Preface

“The ICT sector is a key driver to a low carbon society and it is fundamental to fight Climate Change”.

In November 2008 three industry representatives of the European Commission’s Ad-hoc Advisory Group on ICT for Energy Efficiency expressed the need for a better understanding of the importance of the ICT sector and a more fundamental integration of ICT solutions in EU policies in order to address the challenge of fighting climate change. The World Bank announced in October 2008 an 87% increase in funding for renewable energy (RE) and energy efficiency (EE) projects and programs in developing countries in the past fiscal year. Indeed, the important role that ICT plays in enabling intelligent energy, cleaner energy, greater energy efficiency and carbon reductions is considered as central to energy policy making worldwide. Without any doubt, the role of ICT is crucial in transforming the knowledge-based society to a low carbon society. Several studies published within the last 12 months conclude that the application of digital technology solutions can reduce world energy consumption from 10% to 25% by 2020.

The energy sector is a complex environment, incorporating a variety of organisations, operational frameworks, and internal and external pressures. Application of intelligent systems and knowledge management in the energy sector has been an active area of research for about two decades and significant successes have been achieved. Perhaps unsurprisingly, therefore, some of the biggest players in the sector were among the earliest adopters of knowledge management, notably oil and gas giants Shell and BP. Energy is not only a significant industry in any economy but also a field which needs effective means to manage data as well as information and knowledge. The energy industry is nowadays trying to become a knowledge-based community that is connected to factories, electricians, managers, consultants, researchers and customers for sharing knowledge, reducing administrative costs and improving the quality of service.

The continuous discussion about how ICT can be used in the energy sector has large potential for opening up new areas of opportunities, both social and business. For instance, the Intelligent Energy – EU-funded programme has lent its support so far to more than 400 international projects involving more than 3,000 European organisations; this programme aims at promoting intelligent solutions in energy and creating better conditions for a more energy-wise future, securing environmental protection. Intelligent Information Systems and Knowledge Management for Energy: Applications for Decision Support, Usage and Environment Protection is a book aimed at enlightening the above concepts and challenges and therefore at providing understanding as to how ICT can contribute to the energy sector. In particular, its specific purposes are:

- To create a big knowledge base for scholars, introducing them to all aspects of intelligent computer applications in the energy sector and indicating other areas fertile for research.
To develop scholars’ capacity in the design, implementation and application of intelligent information systems and knowledge management in the energy sector

To increase the awareness of the role of intelligent information systems and knowledge management in the energy sector, as well as of the challenges and opportunities for future research.

The book presents insights gained by leading professionals from the practice, research, academic, and consulting side in the field. This is why it should be useful to a variety of target groups, which are interested in the interrelationships between information and communication technologies and energy. The Foreword is written by a senior respected academic researcher and energy policy maker Emmanuel Samouilidis of the National Technical University of Athens, Greece. The book is divided into three sections, each one dealing with selected aspects of information and communication technologies in the energy sector.

Section 1: Theories and Concepts

The five chapters in Section 1 present advanced theories and modern ICT and knowledge management concepts in several fields of energy. Chapter 1 introduces the basic theory of Artificial Intelligence (AI) and its application to the energy sector. AI-based systems are being developed and deployed worldwide in a wide variety of applications, mainly because of their symbolic reasoning, flexibility and explanation capabilities. This chapter presents a review of the main AI techniques such as expert systems, artificial neural networks, genetic algorithms, fuzzy logic and hybrid systems, and describes a wide range of modern AI-based energy applications.

Chapter 2 analyzes the key issue of the control of energy generation systems and presents an innovative concept based on the use of intelligent control algorithms (fuzzy logic controller, genetic algorithm, etc.) in order to reduce the PEMFC (Proton Exchange Membrane Fuel Cells) stress concerning the output load power dynamic.

Chapter 3 presents an overview of the challenges presented to modern power utility companies and how many organizations are facing particularly pressing problems with regards to an ageing workforce and a general shortage of skills; a situation that is anticipated to worsen in the future. It is proposed that knowledge management (KM) and decision support (DS) may contribute to a solution to these challenges. The chapter describes the end-to-end processes associated with KM and DS in a power utility context and attempts to provide guidance on effective practices for each stage of the described processes.

Chapter 4 introduces the multiobjective particle swarm optimization (MOPSO) technique to solve environmental/economic dispatch (EED) problem. The proposed MOPSO technique evolves a multiobjective version of PSO by proposing redefinition of global best and local best individuals in multiobjective optimization domain. The proposed MOPSO technique has been implemented to solve the EED problem with competing and non-commensurable cost and emission objectives.

Adjustable speed induction generators, especially the Doubly-Fed Induction Generators (DFIG) are becoming increasingly popular due to its various advantages over fixed speed generator systems. A DFIG in a wind turbine has ability to generate maximum power with varying rotational speed, ability to control active and reactive by integration of electronic power converters such as the back-to-back converter, low rotor power rating resulting in low cost converter components, etc, DFIG have become very popular in large wind power conversion systems. Chapter 5 presents an extensive literature survey over past 25 years on the different aspects of DFIG.
Section 2: Models and Tools

The second section of this book moves from a more theoretical focus to consider practical models and tools that have evolved to support the solving of specific problems in the energy sector.

The first chapter in this section, Chapter 6, investigates the use of neural networks (NN) for modeling of residential energy consumption. Currently, engineering and conditional demand analysis (CDA) approaches are mainly used for residential energy modeling. The studies on the use of NN for residential energy consumption modeling are limited to estimating the energy use of individual or a group of buildings. This chapter presents a national residential end-use energy consumption model, using NN approach. The comparative evaluation of the results of the model shows that the NN approach can be used to accurately predict and categorize the energy consumption in the residential sector. Based on the specific advantages and disadvantages of three models, developing a hybrid model consisting of NN and engineering models is suggested.

The Kyoto Protocol contains market mechanisms that enable industrialized countries to invest in greenhouse gas emission (GHG) reduction projects on the territory of other countries, either developing, or industrialised, such as the Clean Development Mechanism (CDM). Chapter 7 presents the Clean Development Mechanism Sustainable Energy Technology Transfer Tool (CDM-SET3) which was developed and applied to a selected set of representative developing countries from Asia, Latin America, sub-Saharan Africa and the Mediterranean. The CDM-SET3 steers towards a successful technology transfer through the CDM, taking also into consideration the overall medium to long-term energy and environmental strategy of the host country.

Chapter 8 presents an expert system model, based on a “multidimensional” approach, for the formulation of modern energy policies, which also incorporates the three objectives (security of supply, competitiveness of energy market and environmental protection) and takes into consideration all the related economical, social and technological parameters. This model was successfully applied in order to support the decisions towards the development of the energy policy priorities in the developing Mediterranean Countries as well as the countries of Gulf Cooperation Council – GCC.

Green energy utilization technology is an effective means of reducing greenhouse gas emissions. Chapter 9 presents the development of the production-of-electricity prediction algorithm (PAS) of the solar cell. In this algorithm, a layered neural network is made to learn based on past weather data and the operation plan of the hybrid system (proposed system) of a solar cell, while a diesel engine generator was examined using this prediction algorithm. Numerical simulation showed that the fuel consumption of the proposed system was modest compared with other operating methods.

Chapter 10 is aimed to outline the value of model-based decision support systems in addressing current challenges aimed to carry out sustainable energy systems and to diffuse the use of strategic energy-environmental planning methods based on the use of partial equilibrium models. The proposed methodology, aimed to derive cost-effective strategies for a sustainable resource management, is based on the experiences gathered in the framework of the Energy Technology Systems Analysis Programme of the International Energy Agency (IEA-ETSAP) and under several national and international projects.

Chapter 11 presents a survey on the models and decision support tools for cogeneration, tri-generation and poly-generation planning. This survey tries to reflect the influence of deregulated energy market and environmental concerns on decision support tasks at utility level. Diverse modelling techniques and solution methods for planning problems will co-exist for a long time. Undoubtedly, the application of intelligent techniques is one of the main trends.
Section 3: Systems and Applications

The final section of this book considers some applications and case studies of ICTs in the energy sector.

Throughout the last two decades many attempts took place in order for energy policy makers and researchers to be able to measure the energy security of supply of a particular country, region and corridor. Chapter 12 presents the Energy Security Risk Assessment System (E.S.R.A.S.) which comprises the Module of Robust Decision Making (RDM) and the Module of Energy Security Indices Calculation (ESIC). The application of the system in nine case study countries is also discussed.

Chapter 13 presents an intelligent information system which consists of an Expert subsystem and a Multi Criteria subsystem. The system supports the state towards the formulation of a modern business environment, since it incorporates the increasing needs for energy reform, successful energy planning, rational use of energy as well as climate change. The pilot system was successfully applied to the thirteen “new” member states of the EU.

Chapter 14 presents case studies and lessons learnt concerning the use of ICT in power system planning and operation under de-regulated markets. This chapter aims at discussing the new emerging trends and critical factors which have shaped and continue to influence decisions of power system planners and operators. Some of these are technical issues while others are economic and financial.

Chapter 15 puts forward a methodology to analyze the working performance of a three-phase induction motor driven centrifugal pump under conditions of voltage and load variations by, defining additional factors for correct interpretation about the nature and extent of voltage unbalance that can exist in a power system network. It defines induction motor derating factors for safe and efficient operation based on operational requirements and devise energy management strategies for efficient utilization of electrical energy by the motor-pump system, considering the voltage and load conditions.

The final chapter 16 presents an intelligent decision support system, addressed to Energy Service Companies (ESCOs) for assessing an operational unit’s (building or industrial sector) energy behaviour and suggesting the appropriate interventions. Its overall scope is to facilitate the ESCO in reaching a decision quickly and accurately, by simulating the whole unit’s energy behaviour.

The work presented in this book has been made possible through the hard work of the contributors who kept the deadlines and were always enthusiastic. The editor would like to thank all the contributors and hopes that this book will encourage the reader to keep strengthening the way ICT can contribute to greater energy efficiency, cleaner energy, environment protection and finally to transforming our knowledge-based society into a low carbon society and economy.