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All You Need to Know About the Next Energy Revolution

Solutions for a Truly Sustainable Future

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We must realise that in the long term, even the most efficient processes, the least wasteful design and manufacturing methods and the highest recycling rates may not be sufficient to achieve levels of dematerialisation high enough to offset the increased demand for materials generated by continued population growth, rising living standards and the universal human preference for the accumulation of goods.

Vaclav Smil, 2014.

*To Bénédicte, Pierre, Nina, Sophie, Anne,
To my family,
To my friends,
That made me who I am.*

Foreword

The practical implementation of the energy transition to a net-zero-carbon system within three decades is a major challenge. This is not surprising considering that energy use is essential for almost all human activities and that the current energy system has been built and developed since the industrial revolution, i.e., over a period of more than two hundred years.

In many ways, we are—as a society and as individuals—fully aware of the possible ways to achieve net-zero carbon. A plethora of energy system studies have been conducted, local energy plans have been prepared, political parties have developed their programs, and many large companies have presented their environmental reports and targets. We—as citizens and professionals—are also aware that many strategies are communicated in a simplified way, that the full complexity—including obstacles and negative side effects—may only become apparent with some delay and that it therefore also takes time, sometimes far too much time, for them to be considered in decision-making.

In his highly commendable book, Erwan Saouter begins by systematically identifying and explaining the health and especially environmental impacts of global population growth and the ever-increasing production and consumption of goods, especially in the rich countries. His factual analysis of developments to date, with a particular focus on the impacts of climate change, clearly demonstrates that it is unsustainable to continue the path followed so far.

The main part of the book deals with solutions, focusing on renewables, energy efficiency and CO₂ capture and storage. Saouter does a good job of explaining the strengths and weaknesses of the different energy carriers and technologies, such as energy density, capacity utilization, CO₂ emissions along the value chain, materials use, health impacts, water use, energy payback and the unprecedented need for rare metals. This invaluable analysis also highlights the interconnected impacts and undesirable side effects, making the trade-offs very tangible and pointing to some uncomfortable truths. The potential of nature-based solutions is also discussed, with their benefits, while addressing their limitations and possible abuse for marketing purposes.

One of the key messages of this book is that any choice we make in the context of the energy transition will inevitably have impacts. These need to be assessed early on, with life cycle assessment (LCA) being the author's preferred method, despite its acknowledged shortcomings and need for continuous improvement.

The final part of the book deals with individual behavioral choices and the problem of our economy and society's dependence on overproduction and overconsumption. It also addresses the issue of encouraging self-restraint (sufficiency) on the part of the rich, for the benefit of the planet and the world's poor. Is this possible, and to what extent? The book concludes with a tacit call for responsibility, a fact-based incentive, and the need to strengthen public policy.

With this book, Erwan Saouter has succeeded in presenting complex relationships using easily understandable language and graphics. This scientific book is highly recommendable to a wide range of readers, from interested citizens to decision-makers and from students to experts addressing the public.

Martin Patel
Chair of Energy Efficiency
Professor at the University of Geneva
Geneva, Switzerland

Preface

In May 2022, the World Meteorological Organization announced in an alarming report that four key indicators of climate change have set new records. These are greenhouse gas concentrations, sea level rise, heat, and ocean acidification. The same report also confirms that the last seven years have been the warmest on record.

The climate emergency is now recognized by most politicians and citizens around the world. More and more people are experiencing the pain of repeated droughts, intense and longer rains, late frosts destroying crops, increasingly destructive floods and storms, and heat waves on entire continents (India, Pakistan, Africa). In April 2022, greenhouse gas emissions, which are responsible for global warming, reached new heights, but the world does not seem to have taken the measure of the impact that our way of life has on the planet.

Two hundred years of industrial revolution, unbridled consumption of natural resources, accumulation of waste and widespread pollution, and greenhouse gas emissions have created the climatic and environmental instability we are witnessing today. And this instability will continue to grow if we continue at this rate. We are now at + 1.1 °C of average global temperature increase and, to avoid reaching + 2 °C, greenhouse gas (GHG) emissions must be stopped as soon as possible. At the current rate of emissions, we would still have about 30 years to reach this limit. The IPCC's predictions are even more alarming, as it predicts an increase of more than 1.5° in the next five years. Of course, these figures and estimates are surrounded by a certain degree of uncertainty and are the subject of much debate. Do we have 10, 20, or 30 years ahead of us? On the scale of human history, these differences do not matter much. But future generations will suffer the consequences of our inaction.

The motivation to write this book came from my time at the World Business Council for Sustainable Development (WBCSD) as director for climate and energy. The WBCSD is a twenty-five-year-old organization, created after the Rio Summit in 1995, on the initiative of private companies who understood that sustainable development was going to become an increasingly important component of good business management. As non-profit association, its aim is to support its members (mostly multinationals) on environmental and societal issues. Originally very technical, the association has published numerous guides and reports, some of which have become

standards, such as the *Greenhouse Gas Protocol* (GHG) which is now used worldwide to calculate a company's greenhouse gas emissions. The WBCSD has also played an important role in the development and use of eco-design tools by R&D departments and has contributed to the adoption of the triptych approach to sustainable development, which is based on the economy, environment, and society.

When I joined this organization, I discovered a world I didn't know existed. A world where a constellation of various organizations, NGOs, *think tanks*, consulting agencies, revolved around the Conference of the Parties (COP), which is the annual meeting of states to set global climate targets. I knew about the COP and the involvement of states in setting climate targets, but I had no idea how many organizations were involved in these annual masses. The COP 27 in Charm-el-Cheik in Egypt in 2022 brought together over 40,000 people from all over the world.

The COPs are organized in two zones: the Blue Zone, reserved for negotiations between states, and the Green Zone, reserved for NGOs, businesses, scientists, local and regional authorities, indigenous peoples, and trade unions; all of which form pressure groups to defend and promote their solutions and points of view. The Green Zone has by far the largest number of participants.

In between COPs, hundreds, perhaps thousands, of climate or *net-zero* conferences are held around the world every year, where the same organizations meet. In the few months following a COP, the progress and decisions made at the previous COP are discussed, and then it is time to prepare for participation in the next COP. During the COVID-19 crisis, I spent hundreds of hours in preparatory seminars and virtual conferences, often with the feeling that I was hearing the same speech, the same litanias, and therefore wasting my time.

What surprised me the most when I attended these meetings was the tireless repetition of the same messages, the same recommendations, the same actions, without ever mentioning the material, social, and economic feasibility. It was as if it was enough to repeat over and over again that the world would eliminate fossil fuels in the next thirty years, that almost all electricity would be produced thanks to solar and wind power, that all cars on the planet would be electric, that the use of forests to capture carbon from the atmosphere would contribute significantly to the fight against global warming, for this to become an absolute, unquestionable truth. I soon discovered that these truths were dogma and that any questioning was excommunicable. The mere mention of the fact that these alternatives to fossil fuels could also have negative impacts on the planet was seen as a betrayal of the cause; a difficult situation for a scientist to maintain.

For many of these pro-climate organizations, the priority is to convince large multinationals to commit to carbon neutrality roadmaps for 2050, rather than requiring these same companies to properly assess and transparently disclose their carbon footprint. While it is welcome that in 2020 more than a thousand companies have committed to carbon neutrality by 2050, it is regrettable that only a few are able to publish a credible and comprehensive carbon footprint.

It is important to understand that the carbon footprint is to climate change what the balance sheet is to the financial strategy of a company. Without a perfect knowledge of a company's financial situation, there is no possible strategy. It is the same

regarding the fight against climate change: without accurate GHG accounting, no serious and credible reduction strategy can be put in place; without a carbon footprint, any commitment to carbon neutrality is pure marketing.

The aim of this book is to present to the general public, in a simple and concise manner, the challenges and opportunities linked to the energy transition to be put in place, but above all to convince them of the urgency and the need to take into account, in addition to the climatic benefits, the environmental, social, and economic impacts associated with the various solutions proposed to us by integrating all the phases of the life cycle.

In the face of confusing messages and multiple roadmaps for achieving a zero-carbon world, this book proposes a return to the basics that we should all know before we can choose the type of development we want.

This book invites us to leave behind dogmatic positions, preconceived and partisan ideas, and to become aware that all the choices available to us have advantages and disadvantages, and that these must be rigorously quantified to prevent today's solutions from becoming tomorrow's disasters. All options are possible, but they all require informed choices.

All the figures presented in the book have been designed or redesigned by the authors from data published in the most recent reports of Intergovernmental Panel on Climate Change (IPCC), United Nations Environment Program (UNEP), International Energy Agency (IEA), Food and Agriculture Organisation (FAO), Organisation for Economic Co-operation and Development (OECD), and many other organizations; or from scientific articles published in peer-reviewed journals which themselves summarize the most recent research on the subject. The data on energy consumption and greenhouse gas emissions are mostly taken from the "Our World in Data" site and the "Global Carbon Project".

The book is organized of 4 independent chapters. Chapter 1 is a quick review of the history of energy in relation with human development, economy, and quality of life. It also lists briefly all the main environmental impacts on the planet this spectacular growth is responsible for. Chapter 2 summarizes the main knowledge regarding climate change, the role of greenhouse gas, and why we are today facing this environmental crisis. The main sources of greenhouse gas are presented with the main options to reverse this trend. Chapter 3 constitutes the core of the book as it presents all solutions available to phase out emissions of GHG and to remove gas already in the atmosphere. The solutions are presented with their potential contribution to limit, or stop, global warming, without considering economic and social aspects. The different types of energy are compared against 8 criteria (energy density, efficiency, CO₂ emissions, raw material consumption, human health, waste generation, and water consumption), using a life cycle assessment approach. The last chapter is a short conclusion and a call for action.

A first version of this book has been published in French by De Boeck publisher in May 2023.¹ For the English version you have in hand, I decided to invite Dr. Thomas Gibon, well known for his work on life cycle assessment of energy

¹ <https://www.deboecksuperieur.com/ouvrage/9782807357648-revolution-energetique>.

systems, to write new sections to cover topics not addressed in the previous version and to better reflect the latest knowledges on this topic. Any mistakes, misinterpretations, or errors are, however, all mine.

Thoiry, France

Erwan Saouter

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A huge recognition and admiration for the work done by “Our World In Data” from Oxford University (<https://ourworldindata.org/about>) and the non-governmental organization “Global Carbon Project” (<https://www.globalcarbonproject.org>), for providing researchers and the public with factual data on today’s major issues.