Nuclear Electricity

7th edition

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NUCLEAR ELECTRICITY

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Acknowledgment

From the 4th edition the book incorporates considerable input from staff at Atomic Energy of Canada Limited, who greatly assisted the development of a broader perspective on the subject and in the rewriting of several chapters. Many others have also helped check particular sections of the book, and have made a major contribution to ensuring its accuracy and completeness. I am very grateful for all such assistance both in relation to this text, and more broadly, in the functioning of the Uranium Information Centre and the World Nuclear Association.

Ian Hore-Lacy

About the Author(s)

Ian Hore-Lacy MSc FACE, a former biology teacher, became General Manager of the Uranium Information Centre in 1995 and Head of Communications for the World Nuclear Association, based in London, in 2001. He has visited a number of nuclear reactors and fuel cycle facilities in several countries, including UK reprocessing plants, Sweden's waste facilities, US waste repositories and French enrichment and mixed oxide fuel fabrication plants.

He joined the mining industry as an environmental scientist in 1974 and gained some acquaintance with uranium mining. From 1988-93 he was Manager, Education and Environment with CRA Limited (now Rio Tinto) and has written several books on environmental and mining topics. He has had continuing involvement with the Australian Science Teachers' Association and in 1992 he received an ASTA Distinguished Service award. Also in 1992 he was admitted as a Fellow of the Australian College of Education.

His particular interests range from the technical to the ethical and theological aspects of mineral resources and their use, especially nuclear power. He has four children.

Earlier editions of this book owed their substance to Ron Hubery as co-author. Ron is a chemical engineer, now retired, who spent eight years working with the Australian Atomic Energy Commission (now ANSTO) on nuclear fuel cycles and reprocessing. He also worked at the uranium production centres of Rum Jungle and Mary Kathleen in Australia

Foreword to sixth edition

During the first fifty years of the 20th Century, the decisions that had to be made by responsible citizens were comparatively straightforward. Since then many factors, including the increased use of technology, the size of the world population and the ease of travel and communication on a global scale, have made life's decisions much more complicated.

The production and use of energy in all forms, need scientific understanding. There are social and environmental consequences from decisions to follow a particular energy policy. In many instances these consequences will be hard to predict and will produce controversy.

Educators have a responsibility to ensure that young people are informed about the reasons for the controversy, from both an economic, scientific and a social point of view. Students must be given the opportunity to weigh up conflicting arguments and to form their own opinions in light of a comprehensive understanding.

Earlier editions of *Nuclear Electricity* provided helpful data and references about nuclear energy, and also about the production of electrical energy from other sources. This includes information regarding the environmental impact of producing electrical energy from alternative sources.

Nuclear Electricity, Edition 6, maintains the education philosophy of previous editions but also includes more recent data and references. There is undoubtedly a challenge for all, particularly scientists, educators and our young people, who will guide developments in the an increasingly complex society of the 21st Century. They will need to be open-minded and well informed on all controversial issues. By accepting the challenge, future generations will be well equipped to take care of themselves and their environment.

Marj Colvill, President, Australian Science Teachers Association.

Introduction

The context

There is a rapidly-increasing world demand for energy, and especially for electricity. Much of the electric demand is for continuous, reliable supply, which generally only fossil fuels and nuclear power can meet.

The fuel for nuclear power to make electricity is uranium, and uranium's only substantial non-weapons use today is to power nuclear reactors. There are some 900 nuclear reactors operating today around the world. These include:

- about 280 small reactors, used for research and for producing isotopes for medicine and industry in 56 countries,*

- over 200 small reactors powering about 150 ships, mostly submarines,

- some 440 larger reactors generating electricity in 31 countries. *

Practically all of the uranium produced today goes into electricity production (though a significant small proportion is used for producing radioisotopes). In particular, uranium is generally used for base-load electricity. Here it competes with coal, and in recent years, natural gas.

Over the last 40 years nuclear energy has become a major source of the world's electricity. It now provides 16 percent of the world's total, equivalent to thirteen times Australia's total electricity production, five times that of Canada, and seven times UK's. It has the potential to contribute much more, especially if greenhouse concerns lead to a change in the relative economic advantage of nuclear electricity or its ethical desirability. Australian and Canadian uranium is needed to fuel some of this electricity generation.

The uranium and nuclear power debate is about options for producing electricity. None of those options are without some risk or side effects.

Since the first edition of this book in 1978 many of the inflated expectations of alternative energy sources have been shown to be unrealistic, (as have some of those for nuclear energy). However, it is important that this return to reality does not lead to their neglect, such alternatives should continue to be developed, and applied where they are appropriate. In particular a great deal can be achieved by matching the location, scale and thermodynamic character of energy sources to particular energy needs. Such action should be a higher priority than merely expanding capacity to supply high-grade electrical energy where for example only low-grade heat is required.

But when the question of utilising nuclear energy arises there are those who wish somehow to put the genie back in the bottle and to return to some pre-nuclear innocence. Such notions seem to achieve undue prominence in Australia because there is no actual utilisation of nuclear power. Australia is probably the only developed country where, when you switch on the light, you are not getting some nuclear electricity to help lighten your way.

To labour that point a little: France gets over 75 percent of its electricity from nuclear power. It is the world's largest electricity exporter, and gains some EUR 2.5 billion per year from those exports. Next door is Italy, a major industrial country without any operating nuclear power plants. It is the world's largest net importer of electricity, and most of that comes ultimately from France.
All Australian and Canadian uranium is sold for peaceful applications, predominantly electricity production, none goes into weapons; this is assured by comprehensive international safeguards arrangements.

I anticipate that my children's, or perhaps my grandchildren's generation will come to look upon weapons as simply an initial aberration of the nuclear age, rather than a major characteristic of it. Arguably the same is true of the bronze and iron ages, where weapons provided incentive for technological development which then became applied very widely.

Certainly, as Figure 1 graphically shows, we cannot indefinitely use fossil fuels as readily as we do today.

The focus here is on electricity. However, as the hydrogen economy comes into sight the potential uses of nuclear power expand to include hydrogen production, both electrolytically and later by thermochemical means. There is also great potential for nuclear power in desalination to provide potable water.

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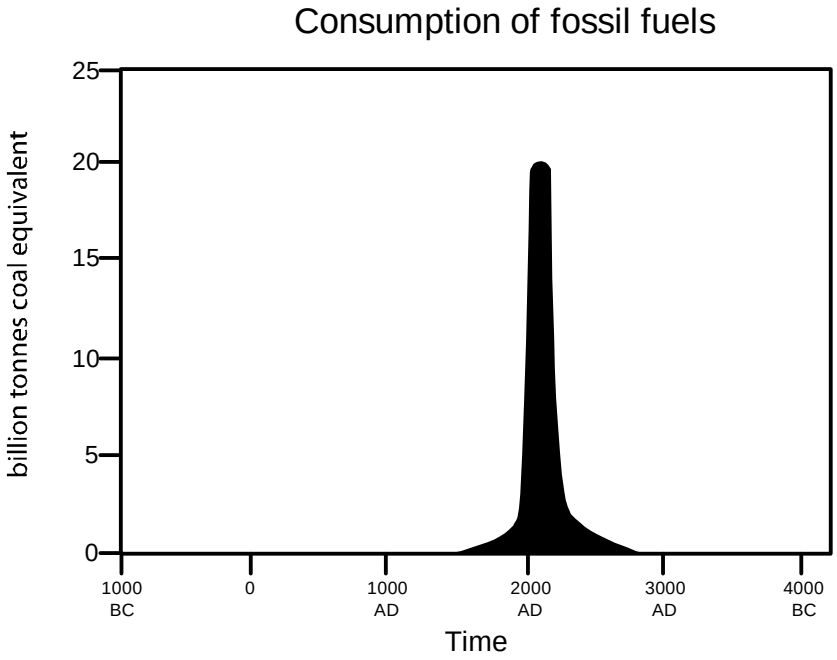
* *Australia has only one research reactor operating and due to be replaced by 2005. Canada has several small research reactors at universities, as well as one large one. Canada also has two small reactors designed for isotope production under construction.**

Figure 1.



Source: Charles McCombie, NAGRA Bulletin # 29, 1997, based on Korff, 1992 (and probably M.K.Hubbert, 1969, who had the peak around 2100).

The book

Considerable effort has been made to include as much up to date and pertinent information as possible on generating electricity from nuclear energy. The figures quoted are conservative, and generalisations are intended to withstand rigorous scrutiny. The reader will not see many of the frequently repeated assertions from supporters or opponents of nuclear energy. The book does not enter into debate on social issues.

Since the first edition, the intention has been to get behind the controversies and selective arguments and present facts about energy demand and how it is met, in part, by nuclear power. The text has been thoroughly checked by experts who carry public responsibility for their professional roles in their area of expertise. The fourth edition was published as a joint Australian and Canadian initiative for schools and the public, and that collaboration has continued.

Every form of energy production and conversion has an effect on the environment and carries risks. Nuclear energy has its challenges but these are frequently misunderstood and often overstated. Nuclear energy remains a safe, reliable, clean, and generally economic source of electricity. But many people do not see it that way.

This 7th edition comes out at a time when the contrast between environmental concern focused on tangible indicators of pollution and global warming is beginning to stand in stark contrast to Romantic environmentalism, which is driven by mistrust of science and technology, and which demonises nuclear power. This contrast is heightened on the one hand by increasing evidence of the contribution to global warming from burning fossil fuels, and on the other by the 1986 Chernobyl disaster.

The introduction to the first edition of this book in the 1970s expressed the opinion that if more effort were put into improving the safety and effectiveness of commercial nuclear power, and correspondingly less into ideological battles with those who wished it had never been invented, then the world would be much better off. With Chernobyl behind us and the great improvements to safety in those plants which most needed it, plus the welcome recycling of military uranium into making electricity, it seems that we are now closer to that state of affairs.

Further information

All the matters covered in this book can be explored in more detail. One convenient way of doing so is by accessing the Uranium Information Centre's or World Nuclear Association's web sites:

http://www.uic.com.au
http://www.world-nuclear.org

In particular, these have a range of Briefing or Information Papers on specific topics, as well as links to other web sites with reliable information.

Figures and Tables