Preface

Energy is key to life and a primary engine for socio-economic development. The Commission on Sustainable Development (CSD) in its 9th session specifically recognized that 'Energy is central to achieving the goals of sustainable development'. Access to energy opens up many new opportunities, while lack thereof is one of the contributing factors to persistent poverty afflicting individuals, communities, nations and regions. Indeed, unless there is universal access to clean and affordable energy services, the United Nations Millennium Development Goals will not be achieved.

Improving access to energy is a multi-faceted challenge with far-reaching implications and long-lasting obligations. Delivering energy services involves several steps (resource extraction/harvesting, conversion/transformation, transmission, distribution and service production at the point of use) and many players from both the public and private sectors.

Technology is the critical link between access, affordability and environmental compatibility of energy services. But technology is more than power plants, motor vehicles and appliances; it includes infrastructures such as buildings, settlement patterns, road and transportation systems, industrial plants and equipment and, of course, the production of goods and services. Each step along the different energy service delivery chains is subject to investment and operating costs—hence, the competition and the choice between technologies and fuels that provide the same energy service. Technology choices are also subject to laws and regulations that reflect national capabilities, social preferences and cultural backgrounds.

Energy extraction, conversion and service production always generate undesirable by-products and waste—far more, in fact, than any other process chain. The careless use of energy can have devastating effects on ecosystems and life on planet Earth. Most energy plants, equipment and infrastructure have long operating lives (25–50 years or more) and, in some cases, require special management long after their operational lives have ceased. Today's choices about how energy services are produced will determine the sustainability of the future energy system and thus of socio-economic progress as a whole.

Dangerous anthropogenic interference with the climate system has emerged as the main global environmental challenge for a global energy system that is 80% reliant for its energy supply on fossil fuel combustion. At the 15th Conference of the Parties to the United Nations Framework Convention on Climate Change held in Copenhagen in December 2009, the international community agreed that the threshold for dangerous interference would be a 2°C rise in global mean temperature: approximately equivalent to a maximum atmospheric greenhouse gas (GHG) concentration of 450 ppm. Since pre-industrial times carbon dioxide (CO_2) from fossil fuel combustion has been the main cause of increased GHG concentrations. Without a drastic shift to an energy system that minimizes GHG emissions in the production of energy services, the 450 ppm threshold will probably be reached within a few decades. GHG mitigation—how best to reconcile the dilemma of continued reliance on (still relatively cheap and plentiful) fossil energy and associated (long-lived) infrastructures while protecting the climate system and still providing affordable energy services—has thus become a major challenge.

Based on the recognition that, on a full life-cycle basis, no technology can provide energy services without interaction with the environment in terms of emissions or waste, a crucial question must be posed: What is the most efficient and cost-effective approach to the decarbonization of the global energy system? The options are known and range from efficiency improvements (not really an option for a quarter of world population without access to modern energy services such as provided by electricity) to the use of renewables, nuclear energy and CO_2 capture and disposal (CCD); in other words, continued use of fossil fuels, but alongside technological measures that prevent the majority of combustion products reaching the atmosphere. CCD, involving geological disposal of captured CO_2, has been advanced as a way of giving fossil fuels a new lease on life in a heavily carbon emission constrained future. Likewise, there is renewed interest in nuclear energy for the generation of low-GHG-emitting electricity. While in the past fossil fuel combustion and nuclear energy had little in common, the advent of CCD may change this and commonalities in the area of waste disposal could emerge. To date, there has been little experience of large-scale CO_2 disposal, geological retention times, leakage rates, etc. Disposal in geological repositories of high-level nuclear waste from reprocessing or spent nuclear fuel is, however, a generally favoured approach, and several countries have embarked upon the development of such repositories.

The question then arises as to how fossil and nuclear fuels stack up against each other in terms of the final waste disposal strategies applied in their respective cases. The Special Report on Carbon Capture and Storage of the Intergovernmental Panel on Climate Change provides a useful synthesis of the knowledge available from a fast-evolving research field. Compared with carbon, geological storage of radioactive waste has a much longer history of research and technology development; however, there has been no recent international research synthesis on the geological storage of radioactive waste, like that of the IPCC report on carbon. Are there lessons to be learned from the much longer R&D work regarding nuclear waste repositories that can be useful for CCD? Is public acceptance of CCD greater than of nuclear waste disposal? How can long-term leakage of CO_2 and ionized radiation be minimized? All these questions need solid answers if informed decision making is to take place.

Effective decision making with respect to the appropriate energy technologies to use, taking into account climate, cost or other considerations, requires comprehensive energy systems analysis and planning at the national level. This type of analysis helps policymakers to study the costs and effectiveness of different GHG mitigation options and to chart long-term scenarios of sustainable energy development. It also helps them test various climate change policies and response strategies, including the flexible mechanisms of the Kyoto Protocol, such as the Clean Development Mechanism (CDM), Joint Implementation (JI) and emissions trading.

The IAEA assists Member States in building national capacity to conduct independent energy and environmental assessments and to develop national strategic energy plans. One cornerstone of this capacity-building effort is comparative assessment of different demand and supply options. This type of planning approach prevents a situation arising where one technology option is rejected (for whatever reason) without an alternative solution having been specified that provides the same energy service in terms of quality and reliability. IAEA assistance involves transferring analytical and planning tools, and training of national experts in hands-on use of these tools to conduct energy and electricity demand and supply studies. A fast-growing planning tool application has been the analysis of least-cost GHG mitigation options. Through these and other activities, the IAEA advises and helps countries to identify the most suitable and feasible national energy mix, irrespective of whether or not this includes nuclear power.

This book must be seen in the context of capacity building and comparative assessment. Its objective is to summarize the state of the art in the fields of CO_2 and nuclear waste disposal by providing an in-depth comparative assessment of their similarities and differences, of related issues that have already been resolved and of the key challenges that remain; it also evaluates the policy implications for moving the process further. It is the product of the first close collaboration between leading scientists involved in the comparative assessment of various aspects of the geological disposal of CO_2 and radioactive waste. The contributors come from a broad range of scientific disciplines, including geology, geography, environmental sciences, engineering, economics, psychology and political science.

I believe the comparative assessment presented here to be of interest to a wide audience. The greatest effort was made by the authors and the editor to ensure the neutrality and objectivity of the comparative technology analyses. Considering the ample opportunities for knowledge transfer and learning between the CCD and radioactive waste management research communities, this book can be expected to trigger more collaborative projects to explore the open issues still further. On the policy side, the insights presented by the authors are likely to provide useable knowledge to assist policymakers in resolving major challenges encountered during the formulation of national energy strategies.

H.-Holger Rogner
Section Head, Planning and Economic Studies Section
Department of Nuclear Energy
International Atomic Energy Agency (IAEA)
Vienna, Austria