

# C4 Power System Technical Performance Key Takeaways from Session 2024



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**cigre**

For power system expertise



# 2. CIGRE 2024 Session: Key Takeaways for SC C4 - Power System Technical Performance

## Paris 2024 Session: SC C4 Statistics

### Synopsis

- 153 synopsis were submitted / 108 (70.5%) were accepted to develop full paper.
  - PS1: Power System Dynamics: 85 submissions / 58 (68%) accepted.
  - PS2: Power Quality and EMC/EMI: 32 submissions / 24 (75%) accepted.
  - PS3: Lightning/Insulation Co-Ordination: 36 submissions / 26 (72%) accepted.
- 68 experts participated in the SC C4 review process

### Full Papers


- 95 papers were submitted / 81 (85%) were accepted / 1 was withdrawn
  - PS1: Power System Dynamics: 49 submissions / 40 (81%) accepted
  - PS2: Power Quality and EMC/EMI: 21 submissions / 18 accepted (85%) / 1 withdrawn.
  - PS3: Lightning/Insulation Co-Ordination: 25 submissions / 23 (92%) accepted.
- 77 experts participated in the SC C4 review process

### NGN papers & Presentations


- 7 submissions / 2 accepted (maximum permitted)

### Posters


- 80 were submitted


 2 new WG/JWG/JTFs created and 5 disbanded


 1 Green Book published

 3 TBs published

 1 Newsletter issued

 3 Webinars delivered and 2 scheduled soon

 Paris 2024 session

 Trondheim 2025 symposium



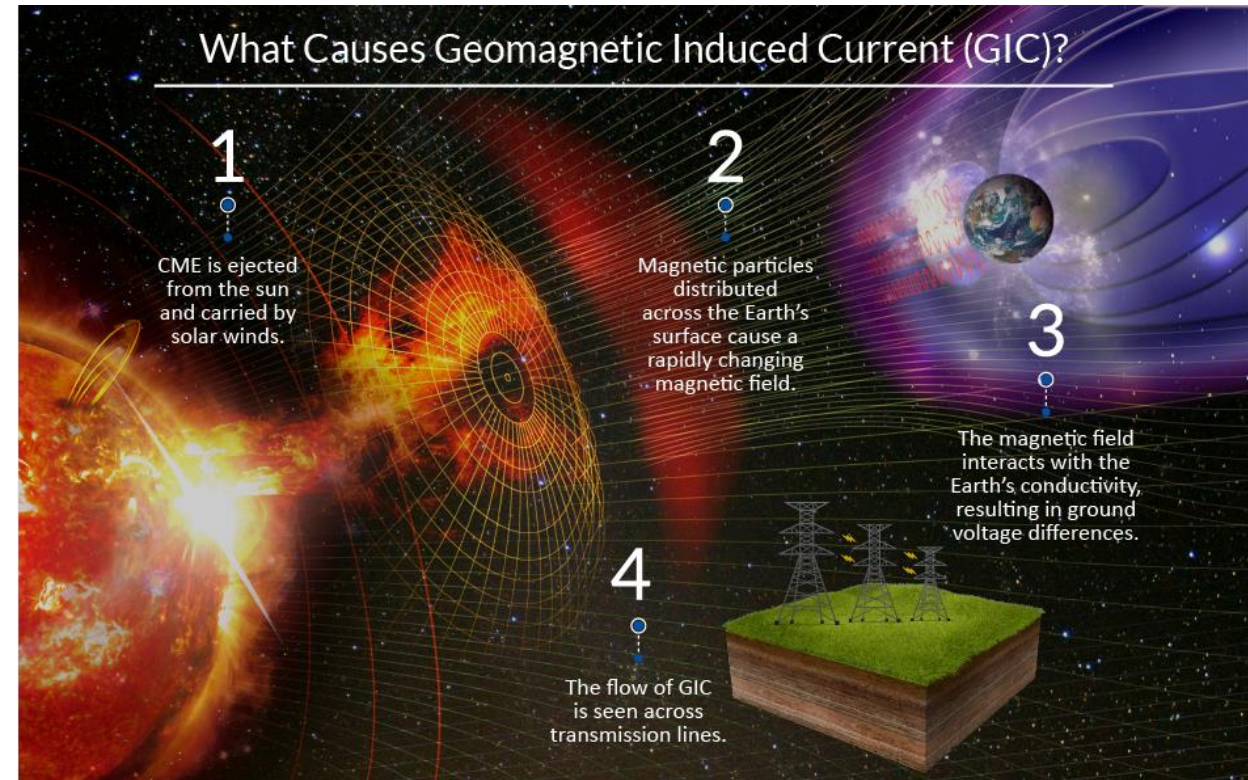
# Key Points PS 1 - Power system dynamics

- The need and use of wide-scale EMT use for **system-wide studies** is increasing.
- **Tools and models** are developing all the time – careful consideration should be given to the validity of the tools and models for type of study.
- Many metrics on identifying **stability risks** have been proposed – each has its unique problems and benefits.
- The impact of large-scale and distributed **power electronic interfaced loads** is an emerging topic and needs further research.
- Great potential in **dynamic capabilities and services from new technologies (GFM)**
- More work on **addressing electrolysers is needed** – no submissions were received in response to the associated question.



# Key Points PS 2 - Power quality (PQ) and electromagnetic compatibility (EMC) analysis

- New tools and methods for the assessment and the mitigation of PQ issues - a key conclusion from the contributions is that complexity in modelling, measurement and mitigation of power quality issues is increasing in the energy transition.
- In the understanding of the problem of GICs, the solution of the geophysical problem is much more advanced than the solution of the engineering problem





# Key Points PS 3 - Insulation co-ordination and lightning interference analysis: challenges, opportunities and advances

- Equipment performance and cause of failures in relation to high frequency transients as well as the influence of pollution.
- Temporary or transient overvoltages and voltage scaling phenomena.
- Need for and knowledge from transient studies, requirements for simulations as well as automatic generation of simulation data.
- Lightning performance, outages and protection of transmission lines, use of additional data in relation to extreme weather events.



### 3. Emerging Trend - Wide-Area EMT Analysis

- Increasing need for large-scale EMT studies
- Challenges: Model complexity, computation time
- Opportunities: Better assessment of IBR interactions, weak grid stability

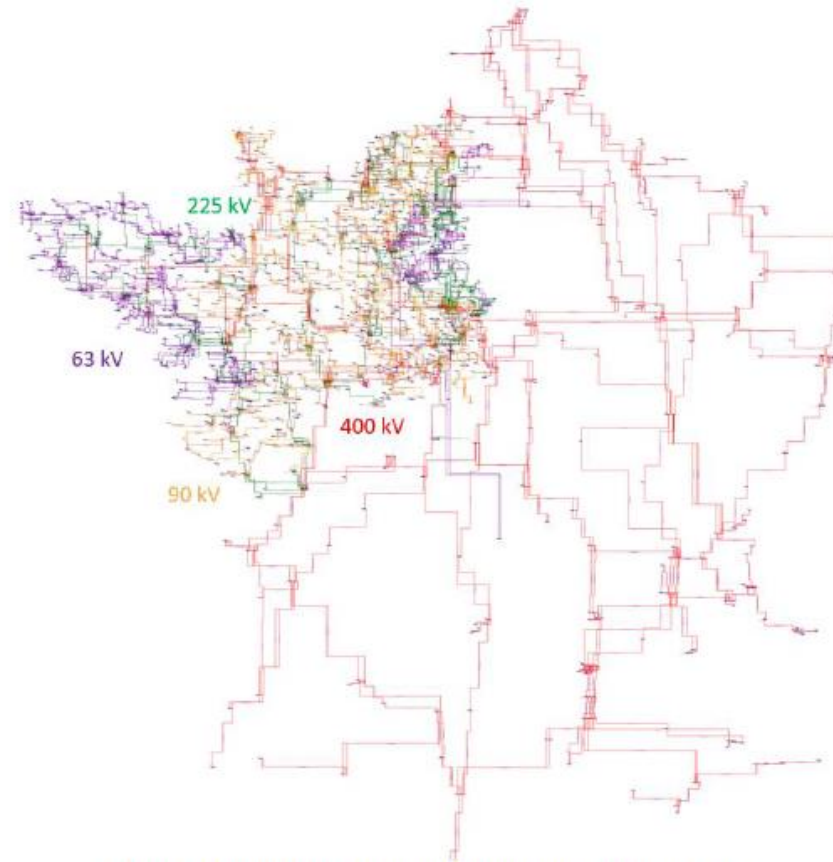


Figure 2 : Overview of the imported network around Celtic.

# 4. Evolution of System Strength Metrics

- Traditional SCR becoming inadequate for high IBR penetration
- New metrics proposed to capture IBR impacts
- Need for metrics considering grid-forming vs grid-following technologies

## 2. MONITORING RESULTS

The real time ESCR monitoring implemented is deploying in the control center room, where instant values (real time and historical data) of ESCR are displayed, for each of the buses. This is a real ESCR monitoring display implemented:

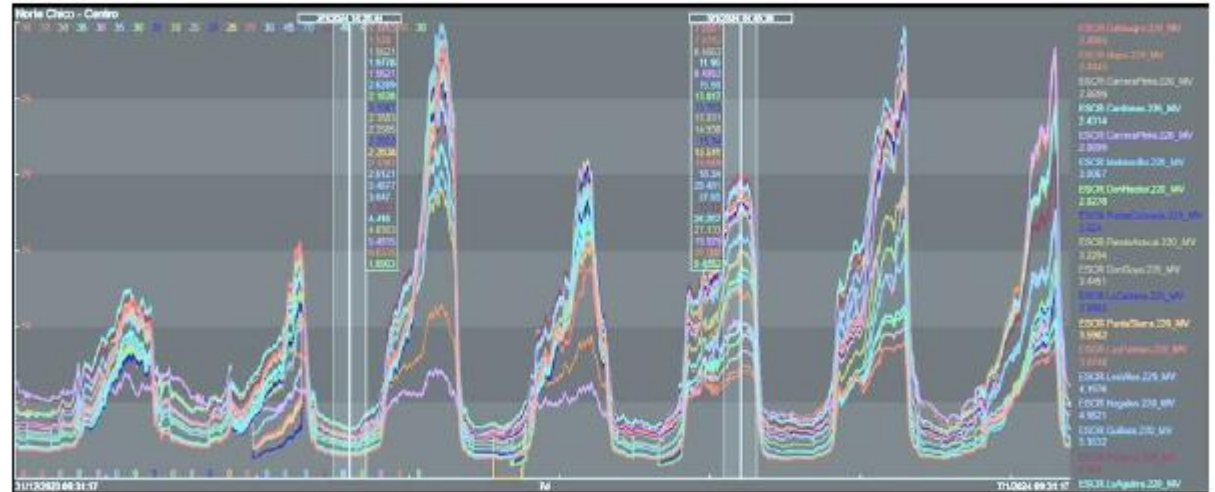


Fig. 9 Real Time Monitoring of ESCR values calculated in SCADA, for a week.

This real time monitoring tool allows to Coordinador to keep adequate situational awareness of the operational risk present in the SEN due to low levels of short circuit and high VRE penetration.

Paper 11503: **REAL TIME SYSTEM STRENGTH MONITORING  
IN THE CHILEAN NATIONAL ELECTRIC SYSTEM**



# 5. AI Applications in Power Systems

- Growing potential for operational and planning support
- Use cases: Model validation, stability assessment, congestion forecasting
- Challenges: Data quality, interpretability, integration with existing tools

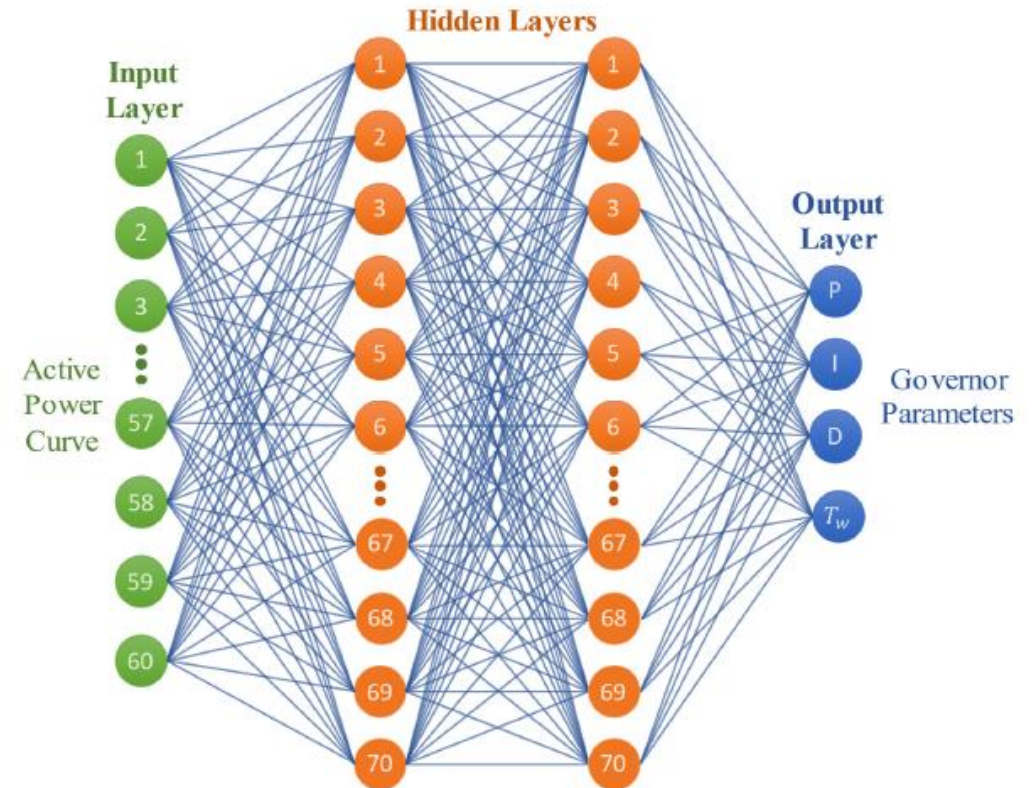


Fig 13. ANN architecture considered.

Paper 11762: Enhancing Dynamic Performance Validation of Transient Stability Models using Argentina's Phasor Measurement Units



# 6. Power Quality in the Energy Transition

- Increasing complexity in PQ analysis and compliance
- Need for new approaches to harmonic allocation and aggregation
- Importance of wide-area PQ monitoring and data analytics

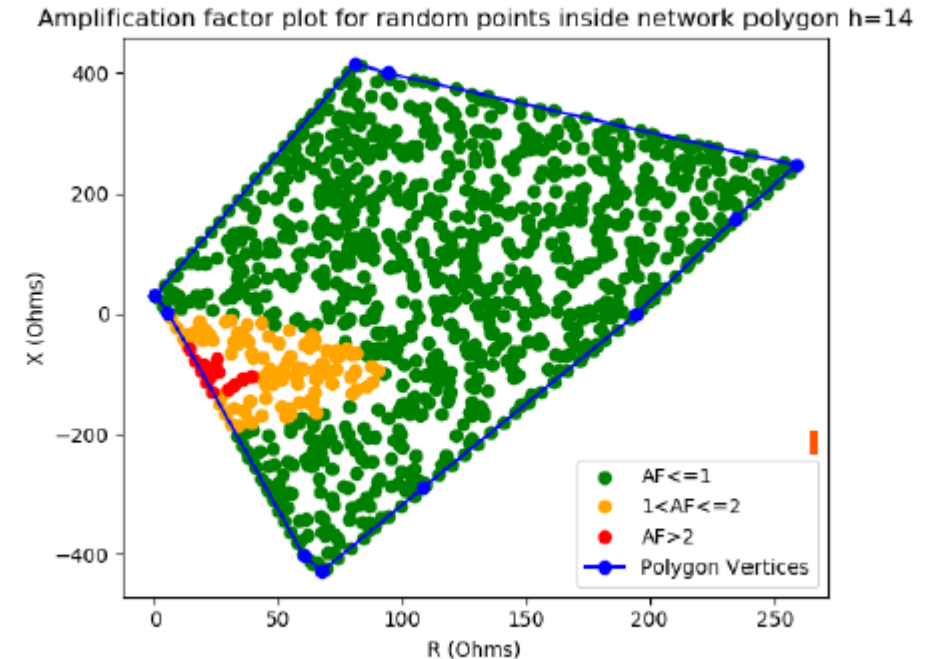


Figure 9 – Plot of the 14<sup>th</sup> order network polygon area sweep AF results for 1110 impedance points.

Paper 11876: **Background harmonics: Quantifying network assumptions and impacts**  
This paper introduces a tool that utilizes concept design impedance values, obtainable through commercial modelling tools, to assess site performance.

# 7. Geomagnetically Induced Currents (GICs)

- Improved real-time GIC estimation methods
- Proposal for open database of GIC measurements
- Need for better validation of GIC models and assumptions

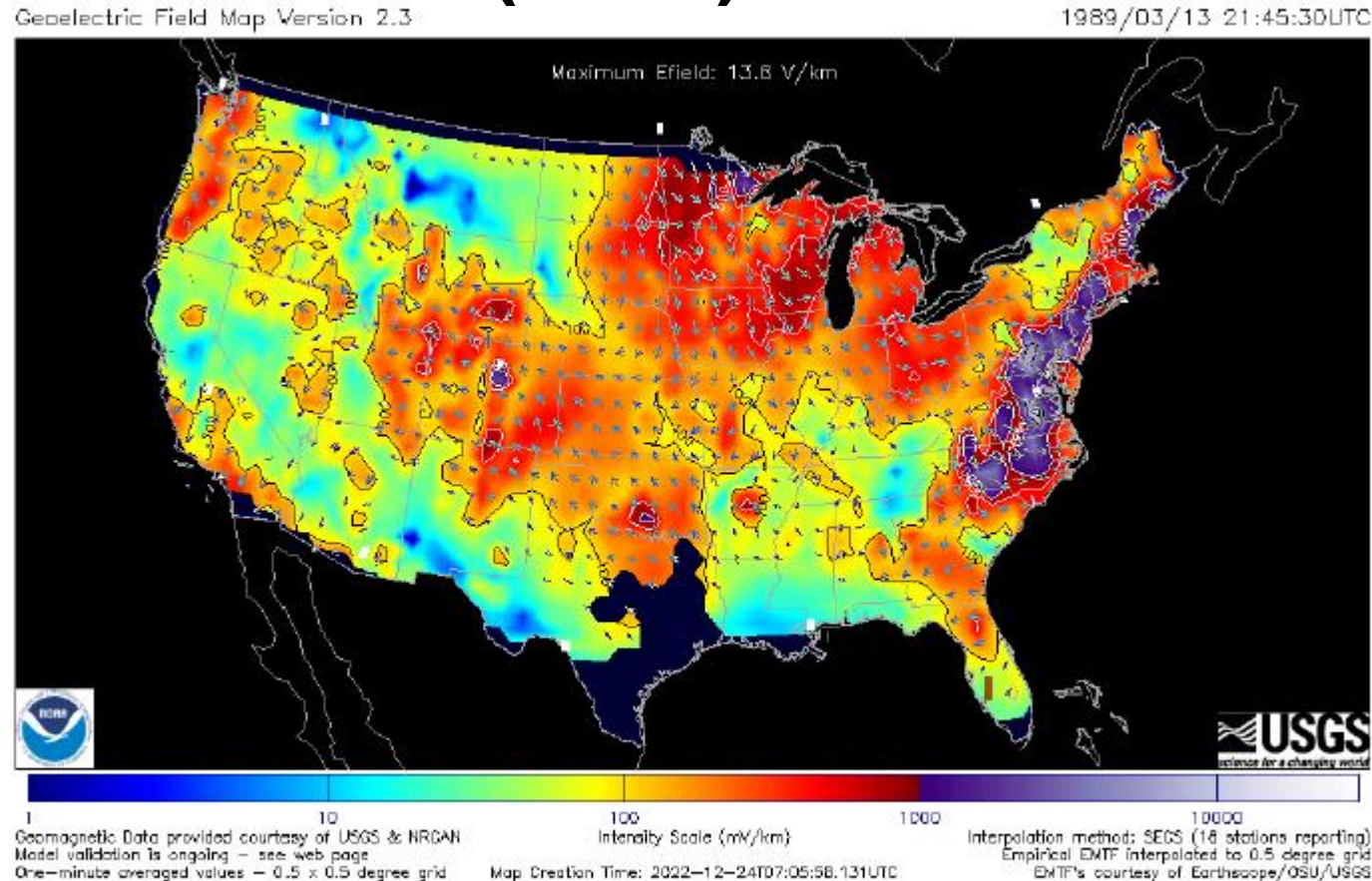


Figure 1 : 1-minute Goelectric Field Map [Source: SWPC]

Paper 10455: An adaptive nearest neighbor algorithm to compute transmission line induced voltage due to geomagnetic disturbance event specified as geoelectric field grid map is presented

# 8. Insulation Coordination Challenges

- Non-standard waveforms becoming more prevalent
- Impact of temporary overvoltages in IBR-dominated grids
- Importance of pollution mapping for insulation design optimization

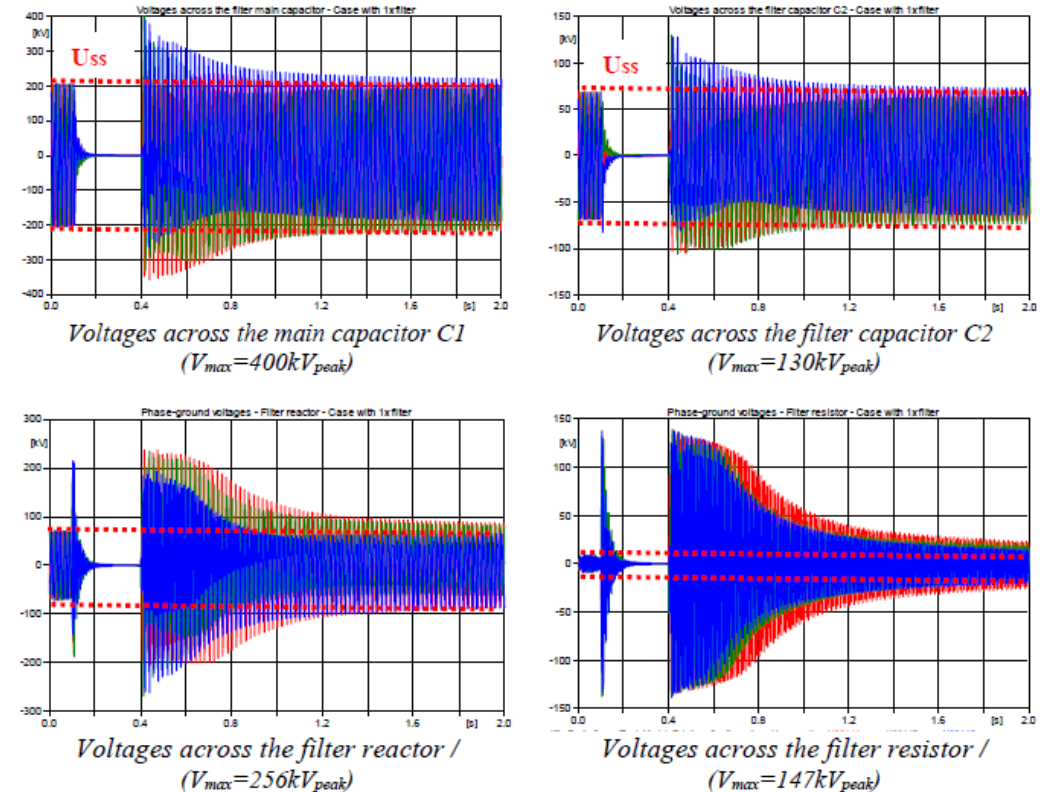


Figure 7. Simulated TOV stresses on each filter component

Paper 10550: **Service Experience in the Dutch Transmission Grid with Non-standard Overvoltage Waveforms & their Impact on the Component Insulation**



# 9. Lightning Protection Advancements

- Increasing role of advanced lightning location systems
- Detailed analysis of lightning density variations along transmission lines
- New approaches for assessing lightning performance of wind farms

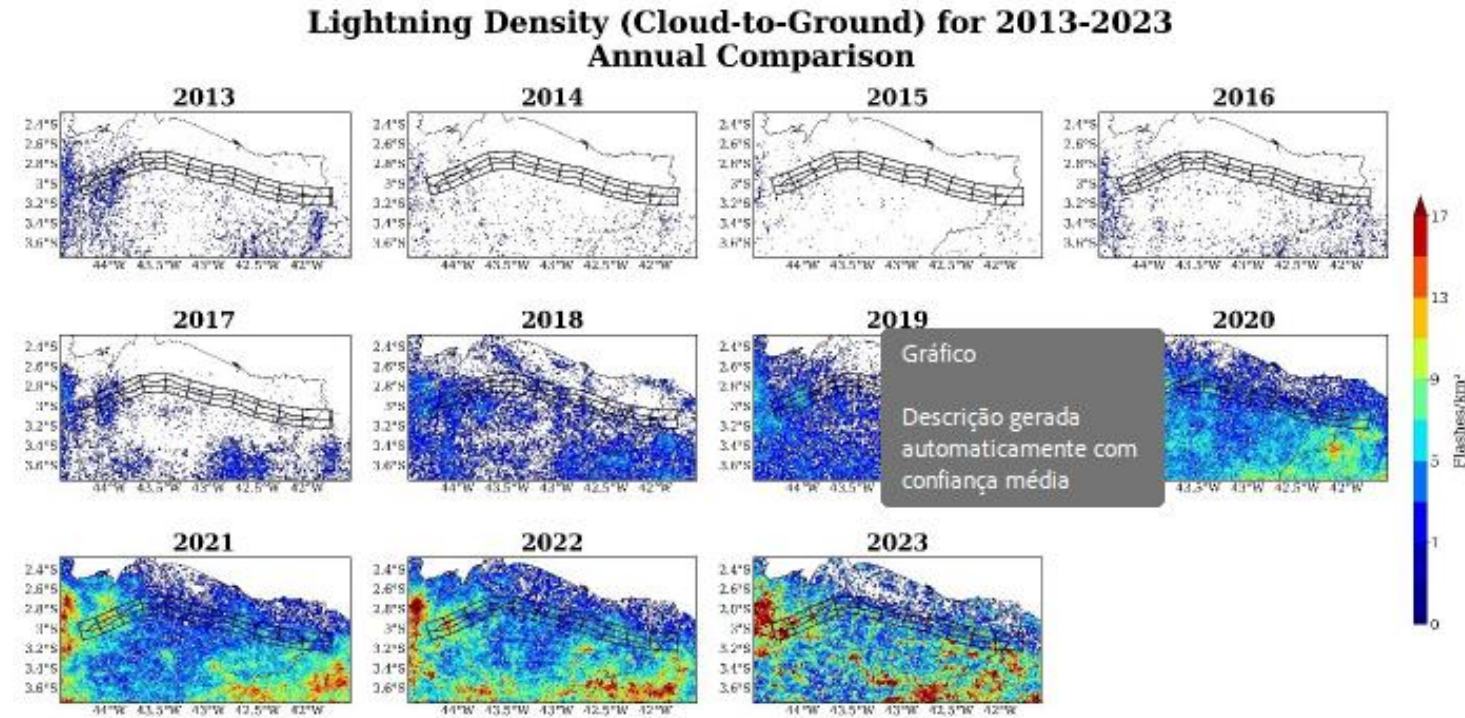


Figure 3: Total annual cloud-to-ground lightning density around the 500-kV Bacabeira-Parnaíba transmission line, for the period 2013-2023.

Paper 10953: **CLIMATE CHARACTERIZATION AND HISTORICAL CHANGES IN DENSITY AND INTENSITY OF LIGHTNING AROUND THE 500 kV BACABEIRA-PARNAÍBA TRANSMISSION LINE**

# 10. Future Focus Areas

- Large-scale electrification impacts (e.g., data centers, electrolyzers)
- Grid-forming technology specifications and testing
- EMC issues in modern power electronic-based systems
- Climate change impacts on insulation coordination

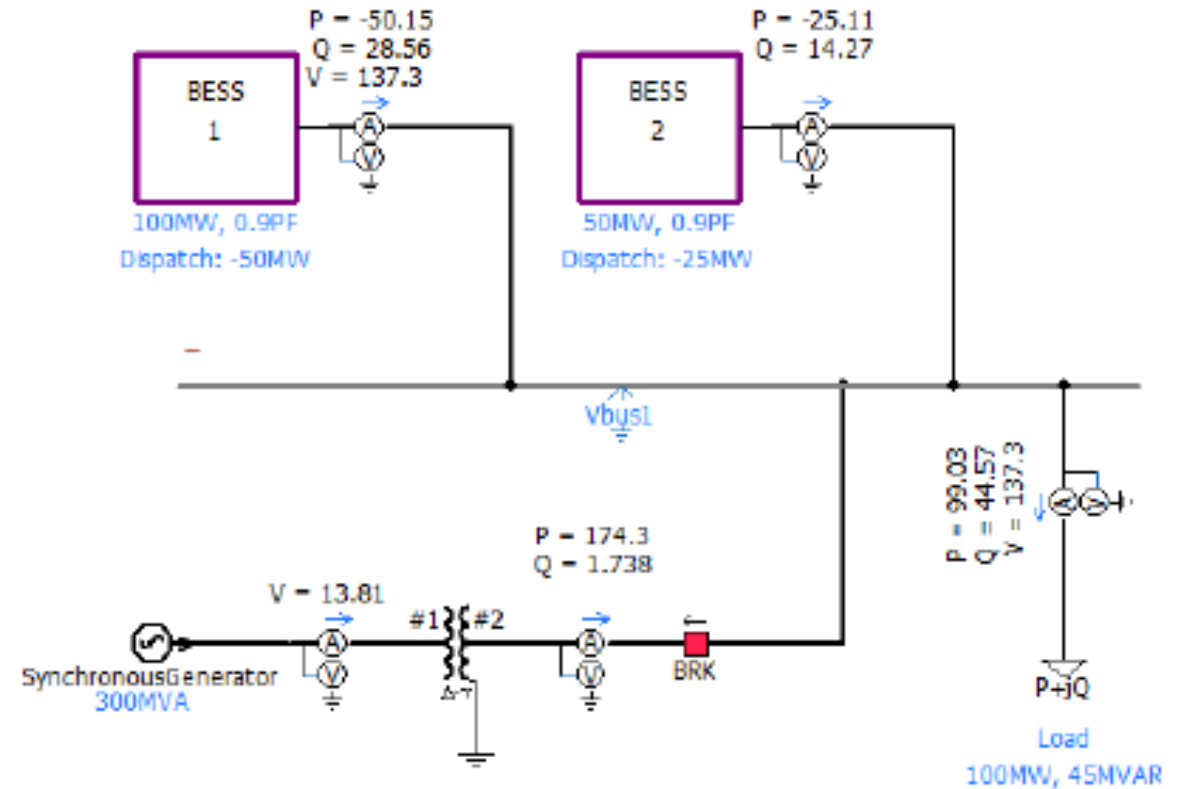


Figure 1: GFM Functional Test System

Paper 10459: **Grid Forming Functional Specifications and Verification Tests for North American Bulk Power System Connected Battery Energy Storage Systems**



# Call for Papers

## CHANGES NEEDED IN THE POWER SYSTEM for the Energy Transition

International Symposium hosted by the Nordic Regional Council of  
CIGRE (NRCC) in Trondheim, Norway on May 12–15, 2025

Participating CIGRE Study Committees (SC): SC A3 Transmission and distribution equipment, SC B1 Insulated cables (co-lead), SC B2 Overhead lines, SC B3 Substations and electrical installations, SC B4 DC systems and power electronics, SC B5 Protection and automation, SC C2 Power system operation and control, SC C3 Power system sustainability and environmental performance, SC C4 Power system technical performance (co-lead), SC C6 Active distribution systems and distributed energy resources.

<b>March 18, 2024</b>	Call for papers
<b>August 1, 2024</b>	Registration starts
<b>September 27, 2024</b>	<b>NEW DATE!</b> Deadline for Synopses in ConfTool
<b>October 18, 2024</b>	Selection of synopses by SCs and information to authors
<b>February 3, 2025</b>	Deadline for full papers
<b>March 3, 2025</b>	Acceptance and other feedback to authors of full papers
<b>April 7, 2025</b>	Final papers to ConfTool

Links to info:

Special report download here:

[https://session.cigre.org/fileadmin/cru-1725973228/user\\_upload/SC\\_C4\\_DAILY\\_SUMMARY\\_2024.pdf](https://session.cigre.org/fileadmin/cru-1725973228/user_upload/SC_C4_DAILY_SUMMARY_2024.pdf)

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