Study Committee C4

Power system technical performance

Paper ID 10381

Active and reactive power control in an island system operated on inverter-based resources

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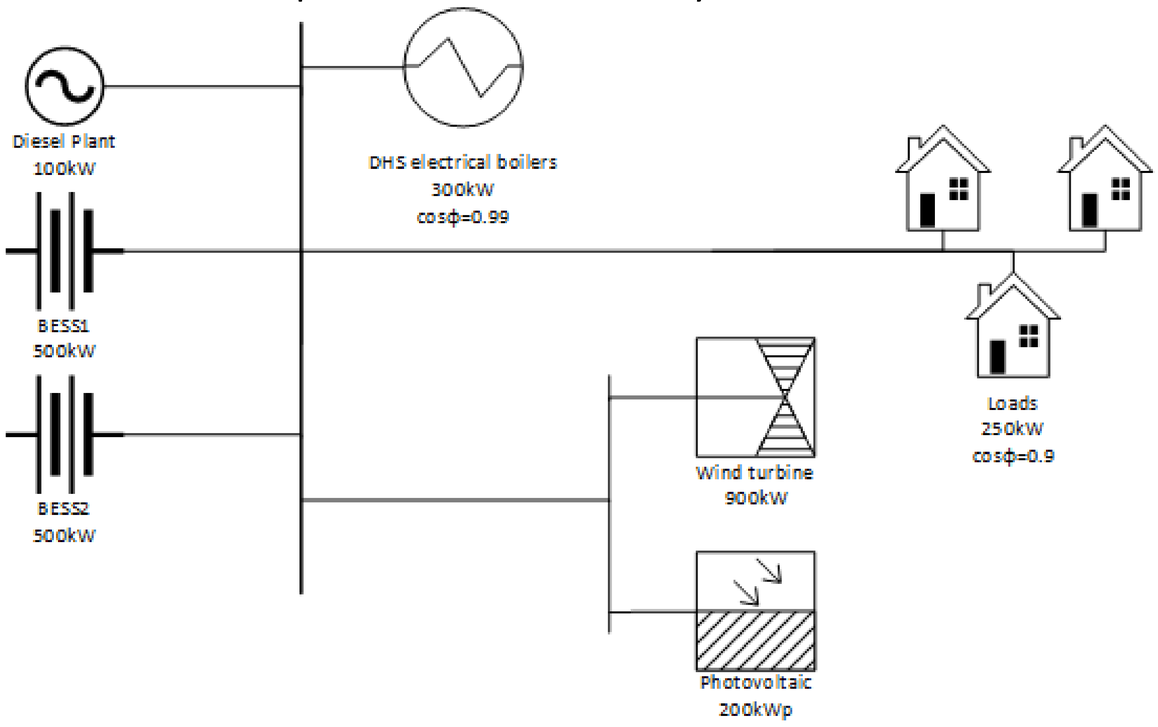
Introduction

- **Synchronous generators' substitution from inverter-based resources** (IBRs) reduces inertia, negatively affects frequency regulation & **requires IBRs shifting to "grid-forming" modes**
- **The implementation of such converter control principles in BESS is investigated**, using the small Greek island system of Ag. Efstratios (aiming for RES share >85%) as a study case

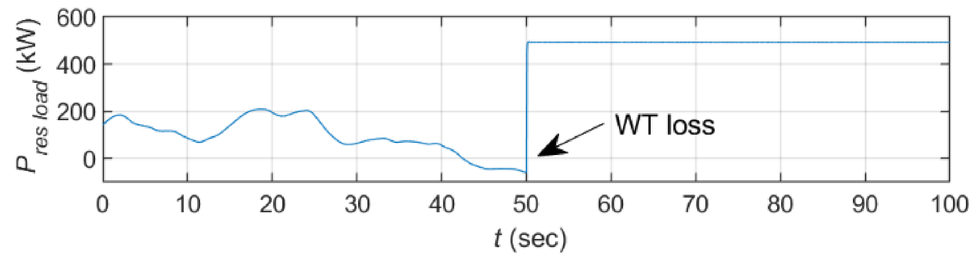
Study case island system

- The main components of the island system are shown below:



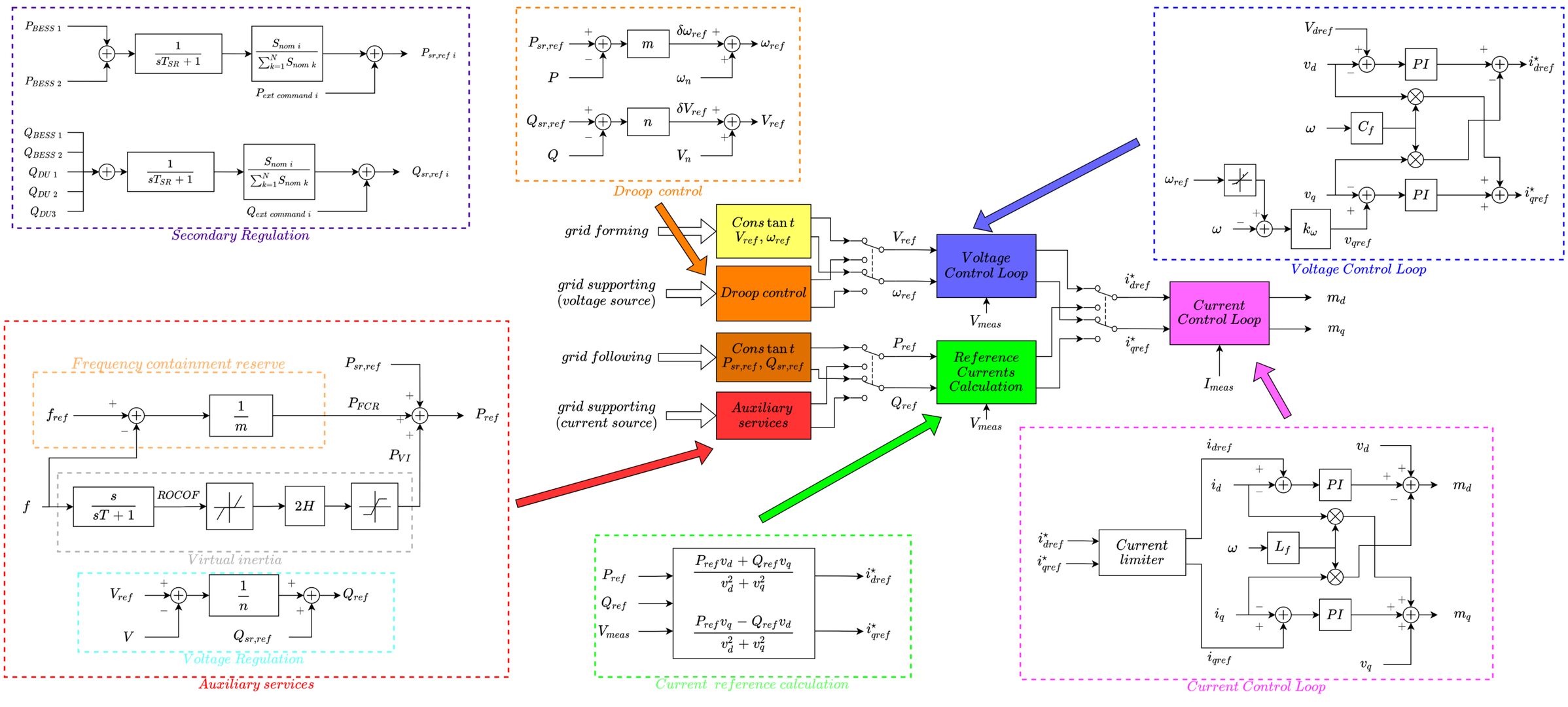
Simulated conditions

- The system **response is simulated** for a 100 s time interval, following a **major contingency**: a disconnection of the largest unit (wind turbine of 900 kW)
- RES do not provide frequency regulation services (grid feeding mode)
- The residual system load (load – RES production) is illustrated below:



BESS control schemes

- BESS converter control principles implemented (**grid forming**, **following** & **supporting** – **current** / **voltage source**) are depicted below:



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Results: BESS control modes

- System response is examined for **3 BESS control modes**

BESS1 grid forming, BESS2 grid support. - current source (GS-CS)

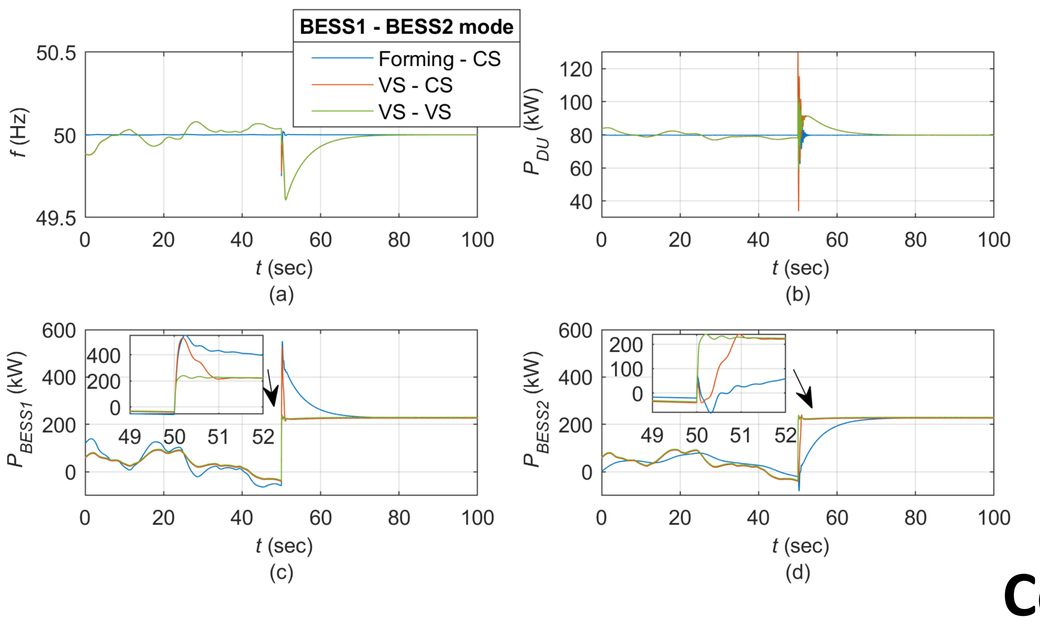
- Flat frequency response
- Fast reserves solely from BESS1
  - x Uneven stress amongst BESS
  - x BESS2 not fully utilized
- Reliability concerns in case of BESS1 loss

BESS1 GS-voltage source (GS-VS), BESS2: GS-CS

- BESS1 takes up the entire power imbalance immediately following the contingency
- BESS1 power change leads to a frequency change, "communicating" the power imbalance to BESS2 & diesel unit (DU), providing primary reserves → Improved power distribution amongst units
- Reliability concerns in case of BESS1 loss

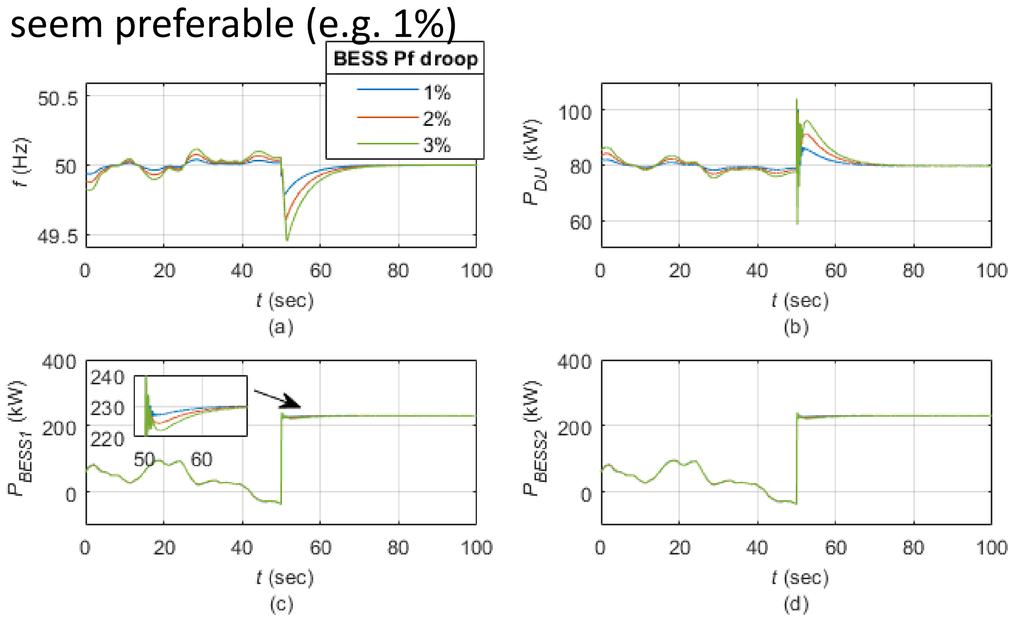
BESS1 & BESS2 GS-VS

- Equal power sharing amongst BESS in all time scales
- Redundancy in case of a BESS failure → Preferable mode (implemented in all the right-hand side simulations)



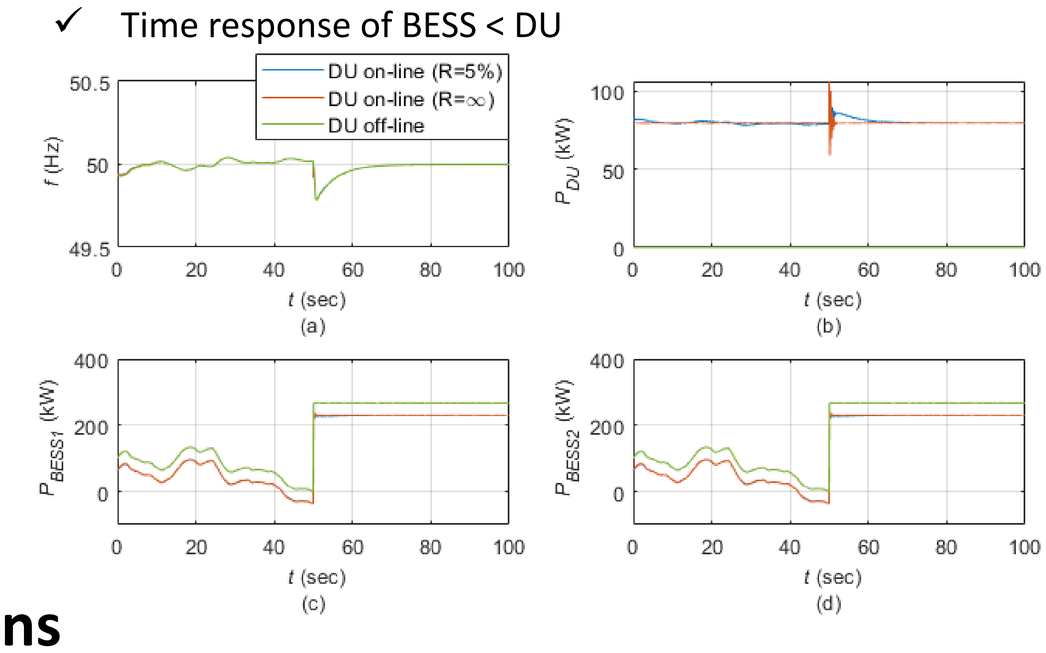
Results: BESS droop coefficients

- Simulation results for BESS droop coefficients (R) of **1%**, **2%** & **3%** are illustrated below
- ↑R → ↑Δf caused deliberately by the BESS controller → ↑contribution to primary regulation of other units
- Small DU size → insignificant contribution → small R values seem preferable (e.g. 1%)



Results: Operation with 100% IBRs

- Response shown for **100% IBRs share**, in comparison to having a DU on-line (**with** & **without** providing primary reserves)
- No observable difference in frequency response with and without DU contribution to primary reserves
  - ✓ DU size is 1/10 of the two BESS combined
  - ✓ Droop coefficient of BESS (1%) < DU (5%)
  - ✓ Time response of BESS < DU



Conclusions

- Operating **both BESS in grid supporting – voltage source mode is preferable**:
  - ✓ Fully utilizing BESS regulating capabilities
  - ✓ Equally sharing the stress amongst the both BESS
  - ✓ Reassuring continuity of service if one BESS trips
- Configuring small **DUs in a less frequency sensitive mode seems preferable**, to reduce their wear and tear
- **System operation without any synchronous generator is perfectly feasible**

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