Frequency and Voltage Analysis of the Hybrid Power System in Suðuroy, Faroe Islands

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- Introduction
- Analysis approach
- Controls and modelling
- Results
- Conclusion

Agenda

Introduction

- The Power Company SEV
- 100by2030
- Electrically isolated from neighbouring countries and other islands
- 35 GWh in 2020
  - 84.9% thermal
  - 11.8% hydro
  - 2.8% wind
  - 0.5% solar

Suðuroy Power System

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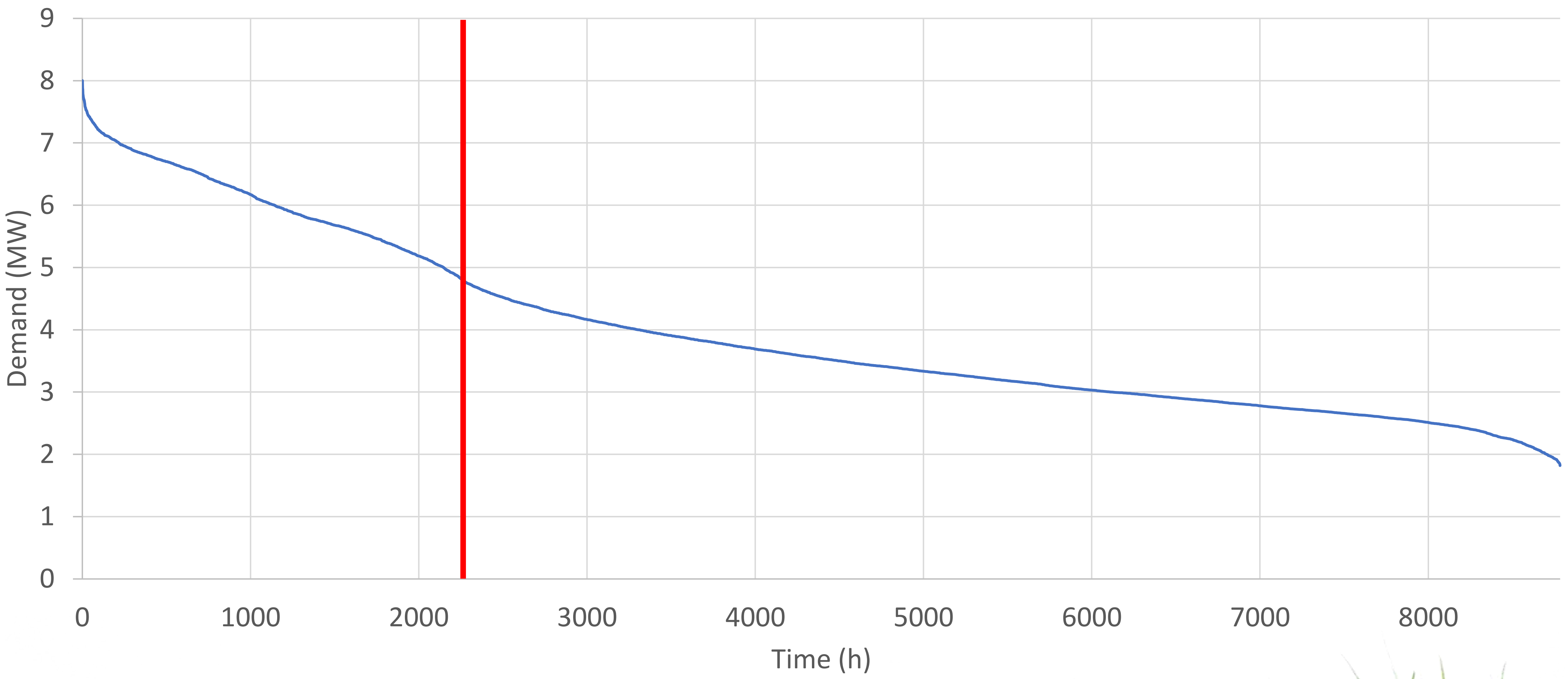
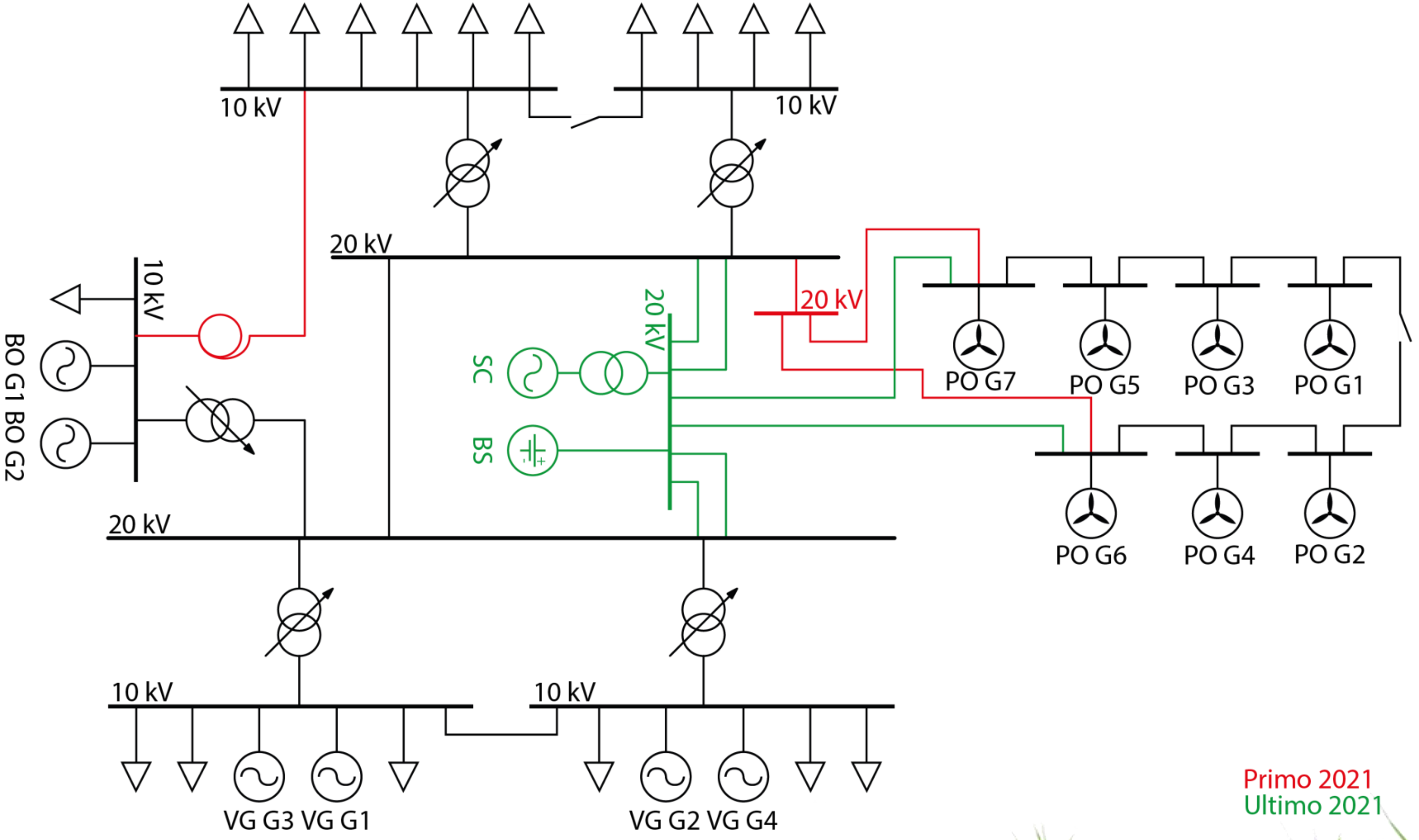
1921
3 MW
1982
13.4 MW
2019
0.26 MW
2021
6.3 MW



Load duration curve 2020

Planned expansions (2021)

- New substation
- Battery system
  - 7.5 MW/7.5 MWh
  - Energy storage **stabilizes frequency**
- Synchronous condenser
  - 8 MVA
  - Supports the grid with **instantaneous inertia** and **short circuit power**



Single line diagram

Analysis approach

Analyse the impact the current configuration with inverter based generation (IBG) has on voltage and frequency fluctuations, using a validated dynamic model of the power system.

Objective

Time period selected based on following criterias:

- All generation types should be online
  - Relatively high production by the PV panels
  - Stable wind conditions
- No starting and stopping of generators
- Weekday

Simulation cases:

1. Replicate study case with RMS simulations
2. Case 1 without PV generation
3. Case 1 without wind power
4. Case 1 without PV and wind power

Study cases

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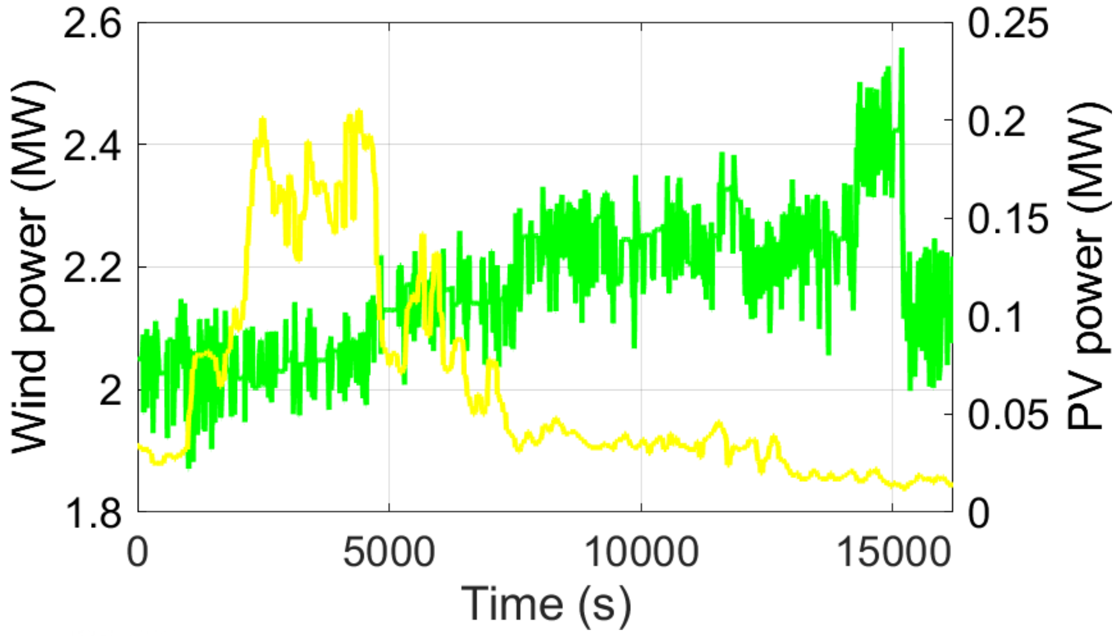
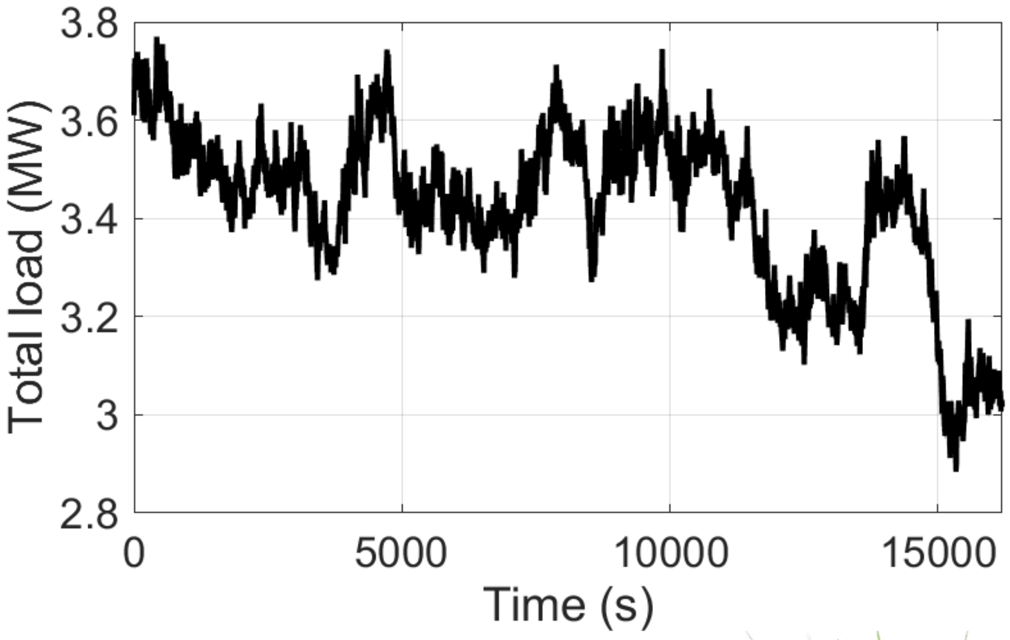
IBG



Load



Measurements from selected time period

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Controls and modelling

Control configuration

- Governor
- Automatic voltage regulator
- Manual secondary control
  - Operator is in charge of keeping frequency and voltage between acceptable limits

Modelling

- Standard PF models
  - Parameterised and validated based on measurements
- Signal representing manual control
- Initial generation and voltage set according to measurements

Control configuration

- Wind power plant
  - Active and reactive power
    - Setpoint regulated, P(f) and Q(U) function is deactivated
  - Emulated inertia is deactivated

- PV plant
  - Not controlled

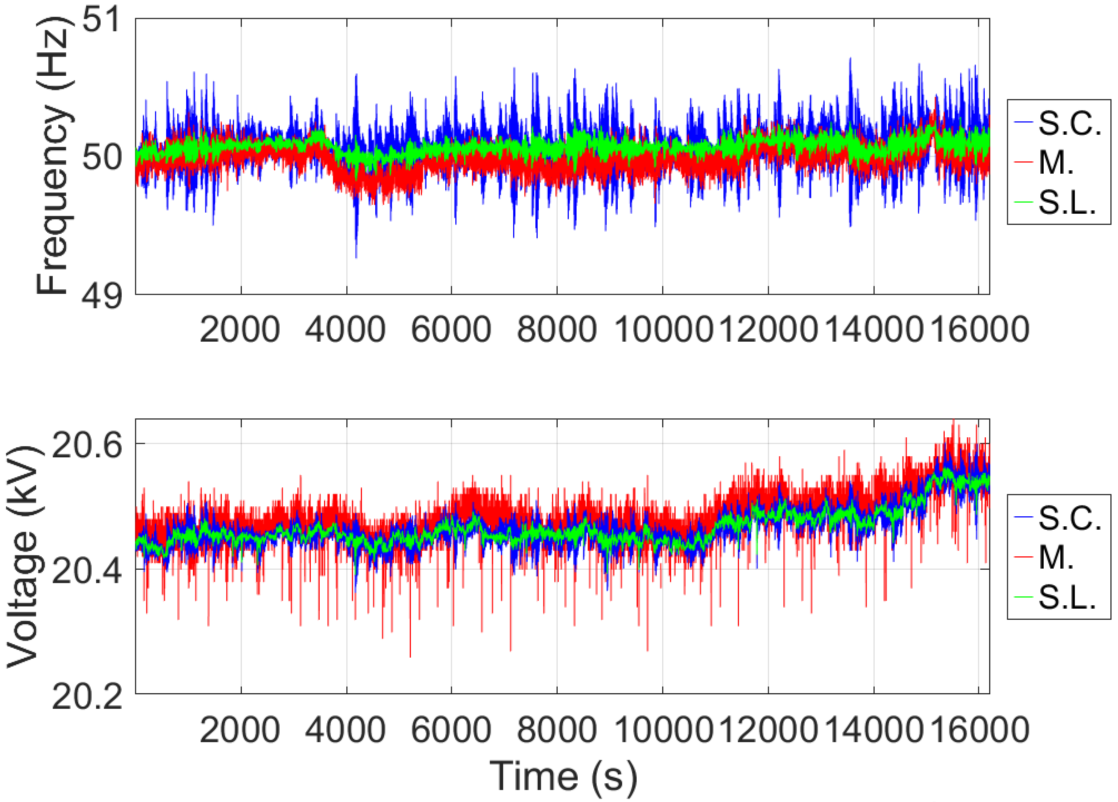
Modelling

- Measurements file from time period used to control P and Q
  - Loads are also controlled like this

Inverter-based generation

Results

	Mean		Standard deviation	
	f (Hz)	U (kV)	f (mHz)	U (V)
Measurement	49.99	20.48	96	38
Simulated, constant	50.05	20.47	153	31
Simulated, linear	50.07	20.47	55	28



Case 1: Replication of Measurements

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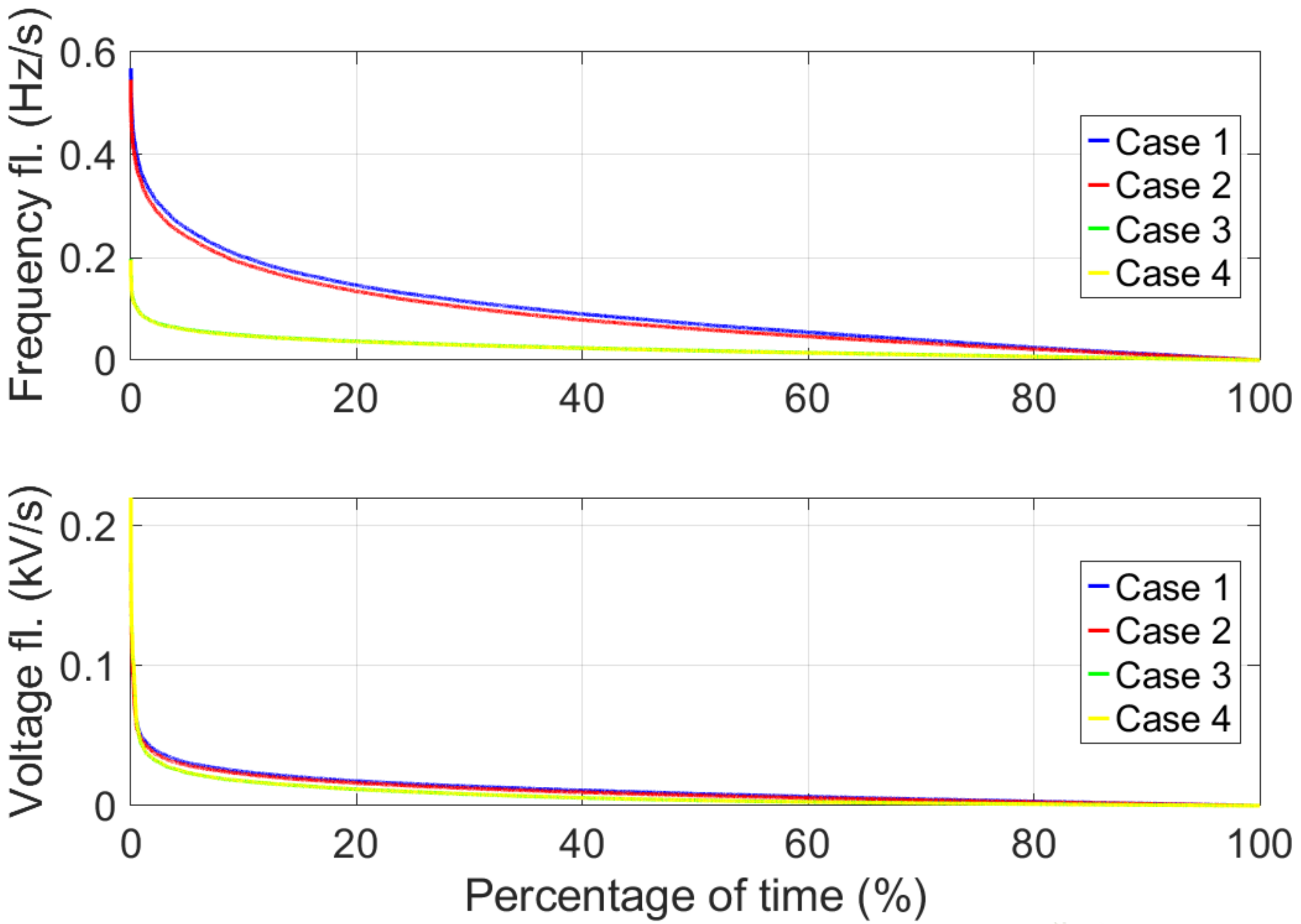

Cases 2-4: Comparison to Case 1

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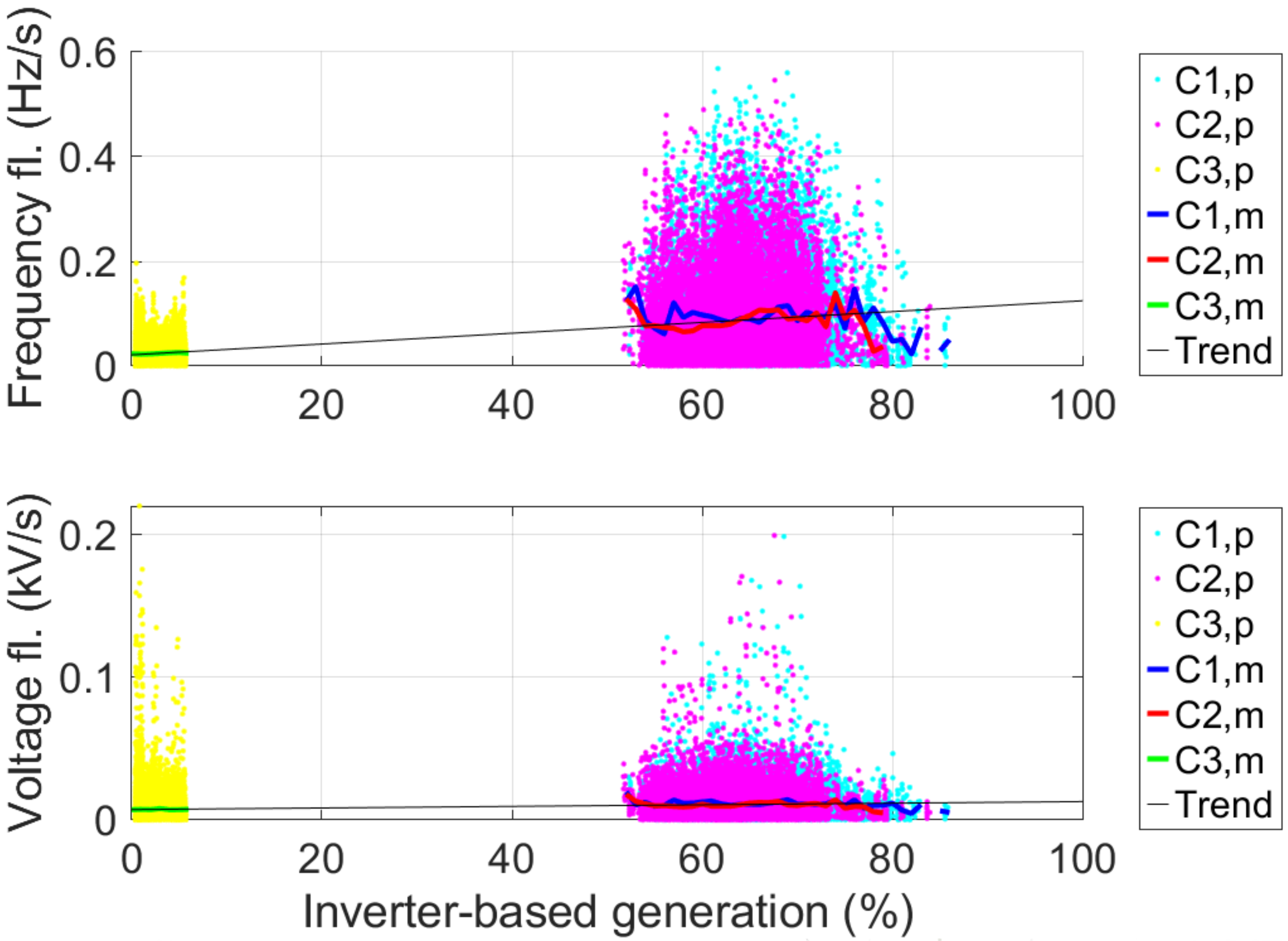
Frequency	Case 1	Case 2	Case 3	Case 4
Max fluct. (mHz/s)	568	546	197	195
Mean fluct. (mHz/s)	92	83	23	23
Std. fluct. (mHz/s)	80	76	19	19
Fluct. =>0.1Hz/s (% of time)	35.5	30.6	0.6	0.6
Voltage	**Case 1**	**Case 2**	**Case 3**	**Case 4**
Max fluct. (V/s)	199	199	220	220
Mean fluct. (V/s)	11	10	7	7
Std. fluct. (V/s)	11	11	11	11
Fluct. =>20V/s (% of time)	15.6	13.3	7.5	7.6



Cases 2-4: Comparison to Case 1

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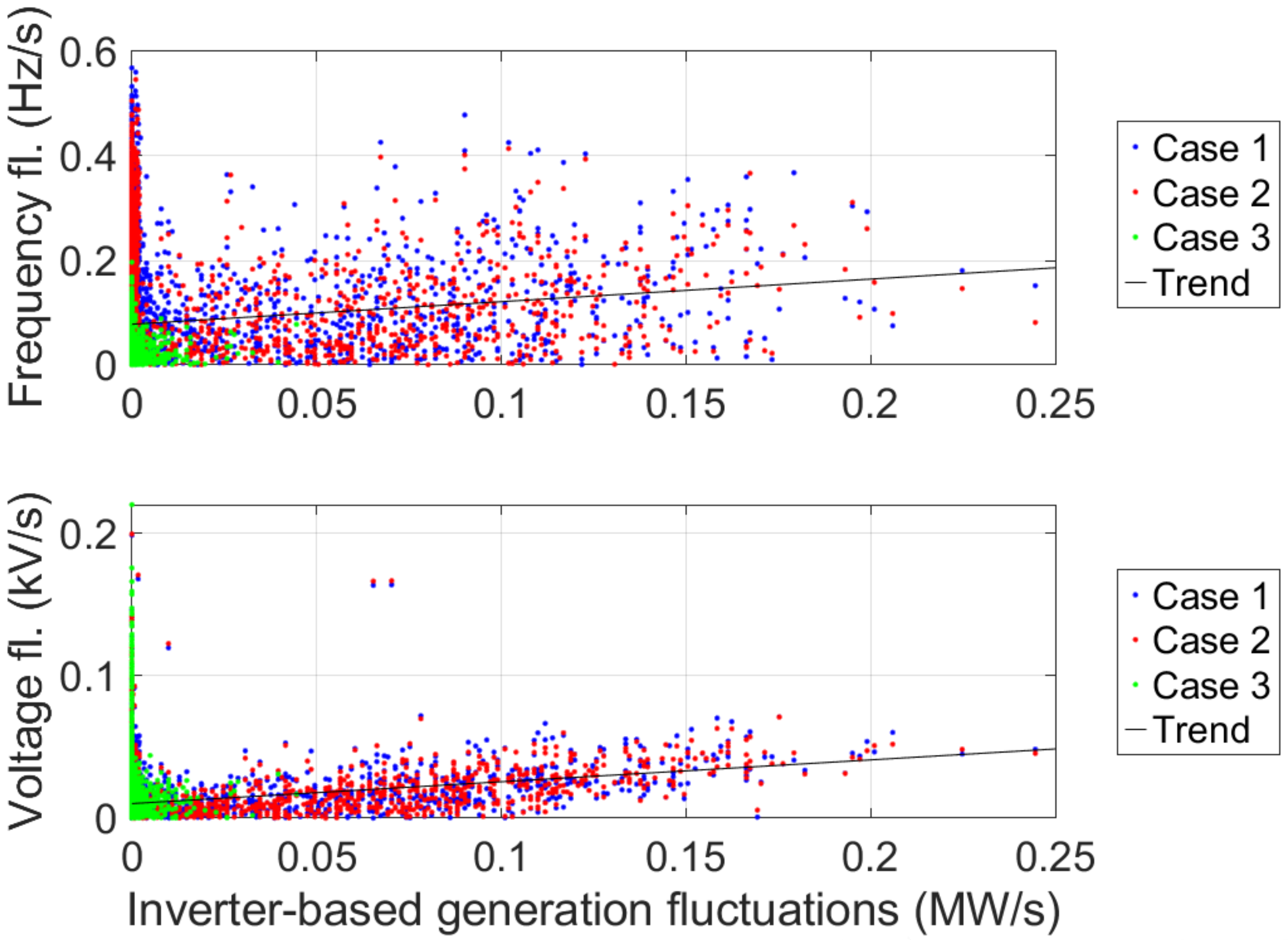
	Frequency		Voltage	
	All data	Fluct. above 0.02	All data	Fluct. above 0.02
Case 1	0.08	0.28	0.23	0.50
Case 2	0.08	0.29	0.25	0.54
Case 3	0.01	0.28	0.04	0.40



Cases 2-4: Comparison to Case 1

- The simulations replicate the measurements within an acceptable degree using the present dynamic model
- When IBG shares and fluctuations increase the frequency fluctuations increase as well
- There does not seem to be a relation between IBG shares and voltage fluctuations
- There is a correlation between IBG fluctuations and voltage fluctuations
- A wider range of IBG shares should be analysed
- The integration of IBG in Suðuroy is at an intermediate state, thus a similar analysis should be conducted with future control configurations and expansions

Conclusion

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Thanks for your attention!

100by 2030

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