1.2 This Book

This book, which is intended as an introduction to the thermo-hydraulics of nuclear power generation for graduates or advanced undergraduates, clearly focuses on just one aspect of the design of nuclear reactors for electricity generation, namely the thermo-hydraulics and issues that affect the thermo-hydraulics. The term "thermo-hydraulics" refers to all the flow processes involved in the removal of heat generated in the reactor core and the use of that heat to drive generators that produce the electricity. Note that though the use of the word "hydraulics" might imply only water flows, in fact the fluids involved range over many coolants and their liquid and vapor phases, including complex multiphase flows. In the present context the word "thermo-hydraulics" also refers to a whole collection of possible flow processes that might occur due not only to normal reactor operation but also to any operational irregularities or accidents.

Clearly, then, any review or analysis of the thermo-hydraulics must include description of how the heat is generated within the nuclear reactor core and, consequently, must include description and quantification of the nuclear physics processes that generate the heat. Thus, following a brief introduction of the background and context of nuclear power generation, chapter 2 provides a review of the fundamental physics of nuclear fission and radioactivity. This leads into chapter 3 which covers some of the basic features of the neutronics of nuclear reactors. This is followed in chapter 4 by a description of the structure of the fission reactors presently used or envisaged for nuclear power generation. With that structure in mind the reader is then equipped to absorb, in chapter 5, how the heat generated by nuclear fission is transferred to the reactor core coolant and thus transported out of the core to be used to drive the turbines and generators that complete the structure of the power station. Chapter 6 reviews some of the basic multiphase flow phenomena that may be associated with those heat transfer processes during both normal operation of a nuclear power plant and during postulated accidents within that reactor. This leads naturally to a discussion in chapter 7 of nuclear reactor safety including descriptions of the three major accidents that dominate the public's impression of the dangers of nuclear power, namely the accidents at Three Mile Island, at Chernobyl and at Fukushima. That discussion naturally includes the important lessons learned from those accidents and other experiences.

There are, of course, many fine text books on nuclear power generation and on the engineering of nuclear power systems (see, for example, Gregg King 1964). Those interested in more detailed treatments of the analytical methods should consult one of the classic texts such as Glasstone and Sesonke (1981) or Duderstadt and Hamilton (1976). Other texts such as Winterton (1981) or Collier and Hewitt (1987) have strong focus on the thermo-hydraulics. In addition, of course, there are many additional aspects associated with nuclear power that are also important such as waste disposal (see, for example, Knief 1980) and the political and economic issues. Other texts are referenced at the conclusion of each chapter. Moreover, today a great deal can be learned from the pages of the internet, for example those constructed by the American Nuclear

Society or the World Nuclear Association (WNA 2011). Indeed, any single book attempting to review the entire field of electricity generation by nuclear power would be huge; even many of the more narrowly focused books include excessive detail. The present text attempts to narrow the thermo-hydraulics down to its essentials without eliminating essential analytical and practical approaches.