

# Climate Change and Renewable Energy

Martin J. Bush

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How to End the Climate Crisis

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*This book is dedicated to all the young people of the world who have found themselves to be living on a planet in serious existential trouble. Never before in the history of planet Earth has a single species, in this case homo sapiens, been so dangerously and mindlessly destructive to the point where its selfish actions threaten to trigger a sixth extinction. There is still time to save most of humanity—but only if there is forceful and rapid international action to curb global heating and slowly and eventually reverse the worsening impacts of the changing climate. For Michael, Corry, Sonny, Zaina, Johnny and Aida, growing up in the thick of the worsening climate crisis, their future welfare and well-being is uncertain and fraught with danger. My hope is that this book will make a small contribution to the groundswell of global action as a younger generation of vocal activists force moribund politicians to finally take stronger and more effective measures to bring the climate crisis to an end.*

# Preface

Many excellent books have been written about global heating and climate change. Even more about renewable sources of energy; but far fewer about how these inexhaustible sources of clean energy are the key to slowing and eventually halting the emissions of the carbon gases that are driving the planet towards a dangerously warmer state.

In this book I show how these climate change-related dimensions are linked and interrelated. I explain how inexhaustible supplies of renewable energy can replace coal, oil and natural gas; how the transport sector will become electrified; and how all new buildings will soon be super energy-efficient and powered by electricity from renewable sources of energy. The fly in the ointment—and it's a very big fly—are the fossil fuel and petrochemical companies and their allies in government agencies who are working night and day to try and block the transition to clean renewable energy.

It's obvious to most people that the planet is in serious trouble. Although the climate deniers and contrarians are trying hard to convince us that global heating is not happening and that the climate is not changing (or if it is, it's not because of what we humans are doing), the scientific evidence for a warming planet caused by the emissions of greenhouse gases from human industry and energy use is now indisputable. Anyone who reads up on the subject and consults the mainstream scientific journals can easily separate fact from fiction.

From north pole to south, the planet has entered an era of unprecedented disruption and deterioration—at least since *homo sapiens* first walked the Earth. The most visible and obvious signs are the stronger and more destructive hurricanes and cyclones, the insufferable heatwaves, the increased

frequency of floods that displace thousands sometimes millions of people, the melting glaciers, and the massively destructive wildfires. But behind the scenes, in the undergrowth of the forests and deep in the oceans, the natural world is struggling to survive. While many urban communities, at least in the wealthy industrialised countries, can mostly handle the extreme weather and the wildfires, the loss of biodiversity and the extinction of numerous species of all types of animals, especially insects, is inevitably going to cause widespread disruption of agriculture, fisheries, and the services provided by natural ecosystems everywhere around the world. There is no technical fix for extinction.

People will flee from lands parched by continuous drought and so scorched by heat that agriculture is almost impossible. The first signs of a regional migration out of the areas of the world most afflicted by drought, floods, and heatwaves are already becoming clear. The links between climate change, migration, and conflict are increasingly being examined and confirmed.

In order to understand why global heating is happening and how it causes the climate to change, it is necessary to grasp some of the basics of climate science. This book explains them in terms that everyone can understand. Then we look more closely at the fossil fuel industries. We count the miners dying from black lung disease, the tailings pond disasters, the mercury emissions, and the coal train fatal accidents. The roll call of disasters for the oil industry is worse: the offshore oil rig explosions and marine pollution; the tanker collisions and oil spills; the pipeline fractures and fires; and the oil train accidents and explosions, are a continual litany of catastrophic disasters. Then there's fracking and the biggest environmental mess of all: the Canadian tar sands.

Huge solar photovoltaic arrays and megawatt scale wind farms are now generating electricity at the same scale as fossil fuel power plants, and at a fraction of the cost. The levelized cost of electricity from solar energy and wind power is now below that of electricity generated by conventional coal, oil and natural gas. Market forces and investor self-interest will eventually side-line the fossil fuels—except where politicians in the pocket of the oil companies and petrochemical conglomerates try to block this inevitable transition. This book takes an eye-opening look into the shadowy, dark-money world of regulatory capture, SLAPP suits, *ad hominem* attacks on climate scientists, and how the oil companies are prepping your children for a fossil fuel future.

Most of the 190-plus countries that signed up to the 2015 Paris Agreement are gradually reducing their emissions of greenhouse gases—or

say they plan to. But three major scientific reports published in late 2018 and early 2019 documented the dangers of moving forward so slowly. Those studies showed that we are not on course to keep global warming to below 2 °C above pre-industrial era levels. Not even close.

Is it possible to limit global warming to less than 2 °C and keep the extreme weather and the impacts of climate change-driven disasters within manageable bounds? That's the wrong question. Of course it's possible. But is it likely? It all depends how rapidly and forcefully governments take action to drive the transition to clean and inexhaustible sources of renewable energy that have zero emissions of greenhouse gases. This book shows how this transition can be accomplished.

Climate scientists are highly trained specialists: meteorologists, atmospheric physicists and chemists, cryosphere experts, glaciologists, biologists, ecologists, foresters, and agronomists. Not to mention all the mathematicians modelling the climate and the statisticians analysing the data. I was trained as a chemical engineer, but never worked in the petrochemical industry. Instead, I used my engineering training to work first on renewable energy technologies and then, after working in several developing countries, to shift to natural resources management, and then finally to climate change adaptation and management. I also have done something that very few climate scientists have experienced. I have actually lived in many of the countries that will suffer the most from climate change: Haiti, Trinidad and Tobago, Mali, Guinea, Madagascar, Egypt, Sudan and Djibouti. I have worked for years at a time in these countries, and seen how vulnerable the populations are to drought, floods, and extreme weather. I have also worked for shorter periods in Ethiopia, Uganda and Bangladesh. But the most exposed and vulnerable countries are the small island developing states: the SIDS. Many of the low-lying islands like Tuvalu, the Maldives, Kiribati, and the Marshall Islands will gradually become uninhabitable as sea levels rise and hurricanes and cyclones drive storm-surge waves hundreds of metres inland, polluting ground water resources, destroying crops, and sweeping away homes and livestock. There is little hope that all of these beautiful islands will survive. In the Caribbean, the islands will be increasingly devastated by stronger more destructive hurricanes, like Hurricane Dorian which smashed into the Bahamas in September 2019.

The focus in this book is on the big picture. The climate scientists and other specialists are doing a brilliant job documenting and reporting how the world's ecosystems, its biodiversity, and the global environment are changing and deteriorating. But sometimes the specialists can't see the wood

for the trees. To employ another analogy, climate scientists are providing us with carefully measured pieces of a huge global jigsaw puzzle. This book explains how these pieces all fit together and shows that what comes into focus is the stark reality of life-threatening climate change on a global scale. In 2019, it was generally accepted that global climate change was now a global climate *crisis*. Several countries, including the UK, have declared a climate emergency.

The book concludes with an analysis that shows how we can all individually take action and pressure politicians and policymakers to make real changes that will reduce emissions of greenhouse gases, accelerate the transition to renewable sources of energy, electrify the transport sector, capture carbon from industrial pollution, and gradually curtail global heating and lessen the destructive impacts of the changing climate. The climate crisis can be brought to an end—but only if strong and game-changing action is taken by governments around the globe. We have the tools: the renewable energy technologies that will shut down the emissions of greenhouse gases, drive out the smog from urban air, and improve the health of millions of urban families are well known, less costly, and easily available. What is lacking is forceful action by the people we have elected to represent us and to govern in our best interests. This has to change.

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# Abbreviations and Symbols

|                 |  |
|-----------------|--|
| AIMS            | Africa, Indian Ocean, Mediterranean and South China Sea: A group of the SIDS |
| ALEC            | American Legislative Exchange Council  |
| AR5             | 5th Assessment Report of the IPCC  |
| bbf             | Barrel, equal to 42 US gallons (about 159 liters)                            |
| BECCS           | Bioenergy with carbon capture and storage                                    |
| CC              | Climate change   |
| CCS             | Carbon capture and storage   |
| CDC             | Centers for Disease Control (USA)  |
| CDR             | Carbon dioxide removal   |
| CH <sub>4</sub> | Methane  |
| CO <sub>2</sub> | Carbon dioxide   |
| COP             | Conference of the Parties (to the UNFCCC)                                    |
| CSA             | Climate smart agriculture  |
| DA              | Designated authority   |
| DAC             | Direct air capture   |
| EBA             | Ecosystem-based adaptation   |
| EEl             | Edison Electric Institute  |
| EEZ             | Economic exclusion zone  |
| ENSO            | El nino southern oscillation   |
| EPA             | Environmental Protection Agency (US)   |
| ESM             | Earth system models  |
| EVI             | Economic vulnerability index   |
| GCC             | Global Climate Coalition   |
| GCF             | Green Climate Fund   |
| GDP             | Gross domestic product   |
| GHG             | Greenhouse gases (principally CO <sub>2</sub> , methane, and nitrous oxide)  |



**xx Abbreviations and Symbols**

|                     |  |
|---------------------|--|
| GIS                 | Geographic information system  |
| GMST                | Global mean surface temperature  |
| Gt                  | Gigatonne (1 billion tonnes)   |
| GtC                 | Gigaton of carbon  |
| GtCO <sub>2</sub>   | Gigatonne of carbon dioxide  |
| GtCO <sub>2</sub> e | Gigatonne of carbon dioxide equivalent (includes other greenhouse gases) |
| GW                  | Gigawatt (1 billion watts)   |
| GWh                 | Gigawatthour (1 billion watthours)                                       |
| G\$                 | Billion dollars (USD)  |
| ha                  | Hectare. 10,000 square metres, equal to 4048 acres                       |
| HDR                 | Human development report   |
| IFPRI               | International Food Policy Research Institute                             |
| INDC                | Intended nationally determined contribution                              |
| IPCC                | Intergovernmental panel on climate change                                |
| IPP                 | Independent power producer   |
| IUCN                | International union for the conservation of nature                       |
| kW <sub>p</sub>     | Kilowatt peak  |
| LDC                 | Least developed country  |
| LED                 | Light emitting diode   |
| MENA                | Middle East and North Africa   |
| MPA                 | Marine protected area  |
| MSL                 | Mean sea level   |
| MtCO <sub>2</sub>   | Million tonnes of CO <sub>2</sub>  |
| MtCO <sub>2</sub> e | Million tonnes of equivalent CO <sub>2</sub>                             |
| MUD                 | Manufacturing uncertainty and doubt                                      |
| MW                  | Megawatt (1 million watts)   |
| MWh                 | Megawatthour (1 million watthours)                                       |
| MW <sub>p</sub>     | Peak megawatt (of a PV array)  |
| NAS                 | National Academy of Science  |
| NASA                | National Aeronautical and Space Agency (USA)                             |
| NDC                 | Nationally determined contribution (to the Paris Agreement Targets)      |
| NEB                 | National Energy Board (Canada)   |
| NET                 | Negative emission technology   |
| NHC                 | National Hurricane Centre (USA)  |
| NOAA                | National Oceanic and Atmospheric Administration (USA)                    |
| pH                  | A measure of acidity. A pH of 7 is neutral. A lower value is more acidic |
| PNG                 | Papua New Guinea   |
| PPA                 | Power purchase agreement   |
| ppb                 | Parts per billion  |
| ppm                 | Parts per million  |

|        |  |
|--------|--|
| PV     | Photovoltaic solar energy                                |
| RCP    | Representative concentration pathway                     |
| RET    | Renewable energy technology                              |
| RF     | Radiative forcing  |
| SIDS   | Small Island Developing State                            |
| SLAPP  | Strategic lawsuit against public participation           |
| SST    | Sea surface temperature                                  |
| t/yr   | Tonnes per year  |
| UNDESA | United Nations Department of Economic and Social Affairs |
| UNEP   | United Nations Environment Program                       |
| UNFCCC | United Nations Framework Convention on Climate Change    |
| WHO    | World Health Organisation                                |
| WMO    | World Meteorological Organisation                        |
| XR     | Extinction Rebellion                                     |

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