Study Committee B4

DC Systems and Power Electronics

Paper 11120_2022

FACTS WITH ENERGY STORAGE FOR RENEWABLE INTEGRATION IN GEORGIA POWER SYSTEM

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Motivation

- Georgia plans to utilize its untapped abundant wind and solar energy resources
- Georgia power system is a relatively small and characterized with low inertia and lack of flexibility. In an isolated operational mode, even small disturbance can lead to severe outages.
- Variable nature of wind and solar energy and consequent fluctuating power output has a negative impact on the system stability and security of supply
- The aim of the study is to investigate the potential positive impact of FACTS with BESS systems on the renewables integration in Georgia power system

Method/Approach

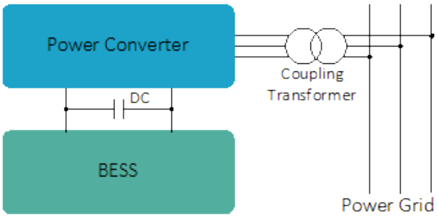
- Multidomain modeling and simulation of power system is the main method used in this study
- Three main simulation domains are considered for the system investigation
    - Load flow simulations
    - Quasi dynamic simulations
    - Dynamic simulations
- All the simulations are performed by comparative approach. Each and every scenario was modeled for two main cases:
    - CASE1: the modeled system operates without FACTS and energy storage
    - CASE2: the modeled system has integrated FACTS with energy storage
- For the scenarios, where the storage system is switched off, the voltage and frequency control functions are distributed to different systems elements

Objects of investigation

- The object of investigation on the one hand is the FACTS with BESS system and on the other hand Georgia power system itself
- The main goal is to investigate the behavior of the power system in different static, and dynamic simulation scenarios
- The contribution of FACTS with BESS system into primary frequency regulation, voltage profile improvement, oscillation damping and load peak shaving are the main aspects to be investigated under this study

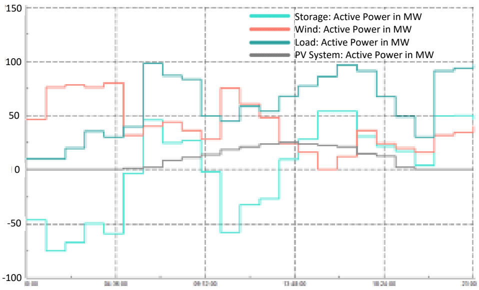
Experimental setup & test results

- Power system is modeled as an equivalent system designed for multidomain simulations. FACTS system is modeled as static synchronous generator with BESS connected the DC bus.



Discussion

- The diagram below depicts the postive impact of the high flexibility and smart control of FACTS with BESS system. It follows the load and generation profiles and optimizes usage of energy stored in BESS. For example, it consumes energy to charge the batteries during the night minimum, because the load is at its minimum and the wind generation is available.



Conclusion

- VSC based FACTS system combined with electrical energy storage system significantly improves the system stability in several aspects
- Combined system improves the network voltage profile by enabling continuous voltage control mode.
- It also enhances primary frequency regulation by near to zero delay activation of the active power reserve and on top of that mitigates the power fluctuations coming from renewable power stations
- It easily manages to shave the load peaks during the high consumption scenarios

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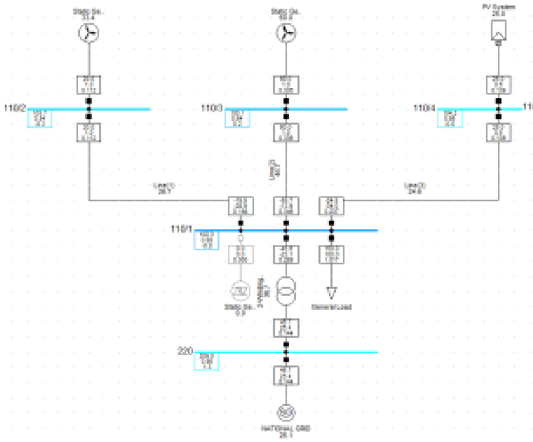
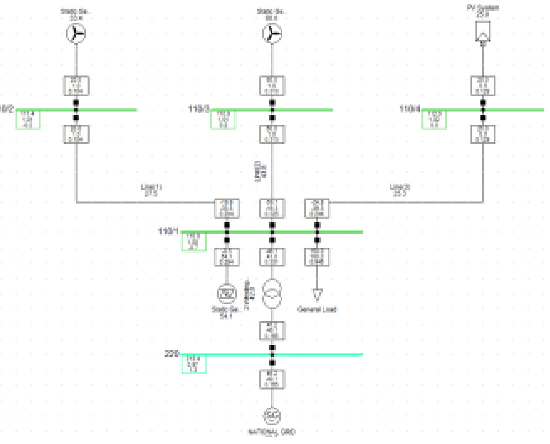
Load flow for CASE 1



Load flow for CASE 2



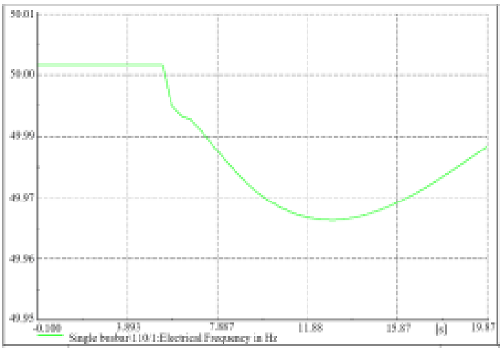
Voltage profile for CASE 1

Busbar Name	Nominal Voltage (kV)	Voltage (p.u.)	Voltage Magnitude (kV)	Voltage Angle (Degree)	Voltage Deviation (%)
SB1 220	220	0.95	209	1.30	- 5
SB2 110/1	110	0.93	102.31	- 0.84	- 7
110/4	110	0.947	104.22	- 0.00	- 5.3
110/2	110	0.942	103.66	- 0.29	- 5.8
110/3	110	0.937	103.12	0.19	- 6.3

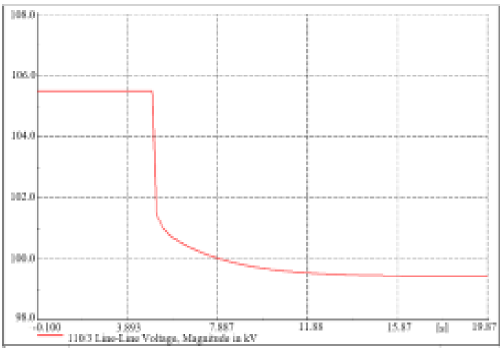
Voltage profile for CASE 2

Busbar Name	Nominal Voltage (kV)	Voltage (p.u.)	Voltage Magnitude (kV)	Voltage Angle (Degree)	Voltage Deviation (%)
SB 1 220	220	0.97	213.4	1.27	- 3
SB2 110/1	110	1	110	- 0.70	0
110/4	110	1.018	111.96	- 0.00	+ 0.18
110/2	110	1.013	111.38	- 0.24	+ 0.13
110/3	110	1.007	110.78	0.19	+ 0.07

Wind power plant outage C1 - Frequency



Wind power plant outage C1 - Voltage



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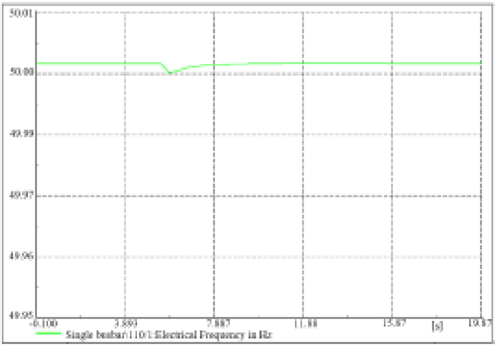
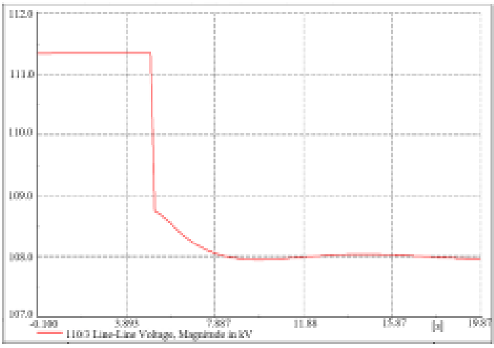
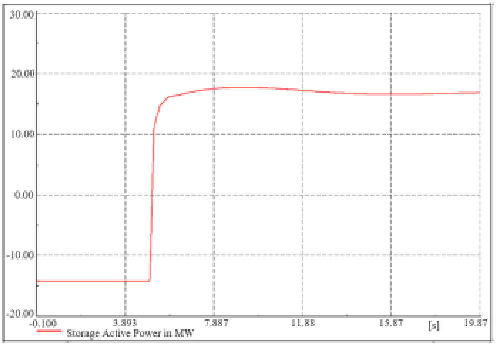
Wind power plant outage C2 - Frequency



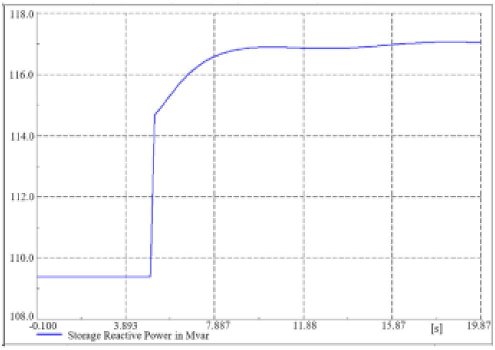
Wind power plant outage C2 - Voltage



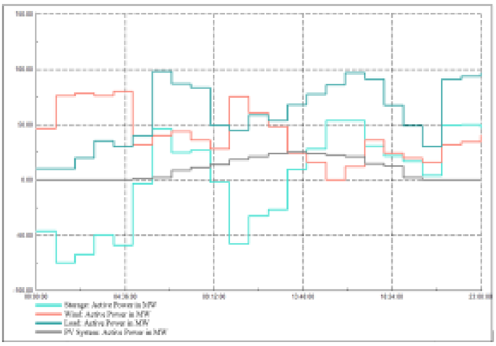
Active power response from FACTS



Reactive power response from FACTS



Quasy dynamics –active power curves



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