

# ENGINEERING SUSTAINABLE LIFE ON EARTH

Alleviating Adverse Climate Change  
Through Better Design

JOHN F. COPLIN

EDITED BY DAVE COPLIN



# ENGINEERING SUSTAINABLE LIFE ON EARTH

Climate scientists have clarified the main causes of climate change, and the tight timescale within which humans must change their behaviour and implement effective solutions, wherever they are needed across the world. This book uncovers many of the powerful actions and uses them effectively to achieve sustainable human life, of improved quality, in a way that is affordable out of earned income for all humans, wherever they live.

The ultimate solution to climate change lies not just in doing and consuming less but does instead entirely revolve around our ability to “out-innovate” the problem. John F. Coplin, CBE, FEng, FCGI, has had a long and distinguished career in engineering and has operated and advised at all levels from heads of state, company chairs, engineering directors, government advisory boards, and on the shop floor. He is perfectly placed to take a wide-ranging approach, applying modern design and innovative engineering at a systemic level in order to provide novel approaches that will have a far-reaching impact on reversing humankind’s impact on the planet. His projections and solutions are based on facts, reasonable calculations, and science learnt from nature. Unafraid to challenge current thinking, John looks at solutions across multiple sectors, including aviation, cars and domestic local transport, clean and renewable energy, food and agriculture, and housing and communities, and describes the particular potential of hydrogen as a fuel.

The book is written in a language for all. It is small enough to be used as a practical guide to where some of the most useful improvements are to be found and as a way to start important conversations.

**John F. Coplin**, aeronautical engineer, chief designer of Rolls-Royce’s RB211 aeroengine. During the 1990s, he was UK science and technology adviser to the Indonesian President. Previously a visiting professor on engineering design at Oxford University and Imperial College and Associate Fellow in Design Engineering at the University of Warwick.



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This book is dedicated to all my grandchildren, Max, Harry, John,  
Ellie, and James Coplin.

May your lives be sustainable and happy.



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# FOREWORD

This book shows how lessons learnt from leadership in design engineering can help avoid a climate disaster causing an extinction event. The extent of the problem and the magnitude of the action required to avert the disaster require us to do more than simply “consume less” but instead highlight the desperate need for us to “out-innovate” the problem through the application of engineering principles, innovation, and research. This will create opportunities that will help recover the environment without having to compromise on too many of the aspects of our lives that currently contribute towards the death of our planet.

Most people are no longer in any doubt that humans are responsible for climate change. This problem grows exponentially as more and more of the Earth’s population seek to achieve an aspirational lifestyle that paradoxically provides valuable progress in terms of health and societal outcomes, but at the same time, causes increasing damage to the environment.

Through this book, I intend to use my experience in aerospace design engineering to show how new developments and innovations, along with appropriate behavioural changes, can not only avert an impending climate disaster but create a sustainable approach to life that enables us to continue to travel, develop, and grow but without doing so at the cost of our planet.

Wherever possible, I have used publicly available data at the time of publishing to help demonstrate what needs attention and to illustrate what

can be done, but I recognize that these numbers are changing quickly as we learn more and our behaviour changes. I'm hopeful you'll find my logic useful, even as the numbers evolve.

We will look at many of the steps that must be taken to avoid a disaster, noting that there are strong interactions linking them all as a reset of our human activity achieves better health and wealth outcomes for all, with increased employment in a larger global market.

However, in order to be effective, we all need to be involved and committed to making the changes required. Further still, the changes must deliver tangible benefits quickly to attract the necessary investment.

Thankfully, everything we need to make this result possible already exists, all we really need now is the action to make it happen as it is only through our collective actions that we can achieve sustainable life in a way that avoids a climate disaster.

As a design engineer, I have spent much of my career with some outstanding colleagues and friends, working within difficult constraints to develop safe solutions for complex systems that can help to move society forwards. I know first-hand what is possible when the right people come together united by a common goal.

Through these experiences, I think three fundamental lessons will help guide design engineers through the challenge that lies ahead in order to engineer sustainable life on Earth. They are simply to understand that:

1. Innovation is essential to sustain the growing population on Earth but innovation carries risk.
2. Those who get things wrong while innovating are usually best placed to get those things right.
3. There is more joy in recovering from a problem than is lost by causing it.

Even in the face of such an intimidating and complex problem, I remain optimistic and enthused by the prospect of what I know engineers can achieve. With the right support and resources and with the will of all the world's citizens behind them, I know they will not just help us avoid disaster, they will also help ensure that all life can flourish in a way that does not deplete our precious environment, but instead, restores and renews it.

John F. Coplin  
London, January 2021

# Part 1

## THE BIG RESET





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# ENGINEERING EXTINCTION?



*As chief designer of engines that power many of the world's wide-bodied jet aircraft, I have a view on achieving safe solutions. Aeroengines are complicated machines demanding peak performance, close to fine limits, from many thousands of parts. They propel the aircraft at just the right speed for the load and atmosphere they fly through. They provide the power to all the aircraft controls. They deliver clean cabin air at just the right pressure and temperature with the right amount of oxygen. They provide heat and refrigeration to feed and hydrate everyone on board. They also deliver much of the braking force required on landing to bring the aircraft to rest. The designer must make sure that when anything unexpected occurs, there is a safe solution that causes neither harm nor alarm. When the unexpected happens, the designer must provide evidence to airline bosses that everything is safe, such that the airline can continue to generate its revenue. This is but a small-scale model of why it takes a systemic approach to achieve sustainable life for all humans on Earth. The surgeons that saved my life, after five component failures in my heart, used the same rules for safety in achieving a good outcome. Years of experience as a visiting professor in design engineering at the University of Oxford and Imperial College, London, plus eight years in the Far East as an adviser to the Government of the Republic of Indonesia, reporting to the Third President Professor Dr Ing BJ Habibie, has given me deep insight to the industries of the ASEAN nations. I have worked with leading-edge high technology companies in many of the most industrialized countries of the world. All this provides a breadth of experience from which to illuminate many of the paths needed to avert a climate disaster by securing a better life for all humans in a sustainable form.*

This book is a story about engineering leadership helping to prevent a climate disaster, while increasing employment globally, improving life quality for millions, and generating revenue for nations to take better care of the poorest in every country. Since many of the new jobs will arise from actions to avoid a climate disaster, engineering a sustainable future means we can both save the planet and the economy.

The UK initiated, and benefitted greatly from, the Industrial Revolution, but sadly at that time was unaware of the climate problem that was being created as a by-product of such progress. Since then, industrialization on a global scale has accelerated the likelihood of an imminent climate disaster, thereby focusing the need for urgent global action to prevent this from happening. Climate scientists have explained the importance of greenhouse gases resulting from human activity and they have also shown the dangerous levels of these gases persisting in Earth's climate, highlighting the urgency of powerful actions to reduce further additions to greenhouse gases to net zero and removing as much of them as possible from the atmosphere. Many actions are needed, and most interact with each other.

We cannot address individual actions, instead, a total system approach is essential.

As a leading engineering designer, I spent over three decades helping to make quieter and more efficient commercial aircraft. Our success has been swamped by the masses of people all over the world now able to afford and enjoy aspects of a more affluent life. Air travel is a great example of this, between 1970 and just before the start of the pandemic, air travel passengers doubled from c. 0.3 to 4.5 billion, representing an increase of 1400% in just 50 years.<sup>1</sup> Advances in all industries have raised living standards and greatly increased spending power for billions of humans. Much of this is spent on products and activities such as the massive increase in air travel that make the prospect of climate disaster loom ever closer.

Climate scientists have identified the main causes of climate change. In the Royal Institution Christmas Lectures for 2020, Professor Chris Jackson, who holds the Chair in Sustainable Geoscience at Manchester University, looked back over deep geological time, charting Earth's climate from hothouse to icehouse and back again and revealing how each of the extremes had led to extinction events.<sup>2</sup> What is so disturbing is the current trend in global warming is rising much faster than any of the changes millions of years back in geological time.

Furthermore, this is happening now when the Earth can no longer accommodate the accumulation of damage caused over the last two centuries since the start of the Industrial Revolution. This emphasizes the extreme urgency for strong corrective measures to drastically slow the actions causing climate damage, and the need to remove greenhouse gases persisting in Earth's atmosphere.

Climate scientists have made it clear that greenhouse gases generated by human activity are to blame and of these, carbon dioxide (CO<sub>2</sub>) is the dominant gas causing concern, augmented by methane, oxides of nitrogen, and fine particulates.

Human activity has adversely affected the role of the interconnected oceans in controlling the balance of greenhouse gases in the atmosphere. Earth's atmosphere is also dynamic, allowing greenhouse gases to have an impact on all of it. In his book, "Sustainable Energy",<sup>3</sup> the late David JC MacKay explained where the damage comes from and who needs to change, noting that it is the behaviour of citizens in the most industrialized nations that must make the biggest changes.



Humans have, and continue to emit far too much greenhouse gas. Moreover, humans continue to destroy the very resources, such as trees, (rain)forests, and peat bogs, that form the Earth's natural way of removing these harmful gases. In a sense, engineers led the world to this position, with no one thinking through what damage would arise as more and more of our global population became active consumers.

Thankfully, today's leading engineers recognize that we must enable the populations of all nations to remove all climate-damaging activities by illuminating safe ways of achieving that. Success requires the consent of everyone, using changes that make business as well as environmental sense. We can see many powerful solutions already, but we need to stimulate further innovations as populations, and human spending power, continue to rise.

Climate change is now at the tipping point where human life gets increasingly difficult and is heading towards disaster. Climate scientists have identified that historic and current high releases of greenhouse gases and fine particulates must be massively reduced. But we cannot address these two issues alone, we must also restore, and supplement, many of nature's natural processes for restoring the right levels of greenhouse gases required for sustainable human life, while still improving the quality of life for all.

Human behaviour, with much of it instigated by the UK's catalytic role in sparking the global Industrial Revolution, is responsible for the dire nature of our situation. Collectively, humans know much of what is needed. It remains to get the many necessary solutions into global mass markets in a way that benefits all citizens.

There remains great scope for further innovation, and refinement, and learning from new experiences as the world population transitions to a new and better way of living and working. I want my readers to be encouraged by the big improvements we know we can achieve, and I want to stimulate people to find, then implement, further developments that make life better, as well as making human life on Earth sustainable.

First, we must be clear about what problems we are required to solve. We must arrest the runaway climate, well before climate change is a disaster from which we cannot recover. This requires us to create better ways of living and working while satisfying the demand for well-paid jobs that generate the revenue to meet the needs of the new businesses, and to

support all citizens with a good quality of life. This can be achieved using innovation and new technology productively in a total system approach to enable communities to win an increased share of global investment and to prosper from new products and services within the global market. Every change requires many complementary changes.

Developments must deliver tangible benefits not just over the long term, but increasingly in the short term if they are to attract the right level of attention and investment from both the public and private sectors. We know that the transition from proof of potential to the mass market is expensive, so there is a real need for governments to share in the risk, because without that, innovations will not reach the level required to generate tax revenues sufficient to support a satisfactory lifestyle for all, and borrowing will become too expensive.

Increased self-reliance is required, both at a national and personal level. This can still be compatible with high levels of global trading needed to ensure mutual understanding between nations. Avoiding a climate disaster requires increased national self-reliance. Self-reliance can be summarized as *Grow, Make, and Support Locally, Everywhere*.

We are now seeing powerful innovations originating in many countries. It is important for all countries to embrace the best innovations together rather than compete if we are to avoid a climate disaster. Many citizens of industrialized nations have a good quality of life, which reduces the number of citizens demanding change. However, to retain human sustainability, these citizens must use all human powers of innovation to raise the revenue to buy the products and services needed to meet the rising aspirations of all citizens. In finding ways to avoid a climate disaster, all nations must create sufficient well-paid jobs to replace jobs that become redundant.

China is increasing its prowess in converting emerging technology to make clean products for global markets and making the whole nation a desirable and sustainable place for all its citizens. This is strongly led by President Xi Jinping, who is a trained chemical engineer. China saw the need for electric transport and took steps to secure a world lead. This has been extended to embrace a hydrogen economy. There remains massive scope for world leadership in many products and services not yet covered by anyone at the necessary world market level. Many industrialized countries, including the UK, have allowed important skills needed for the future to decline, as employment has been exported to nations able to manufacture

and provide services at a lower cost than the domestic equivalent. These countries must find the means to engage all their workforce productively.

Recovery from the COVID-19 pandemic, and the disruption of trading arising from the rise of increasingly divisive populist politics and policies, focuses on the urgent need to fix weaknesses in global mass markets while the need is visible for everyone to see, and also while interest rates are low. It has never been easier to address new markets across the globe, as we can speak with anyone wherever they are, using technology that has been with us for over a decade. Smart large companies are funding educational scholarships around the world, where the local national buying power is expected to grow. This strengthens bonds between countries, but it can result in political dominance that has dangers in terms of cultural freedom and reduced diversity.

Mother Nature has given humans the collective ability and guidance from the natural world to provide the means for an increasing world population and to live with improved lifestyles that are affordable out of earned incomes. But it comes at a cost, and one we must understand before we can manage it.

One of the most important principles in the foundation of understanding where best to focus our efforts in the war against climate disaster comes from Swedish physician and academic, Hans Rosling, whose 2018 book “Factfulness”, based on work through his “Gapminder Foundation”, has been instrumental in breaking free of decades-old misconceptions, which to this day, continue to misguide our understanding and approach to the key challenges faced by our global society.<sup>4</sup>

Rosling provides a framework to simply understand the changing behaviour of the global population by shunning the traditional and, in his view, woefully outdated misconception that the world is divided in two: the “developed” and the “developing” world, the poor and the rich, or even “the West and the rest”. Rosling highlights in an accessible way that the bulk of Earth’s population (c. 71%) is neither very rich nor very poor, but somewhere in between. He goes further to show that it is far more helpful to us, especially when considering the issue of climate change, to understand that the Earth’s seven billion people are spread, Pareto-like, across four levels of income. From the poorest, who exist on less than US\$2 per day, the next group (Level 2) who exist on up to US\$8 per day, the next

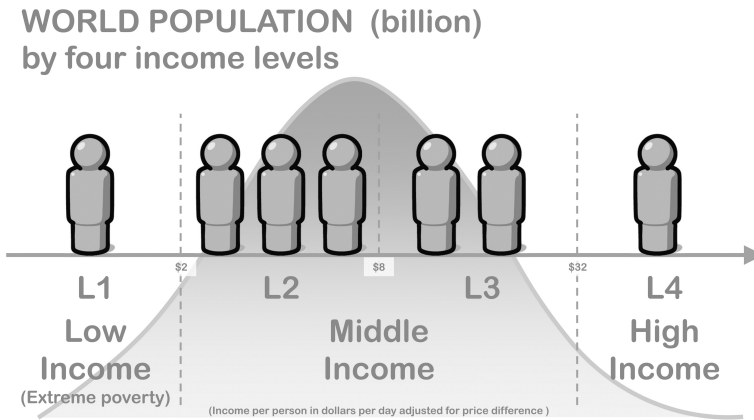


Figure 1.1 World population by income levels.<sup>5</sup>

group (Level 3) who live on under US\$32 per day and the richest (Level 4), who exist on more than US\$32 per day (Figure 1.1).

This model is helpful as it shows the natural aspiration of all Earth's citizens to move from the left to the right not just in order to access greater wealth, but more importantly to achieve the greater life outcomes that come as a result of increasing wealth (e.g. longer life, lower infant mortality, better education).

If we understand the model and natural migration from left to right, we can then start to really understand, not just the impact on the environment, but the largest contributors.

Rosling's work does just that as he and the Gapminder team carefully show how 50% of the world's CO<sub>2</sub> emissions come from the one billion people in Level 4, 25% from the next billion, and in fact, it keeps halving as you move through the global population in descending order, ranked by income (Figure 1.2).

The world's population is 7.7 billion, rising to a likely peak of 11 billion in 2100.<sup>7</sup> Each of the Earth's richest 1 billion people contributes about 25% from four broad sources: food, accommodation, travel, and everything else, including education and public services and non-food retail.

Each year, the world output of CO<sub>2</sub> equivalent amounts to more than 35 billion tonnes and is rising faster despite all our best efforts to suppress the accelerating increases. China is the biggest polluter at c. 29%, followed by the United States at 15% and the UK contributes about 1%.<sup>8</sup> In 2019,