

Preface

This book is intended to be a technology resource for students of electrical science and for electrical engineering departments in universities and colleges with an interest in developing courses focused on the rapidly burgeoning topic of solar radiation collection. This development has been awakened by a growing concern of the impending dangers, for future generations, of climate change. The author hopes that this text will contribute, in some small way, to the evolution of a technological route out of our self-inflicted predicament caused by an unsustainable addiction to fossil fuels.

During the first decade of the twenty-first century, it is probably now fair to say that the vast majority of reputable scientists with an interest in anthropogenic global warming would have accepted that the ‘canary in the mine’ providing the warning for its arrival would be the state of summer sea ice in the Arctic. Should it ‘expire’, this would herald ‘real evidence’ for the dubious non-scientific world of dangerous man-made climate change. In the summer of 2012 the canary fell off its perch! Arctic Sea ice cover in late summer of 2013 almost disappeared.

The reaction to this cataclysmic event in the media and other electronic outlets which generally claim to be representative of public opinion was almost precisely nothing. In 2013, *Homo sapiens*’ collective head was still stuck firmly in the ground despite the seemingly endless breeching of weather records around the world, particularly in the United States, where the ‘bread-basket’ southern states are suffering ‘dust-bowl’ conditions as global warming brings desertification. The record breaking hurricane Sandy which struck the East Coast of North America in the autumn of 2012—dubbed the Frankenstorm in the US media and in blogs on the Internet—had a devastating impact on New York, and some reports and reactions suggested that it may have been the ‘light bulb switch on’ moment in the consciousness of the US public. At the very least, it is perhaps valid to suggest that the ‘Denial Lobby’, which for 25 years has strenuously and vociferously dismissed the notion of anthropogenic climate change, has finally been defeated. The battle now, is over whether society should adapt to the inevitable ravages wreaked by global warming, or should it adopt the obvious fundamental solution to the problem which entails abandoning the fossil fuels which by combustion are ‘poisoning’ the

atmosphere? These alternative futures are well described in Jorgen Randers' book entitled simply "2052". The dilemma for mankind is succinctly put in this quotation from that book (the additional observations in parentheses are mine):-

Thus the main challenge in our global future is not to solve the problems we are facing (these are do-able), but to reach an agreement to do so (almost impossible). The real challenge is to have people and capital owners accept short-term sacrifice, roll up their sleeves, and do the heavy lifting. The agreement to act will arise, sooner or later, but it will come late in the day, and the resulting solution even later. As a consequence, humanity will have to live with the unsolved problem (of climate change) longer than if the action had been started at once. Waiting for the 'market' (as we are doing) to give the start signal will lengthen the temporary period of forced sacrifice. Forward-looking political leadership (almost extinct) could kick start the societal response but may be kept from doing so by the democratic majority of voters with a short term perspective.

The science of climate change and the dangers it poses for mankind has been reiterated five times by climate scientists on the International Panel on Climate Change (IPCC5), and with increasing forcefulness. The latest warning has very recently (Spring 2014) been spelt out, comprehensively and with all the relevant evidence, in the 5th Report sponsored by the United Nations.

A feature of renewable power sources such as wind, wave and solar, which is raised repeatedly in debates about their capacity to replace fossil fuel powered electricity generators, is intermittency of supply. However, at the global, or continental level (Europe, say), the variability of renewables can be addressed more easily. When the wind is not blowing in Scotland, or the sun is not shining in Germany, the former will likely be gusting in Portugal, while the latter will be sizzling in Spain! Under the auspices of the European Community, several reports have been generated to assess the feasibility of a direct current (DC) super-grid connecting geothermal power stations in central Europe, solar power stations in southern Europe and North Africa, wind farms in Western Europe, wave/tidal systems in Scandinavia and Portugal, and hydroelectric stations in Northern Europe. This system would be backed up by massive storage facilities based on pumped hydro-storage in reservoirs or artificial lagoons, on compressed gas and hot water thermal storage using cathedral sized underground caverns, on massive fly-wheel farms, on battery storage barns the size of football pitches and on huge super-cooled magnetic storage devices. Prototype examples of all of these technologies already exist, and undersea power lines from Scotland to the continent of Europe are seriously being evaluated.

Clearly the technologies already largely exist to make a Europe-wide electrical power supply system a reality. In fact, it should be emphasized that almost all of the renewable technologies listed above are relatively conventional. In principle, therefore, sustainable power systems based on these technologies could be executed very quickly if drive, leadership, determination, enthusiasm and cooperation can be imbued in the international community, to recruit and deploy significant human and capital resources towards implementing the task. But where, at 'short notice', would the scientists and engineers required to implement the paradigm shift to renewables

come from, and how could the required unprecedented expansion of manufacturing capability be achieved? The major components of renewable power stations, such as turbines, gear trains, generators, propeller blades, nacelles, control electronics, management systems, metering, mirrors, etc., are, in engineering terms, not unlike what is currently manufactured in considerable volume by the automobile and aeronautic industries. Consequently, the answer to the above question is not too difficult to find if we accept that the future has to be oil-free. We must shift the manufacturing emphasis of these major factories, away from building, soon-to-be-redundant vehicles and aircraft, towards providing the infrastructure for renewable power plants, and we must use the capabilities of other fossil fuel dependent industries, such as those involved in chemicals and plastics, to develop storage systems and materials for a superconducting grid.

The book seeks to provide coherent and wide ranging instructional material on electromagnetic solar power collection techniques by collating all of the currently available developments in this technology sector embellished with enough mathematical detail and discussion to enable the reader to fully comprehend the basic physics. As far as the author is aware, the full range of solar power technologies has not previously been presented in a single textbook, which seeks to illuminate and explain through electromagnetism the technological challenges associated with collecting direct radiation from the sun, the primary source of almost all renewable energy, including wind, wave and biomass.

An introductory chapter establishes the ‘technological route’ that mankind needs to pursue in order to transition away from fossil fuels towards renewables. It also introduces the range of solar techniques available to assist in this endeavour. Subsequently, the content of the book divides naturally into two sections. The first section, Chaps. 2–6, provides the mathematical and conceptual tools which are required to develop fully analysed and comprehensive treatments of the primary solar radiation collection systems as expounded in Chaps. 7–10.

In the early chapters (Chaps. 2–5) which provide the basic electromagnetic theory, the electrical science and the mathematical tools to support the chapters on solar power collection technologies, the author’s conscious choice has been to present this material through the agency of classical electromagnetism and waves as opposed to the quantum electro-dynamic approach which emphasises the exchange of particles or photons in the treatment of fields. This preference is justified in Chap. 6 which examines the wave/particle duality issue in some detail.

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 and solar energy. 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 for his assistance with

image manipulation 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.

Electromagnetic Foundations of Solar Radiation
Collection

A Technology for Sustainability

Sangster, A.J.

2014, XVI, 277 p. 143 illus., Hardcover

ISBN: 978-3-319-08511-1