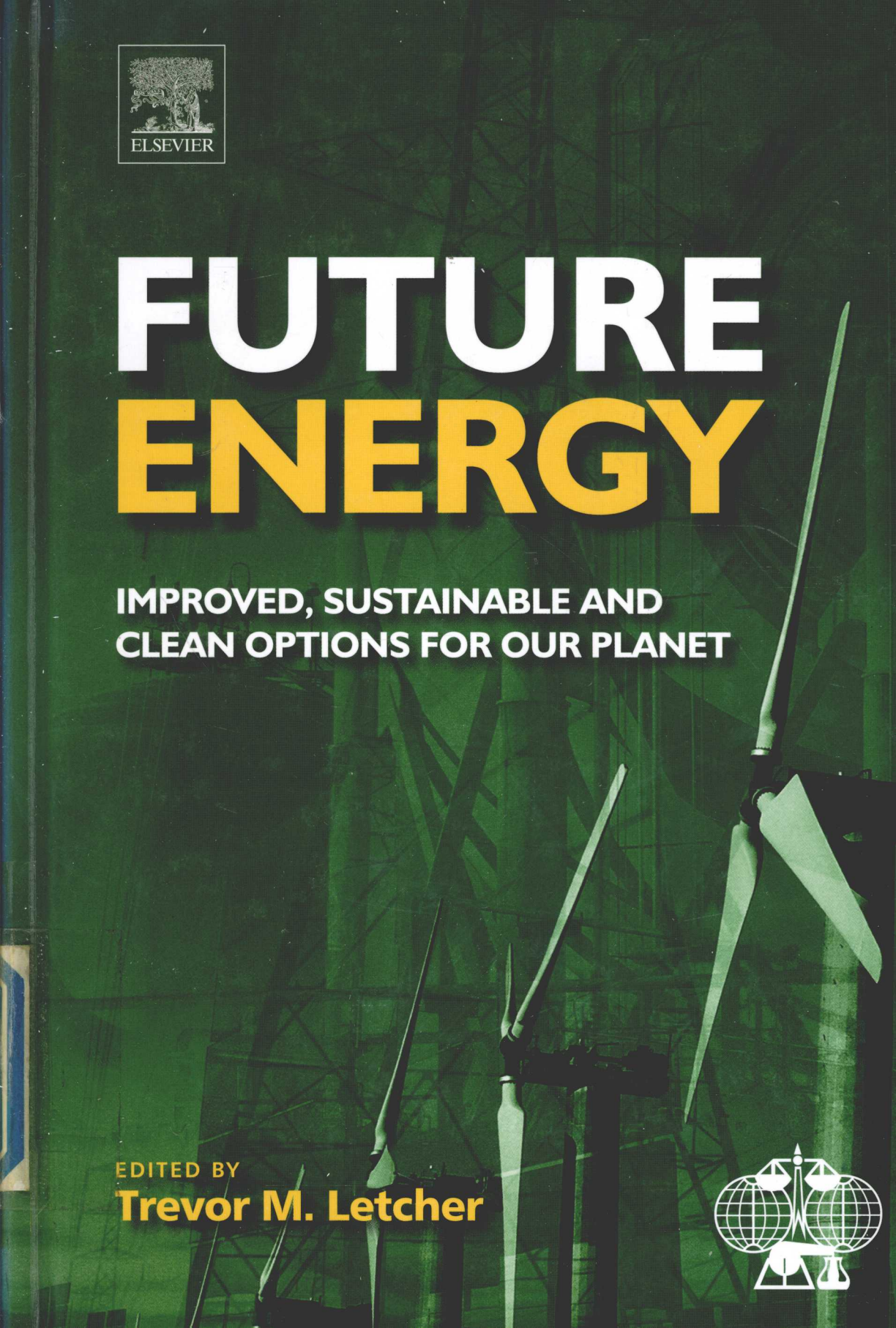
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EDITED BY
Trevor M. Letcher

Future Energy: Improved, Sustainable and Clean Options for our Planet

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Future Energy: Improved, Sustainable and Clean Options for our Planet

Foreword

Energy is the lifeblood of modern societies. Since the industrial revolution, fossil fuels have powered the economies of the developed world, bringing new levels of prosperity and human welfare.

But there has been a price, and one that only relatively recently we have begun to fully appreciate. Carbon dioxide emissions from fossil fuels, combined with land-use changes, have driven the concentration of this most significant greenhouse gas to levels in our atmosphere not seen for at least 800 000 years, and probably many millions of years.

The consequence has been a warming world, driving the climate changes that are already being experienced in many regions, and which are set to accelerate.

In the past century, global temperatures have risen by over 0.7°C and sea levels have risen by about 20 cm. Eleven of the warmest years on record have now occurred in the past 12 years. Ice caps are disappearing from many mountain peaks, and summer and autumn Arctic sea ice has thinned by up to 40% in recent decades. The 2003 European heat wave caused around 15 000 fatalities in France alone, and over 30 000 across the continent.

The scientific evidence that climate change is happening and that recent warming is attributable to human activities is now established beyond any reasonable doubt. In my view, climate change is the most severe problem that our civilization has yet had to face, with the potential to magnify other great human scourges such as poverty, food and water security, and disease. The debate is not 'whether to act', but 'how much do we need to do, and how quickly?'

The challenge presented to us is clear. We must reduce greenhouse gas emissions from human activities to a fraction of current levels, and as part of this we must transform how we source our energy and how we use it.

The backdrop for this challenge is stark. Populations are rising dramatically – the global population is expected to rise from just over 6.6 billion currently to 9.1 billion people by 2050. Most of this growth will be in the developing world, where people understandably aspire to the levels of prosperity and lifestyle achieved in the most developed countries. The World Bank reports that global GDP growth in 2006 was 3.9%, with rapid expansion occurring in developing economies, which are growing more than twice as fast as high-income countries.

As a result of these rises in population and wealth, energy demand is increasing at an incredible rate. The IEA forecasts an increase of over 50% in energy demand by 2030 on current trends. Half of all CO_2 emissions from burning fossil

fuels over the last 200 years were released in the last 30 years, a trend which will continue to accelerate without radical intervention, in developed and developing countries alike. China's emissions alone are set to double by 2030, with new coal-fired power stations becoming operational about every five days.

No one could trivialize the challenge, but I firmly believe it is one that is fully within our grasp to meet. There is no single 'silver bullet' technological solution – we will need 'every tool in the bag' so to speak, and every sector will need to contribute an increasing 'wedge' of carbon reductions over the next 50 years.

As a starting point, we must make maximum use of those low-carbon technologies that are already at our disposal. First amongst these is energy efficiency. There are many established technologies that can be introduced in our homes and businesses now, often at negative cost. Yet very often we do not do so.

For many countries nuclear power has for decades provided a source of reliable, low-carbon energy at scale. In the UK, I believe the government has been right to revisit the question of replacing the current fleet of nuclear plants as these reach the end of their operational lives, in the context of a competitive energy market, and in parallel to identifying long-term solutions for dealing with the UK's legacy waste. It is worth noting that future generations of nuclear plant will be more efficient and produce less waste than those now operating.

Nonetheless, new low-carbon solutions will also be required in both the short and longer terms. Research, development and demonstration work is needed across the range of the most promising technologies – such as renewables, biofuels, hydrogen and fuel cells, and cleaner coal technologies. Crucially, we need to speed the deployment of carbon capture and sequestration technologies and reduce their cost, so that the new fossil-fuel capacity which will inevitably come on-stream through much of this century can avoid adding to the exponential growth in carbon emissions. Developing and demonstrating these technologies now means we can help countries such as China and India to dramatically reduce the impact of their development.

The UK government's Stern Report has recommended a doubling of global R&D spend, and that deployment incentives should increase up to five-fold from current levels. I fully endorse this view, and the sentiment that we must radically step up the scale of current activities.

In the UK we are contributing by establishing a new public/private Energy Technologies Institute, with the ambition to fund this to a level of around £1 billion over a 10-year period. In time I hope this will develop as part of a network of centers of excellence across the world, providing a vehicle for greater international cooperation.

I believe that this book provides a lasting and helpful guide to the potential sources of energy that we may all come to rely on in the future.

Sir David King
Director, Smith School of Enterprise and Environment
Oxford University
2 January 2008

Preface

Over the past 120 years, development in our society has been staggering. We have moved from the horse and buggy to space flight. It is true – unfortunately literally – that we have grown fat and happy on carbon: coal, oil and gas, in that order. Now, however, the banquet is on its last course and there is really not much time left.

Ominous graphs are published on oil reserves versus time, and the peak is anywhere from 2004 to 2030. Meanwhile, oil companies drill and drill throughout the world for new wells with little success. The academic geologists persistently point to a much narrower band of dates for the maximum of oil delivery, and come up with dates between 2010 and 2020, with some saying we have already passed the peak.

In discussing the degree of urgency, many take a high spirited view: 'Well, so oil is running out. But we have lots of coal, and if not coal then let's use solar energy.' The worry about this carefree attitude is that it neglects the time which it takes to build any one of the alternative energy technologies. When all the claims and counter-claims are in, we need at least 25 years (and for nuclear over 50 years) and we do not know where our energy will come from after 2050. Or shall we fall back upon the cheapest source – coal – and risk the rising seas and the wipeout of our coastal cities?

There is a broad range of choice in the new sources of energy and the great strength of the present book is that the editor has gathered most of them together. Coal is really the least attractive. This arises not only because of the large contribution to the threatening greenhouse effect, but also because of the suspended particles which the protracted use of coal will cause. Nevertheless, coal is alive and quite well because it has the tremendous advantage of being able to promise electricity at a cost of 2 US cents per kilowatt hour.

Nuclear power, so much feared since Chernobyl, is on a comeback, based on a device which confines each unit of the fuel in a small sheath of ceramic material so that it becomes difficult to imagine that there could be a meltdown. But a nuclear supply suffers other problems, among which is that uranium fuel may not be there for us after the USA, India and China have built their last nuclear reactors, some 60 years from now.

There are a heap of newcomers in various stages of growth from hardly patented to technologies which are already booming. These include wave and wind

energy, with the latter providing the lowest cost of electricity. There is movement in other new concepts, including tidal waters and also solar energy. One solar energy method allows it to function 24 hours a day using heat from tropical waters. This process produces not only electricity and hydrogen, but also fresh water, the second most needed commodity after energy.

Much of this and more is explained and presented fully in the present volume. Its editor has shown wisdom in limiting the presentations to methods which really are healthy runners in the race for leading energy technology for 2050. There is, as many reading this book may know, another school, where the talk is about the Casimer Effect, zero point energy and 'energy from the vacuum'. This is exciting talk in which, quite often, the deceptive phrase 'free energy' slips in, but it is unlikely to get as far as asking for an economic analysis – if it gets that far at all.

Another strength of our editor is the breadth of his selection. His choices run from South Africa to the UK and Ireland, through Turkey and to China. It is an array, a display, of Frontier Energy early in the 21st century and should form a unique base book for studies for at least the next 10 years.

John O'M. Bockris
Gainesville, Florida
1 November 2007

Introduction

The book *Future Energy* has been produced in order for the reader to make reasonable, logical and correct decisions on our future energy as a result of two of the most serious problems that the civilized world has had to face: the looming shortage of oil (which supplies most of our transport fuel) and the alarming rise in atmospheric carbon dioxide over the past 50 years, which threatens to change the world's climate through global warming.

Future Energy focuses on all the types of energy available to us, taking into account a future involving a reduction in oil and gas production and the rapidly increasing amount of carbon dioxide in our atmosphere. It is unique in the genre of books of similar title, currently on sale, in that each chapter has been written by an expert, scientist or engineer, working in the field.

The book is divided into four parts:

- Fossil Fuel and Nuclear Energy
- Renewable Energy
- Potentially Important New Types of Energy
- New Aspects to Future Energy.

Each chapter highlights the basic theory, implementation, scope, problems and costs associated with a particular type of energy. The traditional fuels are included because they will be with us for decades to come – but, we hope, in a cleaner form. The renewable energy types include wind power, wave power, tidal energy, two forms of solar energy, biomass, hydroelectricity, and geothermal energy. Potentially important new types of energy include pebble bed nuclear reactors, nuclear fusion, methane hydrates, and recent developments in fuel cells and batteries. In conclusion, the final section highlights new aspects to future energy usage with chapters on carbon dioxide capture and storage, and smart houses of the future, ending with a chapter on possible scenarios for electricity production and transport fuels to the year 2050. Looking at the whole spectrum of options in the book, the reader should have a good understanding of the options that best suit us now and in the future.

Before coming to grips with these energy options, it is perhaps useful to step back and look at the root causes of our present energy predicament. One of the basic driving forces (but rarely spoken about) is the rapid growth in the world's population, with the concomitant need for more energy. Population numbers

have grown from 2 billion in 1930 to 4 billion in 1980 and 6 billion in 2000 – a veritable explosion. Most of the advanced industrialized nations are at zero population growth (or negative), but most of the less developed nations are growing at a rapid rate. Only China, with its draconian laws of 'one child per family', appears to be seriously concerned. Malthus wrote about exploding populations 200 years ago but few have heeded his warning.

Another root cause, especially in the West, is our excessive indulgence when it comes to energy use. Politicians tell us to 'conserve energy'.[1] What they really mean is that we should reduce the amount of energy we use in our daily lives. We should be reducing air travel, not building new runways, reducing the amount of electricity we use at home, walking more and driving less, reducing the heating level in our homes, and having more energy-efficient homes, etc. Chapter 19 on 'Smart Houses' addresses many of these issues, such as better insulation, heat pumps, solar water heaters, recycling, micro-CHP, and co-generation. Governments need to: give big incentives for energy-saving devices; introduce new rulings on improved minimum emission standards for vehicles; improve public transport and develop high-speed trains; increase taxes on inefficient vehicles; decrease speed limits on motorways; increase taxes on aviation fuel and air tickets, etc. Implementation of these concepts and rulings will go a long way, certainly in the short term, towards solving the energy crisis.

We have the technical know-how to use less energy per capita and yet retain a reasonable standard of living, but we do not appear to have the will to implement it. The public are either not convinced of the need to reduce energy usage, too lazy or just plain greedy. Governments are aware of the energy problems, and know of such pointers as 'the peaking of oil reserves', but still they do not enforce energy-saving actions and only pay lip-service to them. One can only assume that the huge tax revenues and profits from oil and gas stocks and shares overwhelm their sense of duty. Oil companies are now so large (five of the largest 10 companies in the world are oil companies) that they appear to be more powerful than state governments.

Since politicians deliberately misunderstand and corporations deliberately ignore the realities of finite fuel sources and our changing climate, what is to be done? The solution lies not in the realm of new technologies but in the area of geopolitics and social–political actions. As educators we believe that only a sustained grass-root's movement to educate the citizens, politicians and corporate leaders of the world has any hope of success. There are such movements but they are slow in making headway. This book is part of that education process. It presents a non-political and unemotional set of solutions to the problems facing us and offers a way forward. We hope that not only students, teachers, professors, and researchers of new energy, but politicians, government decision-makers,

[1] We do not need to conserve energy. The conservation of energy is an alternate statement of the First Law of Thermodynamics, i.e. energy can be neither created nor destroyed, only transformed from one kind into another.

captains of industry, corporate leaders, journalists, editors, and all interested people will read the book, and take heed of its contents and underlying message.

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