

NATIONAL TECHNICAL UNIVERSITY OF UKRAINE
«IGOR SIKORSKY KYIV POLITECHNIC INSTITUTE»

Faculty of Electric Power Engineering and Automatics

Department of Power System Automation

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Master's Thesis

of the specialty 141 Electrical Energetics, Electrical Engineering and Electromechanics (Control, Protection, and Automation of Electric Power Systems) on the topic: «Investigation of the modes of operation of renewable energy sources with energy storage in distribution electrical grids»

Performed: student of VI year, group EK-81mp
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Reviewer _____

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I certify that in this master's thesis there are no borrowings from the works of other authors without corresponding references.

Student _____
(signature)

Kyiv – 2019

**NATIONAL TECHNICAL UNIVERSITY OF UKRAINE
«IGOR SIKORSKY KYIV POLYTECHNIC INSTITUTE»**

Faculty of Electric Power Engineering and Automatics

Department of Power System Automation

Higher education level - the second (master's) in educational and professional program

Specialty 141 Electrical Energetics, Electrical Engineering and Electromechanics (Control, Protection, and Automation of Electric Power Systems)

APPROVED

Head of Department

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TASK

for the master's thesis of the student

Kostiantyn Lysak

(name and surname)

1. Thesis topic Investigation of the modes of operation of renewable energy sources with energy storage in distribution electrical grids

Supervisor Artem Nesterko Ph.D. Senior Lecturer,

(name, surname, scientific degree, academic title)

approved by university order from «13» November 2019. №3906-c

2. The term of submission of the thesis by the student 12.12.2019p.

3. Object under investigation Part of electricity distribution network with connected renewable energy source.

4. Subject under investigation (Initial data - for the master's thesis on educational and professional program.) managing power consumption and recoverability of the terminal with renewable energy sources and energy storage in the distribution grid.

5. List of tasks to be completed Part of distribution grid, algorithm of power distribution controller. Setting and selection of control signal parameters for renewable energy sources. Setting up the general model of renewable energy with energy storage and controller in MATLAB & Simulink software.

6. List of graphic (illustrative) material Electrical distribution grid, model of control controller, scheme of electric energy storage, research results.

7. Indicative list of publications _____

8. Master`s chapters advisors

Chapter	Name, surname, advisor`s post	Signature, date	
		the task gave	the task accepted
Development of a startup project	Serhii Bakhmachuk Senior Lecturer		
Occupational Health	Larysa Tretiakova Doctor of Technical Sciences, Full Professor		

9. Date of issue of the assignment 02.09.2019.

Calendar Schedule

№ t/p	The name of the stages of the master's thesis	The term of completion of the stages of the master's thesis	Note
1.	Formation of scientific and technical problem, analysis of the state of the solution of the problem by the materials of scientific publications.	25.09.2019.	
2.	Analysis of possible research methods and options for solving the problem.	10.10.2019.	
3.	Modeling of the part of the electric distribution grid in MATLAB & Simulink software, investigation of the operation of renewable energy sources with energy storage devices and influence on the mode of operation of the electric distribution grid.	31.10.2019.	
4.	Development and implementation of the algorithm of operation of the power distribution control controller in MATLAB & Simulink software, to maintain the voltage level within acceptable limits.	10.10.2019.	
5.	Setting and selection of control signal parameters for renewable energy sources. Setting up the model of electric distribution grid together with the controller in MATLAB & Simulink software.	20.10.2019.	
6.	Analysis of the operation of this system form graphical representations of control signals of the controller, the voltage levels of the grid within the time of network operation in the MATLAB & Simulink software.	30.11.2019.	
7.	Forming conclusions from the results of the investigation.	10.12.2019.	

Student

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Supervisor

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РЕФЕРАТ

Магістерська дисертація виконана на 74 аркушах, яка містить 20 рисунків, 15 таблиць, 8 листів графічної частини, 28 літературних посилань та 2 додатки.

Актуальність теми – Через швидкий розвиток ВДЕ та встановлення їх як ДРГ у РЕМ, виникає необхідність у постійному автоматичному керуванні енергосистемою для запобігання порушення допустимого рівня напруги.

Мета дослідження – розробити систему управління НЕ для регулювання значення напруги вузла, де електростанція підключена на базі ВДЕ з блоком накопичення електроенергії та дослідження його впливу на напругу РЕМ.

Об'єкт дослідження – Режим роботи РЕМ при паралельній роботі ДРГ з керованим НЕ.

Предмет дослідження – Підхід до регулювання напруги вузла підключення терміналу ДРГ з керованим НЕ.

Результати роботи – на базі досліджуваної області ДРГ - дослідження впливу джерел ДРГ з НЕ у РЕМ.

Рекомендації (практичне значення одержаних результатів) – цю розробку можуть використовувати інженерні організації для створення нових пристроїв для автоматизації керованих НЕ.

Публікації за тематикою досліджень: - " ДОСЛІДЖЕННЯ РОБОТИ КЕРОВАНОГО НАКОПИЧУВАЧА ЕЛЕКТРОЕНЕРГІЇ У РОЗПОДІЛЬНІЙ ЕЛЕКТРИЧНІЙ МЕРЕЖІ" в Міжнародному науково-технічному журналі молодих вчених та аспірантів.

Ключові слова: ВІДНОВЛЕННІ ДЖЕРЕЛА ЕНЕРГЕТИКИ, ДЖЕРЕЛА РОЗПОДІЛЕНОГО ГЕНЕРУВАННЯ, ВІТРОВА ЕЛЕКТРОСТАНЦІЯ, РЕГУЛЮВАННЯ НАПРУГИ, РОЗПОДІЛЬНА ЕЛЕКТРИЧНА МЕРЕЖА

ABSTRACT

The master`s thesis is completed on 74 pages, 20 drawings, 15 tables, 8 graphics sheet, 2 appendices and 28 links.

Topicality of the topic – Due to the rapid development of RES and the establishment of them as DGS in the DG, there is a need for continuous automatic control of the power system to prevent disturbance of the permissible voltage level.

The aim – to develop control system of the ESU for regulating the voltage value of terminal where power plant is connected based on a RES with a power storage unit and investigating its effect on voltage in a DG.

Object of study – Modes of operation of the DG within connection to a parallel operation of a DGS with a controlled ESU.

Subject of research – Approach to the regulation of the voltage of connected terminal by the DGS with a controlled ESU.

The results of the work – on the basis of the studied area of the DGS, a study of the influence of sources of DGS with energy storage on the DG.

Recommendations (practical meaning of the results obtained) – this development can be used by design organizations to create new devices for automation of ESU.

Research publications: - "RESEARCH OF CONTROLLED ELECTRIC POWER STORAGE IN THE DISTRIBUTION ELECTRICAL NETWORK" in the International Scientific and Technical Journal of Young Scientists and Aspirants

Key words: RENEWABLE ENERGY SOURCES, DISTRIBUTION SOURCES OF GENERATION, WIND POWER STATION, REGULATION OF VOLTAGE, DISTRIBUTION GRID

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LIST OF CONDITIONAL ABBREVIATIONS

- RES – renewable energy sources;
- DGS – sources of distributed generation;
- DG – distribution grid;
- ESU – energy storage unit;
- WPP – wind power plant;
- UES – united electricity system;
- RE – renewable energy;
- PS – power system;
- REP – regional energy plan;
- WT – wind turbine;
- RPA – relay protection and automation;
- RB – rechargeable batteries;
- HERB – high energy rechargeable batteries;
- HHPF – hazardous and harmful production factors.

INTRODUCTION

Since the last century, the world energy industry has been developing according to the scheme of increasing the capacity of power equipment and the formation of integrated energy complexes. The largest and most powerful of which are the Russian EEC, ENTSO-E of Europe and the UES of Ukraine. But increasingly, due to the environmental situation and the increasing demand for electricity, the path of development is changing. Namely, the transition to the concept of sustainable energy development. The main link is the use of a large number of additional sources of electricity generation, which in a general sense can be attributed to one term, such as distributed generation (DG), and the objects of this term - sources of distribution generation (DGS). The WG is defined as the electricity source connected to the consumer and directly to the distribution network. [1]

Such changes are associated with the emergence of high-efficiency gas turbine and steam plants and the development of renewable energy (RE). Of the latter, wind power plants (WPPs), with a total installed capacity of more than 31 GW in the world, are currently most popular. [2] Conversion of solar energy through photovoltaic panels has become a convenient and reliable source of electricity for those consumers who are far from industrial centers and are of small scale. It is in this direction that energy in virtually the whole world has been moving in recent years, and Ukraine is also moving towards creating energy independence.

Despite all the advantages that can be obtained when connecting the DRG to the network, an important feature is their impact on the reliability of the latter, the functioning of the RAS, the quality of electricity, and most importantly, the level of voltage in the electrical network. For example, in [3], a model of a hybrid power plant was proposed together with a wind and solar station in combination with an electric energy storage. The purpose of these robots was to develop the working model, the prototype of the station. But in turn, nothing is mentioned about the equally important study of the consequences of connection of this model to the electrical distribution network, the parameters of the network itself, and the approach to control are not taken into account.

On this basis, it becomes necessary to develop methods for regulating and investigating the operation of the network under these conditions, which differ significantly from typical approaches to managing it.

CHAPTER 1

MODELS OF ELEMENTS OF THE DISTRIBUTION NETWORK

1.1. Description of the distribution network

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LIST OF SOURCES

1. Voropay N. Small energy in a market environment: analysis of requirements and development conditions // Fuel and Energy Complex of Russia. - 2003. – № 2. - p. 97-98.
2. Energy of the XXI century: Development conditions, technologies, forecasts / L. Belyaev, A. Lagerev, V. Posekalin. Managing editor N. Voropay. - Novosibirsk: Nauka, 2004. – p. 386.
3.

APPENDIX 1