C4 – Power System Technical Performance

PS 3 / Challenges and Advances is Power System Dynamics

Paper ID : 10931

Taking advantage of grid-forming BESS behaviour during major outages: contribution to improve the share of renewable energy in French isolated power systems

Guilherme SANTOS PEREIRA, Fabien BENAVENT, Jakub WITKOWSKI and Grégoire PRIME – EDF

Motivation

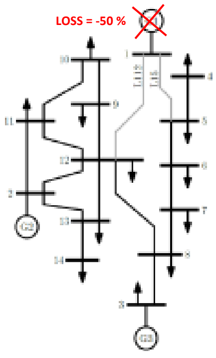
- EDF large isolated systems have an objective to reach 100% renewable generation in the next few decades
- GFo BESS is a well-known solution to stabilize microgrids but fewer work has been done on larger Island systems.
- UFLS is part of frequency containment control in large French isolated systems
- Lack of studies on the operation of UFLS when grid frequency is defined partly or completely by GFo BESS
- **Aim of study:** evaluate the correct operation of UFLS and therefore frequency stability with different combination of SC and BESS in French isolated Systems

System	Yearly electric consumption	Renewable share	Main renewable sources
Guadeloupe	1700 GWh	34%	Solar, wind, biomass, geothermal
Martinique	1600 GWh	25%	Solar, wind, biomass
Réunion	3000 GWh	29%	Solar, wind, hydro, biomass
Guyane	1000 GWh	70%	Solar, hydro
Corse	2200 GWh	35%	Solar, wind, hydro, biomass

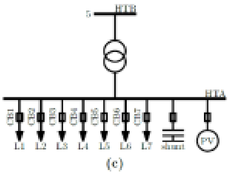
Large French isolated systems operated by EDF

Object of investigation and approach

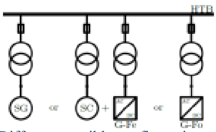
- Anonymized French isolated system phasor (RMS) PowerFactory model with different SC and BESS (either GFo or GFl) mix
- **Simulation event:** loss of power plant G1 (50% of total generation)
- Frequency Containment reserve cannot cover the loss of G1, therefore UFLS is necessary to stabilize the system frequency



Single-line diagram (SLD) of French isolated power system, incident is G1 Loss



Bus 5 representation : seven sheddable general loads, one bank of shunt capacitors, and one PV plant.

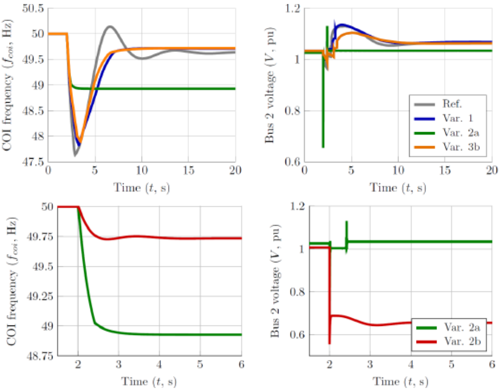


Different possible configurations for each power pant G2 et G3

Simulation setup

Variant	Reference	Var1 - SC + GFl BESS	Var2a - GFo BESS oversized	Var2b - GFo BESS undersized	Var3a/b - SC + GFo BESS
Consumption	240 MW				
Solar	30%	50%			
G1- loss	50% (LOST)				
G2	Conventional 10% of load 47MVA, 180 MWs 24MW/Hz	CS 47MVA, 180 MWs GFl BESS 24 MW/Hz	GFo BESS 47MVA, 180 MWs 24MW/Hz	GFo BESS 24 MVA, 180 MWs 24 MW/Hz	CS 47 MVA, 180 MWs GFo BESS 24 MVA, 72 MWs 24 MW/Hz
G3	Conventional 20% of load 112MVA, 490 MWs 56MW/Hz	CS 112 MVA, 490 MWs GFl BESS 56 MW/Hz	GFo BESS 112 MVA, 490 MWs, 56MW/Hz	GFo BESS 24 MVA, 490MWs, 56 MW/Hz	CS 112 MVA, 490 MWs GFo BESS 24 MVA, 72 MW.s 56 MW/Hz

Simulation results



Variant	Results
Reference	Steady, load Shedding : ~100 MW
Var1 - SC + GFl BESS	Steady, load Shedding : ~100 MW
Var2a - GFo BESS oversized BEST CONFIGURATION	Steady, load Shedding : ~35 MW Zero Load Shedding possible
Var2b - GFo BESS undersized	Unsteady, voltage collapse
Var3a - SC + GFo BESS	Unsteady, GFo BESS loss of synchronism
Var3b - SC + GFo BESS - new synchronism algorithm	Steady, load Shedding : ~100 MW

Conclusion

- GFo BESS operation during current/power limitation is of crucial importance for system stability and needs to be specified accordingly for future projects :
  - Var3a and var3b lead to different output
  - Var2b leads to system collapse
- Comparison between var1 and var3b : no clear interest of GFo compared to GFl if enough inertia is provided by SC.
- Field experiments seem necessary to address the on-the-ground aspects of GFo that are difficult to be captured through simplified models and simulation tools

VRES: Variable Renewable Energy source
SEI: Système Energétiques Insulaires
BESS: Battery Energy Storage System
GFo: Grid Forming
GFl: Grid Following
SC: Synchronous condenser
COI: Center Of Inertia
UFLS: Under Frequency Load Shedding

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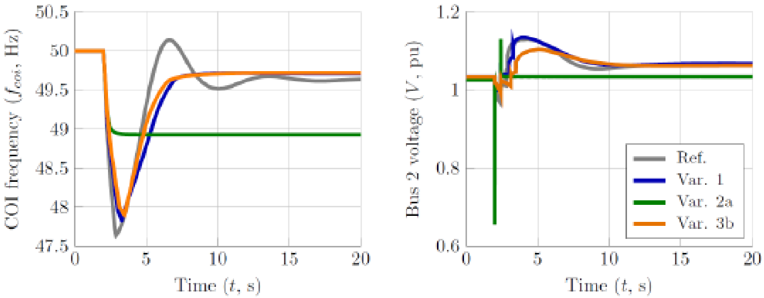
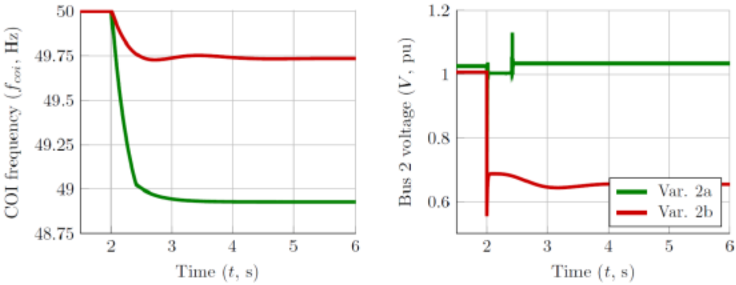
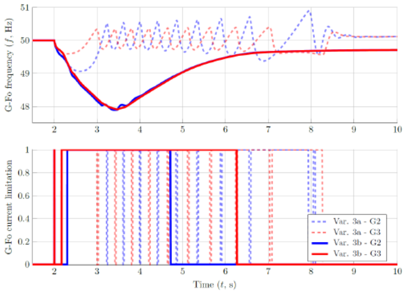
Stable cases: Ref, Var 1, Var 2a, Var 3b



Voltage collapse in case of undersized GFo (Var 2b)



Loss of synchronism due to the effect of current saturation (Var 3a)
Application of a modified synchronization algorithm (Var 3b)



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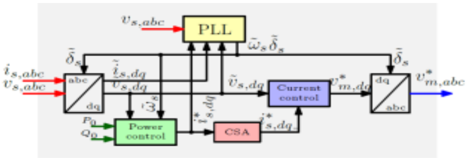
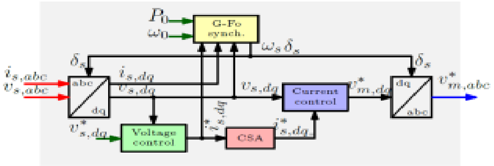
Grid Following control (a) and Grid Forming control (b)



(a)



(b)

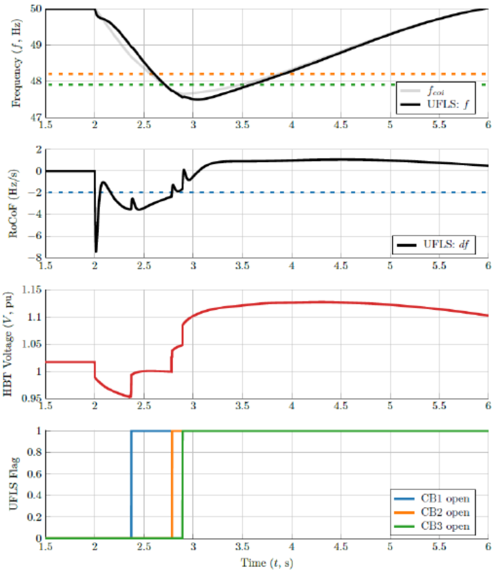
- **Var 3a:** active power used in G-Fo synch. is the measured active power
- **Var 3b:** active power used in G-Fo synch. is the product of measured voltages and unsaturated current references

$$P = v_{s,d} i_{s,d} + v_{s,q} i_{s,q} \qquad \text{(Var 3a)}$$

$$P_{unsat} = v_{s,d} i^*_{s,d} + v_{s,q} i^*_{s,q} \qquad \text{(Var 3b)}$$

Source: **K. V. Kkuni and G. Yang, "Effects of current limit for grid forming converters on transient stability: analysis and solution," Jun. 2021**

Illustration of Under Frequency Load Shedding operation



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