Preface

As Environmental issues remain at the forefront of Energy research, Renewable Energy is now an all-important field of study. As, furthermore, Smart Technology continues to rise while always becoming refined, its applications broaden and they enhance in their potential impact on leading to paradigm shifts and even revolutionize views and studies about sustainability. This potential can only be fully realized with a thorough understanding of the most recent breakthroughs in the fields of *Renewable Energy and Smart Technology* themselves and in their emerging methodolologies from Mathematics, Statistics, Analytics, Probability Theory and Stochastics, Operational Research and Artificial Intelligence.

Research Advancements in Smart Technology, Optimization, and Renewable Energy is a worldwide collection of innovative research that explores the recent steps forward towards smart applications in sustainability. Featuring the coverage on a wide range of topics including energy assessment, neural fuzzy control, and biogeography, this work is ideally designed for academicians, researchers, and students, ecomomists, managers, advocates, policy-makers, engineers, multiplyers and implementers of solutions, and artists.

The objective of this book project has been to gather along with their considerations, research studies and contributions the global investigators, experts and scholars in the scientific areas of Optimization and Analytics from all over the world, to share their knowledge, experience and newest trends in views and insights on the current research achievements related with *Renewable Energy and Smart Technology*. This book provides to the international research community a "golden opportunity" to familiarize and deepen, to interact and share their novel academic and practical results, findings and most recent discoveries among their friends and colleagues. The book is published by *IGI Global* which gave confidence, encouragement and support at every stage and in every direction of communication, of academic and creative inquiry.

Modern days' challenges of *Renewable Energy and Smart Technology* in natural science and engineering, in economies and societies, in sustainability and social complexity, in environmental, geo and earth sciences, in OR and decision support systems, are becoming more and more recognized and acknowledged in all over the world. Careful multidisciplinary discourse and research is urgently necessitated in order to finding accurate while, at the same time, stable solutions, to make deep insights and impacting contributions which are future-oriented and sustainable. They emanate from real-work motivations and needs, and along excellent, innovative and creative notions, concepts and models they lead towards powerful systems of recommendation and decision help that are prepared to deliver efficient and effective agendas of cultural, social, managerial and politics decisions, locally and globally. This process of analysis, innovation, creativity and construction requires both smartest networks and

disciplinary communication dynamics and stimulating interdisciplinary collaborations and networks that are based on curiosity, freedom, mutual respect and responsibility.

At all of these points, modern *Optimization* and *Optimal Control*, *Data Mining, Machine Learning, AI* and *OR* come into play as *key technologies* of modeling, regularization and careful selection, of pre- and post-processing, of simulation and preparation, of guidance and interest, of continuous respect and concern.

The population of people on earth steadily grows, putting on the agenda numerous and hard questions, so many urgent problems. For instance, there is the need to offer all the necessary food, clothes, housing, services, infrastructure, medical and many further commodities and goods of all kinds. *Optimization* and *Decision-making* has to find, choose and allocate new territories, particularly, in the rural countrysides, and vast amounts of energy, while all of this should be implemented with not more than a moderate complexity by organizations and governments, within an overall atmosphere of care, empathy and freedom. In situations like these, *Smart Technology, Optimization, and Renewable Energy are making a big difference* and emerge as *Key Technologies* of the future, as represented in this book in such impressive ways.

We editors cordially thank all the authors and all the reviewers for their remarkable contributions. Best and high-quality chapters have been encouraged, chosen and reviewed in order to become published in our book *Research Advancements in Smart Technology, Optimization, and Renewable Energy* by IGI Global.

In order to name some of the numerous topics of this book's chapters, we may list the following ones, but there are *many more*:

- *Algorithms,*
- *Biogeography,*
- *Economic Load Dispatch,*
- *Electric Power Sector,*
- *Energy Assessment,*
- *Energy Management Strategies,*
- *Grey Wolf Optimization,*
- *Hybrid Systems,*
- *Neural Fuzzy Control,*
- *System Optimization,*
- *Teaching-Learning-Based Optimization.*

Let us emphasize the high importance of this work for everyone related with its subjects, challenges and promises, interested in them, and for its future readers and appliers. In fact, we trust that in the years to come, *Smart Technology, Optimization, and Renewable Energy* will remain in the core of giving *Decision-Making Help* and *Support* which this book aims at. In this context, we especially name *Stochastic Optimal Control* in the presence of *Impulses* and *Regime Switching* in economic and cultural frames. Here, we are also working on scientifically, towards further involvement of real-life situations and cases, with all their enormous uncertainties and with "human factors", for an *optimal decision-making*.

Based on very careful and rigorous reviewing processes, 17 chapters were accepted for publication and became part of this exclusive collection of chapters – our book *"Research Advancements in Smart Technology, Optimization, and Renewable Energy"*. Short descriptions of these chapters are following subsequently.

In their chapter *"Prediction of Menstrual Cycle Phase by Wearable Heart Rate Sensor"*, *Junichiro Hayano* (Nagoya City University, Graduate School of Medical Sciences, Japan) and *Emi Yuda* (Tohoku University, Graduate School of Engineering, Japan) introduce comprehensive analyses of long-term heart rate data that may be useful for revealing their associations with the menstrual cycle phase. In fact, prediction of menstrual cycle phase and fertile window by easily measurable bio-signals has been a yet unmet need; such technological development will greatly contribute to women's quality of life. Though many studies reported differences in autonomic indices of heart-rate variability (HRV) between follicular and luteal phases, they not yet reached the level that can predict the menstrual cycle phases. Recent development of wearable sensors enabled heart-rate monitoring during daily life; long-term heart rate data obtained herewith include a lot of information, and information that can be extracted by conventional HRV analysis is just a part of it. This chapter ought to mean a significant future advance.

With their contribution *"Enhancing User Experience in Public Spaces by Measuring Passengers' Flow and Perception Through ICT: The Case of the Municipal Market of Chania"*, *Anna Karagianni, Vasiliki Geropanta, Panagiotis Parthenios* (all from Technical University of Crete), *Riccardo Porreca* (UTE University of Quito, Ecuador), *Sofia Mavroudi, Antonios Vogiatzis, Lais-Ioanna Margiori, Christos Mpaknis, Eleutheria Papadosifou* and *Asimina Ioanna Sampani* (all from Technical University of Crete), investigates user-spatial experience transformations in hyper-connected public spaces and transform them to hybrid spaces. They conduct an experiment in the Municipal Market of Chania, Crete, in which they evaluate user behaviors on a population of 33 participants comparing their spatial experiences before and after the use of ICT. Through qualitative and quantitative methods, the authors analyze the behavioral change among users with and without access to Crete 3D, an online ICT-based innovative informative platform, in order to create a theoretical framework on user interaction with built space. This process permits for knowledge transfer in a twofold way: how to use metrics to evaluate user-building interaction and how users can quickly understand the building in use.

Elias Munapo (North West University, South Africa) in his chapter *"Improving the Optimality Verification and the Parallel Processing of the General Knapsack Linear Integer Problem"* presents a new approach to the verification process of optimality for the general knapsack linear integer problem which is very difficult to solve. A solution may be well estimated but it can still be very difficult to verify optimality using branch-and-bound related methods. In his chapter, a new objective function is generated which is also used for a more binding equality constraint that can be shown to significantly reduce the search region for branch-and-bound related algorithms. The verification process for optimality offered is easier than most of the available branch-and-bound related approaches. The proposed approach is widely parallelizable, allowing for the use of the much needed independent parallel processing.

In their chapter *"New Direction to the Scheduling Problem: A Pre-Processing Integer Formulation Approach"*, *Elias Munapo* (North West University, South Africa) (Elias.Munapo@nwu.ac.za) and *Olusegun Sunday Ewemooje* (Federal University of Technology Akure, Nigeria) present a new direction to the scheduling problem by exploring the Moore-Hodgson algorithm used within the context of integer programming to come up with complementarity conditions, extra more biding constraints and a strong lower bound for the scheduling problem. With Moore-Hodgson algorithm, the alternate optimal solutions cannot be easily generated from one optimal solution, but with integer formulation this is not a problem. As integer formulations are sometimes very difficult to handle as the number jobs increases, the authors present the integer formulation using infeasibility to verify optimality with branch-and-bound related algorithms. Hence, the lower bound is obtained using pre-processing and shown to be quite accurate, and it can be employed whenever quick scheduling decisions are required.

In the chapter *"Use of the Neural Network Controller of Sprung Mass to Reduce Vibrations From Road Irregularities"*, *Zakhid Godzhae*v, *Sergey Senkevich, Viktor Kuzmin* (all from Federal State Budgetary Scientific Institution "Federal Scientific Agroengineering Center VIM", Russia) and *Izzet Melikov* (Dagestan State Agricultural University named after M.M. Dzhambulatov, Russia) propose a new operation regime of the controller based on neuron nets by combining the advantages of the adaptive, radial and basic functions of the neuron net. Its advantages are a learning ability in real time to process indefinite, nonlinear disturbances, and to change the value of the active force in the hydraulic leaf spring by adjusting the weight coefficients of the neuron net or the radial parameters of the basic function. In fact, hydraulic systems which damp active oscillation operate according to a certain non-linear and time-varying algorithm. It is hard to create a controller based on its dynamic model. The author's model is a ¼ hydraulic active sprung mass of a mobile vehicle. The modeling shows that the use of a neuron net controller makes the sprung mass much more efficient.

In his contribution *"The Traveling Salesman Problem, Network Properties, Convex Quadratic Formulation, and Solution"*, *Elias Munapo* (North West University, South Africa) presents a traveling salesman problem, its network properties, convex quadratic formulation and its solution. He shows that adding or subtracting a constant to all arcs with special features in a traveling salesman problem (TSP) network model does not change an optimal solution of the TSP, and that adding or subtracting a constant to all arcs emanating from the same node in a TSP network does not change the TSP's optimal solution. In addition, a minimal spanning tree is employed to detect sub-tours; then sub-tour elimination constraints are generated. From the formulated linear integer model of the TSP network a convex quadratic program is constructed. Finally, interior point algorithms are applied to solve the TSP in polynomial time.

The chapter *"Optimal Sizing of Hybrid Wind and Solar Renewable Energy System: A Case Study of Ethiopia"* by *Diriba Kajela Geleta* (Madda Walabu University, Oromia, Ethiopia) and *Mukhdeep Singh Manshahia* (Punjabi University Patiala, India) employ a nature inspired methodology to optimize hybrids of renewable energy system in the case of Jeldu district of Ethiopia. Indeed, if properly designed and utilized, the Earth has a rich potential of clean energy to satisfy the energy demand of the world. The authors aim to minimize the total cost of the system designed by using appropriate numbers of components based on the pre-designed constraints to satisfy the load demand. MATLAB code was designed and the results were discussed. The authors observed that the proposed approach solved the optimum sizing of the defined problem with high convergence, and energy demand of the village can be optimally satisfied by the use of wind and solar hybrid system. This paper can help countries like Ethiopia to increase access to electricity.

Vladimir Panchenko (Russian University of Transport, Russia) in his chapter *"Prospects for Energy Supply of the Arctic Zone Objects Using Frost-resistant Solar Modules"* aims at the prospect of using frost-resistant solar modules with extended service life of various designs for energy supply of infrastructure facilities of the Arctic zone. He gives the general characteristic of the region under consideration and reflects on energy specifics, directions of energy development based on renewable energy sources. The author proposes frost-resistant planar photovoltaic modules and solar roofing panels with an extended service life for power supply of objects, and frost-resistant planar photovoltaic thermal roofing panels and concentrator solar installation with high-voltage matrix solar modules with a voltage of 1000 V and an electrical efficiency of up to 28% for simultaneous heat and power generation. The addressed solar modules have an extended rated power period due to the technology of sealing solar cells with a two-component polysiloxane compound; they can work effectively at large negative ambient temperatures and large ranges of its fluctuation.

In their contribution *"Development of Self-Organized Group Method of Data Handling (GMDH) Algorithm to Increase Permeate Flux (%) of Helical Shaped Membrane"*, *Anirban Banik, Mrinmoy Majumder, Sushant Kumar Biswal* and *Tarun Kanti Bandyopadhyay* (all from National Institute of Technology Agartala, India) focus on enhancing the permeate flux of helical shaped membrane using Group Method of Data Handling (GMDH) algorithm. Variables such as operating pressure, pore size, and feed velocity were selected as input, and permeate flux as output variable. The uncertainty analysis evaluates the acceptability of the model and it is found that values of Nash-Sutcliffe efficiency (NSE), ratio of the root mean squared error to the standard deviation (RSR), percent bias (PBIAS) are close to the best values, showing the model acceptability. The effect of input parameters on model output is calibrated using sensitivity analysis. It shows that pore size is the most sensitive parameter followed by feed velocity. The optimum values of pore size, operating pressure, and feed velocity are calibrated and found to be 2.21μm, 1.31×10-03KPa, and 0.37m/sec, respectively. The errors in GMDH model are compared with multi-linear regression (MLR) model, showing that GMDH predicts results with minimal error; the predicted variable follows the actual one with good accuracy.

The contribution *"Transmission Risk Optimization in Interconnected Systems: Risk Adjusted Available Transfer Capability"* by *Nimal Madhu M, Jai Govind Singh, Weerakorn Ongsakul* (all from Asian Institute of Technology, Thailand) and *Vivek Mohan* (National Institute of Technology Tiruchirappalli, India) is concerned with Available Transfer Capability as a key indicator of transmission reliability, varying with the variation in power flow pattern through the network. ATC determination addressing uncertainties in renewable generation and demand is of key significance for safe and economic operation of a power system, especially, in a competitive market. A two-stage risk-adjusted stochastic optimal power dispatch is presented minimizing the reduction in ATC due to variation in active power output from renewable energy sources and load. For a combined transmission-distribution system with renewable and conventional energy sources, ATC is estimated combining continuation power flow and power transfer sensitivity factor methods. The joint probability distribution function of ATC is derived. Risk, quantified as the variance of ATC, is minimized using stochastic weight trade-off non-dominated sorting particle swarm optimization, considering various operational objectives of a network operator.

Firuz Ahamed Nahid, Weerakorn Ongsakul, Nimal Madhu M, and *Tanawat Laopaiboon* (all from Asian Institute of Technology, Thailand) in their chapter *"Hybrid Neural Networks for Renewable Energy Forecasting: Solar and Wind Energy Forecasting using LSTM and RNN"* address forecasting of stochastic renewable energy sources as involved in one of the key applications of AI algorithms in power sector. To manage the generation of electricity from solar or wind effectively, accurate forecasting models are imperative. Therefore, a sophisticated hybrid Neural Network formulation is discussed in this chapter. A combination of Long-Short-Term Memory and Recurrent Neural Networks is formulated for very short-term forecasting of wind speed and solar radiation. In intervals of 15-30 minutes, time series forecasts are made that are ahead by multiple steps. Point-wise and probabilistic forecasting approaches are combined for maximum energy harvest. Historic data are collected for solar radiation, wind speed, temperature and relative humidity, and used to train the model. The proposed model is compared with Convolutional and LSTM Neural Networks individually in terms of RMSE, MAPE, MAE and Correlation; it is identified to have better forecasting accuracy.

In their chapter *"Multi-Fuel Power Dispatch Considering Prohibited Operating Zones and Tie-Line Flow Limits Using Ant Lion Optimizer"*, *Ganesan Sivarajan* (Government College of Engineering, Salem, India), *Jayakumar N* (Government Polytechnic College, Uthangarai, India), *Balachandar P* (Government Polytechnic College, Valangaiman, India) and *Subramanian Srikrishna* (Annamalai University,

India) point out that electrical power generation from fossil fuel releases several contaminants into the air, even more if the generating unit is fed by Multiple Fuel Sources (MFS). Stringent environmental regulations have forced the utilities to produce electricity at the cheapest price and the minimum level of pollutant emissions. Restriction in generator operations increases the complexity in plant operations. Cost effective and environmental responsive operations in MFS environment is a multi-objective constrained optimization problem. Ant Lion Optimizer (ALO) has been chosen for solving the MFS dispatch problems. Fuzzy decision-making mechanism is integrated into the search process of ALO to fetch the Best Compromise Solution (BCS). The intended algorithm is implemented on the standard test systems considering the prevailing operational constraints, e.g., valve-point loadings, CO2 emission, prohibited operating zones and tie-line flow limits.

In the chapter *"Oppositional Differential Search Algorithm for the Optimal Tuning of Both Single Input and Dual Input Power System Stabilizer"*, *Sourav Paul* (Dr. B C Roy Engineering College, India) and *Provas Kumar Roy* (Kalyani Government Engineering College, Kalyani, India) are concerned with low frequency oscillation as a major threat in large interconnected power system, as it curtains the power transfer capability of the line. Power System Stabilizer (PSS) helps in diminishing these low frequency oscillations by providing auxiliary control signal to the generator excitation input, thereby restoring stability of the system. The authors incorporate the concept of oppositional based learning (OBL) along with differential search algorithm (DSA) to solve the PSS problem. The proposed technique has been implemented on both single input and dual input PSS, and a comparative study is conducted to show the supremacy of the new techniques. The convergence characteristics authenticate the sovereignty of the considered algorithms as well.

The contribution *"Extreme Value Metaheuristics and Coupled Mapped Lattice Approaches for Gas Turbine-Absorption Chiller Optimization"* by *Timothy Ganesan* (Royal Bank of Canada), *Pandian Vasant* (Universiti Teknologi Petronas, Malaysia), *Igor Litvinchev* (Nuevo Leon State University, Mexico) and *Mohd Shiraz Aris* (TNB Research, Malaysia) focuses on two novel optimization methodologies: extreme value stochastic engines (random number generators) and the coupled map lattice (CML), in the light of the increasing complexity of engineering systems which has spurred the development of highly efficient optimization techniques. This chapter incorporates extreme value distributions into stochastic engines of conventional metaheuristics and the implementation of CMLs to improve the overall optimization. The core idea is to deal with highly complex, large-scale multi-objective (MO) problems. Differential evolution (DE) approach is employed (incorporated with the extreme value stochastic engine) while the CML is used independently (as an analogue to evolutionary algorithms). Then the techniques are applied to optimize a real-world MO Gas Turbine - Absorption Chiller system. The authors carry out comparative analyses among the conventional DE approach (Gauss-DE), extreme value DE strategies and the CML.

Iurii V. Krak (Taras Shevchenko National University of Kyiv Glushkov Cybernetics Institute, Ukraine), *Olexander V. Barmak* and *Eduard A. Manziuk* (both from National University of Khmelnytskyi, Ukraine) in their chapter *"Visual Analytics to Build a Machine Learning Model"* are concerned with the active involvement of a human in the process of building a model, one of the most interesting and promising areas of machine learning. But there are problems with effective integration of humans into a workflow. Therefore, it is necessary to prepare techniques and information technologies that could allow for an effective use of human intellectual capabilities, thereby expanding the machine learning tools. The authors consider visual analytics with the goal of building a machine learning model by a human, and the technique of transferring this model to the machine level. This has made it possible to expand the capabilities of machine learning through an active and productive employment of human intellectual abilities.

In their chapter *"Smart Connected Digital Products and IoT Platform With the Digital Twin"*, *Yuvaraj D* (Cihan University, Duhok, Kurdistan Region, Iraq), *Mohamed Uvaze Ahamed A* (Cihan University, Erbil, Kurdistan Region, Iraq), *Jayanthiladevi A* (Institute of Scientific Research, Bangalore, India), *Balamurugan Easwaran* (University of Africa, Toru-Orua, Nigeria) and *Thamarai Selvi R* (Bishop Heber College, India) address digital illustration with a novel prevalence for a physical product, gain larger insight into that product's state performance and behavior. Digital twin is an unequivocal advanced copy of an item, method or control. This living model creates a thread between the physical and digital worlds. A model of a physical object - a "twin" - enables one to observe its standing, diagnose problems and take a look at solutions remotely. It is a dynamical virtual illustration of a tool which is unendingly fed with knowledge from embedded sensors and packages. This provides to some degree a correct period of time standing of the physical device. Digital twins drive innovation and performance, offering the development of prognostic analytics, and they give firms the flexibility to boost client expertise.

In the chapter *"Taxonomy of Influence Maximization Techniques in Unknown Social Networks: Influence Maximization Techniques"*, *B Bazeer Ahamed* (Al Musanna College of Technology, Oman), and *Sudhakaran Periakaruppan* (TRP Engineering College, India) deal with influence maximization in Online Social Networks (OSNs) which is the problem of discovering few nodes or users in a social network; they are termed as "seed nodes" and can help for spread of influence in a network. With the tremendous growth of social networking the influence exerted by users of a social network on other online users has caught the attention of researchers to develop effective influence maximization algorithms to be applied in the field of business strategies. The main application of influence maximization aims to promote the product to a set of users. However, this poses a real challenge in influence maximization algorithms to deal with a vast amount of users or nodes obtainable in any OSN. The authors focus on graph mining of OSNs for generating "seed sets" by employing standard influence maximization techniques. Many standard influence maximization models are used for calculating spread of influence; a novel influence maximization technique named as DegGreedy technique has been illustrated along with experimental results for comparing with existing techniques.

To all the *authors* of this book, we convey our sincere appreciation and gratitude for having shared their excellence, dedication and idealism with the academic community and, finally, with humankind. Furthermore, we send our gratitude to the publishing house of IGI Global, for making possible and become reality a truly international, excellent book of real-life significance and of potential high impact for the world of tomorrow, for this present generation and for the generations to come.

Now, we would like to wish us all a lot of joy and gain when browsing and reading this interesting work, and we hope that a remarkable benefit is going to be received from it science-wise, personally and societally.

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