Optimization and Control of Hydro Generation Scheduling using Hybrid Firefly Algorithm and Particle Swarm Optimization Techniques

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SUPERVISOR'S DECLARATION

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I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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OPTIMIZATION AND CONTROL OF HYDRO GENERATION SCHEDULING USING HYBRID FIREFLY ALGORITHM AND PARTICLE SWARM OPTIMIZATION TECHNIQUES

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Thesis submitted in fulfillment of the requirements
for the award of the degree of
Doctor of Philosophy of Engineering

Faculty of Electrical & Electronics Engineering
UNIVERSITI MALAYSIA PAHANG

April 2018

ACKNOWLEDGEMENTS

In the name of Allah, and all praise be to Allah, and prayers and peace be upon the Messenger of Allah, his family, his companions, and those who followed him. Grateful to Allah because of His grace, these studies have been carried out successfully.

In this opportunity, I would like to express gratitude and infinite thanks to Assoc. Prof. Dr. Mohd Herwan Bin Sulaiman as this dissertation project supervisor who has provided instruction, guidance, criticism, encouragement and advice that is meaningful to me from an early stage planning and up to the final stage of this study can be completed successfully.

I also would like to express very special thanks to my beloved parents, my new wife, my siblings, family, and friends that cannot be mentioned here in the supports, suggestions and contributions of valuable ideas and their cooperation for in completing my dissertation.

My sincere thanks go to University Malaysia Pahang (UMP). Lecturers of Faculty of Electrical and Electronics Engineering also deserve special thanks for their guidance.

TABLE OF CONTENT

DECLARATION

TITLE PAGE

ACKNOWLEDGEMENTS **ii**

ABSTRAK **iii**

ABSTRACT **iv**

TABLE OF CONTENT **v**

LIST OF TABLES **xi**

LIST OF FIGURES **xii**

LIST OF SYMBOLS **xv**

LIST OF ABBREVIATIONS **xvi**

CHAPTER 1 INTRODUCTION **1**

1.1 Introduction 1

1.2 Problem Statement 2

1.3 Objectives of Thesis 4

1.4 Thesis Scope 4

1.5 Contributions 5

1.6 Thesis Organization 5

CHAPTER 2 LITERATURE REVIEW **7**

2.1 Introduction 7

2.2 Hydropower Schemes 7

2.2.1 Classification and Strategic Production 7

2.2.2 SHP Advantages Over Other Sources 9
2.2.3 Development of Existing SHP 11
2.2.4 The Process of SHP Modelling 13
2.2.5 Characteristics of Hydropower Plant/Turbine 14
2.2.6 Evaluation Suitable Choice Economically 17
2.3 Hydropower Optimal Scheduling 18
2.3.1 Short-term Hydropower Scheduling 19
2.3.2 Daily-term Hydropower Scheduling 21
2.3.3 Long-term Hydropower Scheduling 23
2.4 Artificial Neural Networks Developments 25
2.4.1 ANN for Hydro Generation Prediction 26
2.4.2 ANN for Flow Water Rate Prediction 28
2.4.3 ANN for Net Head Prediction 30
2.4.4 ANN for Pattern Modelling 30
2.5 Fuzzy Logic Controller 31
2.5.1 Application of FLC with Hydropower Plant 31
2.5.2 Enhancement of FLC with Hydropower Plant 35
2.6 Critical reviews 37
2.7 SUMMARY 39

CHAPTER 3 OPTIMIZATION OF ANNUAL HYDRO GENERATION SCHEDULING 40

3.1 Introduction 40
3.2 Hydropower Function 40
3.3 Himreen Lake Dam (HLD) Hydropower Plant 43
3.3.1 Dataset Collection 44

3.3.2 Actual Observed System Operator (AOSO) 47
3.3.3 Standard System Operator (SSO) of HLD Hydropower Plant 49
3.3.4 Implementation of SSO by MATLAB 49
3.3.5 Himreen Lake Dam (HLD) Application 50
3.4 Feature Optimization 50
3.4.1 Particle Swarm Optimization (PSO) 50
3.4.1.1 PSO Operation 51
3.4.1.2 Algorithm of Multi-objective optimization 52
3.4.1.3 Pseudo Code for PSO 53
3.4.2 Fireflies' Behaviour and Operation 54
3.4.2.1 Mathematical Model of Fireflies Algorithm Optimization 55
3.4.2.2 Execution of Firefly Algorithm (FA) 56
3.4.2.3 Pseudo code of Firefly Algorithm 57
3.4.2.4 Firefly's Algorithm (FA) characteristics 58
3.5 Problem Formulation and Constraints 59
3.5.1 The AOSO of HLD Hydropower Plant 59
3.5.2 The SSO of HLD Hydropower Plant 62
3.6 Proposed Approach 63
3.6.1 Series division method (SDM) 63
3.6.2 Series Division Firefly Algorithm (SDFA) 64
3.6.3 Series Division Particle Swarm Optimization (SDPSO) 66
3.6.4 Hybrid FA and PSO (FPSO) Algorithm 66
3.7 System Validation 68
Summary 71

CHAPTER 4 HYDRO GENERATION PREDICTION, MODELLING AND CONTROL 72

4.1 Introduction 72

4.2 Artificial Neural Networks Developments 72

4.2.1 Identification and Properties of ANN Models 73

4.2.2 Network Types 73

4.2.3 The Network Activation Function 74

4.2.4 Standardizing and Normalized Data 75

4.2.5 Back Propagation Neural Network (BPNN) 76

4.2.6 Cross-validation and k-fold 77

4.3 Hybrid Back Propagation Neural Network (BPNN) Model 80

4.3.1 Firefly Algorithm with BPNN Model 80

4.3.2 Robust Firefly Algorithm (RFA) with BPNN Model 81

4.4 AOSO Modelling Elaboration using ANN 85

4.4.1 Efficient Modelling Prediction 85

4.4.2 AOSO Model Simulation Test 86

4.5 Fuzzy Logic Controller (FLC) 88

4.5.1 Proposed Fuzzy Artificial Neural Network (FANN) 89

4.5.1.1 Scenario I; Tuning Fuzzy Artificial Neural Network 89

4.5.1.2 Scenario II; Normalized Firefly Fuzzy Neural Networ 92

4.5.1.3 Scenario III; Right-Angle Fuzzy Neural Network 94

4.6 Summary 96

CHAPTER 5 RESULTS AND DISCUSSION 97

5.1 Introduction 97

5.2 Swarm Intelligence 97

5.2.1 Firefly Particle Swarm Optimization (FPSO) 99
5.2.2 Series Division Method 100
5.3 Total Evaluation of ANN 111
5.3.1 Primary Tests of The ANN Models for Training and Validation 112
5.3.2 Cross-Validation and k-fold 115
5.3.3 FA- BPNN with Cross-Validation and k-fold 116
5.3.4 RFA- BPNN with Cross-Validation and k-fold 118
5.4 The proposed FANN 119
5.4.1 Artificial Neural Network (ANN) Model 119
5.4.2 Fuzzy Artificial Neural Network (FANN) Model 121
5.5 Data Collection and Analysis 124
5.5.1 AOSO Parameters of HLD Model 124
5.5.1.1 Minimum and Maximum Values 124
5.5.1.2 Relationships 125
5.5.1.3 Description Statistic 126
5.5.1.4 Constructing a Histogram 126
5.5.1.5 Identify of Box Plots 128
5.5.1.6 Normal Probability Distribution for AOSO Parameters 129
5.5.1.7 ANOVA for AOSO Parameters Testing 130
5.5.2 PSO, FA, SD-PSO, SD-FA, and FPSO 133
5.5.2.1 Identify of Box Plots 133
5.5.2.2 ANOVA Testing 133
5.5.2.3 Validation Depends on Iterations 134
5.5.2.4 Validation Depends on Average Raw Data 136

5.5.3 BPNN, FA-BPNN, and RFA-BPNN Model Parameters 138

5.5.3.1 Identify of Box Plots 138

5.5.3.2 ANOVA Testing 139

5.5.3.3 Validation 140

5.5.4 ANN, FANN, NFANN, and RFANN Models 142

5.5.4.1 Constructing a Histogram 142

5.5.4.2 Identify of Box Plots 143

5.5.4.3 ANOVA Testing 144

CHAPTER 6 CONCLUSION AND RECOMMENDATIONS 146

6.1 Conclusion 146

6.2 Future Recommendations 147

REFERENCES 149

APPENDIX A List of Publications 168

APPENDIX B Himreen Lake Dam (HLD) 170

LIST OF TABLES

Table 2.1	Hydropower scheme classification	8
Table 2.2	Net head classification for applications of hydro-turbines	15
Table 2.3	Rotational speed of small hydel turbines	17
Table 3.1	Main design parameters of the hydropower plant	47
Table 4.1	Rules of flow rate, and net head of the and generation control	90
Table 5.1	Optimal hydro generation using algorithms (MW)	110
Table 5.2	Optimum input parameters contributions algorithms	110
Table 5.3	The comparison of this study with parameters of research works	111
Table 5.4	The comparison of this study with result of research works	112
Table 5.5	Derived SLP and MLP ANNs	115
Table 5.6	Five-fold cross validation dataset	116
Table 5.7	FA-BPNN on five-fold cross validation dataset	117
Table 5.8	RFA-BPNN on five-fold cross validation dataset	118
Table 5.9	One-way ANOVA (Single Factor)	131
Table 5.10	One-way ANOVA (Tukey HSD)	131
Table 5.11	Two way ANOVA (Two-Factor Without Replication)	131
Table 5.12	P-values of one and two way ANOVA test for NH, RF with HG	134
Table 5.13	The average of actual value of hydropower generation (MW)	137
Table 5.14	P-values of ANOVA test for NH, FR with HG: via BPNN	139
Table 5.15	P-values of ANOVA test for NH, FR with HG: via FA-BPNN	139
Table 5.16	P-values of ANOVA test for NH, FR with HG: via RFA-BPNN	140
Table 5.17	P-values of one and two way ANOVA test for NH, RF with HG	145

LIST OF FIGURES

Figure 2.1	Strategic Production and Installed Capacity for SHP	9
Figure 2.2	Total Cost Electricity Production Per kWh	9
Figure 2.3	Run-of-River	12
Figure 2.4	Turbine terms of net head and flow rate variations	15
Figure 2.5	Hydropower Scheduling Explaining	18
Figure 2.6	Structure of the ANNs	25
Figure 3.1	Himreen Lake dam	44
Figure 3.2	Chronological flow rate of water	45
Figure 3.3	Chronological net head of turbine	45
Figure 3.4	Chronological power productions	46
Figure 3.5	Average min and max climate temperatures at work site	46
Figure 3.6	Relationship between flow rate of water and power production	48
Figure 3.7	Relationship between net head of turbine and power production	48
Figure 3.8	Flowchart of PSO algorithm	53
Figure 3.9	Flowchart of Firefly Algorithm	57
Figure 3.10	Local and global optimum points	63
Figure 3.11	Flowchart of the proposed SDM with FA by AOSO and SSO	65
Figure 3.12	Flowchart of the proposed FPSO algorithm by AOSO and SSO	67
Figure 4.1	Typical architecture of FFBP	77
Figure 4.2	Flowchart of k-fold cross-validation	79
Figure 4.3	Example of k-fold cross-validation	79
Figure 4.4	Depiction of initial weights	81
Figure 4.5	Mechanism of original back propagation neural network	82
Figure 4.6	Flowchart of suggested RFA	83
Figure 4.7	The architecture of the ANN modelling in the testing process	87
Figure 4.8	Architecture of the FANN modeling in testing	89
Figure 4.9	Tuned membership function for net head	90
Figure 4.10	Tuned membership function for flow rate	91
Figure 4.11	Tuned membership function for power generation	91
Figure 4.12	Surface map for rule base of the TFANN	91
Figure 4.13	Right-angle triangle membership functions for flow rate	95
Figure 5.1	Convergence graph of FA	99
Figure 5.2	Convergence graph of PSO	99

Figure 5.3	Convergence graph of FPSO	100
Figure 5.4	Convergence graph of SDFA for one division- AOSO	101
Figure 5.5	Convergence graph of SDFA for two divisions – AOSO	101
Figure 5.6	Convergence graph of SDFA for three divisions - AOSO	102
Figure 5.7	Convergence graph of SDFA for four divisions – AOSO	102
Figure 5.8	Convergence graph of SDFA for five divisions – AOSO	102
Figure 5.9	Convergence graph of SDFA for all divisions – AOSO	103
Figure 5.10	Convergence graph of SDFA for one division - SSO	103
Figure 5.11	Convergence graph of SDFA for two divisions - SSO	103
Figure 5.12	Convergence graph of SDFA for three divisions - SSO	104
Figure 5.13	Convergence graph of SDFA for four divisions – SSO	104
Figure 5.14	Convergence graph of SDFA for five divisions - SSO	104
Figure 5.15	Convergence graph of SDFA for all divisions – SSO	105
Figure 5.16	Convergence graph of SDPSO for one division - AOSO	106
Figure 5.17	Convergence graph of SDPSO for two divisions - AOSO	106
Figure 5.18	Convergence graph of SDPSO for three divisions - AOSO	106
Figure 5.19	Convergence graph of SDPSO for four divisions - AOSO	107
Figure 5.20	Convergence graph of SDPSO for five divisions - AOSO	107
Figure 5.21	Convergence graph of SDPSO for all divisions - AOSO	107
Figure 5.22	Convergence graph of SDPSO for one division – SSO	108
Figure 5.23	Convergence graph of SDPSO for two divisions – SSO	108
Figure 5.24	Convergence graph of SDPSO for three divisions – SSO	108
Figure 5.25	Convergence graph of SDPSO for four divisions – SSO	109
Figure 5.26	Convergence graph of SDPSO for five divisions – SSO	109
Figure 5.27	Convergence graph of SDPSO for all divisions – SSO	109
Figure 5.28	Training window of ANN91 model	113
Figure 5.29	Regression plot of ANN91 model	114
Figure 5.30	Regression plot of RFA-BPNN model	119
Figure 5.31	Hydro generation of AOSO against ANN model	120
Figure 5.32	Hydro generation of TFANN against AOSO and ANN model	122
Figure 5.33	Hydro generation of NFANN against AOSO and ANN model	123
Figure 5.34	Hydro generation of RFANN against AOSO and ANN model	123
Figure 5.35	Parameter limits for AOSO model	124
Figure 5.36	Average parameter values for AOSO model	125
Figure 5.37	Relationship of input parameters with hydropower generation	125

Figure 5.38	Description statistic of AOSO model	126
Figure 5.39	Frequent histogram of flow rate	127
Figure 5.40	Frequent histogram of net head	127
Figure 5.41	Frequent histogram of hydro generation	128
Figure 5.42	Box plots of hydropower parameters obtained by AOSO model	129
Figure 5.43	Normal probability plot obtained by flow rate	129
Figure 5.44	Normal probability plot obtained by net head	130
Figure 5.45	Normal probability plot obtained by hydro generation	130
Figure 5.46	Box plots of hydro generation obtained by contributions	133
Figure 5.47	Comparing FPSO with PSO and FA	135
Figure 5.48	Comparing SD-PSO with PSO	135
Figure 5.49	Comparing SD-FA with FA	135
Figure 5.50	Comparing SD-FA, SD-PSO, PSO, and FA with actual data	136
Figure 5.51	Comparing FPSO, PSO, and FA with actual data	137
Figure 5.52	Box plots of K-fold obtained by BPNN train	138
Figure 5.53	Box plots of K-fold obtained by BPNN test	138
Figure 5.54	Training error of 5-fold cross validation	140
Figure 5.55	Testing error of 5-fold cross validation	141
Figure 5.56	Training error of BPNN, FA-BPNN, and RFA-BPNN for k1	141
Figure 5.57	Testing error of BPNN, FA-BPNN, and RFA-BPNN for k1	142
Figure 5.58	Frequent TFANN histogram of hydro generation	142
Figure 5.59	Frequent NFANN histogram of hydro generation	143
Figure 5.60	Frequent RFANN histogram of hydro generation	143
Figure 5.61	Box plots of TFANN, NFANN, and RFANN models	144

LIST OF SYMBOLS

i	hydropower unit, i ∈ {1,…, I}
h	actual observed system operator
s	standard system operator
t	time periods, t ∈ {1,…, I}
p	total power of plant
ϕ	latitude of hydropower plant (°)
ρ	water density (kg/m^3)
θ	constant with value 0 if 0<Te<20 or 20 if 20<Te<50 (.C)
η_i	turbine efficiency
lcr_i	elevation of the turbine rotor
R_{zw}	element (z,w) of matrix of coefficients with T (kg/m^3)
T	water temperature in the reservoir (.C)
K_0	theatrical coeffect with load losses in canal intake (s^2/m^5)
Q	plant turbined outflow (m^3/s)
K_i^{ag}	aggregation coefficient of hydraulic load losses (s^2/m^5)
u_i	binary number, if unit i is operation (ui=1) or not (ui=0)
g	gravity acceleration (m/s^2)

LIST OF ABBREVIATIONS

AHGS	annual hydro generation scheduling
ANOVA	analysis of variance
AI	artificial intelligence
ANN	Artificial neural network
AOSO	actual observed system operator
BP	back propagation
BPNN	back propagation neural network
CDM	clean development mechanism
CO_2	carbon dioxide
FA	firefly algorithm
FA	firefly algorithm
FA-BPNN	firefly algorithm with back propagation neural network
FANN	fuzzy artificial neural network
FLC	fuzzy logic control
FNN	fuzzy neural network
FPSO	hybrid algorithm
HLD	himreen lake dam
LHP	large hydropower plant
MHP	mini hydropower plant
MiHP	micro hydropower plant
NFA	normalized firefly algorithm
NFA-FNN	normalized firefly with fuzzy neural network
NFANN	normalized firefly fuzzy artificial neural network
PHP	pico hydropower plant
PSO	particle swarm optimization
RATMF	right-angle triangle membership function
RFA	rough firefly algorithm
RFABPNN	rough firefly with back propagation neural network
SDM	series division method
SHP	small hydropower plant
SSO	standard system operator

Pp_i	electrical power production (KW)
Rfl	reservoir forebay level (m)
Rtl	reservoir tailrace level (m)
hll^{atm}	hydraulic losses due to the atmospheric pressure
bl_i	thrust bearing losses (MW)
Bt_i	turbine hydraulic thrust (N)
Dg_i	portion of thrust bearing losses references of generator
Dt_i	portion of thrust bearing losses references of turbine
Wg_i	generator weight (N)
Wt_i	turbine weight (N)
tip_i	turbine input power
top_i	turbine output power
gip_i	generator input power
gop_i	generator output power
tl_i	turbine losses
gl_i	generator losses
$F_{Fitnees}$	total generation (KW/h)
Nh_i^{min}, Nh_i^{max}	minimum and maximum net head of turbine
Fr_i^{min}, Fr_i^{max}	minimum and maximum flow rate of water
Ch_{1i} - Ch_{6i}	hydropower generation coefficient
Re_i^{max}, Re_i^{min}	maximum and minimum storage volume (M^3) of reservoir
Ir_i	irrigation gate
spl_i	Spillway
C_d	chronological order of the year = 60s × 60m × 24h = 86,400
C_y	chronological order of the year = CD × 365d =31,536,000
S^h	size of HLD

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ABSTRAK

Keperluan asas penjadualan sistem janakuasa hidro adalah untuk menentukan jumlah optima kuasa yang dijana untuk unit hidro dalam sistem bagi tempoh penjadualan setahun atau beberapa tahun sambil memenuhi kekangan sistem hidroelektrik. Penjadualan penjanakuasa hidro tahunan (AHGS) adalah masalah pengoptimuman berbentuk tak-linear, tidak cembung dan tidak lancar yang rumit dengan ruang penyelesaian selanjar. Model ini mengambil kira aliran masuk air harian, batasan pada tahap takungan, pergantungan penjanaan kuasa kepada bilangan unit hidro yang ada yang disebabkan oleh variasi kuasa, permulaan dan penutupan unit hidro. Selain itu, ramalan janakuasa hidro biasanya mempunyai struktur komposit seperti tak-linear, tidak-kekal serta turun-naik yang menjadikan meramalnya begitu sukar. Untuk menangani masalah ini, algoritma hibrid iaitu pengoptimuman zarah kunang-kunang (FPSO) dan Kaedah Bahagian Siri (SDM) berdasarkan pengoptimuman pintar praktikal dan algoritma kunang-kunang telah dicadangkan. Kaedah FPSO melakukan pencarian tempatan melalui langkah tarikan intensiti cahaya yang diubah suai dengan pengendali PSO. Aplikasi rangkaian neural penyebaran belakang (BPNN) sangat pelbagai dan tepu. Untuk tujuan ini, pendekatan yang dicadangkan adalah melibatkan hibridisasi FA dengan algoritma kasar (RA), di mana RA digunakan untuk mengawal langkah-langkah rawak untuk FA sambil mengoptimumkan beban model piawai BPNN. Selepas itu, model ramalan simulasi pegun diperolehi. Kaedah kawalan kabur baru untuk penjanaan kuasa hidro dengan kehadiran pemboleh ubah rawak input berdasarkan teori kestabilan iaitu kaedah kawalan kunang-kunang kabur (NFNN) yang baru direka untuk mengawal kestabilan sistem hidro-turbin. Tambahan pula, keadaan kestabilan yang lebih santai dan mudah diberikan sebagai satu set baru fungsi keahlian segitiga sudut tegak (RFANN), yang telah dijamin oleh derivasi matematik yang ketat. Kaedah kawalan mempunyai keteguhan yang baik dan dapat menahan gangguan rawak. Penjanaan tenaga hidro yang optimum yang diperhatikan meningkat kepada maksimum berbanding nilai sebenar oleh PSO, SD-PSO, SD-FA, FPSO. AHGS meningkat sebanyak 1.5%, 2.3%, 3.1%, 2.5%. Kaedah yang dicadangkan diuji pada data baris loji kuasa hidro Himreen Lake Dam. Pengawal SD-FA yang dicadangkan menunjukkan lebih baik dan mantap berbanding dengan algoritma lain, yang dapat menahan gangguan rawak

ABSTRACT

The fundamental requirement of hydropower system scheduling is to determine the optimal amount of generated powers for the hydro unit of the system in the scheduling horizon of 1 year or few years while satisfying the constraints of the hydroelectric system. Annual hydro generation scheduling (AHGS) is a complicated non-linear, non-convex and non-smooth optimization problem with discontinuous solution space. The model considers daily water inflows, limits on reservoir level, power generation depends on the available head of hydro units caused by power variations, start-up, and shut-down of hydro units. Moreover, hydro generation prediction typically has composite structures such as non-linearity, non-stationarity, and fluctuation due to unexpected variable of input parameters, which converts its prediction to be very tough. Artificial intelligence (AI) methods are normally selected to deal with this problem. However, they are suffering from partial optimization, falling in solutions of local minima, and low speed of convergence. To deal with these problems, this thesis introduces three approved intelligent controllers for hydropower generation. Firstly, a hybrid algorithm namely firefly particle swarm optimization (FPSO) and series division method (SDM) based on the practical swarm optimization and the firefly algorithm is proposed. In the FPSO method, the local search is performed through the modified light intensity attraction step with PSO operator. Secondly, this approach hybridizing the FA with the rough algorithm (RA), where RA is used to control the steps of randomness for the FA while optimizing the weights of the standard BPNN model. After that, the stationary simulation prediction model is obtained. Thirdly, a novel normalized firefly fuzzy control method (NFANN) is designed for stability control of a hydro-turbine system. Moreover, the more relaxed and simplified sufficient stability conditions are given as a new set of right-angle triangle membership function (RFANN), which has been guaranteed by strict mathematical derivation. The proposed methods tested on raw data of hydropower plant of Himreen Lake Dam. The optimal hydropower generation that observed is increased to the maximum over the actual value by PSO, SD-PSO, SD-FA, and FPSO increased by 1.5%, 2.3%, 3.1%, 2.5% respectively. The proposed SD-FA controller showed better and robustness compared to the other algorithm, which could resist the random disturbances.

REFERENCES

Aad, G., Abbott, B., Abdallah, J., Abdelalim, A., Abdesselam, A., Abdinov, O., . . . Abreu, H. (2013). Jet energy measurement with the ATLAS detector in proton-proton collisions at\sqrt {\mathrm {s}}= 7\\mathrm {TeV}. *The European Physical Journal C, 73*(3), 2304.

Aamer, A. A. E.-S. a. S. T. (2016). Particle Swarm Optimization Technique to Determine Class Location in Illiteracy Problem. *Research Journal of Applied Sciences, 11*(5).

Affonso, C., Sassi, R. J., & Barreiros, R. M. (2015). Biological image classification using rough-fuzzy artificial neural network. *Expert Systems with Applications, 42*(24), 9482-9488.

Afrand, M., Ahmadi Nadooshan, A., Hassani, M., Yarmand, H., & Dahari, M. (2016). Predicting the viscosity of multi-walled carbon nanotubes/water nanofluid by developing an optimal artificial neural network based on experimental data. *International Communications in Heat and Mass Transfer, 77*, 49-53.

Agarwal, T. (2012). Review of pump as turbine (PAT) for micro-hydropower. *International Journal of Emerging Technology and Advanced Engineering, 2*(11), 163-168.

Ahmad-Rashid, K. (2017). Present and Future for Hydropower Developments in Kurdistan. *Energy Procedia, 112*(Supplement C), 632-639.

Ahmad, S. B. a. R. (2016). An Improved Artificial Bee Colony Algorithm for Constrained Optimization. *Research Journal of Applied Sciences, 11*(1).

Alweshah, M., & Abdullah, S. (2015). Hybridizing firefly algorithms with a probabilistic neural network for solving classification problems. *Applied Soft Computing, 35*, 513-524.

Ameli, A., Farrokhifard, M., Ahmadifar, A., Safari, A., & Shayanfar, H. A. (2013, 5-8 May 2013). *Optimal tuning of Power System Stabilizers in a multi-machine system using firefly algorithm.* Paper presented at the Environment and Electrical Engineering (EEEIC), 2013 12th International Conference on.

Aminloei, R. T., & Ghaderi, S. (2010). Generation planning in Iranian power plants with fuzzy hierarchical production planning. *Energy Conversion and Management, 51*(6), 1230-1241.

Amjady, N., & Soleymanpour, H. R. (2010). Daily hydrothermal generation scheduling by a new modified adaptive particle swarm optimization technique. *Electric power systems research, 80*(6), 723-732.

Anagnostopoulos, J. S., & Papantonis, D. E. (2007a). Optimal sizing of a run-of-river small hydropower plant. *Energy Conversion and Management, 48*(10), 2663-2670.

Anagnostopoulos, J. S., & Papantonis, D. E. (2007b). Pumping station design for a pumped-storage wind-hydro power plant. *Energy Conversion and Management, 48*(11), 3009-3017.

Ashtiani, H. R. R., & Shahsavari, P. (2016). A comparative study on the phenomenological and artificial neural network models to predict hot deformation behavior of AlCuMgPb alloy. *Journal of Alloys and Compounds, 687*, 263-273.

Aslan, Y., & Yağan, Y. E. (2017). Artificial neural-network-based fault location for power distribution lines using the frequency spectra of fault data. *Electrical Engineering, 99*(1), 301-311. doi:10.1007/s00202-016-0428-8

Atieh, M., Gharabaghi, B., & Rudra, R. (2015). Entropy-based neural networks model for flow duration curves at ungauged sites. *Journal of Hydrology, 529*, 1007-1020.

Ayancik, F., Acar, E., Celebioglu, K., & Aradag, S. (2017). Simulation-based design and optimization of Francis turbine runners by using multiple types of metamodels. *Proceedings of the Institution of Mechanical Engineers, Part C: Journal of Mechanical Engineering Science, 231*(8), 1427-1444.

Azizi, S., & Ahmadloo, E. (2016). Prediction of heat transfer coefficient during condensation of R134a in inclined tubes using artificial neural network. *Applied Thermal Engineering, 106*, 203-210.

Balachennaiah, P., Suryakalavathi, M., & Nagendra, P. (2016). Optimizing real power loss and voltage stability limit of a large transmission network using firefly algorithm. *Engineering Science and Technology, an International Journal, 19*(2), 800-810.

Banos, R., Manzano-Agugliaro, F., Montoya, F., Gil, C., Alcayde, A., & Gómez, J. (2011). Optimization methods applied to renewable and sustainable energy: A review. *Renewable and Sustainable Energy Reviews, 15*(4), 1753-1766.

Barrow, D. K., & Crone, S. F. (2016). Cross-validation aggregation for combining autoregressive neural network forecasts. *International Journal of Forecasting, 32*(4), 1120-1137.

Bashiri, S. A. Z. A. a. M. (2016). Modeling Police Patrol Routing and its Problem-Solving Technique Based on the Ant Colony Optimization Algorithm(case Study: Iran’s Police). *Research Journal of Applied Sciences, 11*(7).

Bazartseren, B., Hildebrandt, G., & Holz, K.-P. (2003). Short-term water level prediction using neural networks and neuro-fuzzy approach. *Neurocomputing, 55*(3), 439-450.

Belsnes, M., Wolfgang, O., Follestad, T., & Aasgård, E. (2016). Applying successive linear programming for stochastic short-term hydropower optimization. *Electric Power Systems Research, 130*, 167-180.

Belsnes, M. M., Wolfgang, O., Follestad, T., & Aasgård, E. K. (2016). Applying successive linear programming for stochastic short-term hydropower optimization. *Electric Power Systems Research, 130*, 167-180.

Bengio, Y., & Grandvalet, Y. (2004). No unbiased estimator of the variance of k-fold cross-validation. *Journal of machine learning research, 5*(Sep), 1089-1105.

Bhat, V. I., & Prakash, R. (2008). Life cycle analysis of run-of river small hydro power plants in India. *The Open Renewable Energy Journal, 1*(1).

Bhushan, B., & Pillai, S. S. (2013, 22-23 Feb. 2013). *Particle Swarm Optimization and Firefly Algorithm: Performance analysis.* Paper presented at the Advance Computing Conference (IACC), 2013 IEEE 3rd International.

Binama, M., Su, W.-T., Li, X.-B., Li, F.-C., Wei, X.-Z., & An, S. (2017). Investigation on pump as turbine (PAT) technical aspects for micro hydropower schemes: A state-of-the-art review. *Renewable and Sustainable Energy Reviews, 79*, 148-179.

Bøckman, T., Fleten, S.-E., Juliussen, E., Langhammer, H. J., & Revdal, I. (2008). Investment timing and optimal capacity choice for small hydropower projects. *European Journal of Operational Research, 190*(1), 255-267.

Borges, C. L., & Pinto, R. J. (2008). Small hydro power plants energy availability modeling for generation reliability evaluation. *IEEE Transactions on Power Systems, 23*(3), 1125-1135.

Box, G. E. (1954a). Some theorems on quadratic forms applied in the study of analysis of variance problems, I. Effect of inequality of variance in the one-way classification. *The annals of mathematical statistics, 25*(2), 290-302.

Box, G. E. (1954b). Some theorems on quadratic forms applied in the study of analysis of variance problems, II. Effects of inequality of variance and of correlation between errors in the two-way classification. *The annals of mathematical statistics, 25*(3), 484-498.

Brezovec, M., Kuzle, I., & Tomisa, T. (2006). Nonlinear digital simulation model of hydroelectric power unit with Kaplan turbine. *IEEE Transactions on Energy Conversion, 21*(1), 235-241.

Buyukada, M. (2016). Co-combustion of peanut hull and coal blends: Artificial neural networks modeling, particle swarm optimization and Monte Carlo simulation. *Bioresource Technology, 216*, 280-286.

Çam, E. (2007). Application of fuzzy logic for load frequency control of hydroelectrical power plants. *Energy conversion and management, 48*(4), 1281-1288.

Carapellucci, R., Giordano, L., & Pierguidi, F. (2015). Techno-economic evaluation of small-hydro power plants: Modelling and characterisation of the Abruzzo region in Italy. *Renewable Energy, 75*, 395-406.

Castronuovo, E. D., & Lopes, J. P. (2004). On the optimization of the daily operation of a wind-hydro power plant. *IEEE Transactions on Power Systems, 19*(3), 1599-1606.

Catalão, J. P. d. S., Pousinho, H. M. I., & Mendes, V. M. F. (2010). Scheduling of head-dependent cascaded hydro systems: Mixed-integer quadratic programming approach. *Energy conversion and management, 51*(3), 524-530.

Chang, J., Li, Y., Yuan, M., & Wang, Y. (2017). Efficiency evaluation of hydropower station operation: A case study of Longyangxia station in the Yellow River, China. *Energy, 135*(Supplement C), 23-31.

Chansareewittaya, S., & Jirapong, P. (2015). Power transfer capability enhancement with multitype FACTS controllers using hybrid particle swarm optimization. *Electrical Engineering, 97*(2), 119-127. doi:10.1007/s00202-014-0317-y

Chiranjeevi, K., Jena, U. R., Murali Krishna, B., & Kumar, J. (2016). Modified Firefly Algorithm (MFA) Based Vector Quantization for Image Compression. In H. S. Behera & D. P. Mohapatra (Eds.), *Computational Intelligence in Data Mining—Volume 2: Proceedings of the International Conference on CIDM, 5-6 December 2015* (pp. 373-382). New Delhi: Springer India.

Chiteka, K., & Enweremadu, C. C. (2016). Prediction of global horizontal solar irradiance in Zimbabwe using artificial neural networks. *Journal of Cleaner Production, 135*, 701-711.

Chuanwen, J., & Bompard, E. (2005). A self-adaptive chaotic particle swarm algorithm for short term hydroelectric system scheduling in deregulated environment. *Energy Conversion and Management, 46*(17), 2689-2696.

Cobaner, M., Haktanir, T., & Kisi, O. (2008). Prediction of hydropower energy using ANN for the feasibility of hydropower plant installation to an existing irrigation dam. *Water resources management, 22*(6), 757-774.

Cobb, B. R., & Sharp, K. V. (2013). Impulse (Turgo and Pelton) turbine performance characteristics and their impact on pico-hydro installations. *Renewable Energy, 50*, 959-964.

Cordova, M., Finardi, E., Ribas, F., de Matos, V., & Scuzziato, M. (2014). Performance evaluation and energy production optimization in the real-time operation of hydropower plants. *Electric Power Systems Research, 116*, 201-207.

Cordova, M. M., Finardi, E. C., Ribas, F. A. C., de Matos, V. L., & Scuzziato, M. R. (2014). Performance evaluation and energy production optimization in the real-time operation of hydropower plants. *Electric Power Systems Research, 116*, 201-207.

Costa, K., & McManus, J. (2017). Efficacy of 230Th normalization in sediments from the Juan de Fuca Ridge, northeast Pacific Ocean. *Geochimica et Cosmochimica Acta, 197*(Supplement C), 215-225.

Cozorici, F., Vadan, I., Munteanu, R. A., Cozorici, I., & Karaissas, P. (2011). *Design and simulation of a small wind-hydro power plant.* Paper presented at the Clean Electrical Power (ICCEP), 2011 International Conference on.

Dechezleprêtre, A., Glachant, M., & Ménière, Y. (2008). The Clean Development Mechanism and the international diffusion of technologies: An empirical study. *Energy policy, 36*(4), 1273-1283.

DelSontro, T., McGinnis, D. F., Sobek, S., Ostrovsky, I., & Wehrli, B. (2010). Extreme methane emissions from a Swiss hydropower reservoir: contribution from bubbling sediments. *Environmental science & technology, 44*(7), 2419-2425.

Dil, E. A., Ghaedi, M., Asfaram, A., Mehrabi, F., Bazrafshan, A. A., & Ghaedi, A. M. (2016). Trace determination of safranin O dye using ultrasound assisted dispersive solid-phase micro extraction: Artificial neural network-genetic algorithm and response surface methodology. *Ultrasonics Sonochemistry, 33*, 129-140.

Donalek, P. J. (2008). *Update on small hydro technologies, and distributed generation including run—of—river plants.* Paper presented at the Power and Energy Society General Meeting-Conversion and Delivery of Electrical Energy in the 21st Century, 2008 IEEE.

Dorn, F. B., Farahmand, H., Skjelbred, H. I., & Belsnes, M. M. (2016). Modelling minimum pressure height in short-term hydropower production planning. *Energy Procedia, 87*, 69-76.

El-Wakeel, A. S. (2014). Design optimization of PM couplings using hybrid particle swarm optimization-simplex method (PSO-SM) algorithm. *Electric Power Systems Research, 116*, 29-35.

Elbatran, A., Yaakob, O., Ahmed, Y. M., & Shabara, H. (2015). Operation, performance and economic analysis of low head micro-hydropower turbines for rural and remote areas: a review. *Renewable and Sustainable Energy Reviews, 43*, 40-50.

Elsafi, S. H. (2014). Artificial neural networks (ANNs) for flood forecasting at Dongola Station in the River Nile, Sudan. *Alexandria Engineering Journal, 53*(3), 655-662.

Estropez, N., & Nagasaka, K. (2005). *A month ahead micro-hydro power generation scheduling using artificial neural network.* Paper presented at the Power Engineering Society General Meeting, 2005. IEEE.

Feng, Z.-k., Niu, W.-j., Cheng, C.-t., & Liao, S.-l. (2017). Hydropower system operation optimization by discrete differential dynamic programming based on orthogonal experiment design. *Energy, 126*, 720-732.

Feng, Z.-k., Niu, W.-j., Cheng, C.-t., & Wu, X.-y. (2017). Optimization of hydropower system operation by uniform dynamic programming for dimensionality reduction. *Energy, 134*, 718-730.

Fenton, L. (1960). The sum of log-normal probability distributions in scatter transmission systems. *IRE Transactions on Communications Systems, 8*(1), 57-67.

Gaiser, K., Erickson, P., Stroeve, P., & Delplanque, J.-P. (2016). An experimental investigation of design parameters for pico-hydro Turgo turbines using a response surface methodology. *Renewable Energy, 85*, 406-418.

Ge, X.-l., Zhang, L.-z., Shu, J., & Xu, N.-f. (2014). Short-term hydropower optimal scheduling considering the optimization of water time delay. *Electric Power Systems Research, 110*, 188-197.

Ge, X., Pan, L., Gao, Z., Tang, S., & Chu, D. (2011). *Hydro-generator units operating condition forecasting and fault diagnosis based on BP neural network.* Paper presented at the Computer Science and Service System (CSSS), 2011 International Conference on.

Gholizadeh, S. (2015). Performance-based optimum seismic design of steel structures by a modified firefly algorithm and a new neural network. *Advances in Engineering Software, 81*, 50-65.

Ghumman, A., Ghazaw, Y. M., Sohail, A., & Watanabe, K. (2011). Runoff forecasting by artificial neural network and conventional model. *Alexandria Engineering Journal, 50*(4), 345-350.

Ghumman, A. R., Ghazaw, Y. M., Sohail, A. R., & Watanabe, K. (2011). Runoff forecasting by artificial neural network and conventional model. *Alexandria Engineering Journal, 50*(4), 345-350.

Gope, S., Goswami, A. K., Tiwari, P. K., & Deb, S. (2016). Rescheduling of real power for congestion management with integration of pumped storage hydro unit using firefly algorithm. *International Journal of Electrical Power & Energy Systems, 83*, 434-442.

Guerraiche, K. R., Mostefa; Zeblah, Abdelkader; Dekhici, Latifa. (2015). Series-Parallel Power System Optimization Using Firefly Algorithm. *International Journal on Electrical Engineering & Informatics, Vol. 7*(Issue 1), p89.

Guisández, I., Pérez-Díaz, J. I., & Wilhelmi, J. R. (2013). Assessment of the economic impact of environmental constraints on annual hydropower plant operation. *Energy Policy, 61*, 1332-1343.

Gutierrez-Corea, F.-V., Manso-Callejo, M.-A., Moreno-Regidor, M.-P., & Manrique-Sancho, M.-T. (2016). Forecasting short-term solar irradiance based on artificial neural networks and data from neighboring meteorological stations. *Solar Energy, 134*, 119-131.

Hahn, B. H., & Valentine, D. T. (2017). Chapter 4 - MATLAB Functions and Data Import-Export Utilities. In B. H. Hahn & D. T. Valentine (Eds.), *Essential MATLAB for Engineers and Scientists (Sixth Edition)* (pp. 99-107): Academic Press.

Haidar, A. M., Senan, M. F., Noman, A., & Radman, T. (2012). Utilization of pico hydro generation in domestic and commercial loads. *Renewable and Sustainable Energy Reviews, 16*(1), 518-524.

Hammid, A. T., Hojabri, M., Sulaiman, M. H., Abdalla, A. N., & Kadhim, A. A. (2016). Load Frequency Control for Hydropower Plants using PID Controller. *Journal of Telecommunication, Electronic and Computer Engineering (JTEC), 8*(10), 47-51.

Hammid, A. T., Sulaiman, M. H. B., & Abdalla, A. N. (2017). Prediction of small hydropower plant power production in Himreen Lake dam (HLD) using artificial neural network. *Alexandria Engineering Journal*.

Han, Y.-M., Geng, Z.-Q., & Zhu, Q.-X. (2016). Energy optimization and prediction of complex petrochemical industries using an improved artificial neural network approach integrating data envelopment analysis. *Energy Conversion and Management, 124*, 73-83.

Harizi, F., Gessoum, A., & Ghanem, K. (2017). Partial aggregation of users for biometric scores normalization. *Digital Signal Processing, 71*(Supplement C), 144-163.

Hayen, L. (1996). Method for constructing a histogram in digital image processing by statistical pixel sampling: Google Patents.

He, L., & Huang, S. (2017). Modified firefly algorithm based multilevel thresholding for color image segmentation. *Neurocomputing, 240*(Supplement C), 152-174.

He, X.-S. Y. X. (2013). Firefly Algorithm: Recent Advances and Applications. *Int. J. of Swarm Intelligence, Vol.1*(No.1), pp.36-50.

Himreen Lake (iq053). (2009-2011.).

Hondo, H. (2005). Life cycle GHG emission analysis of power generation systems: Japanese case. *Energy, 30*(11), 2042-2056.

Hydraulic Turbines, Storage Pumps and Pump-turbines, in Model Acceptance tests. (1999). *International Electrotechnic Commission, I.,*.

Ibrahim, I. A., & Khatib, T. (2017). A novel hybrid model for hourly global solar radiation prediction using random forests technique and firefly algorithm. *Energy Conversion and Management, 138*, 413-425.

Ichiyanagi, K., Goto, Y., Mizuno, K., Yokomizu, Y., & Matsumura, T. (1995). *An artificial neural network to predict river flow rate into a dam for a hydro-power plant.* Paper presented at the Neural Networks, 1995. Proceedings., IEEE International Conference on.

Illias, H. A., Chai, X. R., & Abu Bakar, A. H. (2016). Hybrid modified evolutionary particle swarm optimisation-time varying acceleration coefficient-artificial neural network for power transformer fault diagnosis. *Measurement, 90*, 94-102.

Imran, M., Kumar, D., Kumar, N., Qayyum, A., Saeed, A., & Bhatti, M. S. (2014). Environmental concerns of underground coal gasification. *Renewable and Sustainable Energy Reviews, 31*, 600-610.

Ioannidou, C., & O'Hanley, J. R. (2018). Eco-friendly location of small hydropower. *European Journal of Operational Research, 264*(3), 907-918.

Iraqi Ministry of Water Resource. www.mowr.gov.iq.

Jaber, A. S., Ahmad, A., & Abdalla, A. N. (2013). An Investigation of Scaled-FLC Using PSO for Multi-area Power System Load Frequency Control. *Energy and Power Engineering, 5*(04), 458.

Jagtap, J., & Kokare, M. (2016). Human age classification using facial skin aging features and artificial neural network. *Cognitive Systems Research, 40*, 116-128.

Jawahar, C., & Michael, P. A. (2017). A review on turbines for micro hydro power plant. *Renewable and Sustainable Energy Reviews, 72*, 882-887.

Jiekang, W., Zhuangzhi, G., & Fan, W. (2014). Short-term multi-objective optimization scheduling for cascaded hydroelectric plants with dynamic generation flow limit based on EMA and DEA. *International journal of electrical power & energy systems, 57*, 189-197.

Kacprzyk, J., Krawczak, M., & Szkatuła, G. (2017). On bilateral matching between fuzzy sets. *Information Sciences, 402*(Supplement C), 244-266.

Kadigi, R. M., Mdoe, N. S., Ashimogo, G. C., & Morardet, S. (2008). Water for irrigation or hydropower generation?—Complex questions regarding water allocation in Tanzania. *Agricultural water management, 95*(8), 984-992.

Kahourzade, S., Mahmoudi, A., & Mokhlis, H. B. (2015). A comparative study of multi-objective optimal power flow based on particle swarm, evolutionary programming, and genetic algorithm. *Electrical Engineering, 97*(1), 1-12. doi:10.1007/s00202-014-0307-0

Kamodkar, R., & Regulwar, D. (2014). Optimal multiobjective reservoir operation with fuzzy decision variables and resources: A compromise approach. *Journal of Hydro-Environment Research, 8*(4), 428-440.

Kandil, N., Wamkeue, R., Saad, M., & Georges, S. (2006). An efficient approach for short term load forecasting using artificial neural networks. *International Journal of Electrical Power & Energy Systems, 28*(8), 525-530.

Karier, T., & Fazio, J. (2017). How hydropower enhances the capacity value of renewables and energy efficiency. *The Electricity Journal, 30*(5), 1-5.

Khadse, C. B., Chaudhari, M. A., & Borghate, V. B. (2016). Conjugate gradient back-propagation based artificial neural network for real time power quality assessment. *International Journal of Electrical Power & Energy Systems, 82*, 197-206.

Khan, M. Y. A., & Koo, J.-Y. (2017). Neural network based diagnosis of partial discharge defects patterns at XLPE cable under DC stress. *Electrical Engineering, 99*(1), 119-132. doi:10.1007/s00202-016-0395-0

Khan, R. (2015). Small Hydro Power in India: Is it a sustainable business? *Applied Energy, 152*, 207-216.

Khan, Y. (2016). Partial discharge pattern analysis using PCA and back-propagation artificial neural network for the estimation of size and position of metallic particle adhering to spacer in GIS. *Electrical Engineering, 98*(1), 29-42. doi:10.1007/s00202-015-0343-4

Kim, E.-H., Oh, S.-K., & Pedrycz, W. (2017). Reinforced rule-based fuzzy models: Design and analysis. *Knowledge-Based Systems, 119*(Supplement C), 44-58.

Kishor, N. (2008). Zero-order TS fuzzy model to predict hydro turbine speed in closed loop operation. *Applied Soft Computing, 8*(2), 1074-1084.

Kostić, S., Stojković, M., & Prohaska, S. (2016). Hydrological flow rate estimation using artificial neural networks: Model development and potential applications. *Applied Mathematics and Computation, 291*, 373-385.

Kucukali, S. (2011). Risk assessment of river-type hydropower plants using fuzzy logic approach. *Energy Policy, 39*(10), 6683-6688.

Kurtulus, B., & Razack, M. (2010). Modeling daily discharge responses of a large karstic aquifer using soft computing methods: artificial neural network and neuro-fuzzy. *Journal of Hydrology, 381*(1), 101-111.

Kusakana, K., Munda, J., & Jimoh, A. (2008). *Economic and environmental analysis of micro hydropower system for rural power supply.* Paper presented at the Power and Energy Conference, 2008. PECon 2008. IEEE 2nd International.

Laamari, Y., Chafaa, K., & Athamena, B. (2015). Particle swarm optimization of an extended Kalman filter for speed and rotor flux estimation of an induction motor drive. *Electrical Engineering, 97*(2), 129-138. doi:10.1007/s00202-014-0322-1

Laghari, J., Mokhlis, H., Bakar, A., & Mohammad, H. (2013). A comprehensive overview of new designs in the hydraulic, electrical equipments and controllers of mini hydro power plants making it cost effective technology. *Renewable and Sustainable Energy Reviews, 20*, 279-293.

Lal, D. K., Barisal, A., & Tripathy, M. (2016). Grey wolf optimizer algorithm based fuzzy PID controller for AGC of multi-area power system with TCPS. *Procedia Computer Science, 92*, 99-105.

Larson, M. G. (2008). Analysis of variance. *Circulation, 117*(1), 115-121.

Lashofer, A., Hawle, W., & Pelikan, B. (2012). *State of technology and design guidelines for the Archimedes screw turbine.* Paper presented at the meeting of Hydro.

Lehner, B., Czisch, G., & Vassolo, S. (2005). The impact of global change on the hydropower potential of Europe: a model-based analysis. *Energy Policy, 33*(7), 839-855.

Letia, T., Astilean, A., Cuibus, O., & Mircescu, D. (2013). Cooperative Control of Hydro-Power Systems. *IFAC Proceedings Volumes, 46*(6), 13-18.

Li, G., Sun, Y., He, Y., Li, X., & Tu, Q. (2014). Short-term power generation energy forecasting model for small hydropower stations using GA-SVM. *Mathematical Problems in Engineering, 2014*.

LI Miao, D. C. H., TAN Jin,YANG Wei, ZHENG Li. (2016). Research on Small Hydropower Generation Forecasting Method Based on Improved BP Neural Network. *Atlantis Press, 3rd International Conference on Materials Engineering, Manufacturing Technology and Control*.

Li, Y., & Zhu, G. (2013). *Prediction on power energy mix of China based on neural network model.* Paper presented at the Power and Energy Society General Meeting (PES), 2013 IEEE.

Liao, S.-l., Liu, B.-x., Cheng, C.-t., Li, Z.-f., & Wu, X.-y. (2017). Long-Term Generation Scheduling of Hydropower System Using Multi-Core Parallelization of Particle Swarm Optimization. *Water Resources Management*, 1-17.

Liao, X., Zhou, J., Ouyang, S., Zhang, R., & Zhang, Y. (2014). Multi-objective artificial bee colony algorithm for long-term scheduling of hydropower system: A case study of china. *Water Util J, 7*, 13-23.

Liao, X., Zhou, J., Zhang, R., & Zhang, Y. (2012). An adaptive artificial bee colony algorithm for long-term economic dispatch in cascaded hydropower systems. *International journal of electrical power & energy systems, 43*(1), 1340-1345.

Lindfield, G., & Penny, J. (2017). Chapter 5 - The Firefly Algorithm. In G. Lindfield & J. Penny (Eds.), *Introduction to Nature-Inspired Optimization* (pp. 85-100). Boston: Academic Press.

Liu, J., Chung, F.-l., & Wang, S. (2017). Bayesian zero-order TSK fuzzy system modeling. *Applied Soft Computing, 55*, 253-264.

Liu, Z.-B., Shu, H.-C., Han, W., & Zhu, W.-T. (2007). Reliability evaluation of distribution system including small hydro power. *Relay, 35*(2), 55-59.

Locke, A. E., Kahali, B., Berndt, S. I., Justice, A. E., Pers, T. H., Day, F. R., . . . Yang, J. (2015). Genetic studies of body mass index yield new insights for obesity biology. *Nature*, *518*(7538), 197-206.

Lu, B., Li, K., Zhang, H., Wang, W., & Gu, H. (2013). Study on the optimal hydropower generation of Zhelin reservoir. *Journal of hydro-environment research, 7*(4), 270-278.

Lu, P., Zhou, J., Wang, C., Qiao, Q., & Mo, L. (2015). Short-term hydro generation scheduling of Xiluodu and Xiangjiaba cascade hydropower stations using improved binary-real coded bee colony optimization algorithm. *Energy Conversion and Management, 91*, 19-31.

Lubitz, W. D., Lyons, M., & Simmons, S. (2014). Performance model of Archimedes screw hydro turbines with variable fill level. *Journal of Hydraulic Engineering, 140*(10), 04014050.

Ma, C., Lian, J., & Wang, J. (2013). Short-term optimal operation of Three-gorge and Gezhouba cascade hydropower stations in non-flood season with operation rules from data mining. *Energy conversion and management*, *65*, 616-627.

Macikowski, B. (2017). *Small Hydropower Plants in Pomerania: The Example of Evolution of Modern Industrial Brick Architecture.* Paper presented at the IOP Conference Series: Materials Science and Engineering.

Maher, P., Smith, N., & Williams, A. (2003). Assessment of pico hydro as an option for off-grid electrification in Kenya. *Renewable Energy, 28*(9), 1357-1369.

Mahmoud, M., Dutton, K., & Denman, M. (2005). Design and simulation of a nonlinear fuzzy controller for a hydropower plant. *Electric Power Systems Research, 73*(2), 87-99.

Mandelli, S., Colombo, E., Redondi, A., Bernardi, F., Saanane, B. B., Mgaya, P., & Malisa, J. (2013). *A small-hydro plant model for feasibility analysis of electrification projects in Rural Tanzania.* Paper presented at the Global Humanitarian Technology Conference (GHTC), 2013 IEEE.

Mantawy, A., Soliman, S., & El-Hawary, M. (2002). *A new tabu search algorithm for the long-term hydro scheduling problem.* Paper presented at the Power Engineering 2002 Large Engineering Systems Conference on, LESCOPE 02.

Marin-Jimenez, J., Carvajal-Quintero, S., & Arango-Aramburo, S. (2014). *Transient stability of colombian national transmission system with Small Hydro plants.* Paper presented at the Central America and Panama Convention (CONCAPAN XXXIV), 2014 IEEE.

Mattar, M., Alazba, A., & El-Abedin, T. Z. (2015). Forecasting furrow irrigation infiltration using artificial neural networks. *Agricultural Water Management, 148*, 63-71.

Mattar, M. A., Alazba, A. A., & Zin El-Abedin, T. K. (2015). Forecasting furrow irrigation infiltration using artificial neural networks. *Agricultural Water Management*, *148*, 63-71.

Mbiu, R. (2014). DESIGN CONSIDERATIONS: SMALL HYDROPOWER GENERATION FOR RURAL ELECTRIFICATION. Paper presented at the Scientific Conference Proceedings.

McGill, R., Tukey, J. W., & Larsen, W. A. (1978). Variations of box plots. *The American Statistician*, *32*(1), 12-16.

Mekki, H., Mellit, A., & Salhi, H. (2016). Artificial neural network-based modelling and fault detection of partial shaded photovoltaic modules. *Simulation Modelling Practice and Theory, 67*, 1-13.

Mia, M., & Dhar, N. R. (2016). Prediction of surface roughness in hard turning under high pressure coolant using Artificial Neural Network. *Measurement, 92*, 464-474.

Michaelowa, A., & Jotzo, F. (2005). Transaction costs, institutional rigidities and the size of the clean development mechanism. *Energy policy, 33*(4), 511-523.

Mishra, M. K., Khare, N., & Agrawal, A. B. (2015). Small hydro power in India: Current status and future perspectives. *Renewable and Sustainable Energy Reviews, 51*, 101-115.

Mishra, S., Singal, S., & Khatod, D. (2011). Optimal installation of small hydropower plant—A review. *Renewable and Sustainable Energy Reviews, 15*(8), 3862-3869.

Mitchell, I. (2013). the Ministry of Business, Innovation, and Employment.

Mo, L., Lu, P., Wang, C., & Zhou, J. (2013). Short-term hydro generation scheduling of Three Gorges–Gezhouba cascaded hydropower plants using hybrid MACS-ADE approach. *Energy conversion and management, 76*, 260-273.

Moeini, R., Afshar, A., & Afshar, M. (2011). Fuzzy rule-based model for hydropower reservoirs operation. *International Journal of Electrical Power & Energy Systems, 33*(2), 171-178.

Mohamed, H. I. (2013). Design of alluvial Egyptian irrigation canals using artificial neural networks method. *Ain Shams Engineering Journal, 4*(2), 163-171.

Mohd Asrul Hery Ibrahim , Z. A. Z., Mustafa Mamat , Ummie Khalthum Mohd Yusof and Azfi Zaidi Mohammad Sofi. (2017). A New Search Direction for Broyden's Family Method with Coefficient of Conjugate Gradient in Solving Unconstrained Optimization Problems. *Research Journal of Applied Sciences, 12*(1).

Monteiro, C., Ramirez-Rosado, I. J., & Fernandez-Jimenez, L. A. (2014). Short-term forecasting model for aggregated regional hydropower generation. *Energy Conversion and Management, 88*, 231-238.

Moreno-Torres, J. G., Sáez, J. A., & Herrera, F. (2012). Study on the impact of partition-induced dataset shift on $ k $-fold cross-validation. *IEEE Transactions on Neural Networks and Learning Systems, 23*(8), 1304-1312.

Moreno, S. R., & Kaviski, E. (2015). DAILY SCHEDULING OF SMALL HYDRO POWER PLANTS DISPATCH WITH MODIFIED PARTICLES SWARM OPTIMIZATION. *Pesquisa Operacional, 35*(1), 25-37.

Mu, J., Ma, C., Zhao, J., & Lian, J. (2015). Optimal operation rules of Three-gorge and Gezhouba cascade hydropower stations in flood season. *Energy conversion and management, 96*, 159-174.

Nabavi-Pelesaraei, A., Rafiee, S., Hosseinzadeh-Bandbafha, H., & Shamshirband, S. (2016). Modeling energy consumption and greenhouse gas emissions for kiwifruit production using artificial neural networks. *Journal of Cleaner Production, 133*, 924-931.

Naidu, K., Mokhlis, H., & Bakar, A. H. A. (2013, 3-5 Dec. 2013). Application of firefly algorithm (FA) based optimization in load frequency control for interconnected reheat thermal power system. Paper presented at the Applied Electrical Engineering and Computing Technologies (AEECT), 2013 IEEE Jordan Conference on.

Naresh, R., & Sharma, J. (2002). Short term hydro scheduling using two-phase neural network. *International journal of electrical power & energy systems, 24*(7), 583-590.

Nasir, B. A. (2013). Design of micro-hydro-electric power station. *International Journal of Engineering and Advanced Technology, 2*(5), 39-47.

Nasir, B. A. (2014). Design considerations of micro-hydro-electric power plant. *Energy Procedia, 50*, 19-29.

Nasr, M. S., Moustafa, M. A. E., Seif, H. A. E., & El Kobrosy, G. (2012). Application of Artificial Neural Network (ANN) for the prediction of EL-AGAMY wastewater treatment plant performance-EGYPT. *Alexandria Engineering Journal, 51*(1), 37-43.

Năstase, G., Şerban, A., Năstase, A. F., Dragomir, G., Brezeanu, A. I., & Iordan, N. F. (2017). Hydropower development in Romania. A review from its beginnings to the present. *Renewable and Sustainable Energy Reviews, 80*(Supplement C), 297-312.

Nayak, J., Naik, B., & Behera, H. (2016). A novel nature inspired firefly algorithm with higher order neural network: performance analysis. *Engineering Science and Technology, an International Journal, 19*(1), 197-211.

Nezam, N., & Dumitrache, I. (2002). Mamdani, Sugeno Fuzzy Systems And Control The Output Flow Of An Equalization Basin. *Journal of Control Engineering and Applied Informatics, 4*(1), 27-32.

Ngaopitakkul, A., & Leelajindakrairerk, M. (2017). Application of probabilistic neural network with transmission and distribution protection schemes for classification of fault types on radial, loop, and underground structures. *Electrical Engineering*. doi:10.1007/s00202-017-0515-5

Olawoyin, R. (2016). Application of backpropagation artificial neural network prediction model for the PAH bioremediation of polluted soil. *Chemosphere, 161*, 145-150. doi:10.1016/j.chemosphere.2016.07.003

Olofintoye, O., Otieno, F., & Adeyemo, J. (2016). Real-time optimal water allocation for daily hydropower generation from the Vanderkloof dam, South Africa. *Applied Soft Computing, 47*, 119-129.

Ong, H., Mahlia, T., & Masjuki, H. (2011). A review on energy scenario and sustainable energy in Malaysia. *Renewable and Sustainable Energy Reviews, 15*(1), 639-647.

Özbay, E., & Gençoğlu, M. T. (2010). *Modeling of small hydro power plants.* Paper presented at the Electrical, Electronics and Computer Engineering (ELECO), 2010 National Conference on.

Paish, O. (2002). Small hydro power: technology and current status. *Renewable and Sustainable Energy Reviews, 6*(6), 537-556.

Pelletier, F., Masson, C., & Tahan, A. (2016). Wind turbine power curve modelling using artificial neural network. *Renewable Energy, 89*, 207-214. doi:

Pérez-Díaz, J. I., & Wilhelmi, J. R. (2010). Assessment of the economic impact of environmental constraints on short-term hydropower plant operation. *Energy Policy, 38*(12), 7960-7970.

Pirouzmand, A., & Kazem Dehdashti, M. (2015). Estimation of relative power distribution and power peaking factor in a VVER-1000 reactor core using artificial neural networks. *Progress in Nuclear Energy, 85*, 17-27.

Pradhan, P. C., Sahu, R. K., & Panda, S. (2016). Firefly algorithm optimized fuzzy PID controller for AGC of multi-area multi-source power systems with UPFC and SMES. *Engineering Science and Technology, an International Journal, 19*(1), 338-354.

Prakash, S., & Sinha, S. (2014). Simulation based neuro-fuzzy hybrid intelligent PI control approach in four-area load frequency control of interconnected power system. *Applied Soft Computing, 23*, 152-164.

Priyadharson, A. S. M., Ganesan, R., & Surarapu, P. K. (2015). PLC–HMI Automation Based Cascaded Fuzzy PID for Efficient Energy Management and Storage in Real Time Performance of a Hydro Electric Pumped Storage Power Plant. *Procedia Technology, 21*, 248-255.

Purohit, P. (2008). Small hydro power projects under clean development mechanism in India: A preliminary assessment. *Energy Policy, 36*(6), 2000-2015.

Rafie, M., & Namin, F. S. (2015). Prediction of subsidence risk by FMEA using artificial neural network and fuzzy inference system. *International Journal of Mining Science and Technology, 25*(4), 655-663.

Rezk, H., & Fathy, A. (2016). Simulation of global MPPT based on teaching–learning-based optimization technique for partially shaded PV system. *Electrical Engineering*, 1-13. doi:10.1007/s00202-016-0449-3

Rodriguez, J. D., Perez, A., & Lozano, J. A. (2010). Sensitivity analysis of k-fold cross validation in prediction error estimation. *IEEE transactions on pattern analysis and machine intelligence, 32*(3), 569-575.

Rohani, A., Taki, M., & Abdollhapour, M. (2017). A novel soft computing model (Gaussian process regression with K-fold cross validation) for daily and monthly solar radiation forecasting. *Renewable Energy*.

Sachdev, H. S., Akella, A. K., & Kumar, N. (2015). Analysis and evaluation of small hydropower plants: A bibliographical survey. *Renewable and Sustainable Energy Reviews, 51*, 1013-1022.

Salhi, I., Belattar, A., & Doubabi, S. (2017). Takagi–Sugeno fuzzy modeling for three-phase micro hydropower plant prototype. *International Journal of Hydrogen Energy*.

Sarasua, J. I., Fraile-Ardanuy, J., Perez, J. I., Wilhelmi, J. R., & Sanchez, J. A. (2007). *Control of a run of river small hydro power plant.* Paper presented at the Power Engineering, Energy and Electrical Drives, 2007. POWERENG 2007. International Conference on.

Scarcelli, R., Zambelli, M., Soares, S., & Carneiro, A. (2017). Ensemble of Markovian stochastic dynamic programming models in different time scales for long term hydropower scheduling. *Electric Power Systems Research, 150*, 129-136.

Scarcelli, R. O., Zambelli, M. S., S Filho, S., & Carneiro, A. A. (2014). *Aggregated inflows on stochastic dynamic programming for long term hydropower scheduling.* Paper presented at the North American Power Symposium (NAPS), 2014.

Scarcelli, R. O. C., Zambelli, M. S., Soares, S., & Carneiro, A. A. F. M. (2017). Ensemble of Markovian stochastic dynamic programming models in different time scales for long term hydropower scheduling. *Electric Power Systems Research, 150*, 129-136.

Schiermeier, Q., Tollefson, J., Scully, T., Witze, A., & Morton, O. (2008). Energy alternatives: Electricity without carbon. *Nature News, 454*(7206), 816-823.

Sharma, A. K., & Thakur, N. (2015). Resource potential and development of small hydro power projects in Jammu and Kashmir in the western Himalayan region: India. *Renewable and Sustainable Energy Reviews, 52*, 1354-1368.

Shinde, S., & Kulkarni, U. (2017). Extended fuzzy hyperline-segment neural network with classification rule extraction. *Neurocomputing*.

Shiri, J., & Kisi, O. (2010). Short-term and long-term streamflow forecasting using a wavelet and neuro-fuzzy conjunction model. *Journal of Hydrology, 394*(3), 486-493.

Shree, S. B., & Kamaraj, N. (2016). Hybrid neuro fuzzy approach for automatic generation control in restructured power system. *International Journal of Electrical Power & Energy Systems, 74*, 274-285.

Singal, S., Saini, R., & Raghuvanshi, C. (2010). Analysis for cost estimation of low head run-of-river small hydropower schemes. *Energy for sustainable Development, 14*(2), 117-126.

Singh, S., & Upadhyay, M. P. (2014). *Study of different issues and challanges of small hydro power plants operation.* Paper presented at the Advances in Energy Conversion Technologies (ICAECT), 2014 International Conference on.

Spitalny, L., Unger, D., & Myrzik, J. (2012). *Potential of small hydro power plants for delivering control energy in Germany.* Paper presented at the Energytech, 2012 IEEE.

Stergiopoulou, A., Stergiopoulos, V., Kalkani, E., Chronopoulos, C., & Papadopoulou, D. (2011). *Back to the future: Rediscovering the Archimedean screws as modern turbines for harnessing Greek small hydropower potential.* Paper presented at the Proceedings of the "Third International Conference on Environmental Management, Engineering, Planning and Economics (CEMEPE 2011) & SECOTOX Conference", Skiathos.

Stojanovic, B., Milivojevic, M., Milivojevic, N., & Antonijevic, D. (2016). A self-tuning system for dam behavior modeling based on evolving artificial neural networks. *Advances in Engineering Software, 97*, 85-95.

Stokelj, T., Paravan, D., & Golob, R. (2000). *Short and mid term hydro power plant reservoir inflow forecasting.* Paper presented at the Power System Technology, 2000. Proceedings. PowerCon 2000. International Conference on.

Sunday, R., Masih, I., Werner, M., & van der Zaag, P. (2014). Streamflow forecasting for operational water management in the Incomati River Basin, Southern Africa. *Physics and Chemistry of the Earth, Parts A/B/C, 72*, 1-12.

Sutter, C., & Parreño, J. C. (2007). Does the current Clean Development Mechanism (CDM) deliver its sustainable development claim? An analysis of officially registered CDM projects. *Climatic change, 84*(1), 75-90.

Timalsina, N., Beckers, F., & Alfredsen, K. (2016). Modelling winter operational strategies of a hydropower system. *Cold Regions Science and Technology, 122*, 1-9.

Tukey, J. W. (1949). Comparing individual means in the analysis of variance. *Biometrics*, 99-114.

Uysal, G., Şorman, A. A., & Şensoy, A. (2016). Streamflow Forecasting Using Different Neural Network Models with Satellite Data for a Snow Dominated Region in Turkey. *Procedia Engineering, 154*, 1185-1192.

Uzlu, E., Akpınar, A., Özturk, H. T., Nacar, S., & Kankal, M. (2014). Estimates of hydroelectric generation using neural networks with the artificial bee colony algorithm for Turkey. *Energy, 69*, 638-647.

Vaisakh, K., Srinivas, L. R., & Meah, K. (2013). Genetic evolving ant direction PSODV hybrid algorithm for OPF with non-smooth cost functions. *Electrical Engineering, 95*(3), 185-199. doi:10.1007/s00202-012-0251-9

van Vliet, M. T. H., van Beek, L. P. H., Eisner, S., Flörke, M., Wada, Y., & Bierkens, M. F. P. (2016). Multi-model assessment of global hydropower and cooling water discharge potential under climate change. *Global Environmental Change, 40*(Supplement C), 156-170.

Vaz, A. G. R., Elsinga, B., van Sark, W. G. J. H. M., & Brito, M. C. (2016). An artificial neural network to assess the impact of neighbouring photovoltaic systems in power forecasting in Utrecht, the Netherlands. *Renewable Energy, 85,* 631-641.

Verma, S., & Mukherjee, V. (2016). Firefly algorithm for congestion management in deregulated environment. *Engineering Science and Technology, an International Journal, 19*(3), 1254-1265.

Wamalwa, F., Sichilalu, S., & Xia, X. (2017). Optimal control of conventional hydropower plant retrofitted with a cascaded pumpback system powered by an on-site hydrokinetic system. *Energy Conversion and Management, 132*, 438-451.

Wang, B., Hu, X., & Li, H. (2017). Rolling bearing performance degradation condition recognition based on mathematical morphological fractal dimension and fuzzy C-means. *Measurement, 109*(Supplement C), 1-8.

Wang, B., Xue, J., Wu, F., & Zhu, D. (2016). Robust Takagi-Sugeno fuzzy control for fractional order hydro-turbine governing system. *ISA transactions, 65*, 72-80.

Wang, C., Zhou, J., Lu, P., & Yuan, L. (2015). Long-term scheduling of large cascade hydropower stations in Jinsha River, China. *Energy conversion and management, 90*, 476-487.

Wang, D., Luo, H., Grunder, O., Lin, Y., & Guo, H. (2017). Multi-step ahead electricity price forecasting using a hybrid model based on two-layer decomposition technique and BP neural network optimized by firefly algorithm. *Applied Energy, 190*, 390-407.

Wang, H., Wang, W., Zhou, X., Sun, H., Zhao, J., Yu, X., & Cui, Z. (2017). Firefly algorithm with neighborhood attraction. *Information Sciences, 382*(Supplement C), 374-387.

Wang, L., Lee, D.-J., Liu, J.-H., Chen, Z.-Z., Kuo, Z.-Y., Lee, W.-J., . . . Tsai, M.-H. (2009). *A small hydro power (SHP) system in Taiwan using outlet-water energy of a reservoir: System introduction and measured results.* Paper presented at the Power & Energy Society General Meeting, 2009. PES'09. IEEE.

Wijesinghe, A., & Lai, L. L. (2011). *Small hydro power plant analysis and development.* Paper presented at the Electric Utility Deregulation and Restructuring and Power Technologies (DRPT), 2011 4th International Conference on.

Williams, A., & Porter, S. (2006). Comparison of hydropower options for developing countries with regard to the environmental, social and economic aspects. *Small, 1*, 10MW.

Williams, A., & Simpson, R. (2009). Pico hydro–Reducing technical risks for rural electrification. *Renewable Energy, 34*(8), 1986-1991.

Williamson, S., Stark, B., & Booker, J. (2013). Performance of a low-head pico-hydro Turgo turbine. *Applied Energy, 102*, 1114-1126.

Williamson, S., Stark, B., & Booker, J. (2014). Low head pico hydro turbine selection using a multi-criteria analysis. *Renewable Energy, 61*, 43-50.

Wu, X.-Y., Cheng, C.-T., Shen, J.-J., Luo, B., Liao, S.-L., & Li, G. (2015). A multi-objective short term hydropower scheduling model for peak shaving. *International journal of electrical power & energy systems, 68*, 278-293.

Xiaoqiu, A., & Jie, L. (2005). Research on seismic response of underground pipelines in solid-liquid media. *Earthquake Engineering and Engineering Vibration*, *25*(2), 136-140.

Xie, F.-w., Hou, Y.-f., Xu, Z.-p., & Rui, Z. (2009). Fuzzy-immune control strategy of a hydro-viscous soft start device of a belt conveyor. *Mining Science and Technology (China), 19*(4), 544-548.

Xie, M., Zhou, J., Li, C., & Lu, P. (2015). Daily generation scheduling of cascade hydro plants considering peak shaving constraints. *Journal of Water Resources Planning and Management, 142*(4), 04015072.

Xie, M., Zhou, J., Li, C., & Zhu, S. (2015). Long-term generation scheduling of Xiluodu and Xiangjiaba cascade hydro plants considering monthly streamflow forecasting error. *Energy conversion and management, 105*, 368-376.

Xinfeng, G., Luoping, P., Zhongxin, G., Shu, T., & Dongdong, C. (2011). *Hydro-generator units operating condition forecasting and fault diagnosis based on GANN*. Paper presented at the 2011 International Conference on Consumer Electronics, Communications and Networks (CECNet).

Xiomara, B., & Soares, S. (2017). *Accuracy assessment of the long-term hydro simulation model used in Brazil based on post-operation data.* Paper presented at the Clean Electrical Power (ICCEP), 2017 6th International Conference on.

Xu, Y., Zhou, J., Xue, X., Fu, W., Zhu, W., & Li, C. (2016). An adaptively fast fuzzy fractional order PID control for pumped storage hydro unit using improved gravitational search algorithm. *Energy Conversion and Management, 111*, 67-78.

Yu, X., Ye, C., & Xiang, L. Application of artificial neural network in the diagnostic system of osteoporosis. *Neurocomputing*.

Yuan, X., Chen, Z., Yuan, Y., & Huang, Y. (2015). Design of fuzzy sliding mode controller for hydraulic turbine regulating system via input state feedback linearization method. *Energy, 93*, 173-187.

Yuan, X., Wang, L., & Yuan, Y. (2008). Application of enhanced PSO approach to optimal scheduling of hydro system. *Energy Conversion and Management, 49*(11), 2966-2972.

Yuan, X., Yuan, Y., & Zhang, Y. (2002). A hybrid chaotic genetic algorithm for short-term hydro system scheduling. *Mathematics and Computers in Simulation, 59*(4), 319-327.

Yuan, X., Zhang, Y., Wang, L., & Yuan, Y. (2008). An enhanced differential evolution algorithm for daily optimal hydro generation scheduling. *Computers & Mathematics with Applications, 55*(11), 2458-2468.

Zambelli, M. S., Luna, I., & Soares, S. (2009). Predictive Control Approach for Long-Term Hydropower Scheduling Using Annual Inflow Forecasting Model. *IFAC Proceedings Volumes, 42*(9), 191-196.

Zhang, H., Zhou, J., Fang, N., Zhang, R., & Zhang, Y. (2013). An efficient multi-objective adaptive differential evolution with chaotic neuron network and its application on long-term hydropower operation with considering ecological environment problem. *International journal of electrical power & energy systems, 45*(1), 60-70.

Zhang, J., Xu, L., Yu, B., & Li, X. (2014). Environmentally feasible potential for hydropower development regarding environmental constraints. *Energy Policy, 73*, 552-562.

Zhang, K., Zhang, B., Chen, B., Jing, L., Zhu, Z., & Kazemi, K. (2016). Modeling and optimization of Newfoundland shrimp waste hydrolysis for microbial growth using response surface methodology and artificial neural networks. *Marine Pollution Bulletin, 109*(1), 245-252.

Zhang, L., Srisukkham, W., Neoh, S. C., Lim, C. P., & Pandit, D. (2017). Classifier Ensemble Reduction Using a Modified Firefly Algorithm: An Empirical Evaluation. *Expert Systems with Applications*.

Zhang, Y., Song, X.-f., & Gong, D.-w. (2017). A return-cost-based binary firefly algorithm for feature selection. *Information Sciences, 418*(Supplement C), 561-574.

Zhang, Y., Xu, J., Yuan, Z., Xu, H., & Yu, Q. (2010). Artificial neural network-genetic algorithm based optimization for the immobilization of cellulase on the smart polymer Eudragit L-100. *Bioresource Technology, 101*(9), 3153-3158.

Zhao, T., Zhao, J., Liu, P., & Lei, X. (2015). Evaluating the marginal utility principle for long-term hydropower scheduling. *Energy conversion and management, 106*, 213-223.

Zomer, R. J., Trabucco, A., Bossio, D. A., & Verchot, L. V. (2008). Climate change mitigation: A spatial analysis of global land suitability for clean development mechanism afforestation and reforestation. *Agriculture, ecosystems & environment, 126*(1), 67-80.