Study Committee C6

Active Distribution Systems and Distributed Energy Resources

11119_2022

RENEWABLE ENERGY HYBRID MINI-GRID CONCEPT FOR RURAL ELECTRIFICATION IN GEORGIA

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Motivation

- Georgia has several high mountainous regions with either lower level of electrification or no electrification at all. Such regions experience similar challenges in gas supply as well. The main source of energy used by locals is lumber.
- In winter due to heavy snow and avalanches mountainous regions are isolated from the rest of the country.
- Deployment of RES hybrid mini-grid coupled with BESS can help to cope with those challenges as it supports RES utilization, minimize use of lumber and fuel and mitigates green house gas (GHG) emissions, while increasing the rural electrification level of the country.

Method/Approach

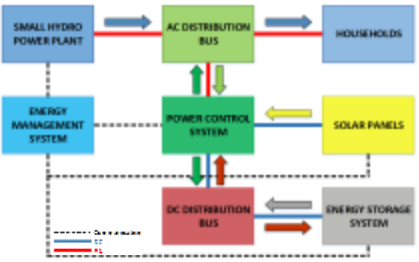
- Taking into account the characteristics of such regions, at the first stage the main concept for renewable energy hybrid mini grid was developed
- Then the multidomain modeling and simulation method was used to test the concept of the system.
- Three main simulation domains are considered for the system investigation
  - Load flow simulations
  - Quasi dynamic simulations
  - Dynamic simulations

Objects of investigation

- The main objects of investigation is the performance of the conceptual mini-grid and behavior of its components in different operational scenarios.
- The contribution of BESS system to mini-grid's active power support, voltage profile improvement and load peak shaving are the main aspects to be investigated under this study
- Three main scenarios are examined:
  1. BESS response to excess PV generation and observation of peak load coincidence with sHPP and PV output
  2. Investigation of BESS response to hybrid mini-grid generation deficit
  3. Investigation of potential positive impact of BESS on voltage regulation and reactive power support

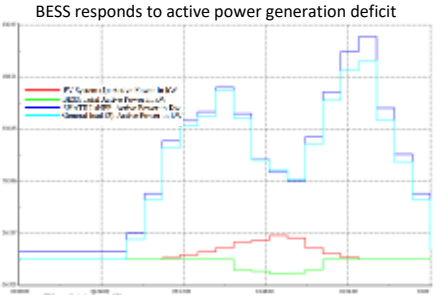
Experimental setup & test results

Conceptual mini grid is modeled as a small system with generation, storage, consumption elements and energy management system. The mini-grid model is designed for load flow, quasi dynamic and dynamic simulations



Discussion

- Result of quasi dynamic simulations show how the BESS responds to active power generation deficit



Conclusion

- According to the simulation results, it can be concluded that renewable-renewable coupled mini-grid together with BESS can ensure stable and reliable operation of off-grid system
- BESS can effectively contribute into energy time-shift, thus in peak shaving and ensures security of electricity supply. BESS was charged either from sHPP or from solar PVs based on the available excess generation sources.
- The BESS improves voltage profile of the mini-grid by introducing the reactive power support. It was able to provide fast response to the sudden disconnection of solar PVs output and managed to provide PVs' equivalent power almost instantaneously.
- Simulations have shown that this concept is promising and supports to electrify mountainous regions isolated from the national electric grid.

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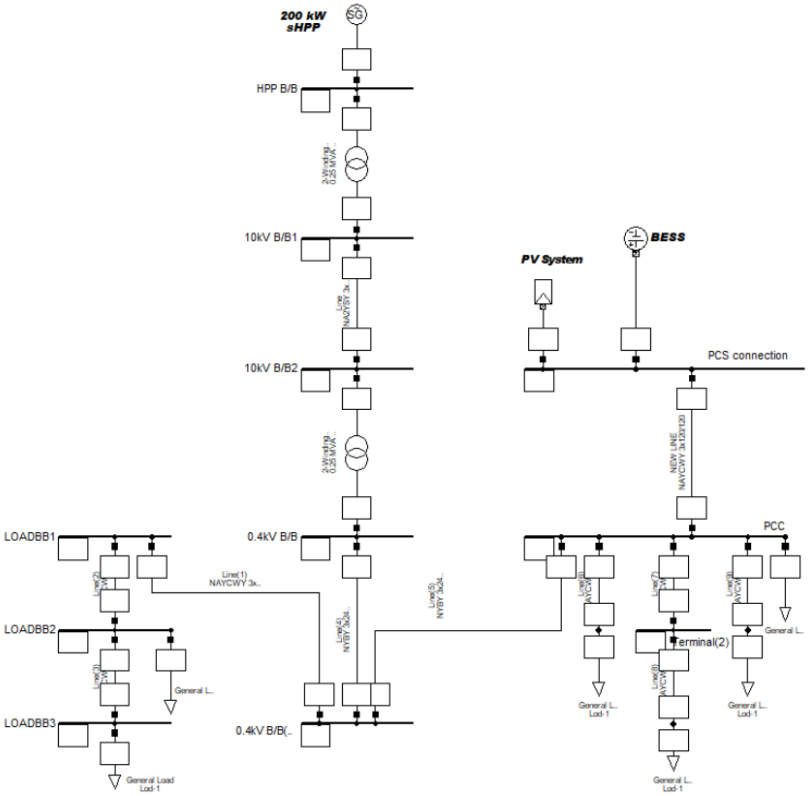
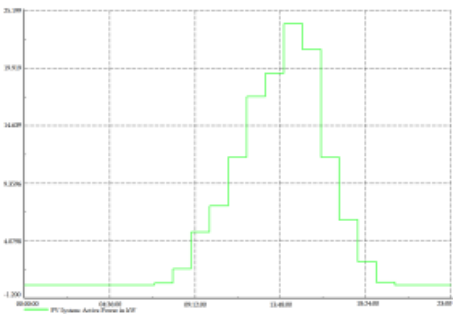
continued

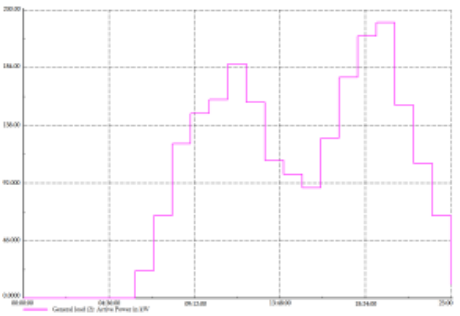
Single line diagram of modeled hybrid mini-grid



Solar daily pattern over summer



Aggregated load response



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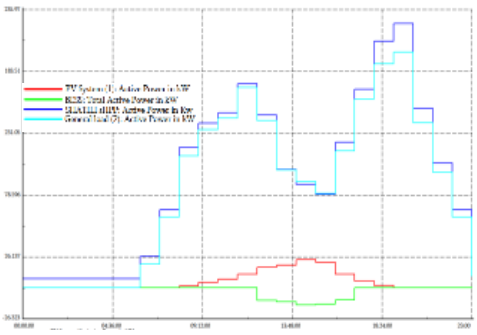
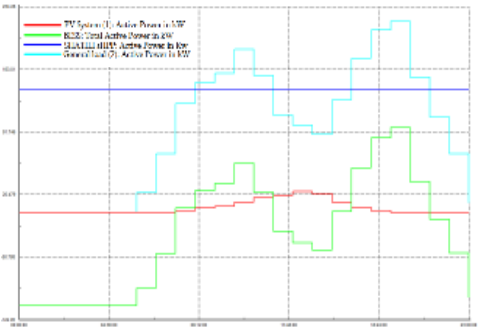
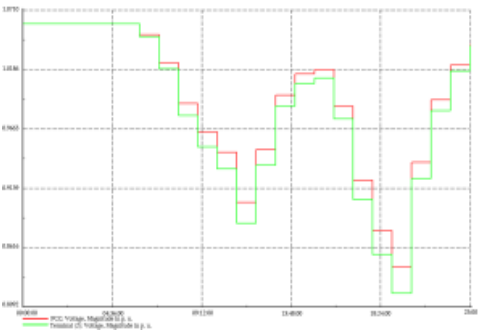
Quasi-dynamics, basic conditions



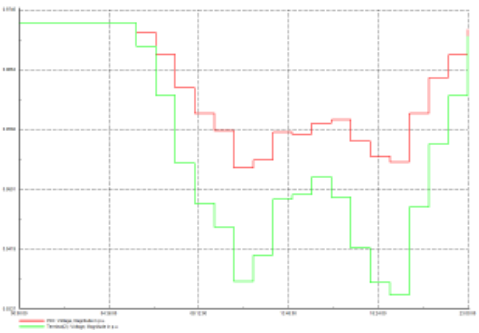
Quasi-dynamics, sHPP=140 kW



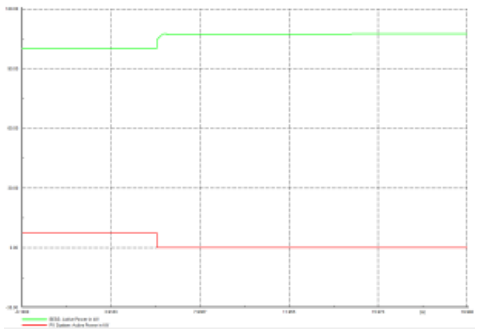
Voltage, without PVs and BESS



Voltage, with PV and BESS



BESS dynamic response



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