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Research proposal- Small Hydropower Impact on-Grid Stability -A case study at Mardan II grid and Relevant 132KV Network

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RESEARCH PROPOSAL - PRESENTATION AND FORMAT GUIDELINES

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In order to have clear understanding of your research proposal it is essential that the proposal be written in plain language, brief, defining technical terms and not assuming any prior knowledge of the research committee.

The proposal will proceed to the faculty postgraduate research committee for consideration and approval. Sometimes revisions will be requested before the proposal can be finally approved. Do not be discouraged by this. Critical peer review is a normal part of the academic process and does not imply that you do not have the ability or your research will not be successful. It is simply a way of ensuring that the foundations for your research are as sound and strong as possible. Comments received from the committee needs to be reflected in amendments or redrafting as agreed with them.

We aim to ensure that you complete your thesis with the minimum of amendments and the most positive assessment by examiners. Approval of your research proposal is the first step on the journey to achieving an excellent outcome from your research leading towards the award of degree in the relevant field.

UNIVERSITY OF ENGINEERING AND TECHNOLOGY, PESHAWAR, PAKISTAN

POSTGRADUATE RESEARCH PROPOSAL

PROJECT TITLE	Small Hydropower Impact On Grid Stability
DEPARTMENT AND SPECIALIZTAION	Electrical Engineering Department *AND* Electrical Power
STUDENT NAME	Nageen Jalal
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RESEARCH SUPERVISOR	*Engr.Iftikhar*
CO-SUPERVISOR (IF ANY)	

COURSES STUDIED

S. NO.	COURSE NO. AND TITLE	GRADE
1.	**Power Electronics**	**B+**
2.	**Power system analysis-I**	**B**
3.	**Power system analysis-II**	**A-**
4.	**Power system operation**	**B+**
5.	**High Voltage engineering**	**A-**
6.	**Power system controls**	**B**
7.	**Research methodology**	**B**
8.	**Material science**	**A-**
9.	**Direct Energy conversion**	**A-**
	C.GPA	**3.39**

1. INTRODUCTION:

Small hydro projects can generally be categorized as either Run-of-River Developments or Water Storage (reservoir) developments, Run-of-river refers to a mode of operation in which the hydro plant uses only the water that is available in the natural flow of the river. A run-of-river plant can only supply all of the electrical needs of an isolated area or industry if the minimum flow in the river is sufficient to meet the load's peak power requirements.

The RETScreen International Clean Energy Project Analysis Software is the leading tool specifically aimed at facilitating pre-feasibility and feasibility analysis of clean energy technologies.Its standardized and integrated project analysis software which can be used worldwide to evaluate the energy production, life-cycle costs and greenhouse gas emission reductions for various types of proposed energy efficient and renewable energy technologies.

RETScreen International addresses a number of renewable energy electricity generating technologies. The widely applied technologies are wind energy, photovoltaic, small hydro and biomass combustion power technologies. Each model also includes integrated product, cost and weather databases [12].

The energy Model in the RET-screen requiring Hydrology Data of Machai Canal, Turbine specifications/Kaplan turbine,efficiencies,Drainage area will give the output power which will be given to the nearest grid i.e. Dargai Grid.

A power system is never in steady state small disturbances in the form of load changes and large perturbations in the form of transmission line tripping, faults, generator loop loss and large load changes occur .

The load data of 132Kv Dargai grid will be utilized in PSS/E software, i.e. Power System Simulator for Engineers.in PSS/E 132KV Network will be designed taking the nearest 132KV grids and respective Power plants that are connected to the Network along the 20MW Dargai Power Station as Branches. After building 132 KV Network the Load flow analysis will be carried out using the available load data of 132KV Dargai grid. Then Dynamic simulation will be carried out which is the study of voltage and frequency at 132KV line at any particular instant along with the amount of connected load at that instant.

Dynamic analysis is used for detailed study of voltage collapse situation and co-ordination of protection and control of generating unit and transmission Network [10].Dynamic simulation is also used whether and how steady state equilibrium point will be reached [10]. Stability involves study of dynamics of system about equilibrium point-initial -condition. [11]

Load-flow analysis, also known as Power-flow, is a common and important tool in power system studies. The basic information gathered from the load-flow studies is the magnitude and phase angle of a voltage at each bus in a system as well as the real- and reactive power flow through the different components. By which, a various operational parameters under different conditions, such as real and reactive losses, can be derived. These attributes are important in investigation, design and comparison of the different options for the connection between the grid and the hydro power plants. Additionally the network configuration and setup for the load-flow analysis will be used to form the basis for the subsequent work related to the power system [3].

In performing Power Flow/Load Flow and stability analysis theoretic analysis of the numerical algorithm such as Convergence, efficiency and numerical stability have a direct bearing on the algorithm implementation [4].

Grid connectivity enables setting up relatively large-scale systems and can operate at high plant load factors improving the economic viability of the operation [1]. In a grid-connected power system the grid acts like a battery with an unlimited storage capacity. Seasonal load variations affects grid efficiency due to which the overall efficiency of a grid connected system will be better than the efficiency of a stand-alone system.

Voltage stability, which is related to the ability of the power system to maintain acceptable voltages at all buses in the system under normal operating conditions and after being subjected to a disturbance.

It is usual to consider voltage instability as a local problem, while a voltage collapse is considered to involve voltages in a larger part of the system. Frequency Stability related to dynamics which influence the system frequency in the range from typically 10 seconds to 10s of minutes. Frequency stability is under the category Mid-Term or Long-Term stability. Physically, frequency stability can be related to issues like lack of active/reactive reserves, poor coordination of protection and inadequacies in system equipment [2].

Computational task like power flow calculations, fault analysis and stability analysis are performed to understand the various aspects of operation of power system.

Power flow solutions provide guidelines for economic dispatch, fault analysis and stability analysis. The analysis of 132KV Network in PSS/E underlines all these computational tasks. Newton Raphson method is generally employed for power flow solutions of any Network in PSS/E. [4]

1.1 The research problem

Stability analysis of 132 KV Dargai grid by integrating Machai Hydropower plant once modelled in RET screen. Dynamic simulation of 132KV network and load flow studies of 132KV Dargai Grid using PSS/E software.

1.2 The purpose of the study

This study is undertaken to solve the issue of stability analysis of most of the Hydropower plants generally at Khyber Pakhyunkhwa.taking specifically the case of Machai Hydropower plant modelling it in RET screen and integrating it to the 132 KV Dargai grid load flow studies of the grid and its Dynamic simulation/transient condition.

1.3 The objectives of the study

1. Establishing 132 KV Network in PSS/E.
2. Load flow studies of Dargai grid using load data of 132 KV Dargai Grid.
3. Dynamic simulation of 132 KV Network i.e. its voltage and frequency limits checking.

1.4 The research questions

1. Whether the 132kv grid is stable (within the capacity of the grid i.e, 200 MW) once another hydropower plant is integrated?
2. Whether the Dynamic simulation is within stability limits (they meet convergence)?
3. Whether the load flow studies of the same grid has been carried out before in PSS/E?
4. Whether the time frame of the Dynamic simulation and connected load is same?

SECTION 2: CONTRIBUTION TO KNOWLEDGE & STATEMENT OF SIGNIFICANCE

2.1 **Contribution to Knowledge (Academic Contribution)**:

Khyber pakhtunkhwa has the largest potential in Hydel.Most of the power plants are owned by IPPs and most of them are working under the Government Authority, PEDO.The benefit of this research is that it will provide a guide line to the stability analysis of Hydel power sector taking the specific case of Machai and analysing 132 KV Dargai Grid for stability which will be analysed in PSS/E comprising of Power Flow/Load Flow and Dynamic simulation/transient conditions.

2.2 **Statement of Significance (Practical Contribution)**

Stability analysis has not been carried out for Hydropower plants at Khyber pakhtunkhwa. This research will address the problem of stability analysis of Hydel sector.as the case of Machai HPP has been taken specifically and as the Machai HPP is not operational yet, i.e. grid accessibility has not been given ,so prior to grid accessibility Machai HPP integration to 132Kv Dargai Grid will be studied in PSS/E.132kv Network stability analysis will be carried out in PSS/E consisting of two phases one is load flow analysis and second is dynamic simulation.

SECTION: 3 LITERATURE REVIEW AND CONCEPTUAL FRAMEWORK

A power system is never in steady state small disturbances in the form of load changes and large perturbations in the form of transmission line tripping, faults, generator loop loss and large load changes occur.

In a power system, power flows from generating station to the load through different branches of the network. The flow of active and reactive power is known as load flow or power flow. Load flow analysis is an important tool used by power engineers for planning and determining the steady state operation of a power system.

Load-flow studies also known as Power flow studies provide a systematic mathematical approach to determine the various bus voltages, phase angles, active and reactive power flows through different branches. Generators, transformer settings and load under steady state conditions. Electric circuit which consists of generators, transmission Network and Distribution Network is used to model an electric Power System [5].

Various operational parameters under different conditions, such as real and reactive losses, can be derived from Load Flow analysis. These attributes are important in investigation, design and comparison of the different options for the connection between the grid and the hydro power plants. Additionally the network configuration and setup for the load-flow analysis will be used to form the basis for the subsequent work related to the power system [3].

Grid connectivity enables setting up relatively large-scale systems and hence they can operate at high plant load factors improving the economic viability of the operation [1]. In a grid-connected power system the grid acts like a battery with an unlimited storage capacity. Seasonal load variations affects efficiency of the grid due to which efficiency of grid connected power system will be higher than that of a stand-alone system of large system [11].

Computational task like power flow calculations, fault analysis and stability analysis are performed to understand the various aspects of operation of power system. [11]

Power flow solutions provide guidelines for economic dispatch, fault analysis and stability analysis. The analysis of 132KV Network in PSS/E underlines all these computational tasks. Newton Raphson method is generally employed for power flow solutions of any Network in PSS/E. [4]In performing Power Flow/Load Flow and stability analysis theoretic analysis of the numerical algorithm such as Convergence, efficiency and numerical stability have a direct bearing on the algorithm implementation [4]. Stability studies are carried out so that the system can withstand credible disturbances. [6] Stability studies are used to determine the operating limits of an existing system i.e. 132Kv Network.

Dynamic analysis is used for detailed study of voltage collapse situation and co-ordination of protection and control of generating unit and transmission Network [10].Dynamic simulation is also used whether and how steady state equilibrium point will be reached [10]. Stability involves study of dynamics of system about equilibrium point-initial -condition. [11]. Power flow programs e.g. PSS/E calculates this equilibrium. [6]Power system is a nonlinear dynamic system.so stability study is the study of nonlinear dynamics. [11]it's the ability of a power system to regain a state of equilibrium after being subjected to a physical disturbance, with most variables bounded so that practically entire system remains intact.it means that real/reactive power balance for load and generation is maintained, voltage and frequency is also maintained at an equilibrium operating condition.so practically the entire system remain intact, even after the disturbance. [11]

Voltage stability relates the ability of the power system to maintain acceptable voltages at all buses in the Network under normal operating conditions and after being subjected to a disturbance. Voltage instability is associated with relatively slow variations in network and load characteristics [8].The power transfer over a transmission Network is limited by the inductive reactance of transmission Network causing voltage drop leading to voltage instability.

Voltage instability is mainly caused by the loads; in response to a disturbance, power consumed by the loads tends to be restored by the action of distribution voltage regulators, tap changing transformers and thermostats.

Restored loads increase the stress on the high voltage network causing more voltage reduction. [8]

Frequency stability is related to dynamics which influence the system frequency in the range from typically 10 seconds to 10s of minutes. Frequency stability is under the category Mid-Term or Long-Term stability. Physically, frequency stability can be related to issues like lack of active/reactive reserves, poor coordination of protection and inadequacies in system equipment [2].

Rotor angle stability is basically generator stability while voltage stability means load stability. At equilibrium the rotor angle is a measure of the amount of power injected by generator into the Network [6].

Power transfer over a transmission line is limited due to rotor angle stability. The rotor angle instability and voltage instability go hand in hand [8]. Rotor angle stability is interlinked to real power transfer. Voltage stability is mainly related to reactive power transfer. Reactive power control affects rotor angle stability [7]. In a large interconnected power system voltage instability may occur while rotor angle stability is still maintained and generator continues to remain in synchronism. Energy import and export occur according to grid demand. [9]

SECTION 4: APPROACH AND METHODOLOGY

1. Modeling Machai Hydropower plant in RETscreen by Plotting its Flow Duration Curve in Ms-Excel.

2. Optimization of Machai HPP in RETScreen and its Emission Analysis/GHG Emission analysis.

3.Financial Analysis in RETScreen

4. Designing 132KV Network in PSS/E (Power System Simulator for Engineers)

5. Integrating Machai-HPP with the 132 KV Dargai Grid.

6.Using Load data of the same area carrying out load flow analysis of 132KV Network.

7. Dynamic Simulation of 132KV Network and drawing its channel plot.

- **Data Collection:**
- Hydrology data for Machai canal will be required to model a Hydropower plant in RETscreen.Turbine specifications, efficiencies and drainage area values will be required.this data will be analysed on RETscreen and energy model will be developed with the help of this data.

- After building energy model optimization of Machai HPP will be done in RETScreen.
- Load data of the same location i.e. upstream location of Machai i.e.Dargai will be required to analyse the grid for load flow and dynamic simulation on PSS/E.
- In the first phase energy model will be developed with the help of Hydrology data.
- In the second phase optimization of Machai HPP will be carried out.
- In the fourth phase environmental and sensitivity analysis will be carried out using RETscreen software.
- In the fifth phase the output power from energy model will be given to grid i.e. Machai hydropower plant will be integrated to the grid.
- In the sixth phase the load data of 132KV Dargai grid will be used for load flow studies of the grid and Dynamic simulation.

This will address the issues of stability study of the grid which has not been carried out yet at Khyber Pakhtunkhwa taking the specific case of Machai Hydropower plant.

SECTION 5: BUDGET AND FEASIBILITY

Show expected costs relevant to the proposed research. You may budget up to Rs:30,000 for the research project from Board of Advanced Studies and Research (BOASAR).

a. **Proposed starting date**

b. **Expected date of completion**

c. **Are facilities available for the work?** **Yes**

d. **Additional facilities required give details.** **Nil**

(Print details here)

Itemized Expenses: (details of expenditure).

Item Cost

Total Rs:

<u>For Section-5 Budget and feasibility</u>

i) Expenditure on all those items which become the property of the Department should be met by the University. To name some of them:-

(a) Books. Journals, photocopying charges from a book which is not available in our Libraries (the photocopy is registered in the Library stock and then issued to the scholar).

(b) Equipment, material and other such things which the supervisor/Chairman/Director Postgraduate Studies/Secretary BOASAR, deem fit to be purchased by the University.

ii) Preparation of maps, Drawings typing of thesis and purchase of material for all these shall not be paid by the university.

iii) Labour charges of any kind, hired by the scholars are not permissible.

iv) Any kind of travelling charges/allowance shall not be paid by the University.

v) No funds will be provided for literature review, transportation, labour or printing of the thesis etc.

vi) It will be the duty of the Postgraduate Advisor to ensure that the materials/equipment bought for the project shall be retained in the department.

vii) The budget of the proposal should not be more than Rs. 30,000/-

SECTION 6: SCEDULE

Include a plan of expected progress in Gantt chart form. A sample is provided below:

Activity	2016?				2016?			
		October	November	…..	January	….	……	
Literature Review								
Phase 1								
Phase 2								
Phase 3								
Thesis Write up								
Submission								

SECTION 7:REFERENCE LIST

[1] "Grid-connected versus stand-alone energy systems for decentralized power—A review of literature" Deepak Paramashivan Kaundinya *, P. Balachandra, N.H. Ravindranath

[2] "Case Studies on System Stability with Increased RES-E Grid Integration",2005

[3] "Planning and analysis of a grid connection for future hydro power plants", Claus Leth-Bak,2012

[4] "Advanced Electric power Network analysis"Booming Zhang,Zheng Yan.

[5] " Analysis of the Load Flow Problem in Power System Planning Studies", Olukayode A. Afolabi, Warsame H. Ali, Penrose Cofie, John Fuller, Pamela Obiomon,Emmanuel S. Kolawole,30 Sept 2016

[6] " Embedded Generation" Nikolas Genkins,2000

[7] "Power System Analysis and Design"B.R.Gupta,S.Chand

[8] " Power System Dynamics and Stability", Richard G. Farmer

[9] " Hydro and Wind Power Integration: A Case Study of Dargai Station in Pakistan", July 6, 2012

[10] "Power System Stability and Control",Prabha Kundur

[11] "Power Sysem Analysis"IIT Kharagpur,Prof A.k. Sinha

[12] "Clean Energy Project Analysis RETScreen® Engineering & Cases " Third Edition

Nageen Jalal Signature and Date:

Recommendation of the Supervisor M.Iftikhar Khan

Remarks:

Recommendation of the Co-Supervisor

Remarks:

Recommendation of the Post-Graduate Advisor

Prof.Dr.Muhammad Naeem Arbab
Signature and Date:

Remarks:

Recommendation and Signature of Project Research Evaluation Committee (PREC):

1.Prof.Dr.Naeem Arbab
Signature and Date:

2.Prof.Dr.Syed Waqar Shah
Signature and Date:

3.Prof.Dr.Amjadullah Khattak

Remarks:

Signature and Date:

Approval by Chairman

Remarks:

Electrical Department

Department chairman
Dr.Syed Waqar shah

s

Recommendation of Secretary

Print Advisor Secretary
BOASAR Name Here

BOASAR

Recommendation of The Dean Faculty	**Prof.Dr.Noor Muhammad**	Signature and Date:

Approval by the Vice Chancellor

