Ph.D. Research Proposal

Doctoral Program in "Department Name"

Intelligent Energy Optimized Multi-Microgrid Model for Dynamic Mode Detection using Deep Reinforcement Learning and Neutrosophic Intelligence

by

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I. INTRODUCTION / BACKGROUND

Energy management is one of the important problems in recent years. Renewable energy sources have importantly set on the need of power under the deployment of distributed networks. Diverse types of renewable energy sources are utilized for the development of distributed Microgrid environment. There have been substantial efforts have been proposed for energy management. Let's know about it first. The distributed network is operated by two modes such as islanded mode and grid connected mode. Islanded mode was detected used remote detection method and passive method. Provisioning of reliable source of electricity is the key goal of energy management system in Microgrid. A suitable power exchange system was developed by proposing a symbiotic organism's search and quasi-oppositional symbiotic organisms search. The load constraints are formulated in two classes in accordance to their maximum and minimum limits.

The power load at Microgrid was balanced by using hybrid particle swarm optimization [3]. The specialty of this HPSO is the involvement of optimal crossing and mutation process to enhance the energy management system. In [4], an information gap decision theory technique was proposed for resolving the problem of severe uncertainties. Energy management system was proposed on multi-Microgrid (MMG) system in a distributed generation unit [5]. This work also designs a hierarchical decentralized system of systems architecture. Further energy management was achieved with the design of two–layer predictive system that estimates operational cost which is also a hierarchical model [6]. The idea of minimizing load tends to manage the production of electricity in balanced manner.

Fuzzy supervisor was used in the forecast of load by taking in account of demanding time of storage, state of charge, current load and irradiations [7]. Load can be effectively managed by choosing the operation of Microgrid which needs to be performed [8], [13]. An Artificial Neural Network was involved to select the working mode of the Microgrids. Multiple usage of neural network makes the entire system complex. A target-oriented robust optimization approach was

developed to enhance net present value to meet the electricity demand [9]. The net present value was completely based on the economical variations.

Sharing of energy cooperatively helps to manage the energy storage system in an environment of two Microgrids [10]. An Online algorithm was proposed for estimating the energy costs of the Microgrid. Adaptive power exchanges are managed in a hybrid energy storage system [11]. A grid–connected multiple Microgrids was developed to enrich the friendliness of the utility grid and Microgrid. A minimization of emission cost was focused based on time of use and demand response program. The time of use was employed to load the daily changes and fuzzy was involved for decision making. A centralized energy management system was proposed in a multi–party Microgrid system [16]. This paper was entirely focused to operate on bidding strategies. An energy management system was developed using distributed predictive control algorithm in accordance to the global optimization. The power flow characteristics are monitored on the Microgrid. For the purpose of energy management, the islanded Microgrid was controlled based on the decision of fuzzifier [14]. Management of power flow control was performed in this paper.

1.1 Research Outline & Scope

A microgrid is a small grid together with distributed loads and energy resources that can operate individually in the case of emergency of distribution networks. Thus, multi-microgrid is a set of microgrid that shares distributed resources that decide whether to stand by ISLANDED or GRID CONNECTED mode. With this idea, consumers continuously receive power from resources

1.2 Research Objectives

The main objective of this paper is to design an Energy management system in Multi-Microgrid environment. The two main objectives are serving power and loads in distributed manner and minimizing load shedding if required.

II. RESEARCH GAPS

2.1 Common Problem Statement

The below mentioned problems on Microgrid environment is existed. The islanded Microgrid is subjected to excess amount of load due to the demand of customers, hence to meet all the requirements the isolated Microgrids exchanges electricity. In this work genetic algorithm was used, which is a slower in performance. Then fuzzy inference system runs by a set of 256 rules. Here the decision making consumes a huge amount of time, due to the development of more number of rules. Cost based priority provisioned energy management system involved multiple computations and it satisfy only for the certain number of requirements. Here, due to the selection of low cost Microgrid the load may occur often only on cost efficient Microgrids.

2.2 Problem Definition

Authors have developed [1] a novel algorithm for serving manifold isolates islands in Microgrid management system. To begin with, the fault is recognized and the micro grids are isolated by breakers and the status is updated. If a negative power balance is detected, further the need for load shedding is performed. Cumulative load priority is used to identify the load priority of isolated Microgrid. An evolution algorithm i.e. genetic algorithm is used to identify a minimum loaded grid. GA works based on its traditional procedure with the operations of crossover and mutation. This algorithm is activated, if similar priority exists.

Problems –

- Traditional Genetic algorithm procedure leads to slower in processing.
- Performs well only when population is high. Similar priority for differing loads are assigned and also priority weights are recalculated

Proposed Solutions –

- Load are managed in the developed energy management system
- Using fuzzy consumes lesser time for decision making

A single – phase AC Microgrid system is proposed in [2] that monitors power quality of the system. Power quality monitoring index is enabled using fuzzy interference system by considering electricity related parameters. The four major parameters are taken into account are voltage, frequency, power factor and total harmonic distortion. Using these parameters, rules are defined in fuzzy interference system to predict power quality.

Problems –

- Power quality monitoring index is not constructed well and fluctuation in power quality
- Fuzzy interference system involves 256 rules that consume larger time for decision making.

Proposed Solutions –

- Minimized number of rules along with the consideration of significant parameters

In paper [3] proposes energy management mode that pre-assigned priorities are formulated using lexicographic in multi–objective optimization procedure. Cost plays a key role in this work, whose power can be sold and bought. The Microgrid in each row is assumed to be in similar priority which is assigned based on the storage and energy capacity. Rolling horizon is used for solving multi–objective optimization problem.

Problem –

- Too many mathematical computation makes the system complex
- Cost is the only metric considered for priority estimation which cannot be satisfied by all the other Microgrid

Proposed Solutions –

- Minimized mathematical computations
- Load based energy management system

In this paper the authors [4] have illustrated Microgrid self-healing strategy by formulating mixed-integer quadratic programming problem. Point of common coupling based islanding grid is identified and then self–healing strategy is applied over it. Multiple checks are taken into account as power balance, power flow, voltage limit, line flow limit, load shedding limit and more.

Problem –

- Load is served with economical generator, which considers only the cheapest where other qualified power generators will be left idle.
- This also leads multiple loads towards particular generator which may cause scarcity of power generation in that particular generator.

Proposed Solutions –

- Multiple criteria are taken in account for serving load

III. RESEARCH CONTRIBUTIONS

In this proposed system, we design a novel energy management system in Microgrid environment. Renewable resources assisted Microgrid is enabled to be operated on anyone of the following two modes as: grid–connected mode and islanded mode. This entire system is categorized into three stages such as,

- Phase 1: working mode prediction
- Phase 2: energy management in islanded mode of operation
- Phase 3: status updation

The architecture of our system is composed of a set of six Microgrid and smart meters, a utility grid and a centralized controller.

- The smart meters are responsible to collect information of the individual Microgrid and report via information line to the centralized controller.

- The centralized controller plays a major role in decision making.
- The process handled in three stages are illustrated in the following,

Phase 1 –

The first stage is to predict the mode of operation of the Microgrid as islanded or grid connected. Neural network based mode classification is performed using weather conditions of the deployed Microgrid. Weather conditions are chosen, since every Microgrid is composed of wind turbines and solar panels to serve consumers. These two renewable resources generate electricity based on the environmental conditions, so weather conditions play a significant role in selection of operating mode. If the light intensity and wind blowing are highly good, then the Microgrid can be operated in islanded mode else grid connected mode.

Phase 2 –

In this stage, energy management of the islanded Microgrid are focused which is equipped to exchange electricity. We propose a novel Bio Neutrosophic Intelligence algorithm that considers *voltage, frequency, power factor, total harmonic distortion and loss of produced power probability*. The above mentioned five parameters are estimated for individual Microgrid by applying two intelligence schemes with minimized number of rules. The low output values obtained first scheme is ignored into optimization algorithm processing. Further an optimal Microgrid is chosen for power exchange using particle swarm optimization algorithm.

Phase 3 –

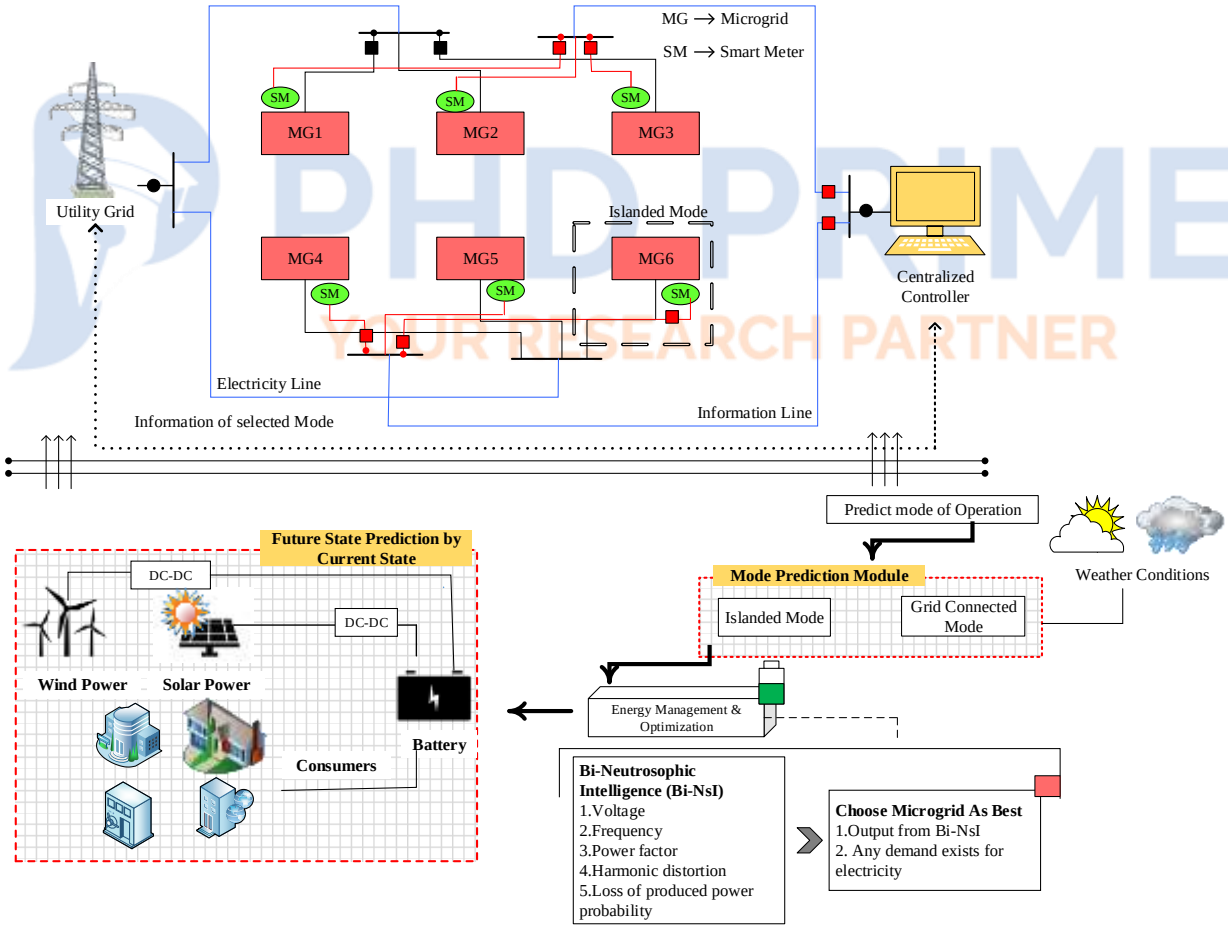
Lastly, Deep Reinforcement Learning is presented to classify the future states of the Microgrid which helps in monitoring the entire system. The future status of the Microgrid can be estimated using its current load information. The computed status information is updated to controller periodically.

Performance Evaluation

The performance of our proposed Microgrid system is compared with the existing work in terms of the following parameters,

- Served load in Grid-Connected Mode
- Served load in Islanded Mode
- Power generated at each Microgrid
- Generator output in Grid-Connected Mode
- Generator output in Islanded Mode
- Exchanged Power

SYSTEM ARCHITECTURE



IV. RESEARCH NOVELTIES

- Accurate strength of mind of operating mode allows managing customer's load and reducing fluctuations in switching operating mode dynamically.
- The consideration of weather conditions (temperature, and cloudy rate) is highly reflects on the production of electricity among the RES.
- Hence, the prediction of operating mode is appropriate. Once the mode is determined, then the MG is insisted to be operated on that particular mode.

V. PREVIOUS WORKS & LIMITATIONS

In this section, what are the works have been previously released in the field of multi-microgrid for energy optimization and management in dynamic mode prediction.

Paper 1

Title – Islanding Detection and Enhancement of Microgrid Performance

Concept –

In this paper, the authors have proposed a hybrid islanding detection method that is composed of remote detection method and passive method. System stability is maintained by adjusting the error rates of voltage and current parameters. Signals are extracted for measuring the voltage and frequency ranges. Based on these values, islanding operation mode is either activated or not else other stabled operation mode is activated.

Paper 2

Title – Optimal Sizing of Distributed Energy Resources in a Microgrid System with Highly Penetrated Renewables

Concept –

In this paper, the authors have concentrated on achieving the objective function of optimizing the net Microgrid cost. According to this work, renewable wind farms integrated Microgrid is taken in account. The loads are categorized into two different classes and each class is

formulated by utility function and concave function respectively. The proposed symbiotic algorithm involves process of mutualism, commensalism and parasitism. In this work, the proposed algorithm is explained with the conventional procedure and the procedure applied for energy is not depicted in detail.

Paper 3

Title – Distributed Day-Ahead Peer-to-Peer Trading for Multi-Microgrid Systems in Active Distribution Networks

Concept –

This paper concentrated on controlling the Microgrid by using the developed non-coperative game. The input parameters taken in account are micro-sources, wind, temperature and load which are initialized in the optimization algorithm. Finally, an optimal economic cost is identified as output for energy management system.

Paper 4

Title – Energy and Frequency Hierarchical Management system Using Information Gap Decision Theory for Islanded Microgrids

Concept –

An Information Gap Decision Theory Technique is proposed in this paper to assist central controller present in the microgrid. The renewable energy sources include wind turbines and photovoltaic units for formulating mathematical expressions. In this paper, the hierarchical energy management system deals with three controls as primary, secondary and tertiary. The severe uncertainties depend on the varying uncertainty budget.

Paper 5

Title – Energy Management of Multiple Microgrids Based on a system of systems Architecture

Concept –

The challenging issue of renewable energy source uncertainty is resolved in this paper by modelling multiple-stage robust management. This process in this paper is handled in two–levels as: first level for balancing power and load, then the second level for exchanging power among Microgrid. The designed bi–level optimization model is developed based on the decision time horizon which is nothing but equally spaced periods. Based on the load and load shedding the balancing is performed in Microgrids.

Paper 6

Title – A Two-layer Energy Management System for Microgrids with Hybrid Energy Storage considering Degradation Costs

Concept –

In this paper, the authors have developed for scheduling the utilities of Microgrids with the aim of minimizing operational cost. A two–layer predictive energy management system is designed based on time horizons that use two control layers based decision–making. The two layers of EMS are composed of power dispatch and energy resources. This works takes in account of degradation cost model for minimizing the operational costs.

Paper 7

Title – Integration of renewable distributed generation with storage and demand side load management in rural islanded Microgrid

Concept –

In this paper, smart load curtailment is achieved by developing Human Activities Tracking System (HATS) with the assistance of sensors. The objective of maximizing load supply is obtained by using fuzzy logic controller. Here four significant parameters are taken into account

of fuzzy logic parameters that includes storage drain time, state of change, running load and solar irradiations.

Paper 8

Title – Wide area monitoring and protection of Microgrid with DGs using modular artificial neural network

Concept –

In this paper the authors have proposed a wide area monitoring system in a distributed Microgrid environment. The three major process focused in this work are fault detection, classification and section identification. This work is operated by two sequential stages to effectively identify the faults. Both the stages use artificial neural network, in first stage the ANN is enabled to detect the mode of operation and in second stage the fault is identified.

Paper 9

Title – A Hierarchical Real-Time Balancing Market Considering Multi-Microgrids With Distributed Sustainable Resources

Concept –

A hierarchical real-time resource balancing approach is proposed in this paper to address energy associated shortage issues under distributed sustainable resources. Enhancing the net present value is the main objective of this work which prioritizes the cost of the distributed energy resources. Here the net present value is composed into total profit, total investment cost and total amount of electricity purchased.

Paper 10

Title – Intelligent Multi-Microgrid Energy Management based on Deep Neural Network and Model Free Reinforcement Learning

Concept – This paper proposes a new model for energy management using intelligent approaches. Initially, a deep neural network (DNN) is proposed for MMG simulation. This is investigated under dynamic retail price signals with no requirement of information consumption. It protects customer privacy. Then, model free reinforcement learning is proposed which purpose is to optimize the pricing. The results of the MMG improve selling power profit and also reduce PAR. The simulation results demonstrate that the DNN regression model.

Paper 11

Title – A Multi-Layer Coordinated Control Scheme to Improve the Operation Friendliness of Grid-Connected Multiple Grids

Concept –

The authors of this paper have proposed a multiple Microgrid environment with number of renewable energy. The aim of this paper is to achieve optimized operation with comforted friendliness. Adaptive management of power between the sub-grids is achieved by the proposed control scheme. In this paper, the designed three level architecture is efficient to local fluctuating power at low frequencies. This scheme is composed of power Papers, suppression of power fluctuation, adjustment of power Papers and droop coefficients.

Paper 12

Title – Multi-objective optimization framework for optimal planning of the Microgrid (MG) under employing demand response program (DRP)

Concept –

An optimal size of Microgrid in order to enhance the investment cost is the main objective of this paper. Max-min fuzzy decision making system is presented that is enabled to estimate the objectives by using membership functions. Power and heat power balance are formulated, further emission cost is also predicted. Once the size is identified, then they are applied with membership functions to compute the satisfactory level.

Paper 13

Title – Faster Detection of Microgrid Islanding Events using an Adaptive Ensemble Classifier

Concept –

Ensemble classifier is proposed in this paper which is an evolutionary computation algorithm in Extreme Machine Learning. In accordance to the decision making rule modeled in ELM ensemble the credibility is estimated. Based on the credibility values the operation mode is classified into islanding or non–islanding.

Paper 14

Title – Operation Mechanism and Strategies for Transactive Electricity Market With Multi-Microgrid in Grid-Connected Mode

Concept –

In this paper, the authors have designed multi–party Microgrid model in a centralized energy management model which running under grid-connected mode. This work is enabled to handle interaction between Microgrid operators and the parties (players) based power supply is implemented and avoids power surplus issue. Under china, this grid connected operational mode is implemented to improve sales side of electricity.

Paper 15

Title – Energy management for multi-microgrid system based on model predictive control

Concept –

The authors of this paper have aimed to minimize the cost of power supply by using the designed distributed predictive control algorithm that is operated with respect to the global optimization. Future electricity demand is estimated using historical power data that are

monitored. Each Microgrid is provided with control values based on which the decision is made in this system.

Paper 16

Title – Supervisory Control for Power Management of an Islanded AC Microgrid Using Frequency Signalling-Based Fuzzy Logic Controller

Concept –

In this paper fuzzy logic controller is presented to manage the supervisory control by adjusting the AC bus frequency. In this work, the Microgrid is comprised of load, solar and supplementary unit. Fuzzy logic rules are modeled based on state of charge that depends on the power of battery charging and discharging. This entire system is enabled to control the power flow over the energy sources.

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