheat, or that enough wheat will be grown, or that grain will be available where it is needed, or that enough bread will be baked where it is most required. Such a statement of potential capacity doesn’t really get you very far. Competing interests will inevitably interfere. What we need to compare is electrical power that can reasonably be delivered to consumer sockets (after taking account of land suitability, land use, losses in the electrical generation and transmission systems), with the rate at which fossil-fuels are being consumed worldwide, to get a more realistic appreciation of the extent to which renewable capacity and global demand are likely to converge.

Here the issue has been examined from a more firmly focused engineering perspective than appears to have been attempted elsewhere. By taking a closer look at the original, readily available, undocred power and energy data for renewable resources, it has been possible to construct, a coherent and comprehensive, scientific account of the current situation, vis-à-vis the potential capacity of alternative power supplies. From this firm knowledge base, an attempt has then been made to develop reliable engineering predictions of the exploitation potential of each of these sustainable resources in a 30–40 year time frame. In so doing it has been necessary to assume that we can depend on technology that is either currently available or is presently under development, and is therefore capable of being brought on-stream in this timescale. Also, by relying on well established electrical engineering laws, techniques and data, the computational process has, hopefully, allowed us to arrive at firm estimates for the power, which might realistically be transmitted to global consumers from these sources.

As far as has been possible I have conducted the energy assessment exercise with my ‘engineering hat’ firmly on, and hopefully much of the content reflects this. However, any book impinging on global warming, the truth or otherwise of anthropogenic forcing, and the problems of weaning mankind off its dependency on fossil fuels, is inevitably dealing with intensely economic and political issues. Consequently, it has obviously been difficult not to enter this political debate to
some extent, no matter how tangential some of these issues may be to the main thrust of the book. Where I have done so, intentionally or unintentionally, I can only hope that the contributions are justifiable and helpful. The approach will probably be dismissed, in some quarters, as being economically naïve, but given the events of 2008 which suggest that ‘economic science’ is on the point of unravelling, who knows what now constitutes sound economics? Notwithstanding the intentionally narrow scope of the exercise, the engineering logic has led inexorably to a global perspective on renewable power supply and transmission, which has some surprising and uncomfortable ramifications for mankind. While several contributors to the debate have hinted at some of these consequences, I am not aware of any alternative assessments of the issues of global electrical supply and demand in the post fossil fuel era, which also highlight the potentially awkward implications that are lying in wait for advanced societies in making the transition to renewables.

Within the main chapters of the book I have attempted to furnish enough in the way of electrical engineering fundamentals to provide a primer for the reader to help him/her to appreciate the following: how renewable sources of energy can be exploited to provide electricity: how the electricity is generated and transmitted: what the constraints are: where the limits to the exploitation of renewable resources lie: how we can overcome intermittency of supply. While we shall need some basic physics and some elementary electrical engineering concepts to intelligently develop our arguments, this is certainly not an electrical engineering book in the college text sense. It contains no electrical engineering science beyond a very basic, school science, level. A good understanding of energy and power relationships, which are often poorly understood by non-scientists, is key to being able to assess or question the claims of the energy industry, particularly in relation to ‘renewables’, and to reach as wide an audience as possible the book attempts, largely through analogy, to illuminate these relationships in Chap. 2. Nonetheless, engineering and scientific concepts are most precisely expressed through mathematics, and for those who did not turn their backs on the subject at an early age, some relevant equations are provided in the referenced ‘notes’. Renewable sources of power and their exploitability are evaluated in Chap. 3, while the enabling topic of massive energy storage is dealt with in Chap. 4. The final chapter is Chap. 5, in which some engineering based conclusions, and I stress ‘engineering based’, tinged with some unavoidable, but hopefully helpful, personal observations, are presented, with the aim of examining the manner in which the technological transition might possibly proceed, to a world in which electricity is supplied entirely from renewable resources, as they become the only source of power that mankind can safely access.

Naturally all views, assertions, claims, calculations and items of factual information contained in this book have been selected or generated by myself, and any errors therein are my responsibility. However, the book would not have seen the light of day without numerous personal interactions (too many to identify), with family, with friends, and with colleagues at the Heriot-Watt University, on the topic of global warming. So if I have talked to you on this topic, I thank you for
your contribution, and the stimulus it may have provided for the creation of this book. I would, also, particularly like to thank my son Iain (Sangster Design) for one of the illustrations, and the members of staff at the Heriot-Watt University library, who have been very helpful in ensuring that I was able to access a wide range of written material, the contents of some of which have been germane to the realisation of this project.

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