MINISTRY OF EDUCATION AND TRAINING
VIETNAM ACADEMY OF SIENCE AND TECHNOLOGY
GRADUATE UNIVERSITY OF SIENCE AND TECHNOLOGY

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RESEARCH ON OPTIMAL CONTROL OF THE DISTRIBUTION POWER SYSTEM WITH THE PARTICIPATION OF WIND AND SOLAR ENERGY SOURCES

SUMMARY OF ELECTRICAL ENGINEERING, ELECTRONICS AND TELECOMUNICATIONS THESIS
MAJOR CODE: 952 02 16

HA NOI – 2022

The thesis has been completed at: Graduate University of Science and Technology- Vietnam Academy of Science and Technology

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INTRODUCTION

1. Urgency of the research

Wind and solar power sources develop very strongly, especially in low-voltage grids. Due to the constant variability of these power sources, the bus voltages and branch currents are outside the allowable limits. At that time, the system will disconnect from these wind and solar power sources and fail to generate power to the grid, affecting investment efficiency and equipment damage. Therefore, it is necessary to have a solution to control and operate the distribution power system to ensure maximum use of wind power, solar power and economic optimization..

2. Objectives, scope, objects and research methods

a, Objectives of the research

+ Proposing solutions to control and optimally operate the distribution power system with the participation of wind and solar power sources in order to make the most of the generating capacity of these power sources and ensure electricity. nodal voltage, branch current is within the allowable limit.

b, Research scope and object

+ Research scope: Researching solutions to control the operation of distribution power systems with the participation of wind and solar power sources.

+ Research object: 1 phase of low voltage grid

c, Research Methods

+ Theoretical research: Analyze, build theoretical basis applied to the problem

+ Tools: Genetic algorithm (GA), Particle swarm optimization (PSO), low voltage grid single phase calculation algorithm, optimal power flow calculation using barrier method, Monte Carlo algorithm, neural network artificial ron for prediction problem.

3. Scientific and practical significance

+ Scientific significance: Reaffirming the correctness of some theories considered and applied to computational research in forecasting, control and reliability calculations. Proposing solutions to control the optimal operation of low-voltage power grids with the participation of wind and solar power sources.

+ Practical significance: Applied to low-voltage power grids to increase the quality of operation of the power system with the participation of new energy sources.

4. Thesis structure

The content of the thesis is presented in three chapters

CHAPTER 1: OVERVIEW OF OPTIMAL OPERATION CONTROL OF DISTRIBUTION POWER SYSTEM WITH PARTICIPATION OF WIND ENERGY, SOLAR ENERGY

1.1. Characteristics of the power system and the control problem for optimal operation of the power system

With today's power system, because the power source is also constantly changing, in addition to controlling the power distribution of traditional power sources, the system also has to control the load, and control the charge/discharge of the energy storage. to balance capacity and make maximum use of wind and solar power.

1.2. Research situation at home and abroad on optimal control and operation of power systems with the participation of wind and solar energy sources

The thesis analyzes 12 vietnamese researchs and 85 foreign researchs on optimal control and operation of power systems with the participation of wind and solar energy sources..

1.3. Analyze the research situation related to the topic and propose research objectives of the thesis

From the above studies, the thesis finds that the above studies have not proposed to calculate the maximum capacity of wind and solar power sources generated on low voltage grids when considering the bus voltage and branch current located in the low voltage grid. allowable value and not taking into account the capacity release of wind and solar power sources. The above studies also do not consider the control of the redistribution of the generating capacity of traditional power sources (optimum power flow) and the beneficial coefficients at the location of wind and solar power sources. Grid control studies often use energy storage to balance capacity and supply power to the load when power is lost from low-voltage transformers. But the investment and operating costs of the energy storage unit are huge.

From the above analysis, the thesis proposes the following main contents:

+ Develop a method to calculate the maximum total capacity of wind and solar power sources generated on a single phase of low voltage grid (including power sources connected to one phase and sources connected to three phases and generating that phase) with force the nodal voltage and branch current to always be within the allowable value when considering the ability to release power to the high-voltage grid, control the optimal distribution of the generating power of traditional power sources and the favorable coefficients. location.

+ Forecasting and controlling loads in order to reduce the negative effects of wind and solar power sources, and optimize the economy. Expanding the load control solution when using an electric vehicle charging station to supply power to the load in case of power failure from a low-voltage transformer.

1.4. Conclusion Chapter 1

In chapter 1, the thesis has stated the characteristics of the power grid with the participation of wind and solar power sources, analyzed the references and proposed the main content of the thesis.

CHAPTER 2: CALCULATIng THE MAXIMUM CAPACITY OF WIND AND SOLAR POWER GENERATED ON THE GRID

2.1. Introduction

After analyzing the references, we find that limiting the maximum capacity of wind and solar power sources is very important. The suitable algorithm to calculate the maximum power sum is either a genetic algorithm (GA) or Particle swarm optimization algorithm (PSO).

2.2. Research on constrained extreme algorithms

Currently, there are many algorithms to find constrained extremes, but through analysis of the studies, we will use genetic algorithms (GA) and swarm algorithms (PSO) for the problem of finding the maximum total power..

2.2.1. Genetic Algorithms (GA)

The genetic algorithm is based on the natural selection mechanism of genetics, including the following steps: coding the individual, determining the fitness function, the operation of selection, crossover, mutation and selection of new individuals.

2.2.2. Particle swarm optimization algorithm (PSO)

The swarm algorithm is based on a flock of birds looking for food to achieve the optimal value in the search domain. The swarm algorithm consists of determining the current position, movement speed and new position based on the best extremum found by the individual and the best extremum that other individuals share with that individual.

2.3. Calculating the maximum total capacity of wind power and solar power generated on 1 phase of low voltage grid

2.3.1. Introduction

From the analysis of studies, the thesis uses a genetic algorithm (GA) to calculate the maximum total capacity of wind and solar power sources on a single phase low voltage grid (including power sources connected to the grid). 1 phase and sources connecting 3 phases and generating that phase) in order to maximize the use of wind power, solar power to the grid and ensure that the bus voltage and branch current are within the allowable value..

2.3.2. Approximate calculation for 1 phase low voltage grid

The thesis presents formulas for approximate calculation of bus voltage, branch current of single phase low voltage grid according to reference number 13..

2.3.3. Using genetic algorithm to calculate the maximum total capacity of wind power, solar power generated on 1 phase of low voltage grid

2.3.3.1. The problem of the maximum total generated power

Objective function: the largest total capacity of wind and solar power sources generated on the grid

$$f_{PVWTi} = \max\left(\sum P_{PVWTi}\right) \quad (2.21)$$

Constraints:

+ Voltage buss:

$$U_{min} \leq U_i \leq U_{max} \quad (2.22)$$

+ Current branches:

$$I_{i-1\rightarrow i} \leq I_{maxi-1\rightarrow i} \quad (2.23)$$

From the load capacity and generating capacity of the solar panels and wind turbines at the buss, we can calculate the current on the branches and the voltage at the buss. Current and voltage must satisfy the formula 2.22, 2.23

2.3.3.2. Using genetic algorithm for the problem of calculating the maximum total capacity of solar panels and wind turbines to the low voltage grid: Algorithm diagram as shown in Figure 2.2

2.3.4. Calculation of test for 1 phase low voltage grid

The diagram of the power grid and the load capacity, resistance, and reactance of the branches in section 2.3.4 of the thesis. Calculation results for the problem of optimizing the capacity of installing wind and solar power sources at buss as shown in Table 2.3

Table 2- 3: Generating capacity of battery rigs and wind turbines at buss

f_{max} (kW)	Capacity of solar panel (PV) and wind turbine (WT) connected to the load									
	1	2	3	4	5	6	7	8	9	10
66	44	6	7	0	2	2	1	0	4	0
….	….	…	…	…	…	…	…	…	…	…
89	14	65	6	2	2	0	0	0	0	0

The total generating capacity of solar panels and wind turbines on the grid is at most 89 kW with the corresponding generating capacity at the buss as shown in Table 2.3 to ensure that the bus voltage is not greater than 231V and not less than 209V. The maximum branch capacity is 82.5 kW, but the total generating capacity can be achieved at 89 kW by one of it supplying power to the load. The results of the study were published in 3th of the publication.

2.4. Calculating the maximum total capacity of wind and solar power sources to the 3-phase grid considering the optimal control of the power system and the location advantage factor

2.4.1. Introduction

Excess capacity of wind and solar power sources generated on a single-phase low-voltage grid will be passed through a step-up transformer and released to a three-phase high-voltage grid. At this time, the released capacity will be bound by the capacity of the high-voltage grid and will be solved through 2 problems:

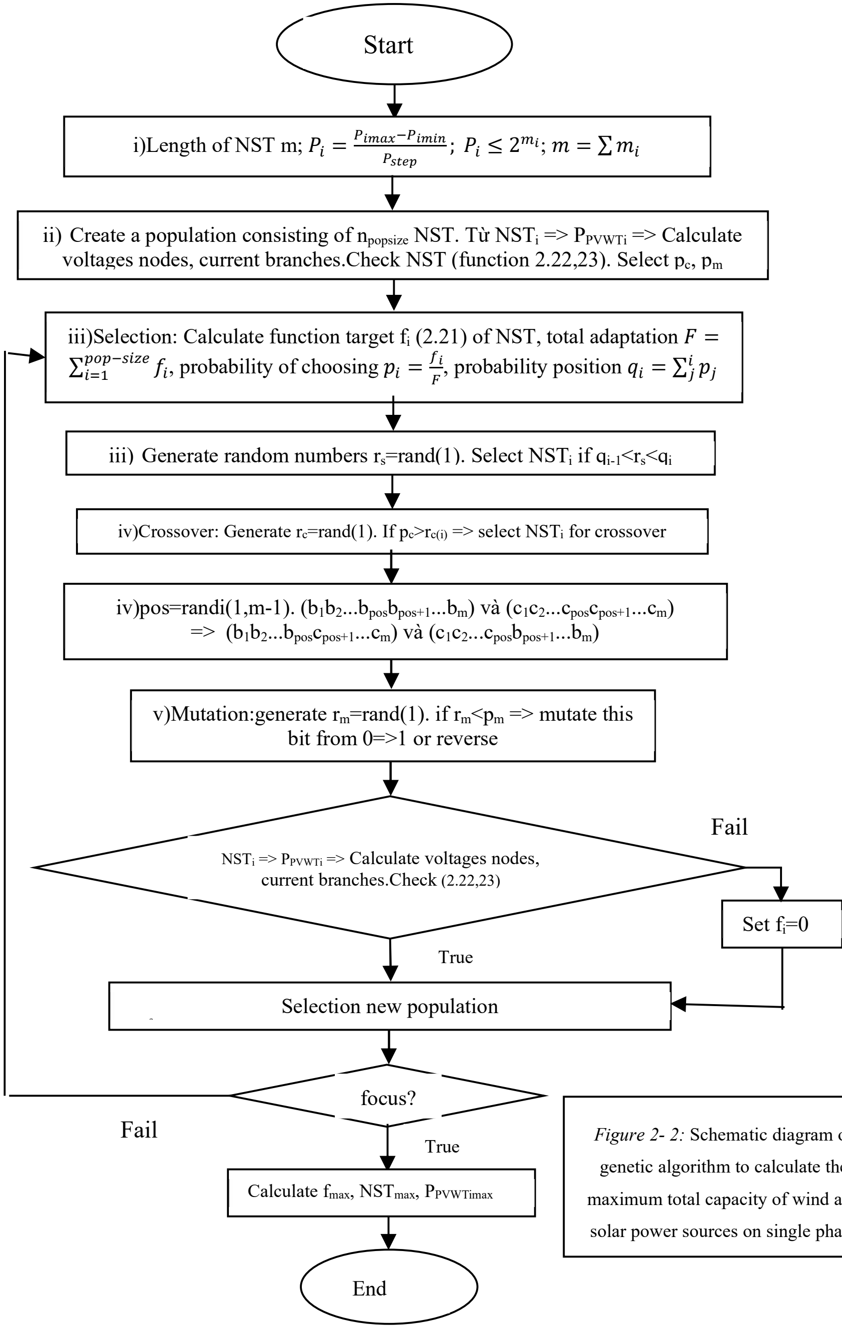


Figure 2- 2: Schematic diagram of genetic algorithm to calculate the maximum total capacity of wind and solar power sources on single phase

+ Problem 1: Calculate the optimal power flow. The thesis will use the barrier method to calculate the generating capacity of the traditional power sources in the system so that the total cost of electricity generation in the system is minimal and the bus voltage, branch current, generating capacity of the power plants are minimized.

+ Problem 2: Calculate the total generating capacity of wind and solar power sources considering the system of self-control of the generating capacity of traditional power sources (calculating the optimal capacity trend). The thesis will use genetic algorithm to find the maximum total generating capacity of wind and solar power sources. The thesis also expands when considering the beneficial coefficients at the construction site of wind and solar power sources and uses the swarm algorithm to calculate and compare the results. The location profitability coefficient reflects the project investment efficiency at construction sites due to the influence of total supply time, wind energy density, solar energy, cost of connecting electricity generation to the grid, construction and operation costs, local support policies.

2.4.2. Calculate the optimal power flow

The objective function for the problem will be to minimize the generation cost (calculated for active power).:

$$min f_G = min \sum_{i=1}^{n} \left(c_{Gi}.P_{Gi}^2 + b_{Gi}.P_{Gi} + a_{Gi} \right) \quad (2.26)$$

Constraint:

+ The sum of active and reactive power input and output at a bus must be zero

$$P_{Lk} - P_{Gk} + V_k.\sum_{m=1}^{N} V_m.[g_{km}.\cos(\theta_k - \theta_m) + b_{km}.\sin(\theta_k - \theta_m)] = 0 \quad (2.27)$$

$$Q_{Lk} - Q_{Gk} + V_k.\sum_{m=1}^{N} V_m.[g_{km}.\sin(\theta_k - \theta_m) + b_{km}.\cos(\theta_k - \theta_m)] = 0 \quad (2.28)$$

+ Limits on active and reactive power generated at the generator

$$P_{Gimin} \le P_{Gi} \le P_{Gimax} \quad (2.29)$$

$$Q_{Gimin} \le Q_{Gi} \le Q_{Gimax} \quad (2.30)$$

+ Limit voltage at buss

$$V_{imin} \le V_i \le V_{imax} \quad (2.32)$$

+ Limit transmission power on the line or transmission current on the line

$$S_{km}^2 \le S_{kmmax}^2 \quad (2.35)$$

Using the method of changing barrier function of Lagrange function combined with Newton iteration, we can find the optimal generating capacity at the power plants in the power system..

2.4.3. Calculating the maximum capacity of wind and solar power sources to the grid when considering the optimal capacity control of traditional power sources in a 3-phase grid

Objective function: the total capacity of solar and wind power generated to the grid at the buss is the largest

$$f = max \sum_{i=1}^{N} P_{PVWT} \quad (2.60)$$

The problem considers the self-control system of optimal generating capacity of traditional power sources in the power system as presented in section (2.4.2). To do this, we proceed as follows:

+ Step 1: When the generating capacity of wind and solar power sources at the buss is zero, calculate the optimal power flow (2.4.2) to ensure convergence.

+ Step 2: Using a genetic algorithm to calculate the maximum total capacity of wind and solar power sources at the buss with the condition that the optimal capacity (2.4.2) always converges.

Using the genetic algorithm to calculate the largest objective function (2.60) when considering the system that always converges (2.4.2), we find the maximum total generating capacity of wind and solar power sources generated on the grid.

2.4.4. Calculating the maximum total capacity of wind and solar power sources to the grid considering the potential and advantages of installation

Objective function: the total capacity of wind power, solar power generated on the grid of all buss (PPVWTi) is the largest when considering the location benefit factor (α_i)

$$f = max \sum_{i=1}^{N} \alpha_i . P_{PVWTi} \qquad (2.63)$$

Constraints of the problem in 2 steps as in section 2.4.3

Using the genetic algorithm to calculate the largest objective function (2.63) when considering the system that always converges (2.4.2), we find the maximum total generating capacity of wind and solar power sources generated on the grid.

Using the Particle swarm optimization algorithm to calculate the largest objective function (2.63) when considering the system that always converges (2.4.2), we find the maximum total generating capacity of wind power, solar power generated to the grid..

2.4.5. Test for 3 phase power grid

2.4.5.1. Calculate the optimization of the power flow

+ Calculation and comparison of software efficiency for 5-bus, 23-bus grids

The thesis uses the data of the 5-buses grid in reference 13 and the 23-buses grid in reference 93 to compare the efficiency of programming software. Experimental calculations show that the results converge better than those calculated in the reference.

+ Calculation for IEEE-24 bus, IEEE-30 bus . power grid

The diagram and parameters of the power grid, the price cost coefficient are shown in section 2.4.5.1 and the appendix in the thesis. Calculation results for the IEEE-24 bus power grid: Convergence in 0.85s with the lowest power generation cost of the system is 1128789122 VND. Bus voltage, branch current are shown in table 2-21, 2-22 in the thesis. The calculation results for the IEEE-30 bus power grid are detailed in Section 2.4.5.1 and Appendix 1 .

Table 2- 20: Power generation at IEEE-24 buses power grid sources

Bus	1	2	7	13	15	16	18	21	22
P(MW)	78,97	70	50	40	30	40	43,62	30	40
Q(MVAr)	0	20,09	20,33	0	0	0	0	0	0

2.4.5.2. Using a genetic algorithm to calculate the maximum total capacity of wind and solar power sources on the grid

Experimental calculation for IEEE 30 power grid with the data in section 2.4.5 of the thesis, we get the results in table 2.26.

Table 2- 26: Table of results to find the optimal value of the total generating capacity of wind and solar power sources

I	f_{max}	Generating capacity of solar and wind power at the buss				
		2	6	7	11	20
1	65	0,2	0,9	4,3	53,9	5,7
…..						
1420	106	18,2	10,5	7,2	1,3	68,8

The maximum total capacity of wind and solar power sources for the high-voltage grid with capacity adjustment from traditional power sources is 106 MW (capacity of buss as shown in table 2.26) to ensure that when the wind power sources If the sun changes the generating capacity from 0% to 100%, traditional power sources (hydroelectricity, thermal power) can change the capacity to ensure that the bus voltage and branch current are within the allowable limits. The results of the study were published in 05th of the publication.

2.4.5.3. Calculating the maximum total capacity of wind and solar power sources to the grid when taking into account the position advantage factor

Applying calculations to the IEEE 30-bus power grid with 6 power buss of hydroelectric and thermal power plants, 24 load buss are connected to sources through 42 branches with corresponding data in section 2.4.5.1 of the thesis and coefficients beneficial position as table 2.28

The optimal value is f = 164.43 (.MW) (genetic algorithm), the corresponding capacity of wind power, solar power at the buss (table 2.28) and the optimal value is f = 164,645 (.MW) (PSO).

Table 2- 28: Generating capacity of wind and solar power sources at buss when using genetic algorithms

Bus	4	6	10	12	15	17	20	28	29	30
α	1	1,5	1	1,3	1	1,2	1,4	1	1,5	1
P (MW)	0,2	0,8	0,1	1,9	0,5	0,5	37,9	0,2	70,4	0,5

From the table of results of installed capacity at the buses, we can see that buses with high position factor are often distributed large capacity (bus 29).

When not considering the benefit factor (set equal to 1 for buses), the result of calculating the maximum total capacity of wind and solar power at the buss is f= 113.4 MW (genetic algorithm) and f = 113,339 MW (PSO). Compared with setting the favorable coefficient, the total capacity is 113 MW, the total generating capacity of wind power and solar power has not changed much, but areas with potential and favorable conditions have been prioritized. to build wind energy, solar energy. The results of the study were published in 2nd of the publication.

2.5. Conclusion of chapter 2

+ Genetic algorithm (GA), PSO algorithm can used to finding the maximum generating capacity of wind and solar power sources on single phase low voltage grid with power constraints bus voltage, current branch and power balance in terms of generation power clearance and control of traditional power distribution power and positional gain. Thanks to the location-benefit factor, economically viable locations will be prioritized to generate larger capacity and not greatly affect the total generating capacity of wind and solar power.

CHAPTER 3: OPTIMIZED CONTROL OF ELECTRIC LOADS

3.1. Introduction

Electrical loads can be divided into two types: movable using time (water pump, electric vehicle charger, water heater, etc.). When adding a Internet connection device, it become movable using time load, it will become a controllable load to help stabilize the power system. These loads allow shifting the usage time (Δt) from the start time (tstart) to the end time (tend). In this chapter, the thesis builds the load optimal on/off control method including 2 problems:

+ Forecasting problem: Using an artificial neural network to forecast the generating capacity of solar panels, wind turbines, load consumption, and electricity prices in the next day.

+ Optimal control problem: Using genetic algorithm to control load on/off, ensuring economic goals and bus voltage, branch current in allowable values, on/off time.

The control block has 2 main control functions to support the safety of the electrical system, including::

+ Automatically control on/off the load according to the bus voltage bus if the voltage exceeds the allowable value. This function only works due to prediction error or user control by hand.

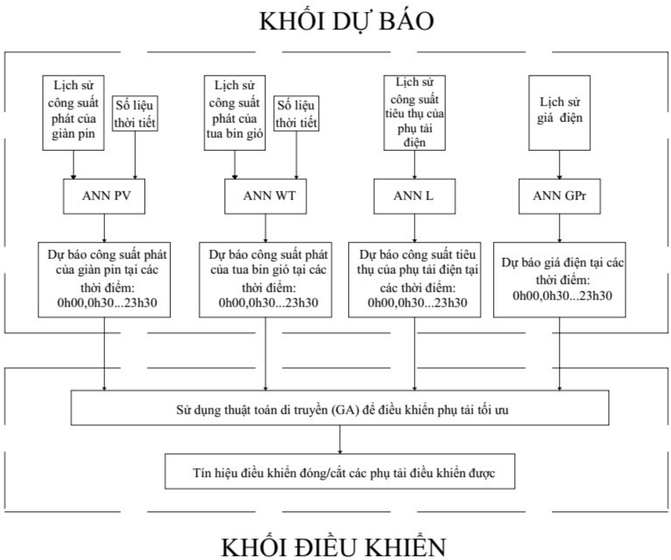


Figure 3.3: Model of load control in low-voltage grid

+ Remote control via the Internet from the system's server connected to the load through the economic optimization problem and ensure stable voltage and current conditions.

In addition, the thesis also proposes a plan to combine electric vehicle charging stations and solar rigs to supply power to loads when power is lost from low-voltage transformers..

3.2. Using artificial neural network for forecasting problem

3.2.1. Research on artificial neural networks used for forecasting

Artificial Neural Networks (Artificial Neural Networks) are built based on the structure of the human brain. Artificial neural network can perform the problems of sample recognition, optimization, recognition, control of linear and nonlinear objects and prediction with higher efficiency than traditional computational methods.

3.2.2. Using multilayer feedforward neural network and Levenberg-Marquardt algorithm to train neural network

Algorithm diagram using Levenberg-Marquardt algorithm network to train neural network for prediction problem as shown in Figure 3.5

3.2.3. Forecasting generating capacity of solar panels and wind turbines

The thesis proposes 4 models with different number of neural networks and inputs to predict the generating capacity of solar panels and wind turbines as shown in Figure 3.6-3.9. In which in model 4, the correction block is based on the data of average transmit power, maximum transmit power, minimum transmit power of the same time and have the same weather state of the dataset used to correct the forecast value.

3.2.4. Forecasting power consumption of electrical loads, electricity prices

The thesis proposes 3 models with different number of neural networks and inputs to predict power consumption of electrical loads and electricity prices as shown in Figure 3.10-3.12.

3.3. Optimal control of electrical load

3.3.1. Formulate the problem

The goal is the total cost of selling electricity to the grid from solar panels and wind turbines minus the total cost of buying electricity from the grid in a maximum of 1 day.

$$f = \max\left(\sum_{t=1}^{48}\sum_{i=1}^{10}\begin{pmatrix} PR_{PV}(t).P_{iPV}(t) + PR_{WT}(t).P_{iWT}(t) \\ -PR_{GR}(t).\left(P_{iLUC}(t) + P_{iLC}(t)\right) \end{pmatrix} + C\right) \tag{3.26}$$

Constraints:

+ Voltage buses:

$$U_{min} \le U_i \le U_{max} \tag{3.27}$$

+ Current branches:

$$I_{i-1\to i} \le I_{maxi- \ \to i} \tag{3.28}$$

+ The limit on/off time of the electrical load:

$$t_{istart} \le t_i \le t_{iend} \tag{3.29}$$

***3.3.2. Using genetic algorithm to optimally control electrical load**:* The genetic algorithm helps to find the optimal loading time to maximize the objective function (3.26) and ensure the condition 3.27-3.29.

3.4. Integrated electric vehicle charger and on grid solar panel to supply electricity for loads

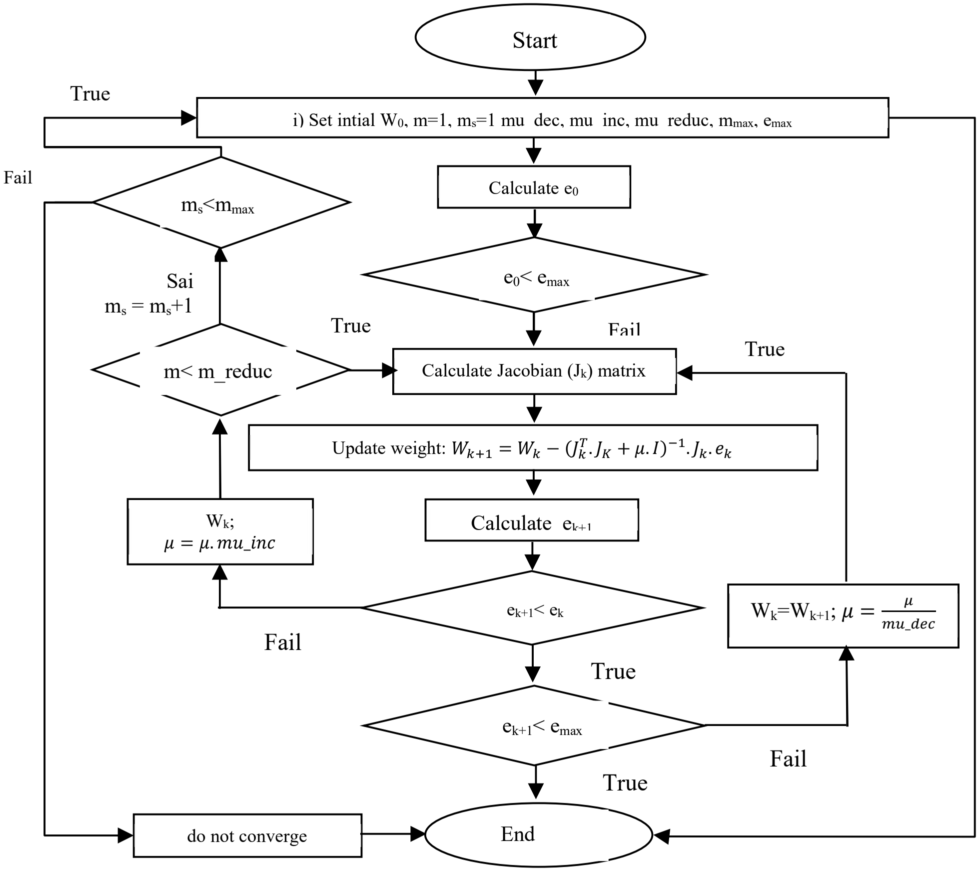


Figure 3. 5: Training neural networks using Levenberg-Marquadt . algorithm

3.4.1. Proposing the principle diagram and conditions of power supply for the load

The proposed principle diagram is shown in Figure 3.15.

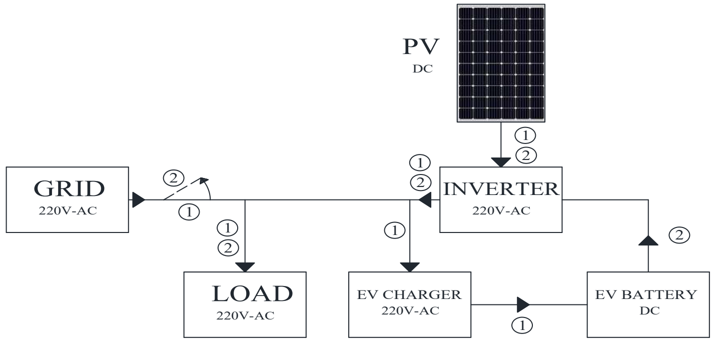


Figure.15: Schematic diagram of the integrated system of electric vehicle charging and on grid solar panel

The system ensures power supply conditions for the load:

$$\begin{cases} A_{fba} \geq 1{,}05.A_{PVL} \\ P_{fba} \geq 1{,}05.P_{PVL} \end{cases} \quad (3.38)$$

A_{fba}: Power supplied from electric vehicle battery, A_{PVL}: used power of the load minus the power supplied from the solar panel, P_{fba}: Discharge capacity from battery, P_{PVL}: The capacity of the load minus the capacity of the solar panel

3.4.2. Evaluating the efficiency of an integrated model of electric vehicle charging station and on grid solar panel

The thesis uses the Monte Carlo algorithm to take random sampling according to the uniform distribution of the time of power failure and the battery capacity of the electric vehicle at the time of power failure and constraint 3.38 to calculate the 1-year average power failure time when integrating the charger into the grid. .

3.4.3. Power distribution control for electric vehicle charging

Controlling the discharger at bus 1 is the power balance button, distributing power to the remaining buss provided that the number of tram stations to be used is at least.

3.5. Calculation for low voltage grid

3.5.1. Apply to forecasting problem

+ Solar panel generation forecast: 458 training days and 150 testing days. The error results of the models are as shown in Table 3.3

Table 3- 3: Average error of the forecast of solar panel generating capacity prediction of the proposed models

Model	1	2	3 (4 weather types)	4(4 weather types)	3 (9 weather types)	4(9 weather types)
Error %	57,4	41,75	19,97	19,63	8,15	7,51

+ Wind turbine generation forecast: 565 training days and 150 test days. The error results of the models are as shown in Table 3.4

Table 3- 4: Average error of wind turbine generating capacity prediction of the proposed models

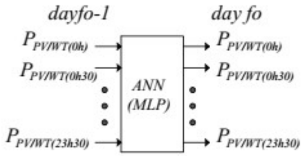
Model	1	2	3 (4 weather types)	4(4 weather types)
Error %	34,08	31,32	18,74	18,37

+ Power consumption forecast: 458 training days and 150 testing days. The error results of the models are as shown in Table 3.5

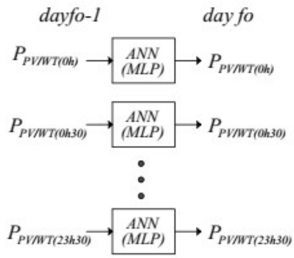
Figure 3- 5: Average error of power consumption forecast results

Model	1	2	3
Error %	24,53	17,8	10,42

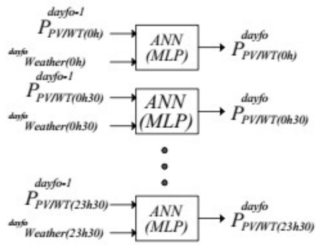
+ Electricity price forecast: 520 training days and 150 testing days. The error results of the models are as shown in Table 3.5



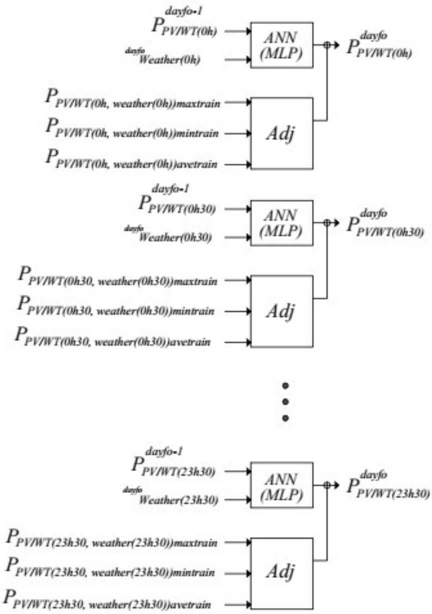
Hình 3.6: Mô hình 1



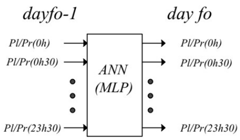
Hình 3.7: Mô hình 2



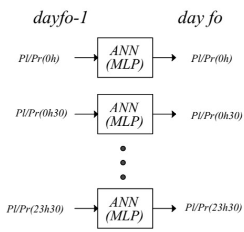
Hình 3.8: Mô hình 3



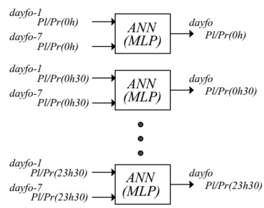
Hình 3.9: Mô hình 4



Hình 3.10: Mô hình 1



Hình 3.11: Mô hình 2



Hình 3.12: Mô hình 3

Figure 3- 5: Average error of electricity price forecast results

Model	1	2	3
Error %	8,95	7,96	5,62

3.5.2. Optimal control of electrical load

3.5.2.1. Parameters of the power grid

Parameters of the power grid are described in detail in Section 3.5.2.1 in the thesis.

3.5.2.2. Using genetic algorithm to control load on/off.

From the forecast data, we proceed to use the genetic algorithm to calculate the load on/off control. The results are as shown in Table 3.11

Table 3.11: Table of optimal turn on time and objective function

Fmax	Load capacity and turn on time							
103938	Load	1	2	4	7	8	9	10
	P	5	7	5	7	10	4	6
	t	1	22	14	14	21	13	0

The the optimal value of 103938 (VND). The results of the study have been published 01st, 04th in the publication.

3.5.3. Integrated electric vehicle charger and on grid solar panel to supply electricity for loads

With the parameters is ηch= 98%, ηdisch = 97%, Δt = 0,5 (h), tendset = 8 (h-AM), tend = 5 (h-AM). Ab= 42 kWh, Pch= 11 kW. Amin = 30% Amax, t = 336 (h) we can calculate that the number of power failure hours can be reduced 100 times with solar panels and 50 times without solar panels. The results of the study were published 01st of publication.

Table 3-14: Power of electric vehicle chargers supply for grid

Power of electric vehicle chargers supply for grid							
Bus	1	2	4	7	8	9	10
P (kW)	1,99	7	5	7	10	4	6

3.6. Conclusion of chapter 3

+ Using a 2-layer feedforward neural network combined with the Levenberg-Marquadt algorithm can predict the generating capacity of solar panels, wind turbines, power consumption and electricity prices. The smallest error result is Model 4 (Figure 3.9) for solar panels, wind turbines and Model 3 (Figure 3.12) for power consumption and price electricity.

+ Using genetic algorithms can calculate the turn on/off time to ensure the bus voltage, current branches are within the allowable range and optimal cost.

+ The integration of solar panels and electric vehicle charging stations saves investment costs and increases power supply reliability.

CONCLUSIONS AND RECOMMENDATIONS

1. Evaluate research results

The research has proposed solutions to limit the output power in terms of power clearance, optimal control of the traditional power source and the positional benefit factor. Predict and control loads, control electric vehicle chargers integrated with solar panels to supply power to loads when power is lost from low-voltage transformers. The algorithms used are algorithms suitable for the object of single phase low voltage grid and are calculated and tested on the test grid..

2. Development direction of research

Apply new techniques to increase the accuracy of the prediction problem. Integrate more optimal control methods and devices such as capacitor system, automatic pressure control system. Building an optimal control method for electric vehicle charging stations combined with solar panels in single phase low voltage grid according to different operating objectives. Apply the proposed control strategies into practice towards effective technology transfer.

NEW CONTRIBUTIONS OF THE THESIS

1- Proposing a method to calculate the maximum total capacity of wind and solar power generated on a single phase of low-voltage grid to ensure that the bus voltage and branch current are within the allowable limits when considering the release of generating capacity to the high-voltage grid, optimally controlling the traditional power sources and taking into account the advantageous of installation location to increase the generating capacity of wind and solar power to single-phase of low-voltage grid.

2- Proposing a corrector model for an artificial neural network to increase accuracy when predicting the generating capacity of solar panels and wind turbines. From there as input data to control the load to reduce the negative impact of solar panels, wind turbines on electrical loads, optimize the economy and propose solutions to control electric vehicle charging stations with integrated ongrid solar to provide power to the load in case of power failure from the low-voltage transformer.

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