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ENHANCING THE POWER SYSTEM TRANSIENT STABILITY BY USING STORAGE DEVICES WITH HIGH PENETRATION OF WIND FARMS

By

Mostafa Ismail Elsayed Ismail Kandil

A Thesis Submitted to the
Faculty of Engineering at Cairo University
in Partial Fulfillment of the
Requirements for the Degree of
MASTER OF SCIENCE
in
Electrical Power and Mechanics Engineering

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
GIZA, EGYPT
2022

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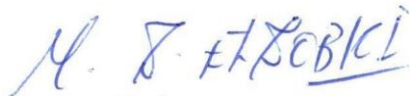
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Under the Supervision of

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Title of Thesis: Enhancing the Power System Transient Stability by Using Storage Devices with High Penetration of Wind Farms.

Key Words: Power system stability, Wind power generation, Stability analysis, Wind turbines, Renewable energy sources, Batteries, Transient analysis.

Summary:

In this thesis, the energy storage devices were presented to be used in enhancing the power system transient stability under high levels of Wind power penetrations. Study was applied on a benchmark system and used PSSE explore as the simulation software. Different locations of the Energy storage were examined and the optimum location for the system under study was presented.

Disclaimer

I hereby declare that this thesis is my own original work and that no part of it has been submitted for a degree qualification at any other university or institute. I further declare that I have appropriately acknowledged all sources used and have cited them in the reference section.

Name: Mostafa Ismail Elsayed Ismail Kandil.

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Dedication

Dedicated to the soul of Prof. Magdy Mohamed Ahmed El-Marsafawy.
To my wife, my father, my mother, and my little girls Lougina & Lara. Without you
all nothing would come out of this work.

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List of Symbols and Abbreviations

| | |
|-----------------------|--|
| <i>AC</i> | Alternating Current |
| <i>BESS</i> | Battery Energy Storage System |
| <i>CAES</i> | Compressed Air Energy Storage |
| <i>DC</i> | Direct Current |
| <i>DFIG</i> | Doubly Fed Induction Generator |
| <i>EEC</i> | Electrical Energy Storage |
| <i>EEHC</i> | Egyptian Electricity Holding Company |
| <i>EPRI</i> | Electric Power Research Institute |
| <i>FACTS</i> | Flexible Alternating Current Transmission System |
| <i>FEES</i> | Flywheel Energy Storage System |
| <i>GE</i> | General Electric |
| <i>GW</i> | Giga Watt |
| <i>HVDC</i> | High Voltage Direct Current |
| <i>IEEE</i> | Institute Of Electronic And Electrical Engineers |
| <i>IGBT</i> | Insulated-Gate Bipolar Transistor. |
| <i>KW</i> | Kilo Watt |
| <i>MW</i> | Mega Watt |
| <i>PCC</i> | Point Of Common Coupling |
| <i>PCS</i> | Power Conditioning System |
| <i>PHS</i> | Pumped Hydraulic Stations |
| <i>PMSG</i> | Permanent Magnet Synchronous Generator |
| <i>PSSE</i> | Power System Simulator For Engineering |
| <i>RES</i> | Renewable Energy Source |
| <i>SCIG</i> | Squirrel Cage Induction Generator |
| <i>SLD</i> | Single Line Diagram |
| <i>SMES</i> | Superconducting Magnetic Energy Storage |
| <i>SOC</i> | State Of Charge |
| <i>STATCOM</i> | Static Synchronous Compensator |
| <i>TES</i> | Thermal Energy Storage |
| <i>UPS</i> | Uninterrupted Power Supplies |
| <i>VSC</i> | Voltage Source Converter |
| <i>VSI</i> | Voltage Source Inverter |
| <i>WECC</i> | Water Electricity Coordination Council |
| <i>WRIG</i> | Wound-Rotor Induction Generator |
| <i>WRSG</i> | Wound-Rotor Synchronous Generator |