# Grid impact analysis of hybrid energy storage systems

2,3
Kaiser Josef SEDILLO [(1)], Dr. Wilhelm SÜßENBACHER [(2)]
[(1) (2)]University of Applied Science Upper Austria

## INTRODUCTION

The increase penetration of renewables energies in the grid poses a unique challenge due to the decrease in rotational inertial. In addition, high renewable energy penetration causes overgeneration or participation errors due to its intermittency. [1] A hybrid energy storage system (HESS) is a fast frequency response ancillary service that provides synthetic inertia which combines a high-power density ultracapacitor system with a traditional large energy battery reserve. [2] The aim of this study is to develop a system level model which illustrates the integration, control, operation and capability of HESS as frequency containment and restoration reserves within a multi-area network. The grid impact analysis will also provide data for a cost comparison to traditional large-scale battery pack solutions. Thus, optimizing the requirements for such facilities.

## METHODOLOGY

Through simulations in DigSILENT PoweFactory™, a modified PST16 grid benchmark was evaluated. Different wind energy penetration levels were tested under the "requirements for grid connection of generators" according to "Commission Regulations (EU) 2016/631". [3] A virtual inertia machine was programmed within the HESS blocks of the software to emulate droop-based control together with a swing-equation topology. The system is integrated to a TYPE IV wind energy turbine which utilizes a back-to-back inverter and rectifier configuration. To represent this in the simulation, the energy storage system is connected to the AC-bus within the collective generation of the wind farm which simplifies to the whole simulation process.

The grid impact study focuses on four contingency measures – limited frequency sensitivity modes (underfrequency and overfrequency), islanding, voltage stability and fault-ride through. Each technical requirement has three operational scenarios tested at different renewable energy penetration levels. First, the base scenario which utilizes no energy storage serves as a control. Second, the homogenous scenario which utilize droop-only large-scale lithium battery packs. Third, the proposed HESS which utilizes the droop and swing synthetic inertia. The data for each simulation were collected and compared. The total HESS reserves were calculated which are then consolidated as part of the economic evaluation of the proposed system.

## RESULTS AND CONCLUSION

Based on the simulations and data of the grid impact study, the proposed HESS is able to meet the present regulations. It is capable of injecting sufficient synthetic inertia to mitigate high RoCoF and frequency fluctuations, whether it's an under or over frequency. The system also illustrates that it can operate during islanding even at high %REP. It is also capable of fault-ride through Moreover, further evaluation show that is compact, practical and feasible enough to be integrated in the existing grid infrastructure. Therefore, the solution proposed in this research could be a vital component in rebuilding the network to integrate more intermittent renewable sources.

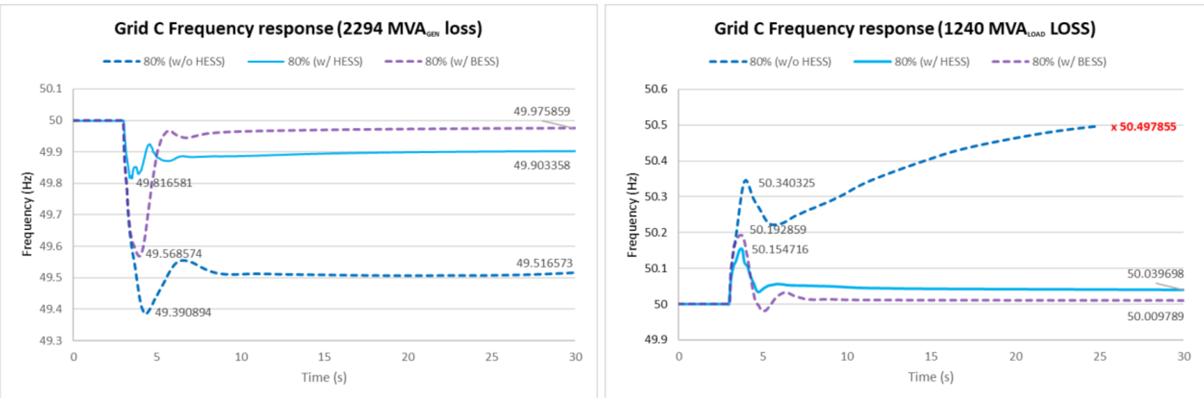


*Figure 1. Sample grid frequency response.*

## REFERENCES


[1] „Dispersed Generation Impact on CE Region Security," ENTSO-E, Brussels, 2014.

[2] N. Chang und Y. Kim, Design and management of energy-efficient hybrid electrical energy etorage systems, Springer, 2014.

[3] European Commission, „Establishing a network code on requirements for grid connection of generators," *COMMISSION REGULATION (EU) 2016/631,* 14 April 2016.