

Key Takeaways – CIGRE SC C2

2026 Paris Session



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Agenda

Inaugural ceremony and Panel 1

Green, resilient grid

C2 Tutorial

International SIPS examples

C2 and C5 Workshop

Recent large disturbances

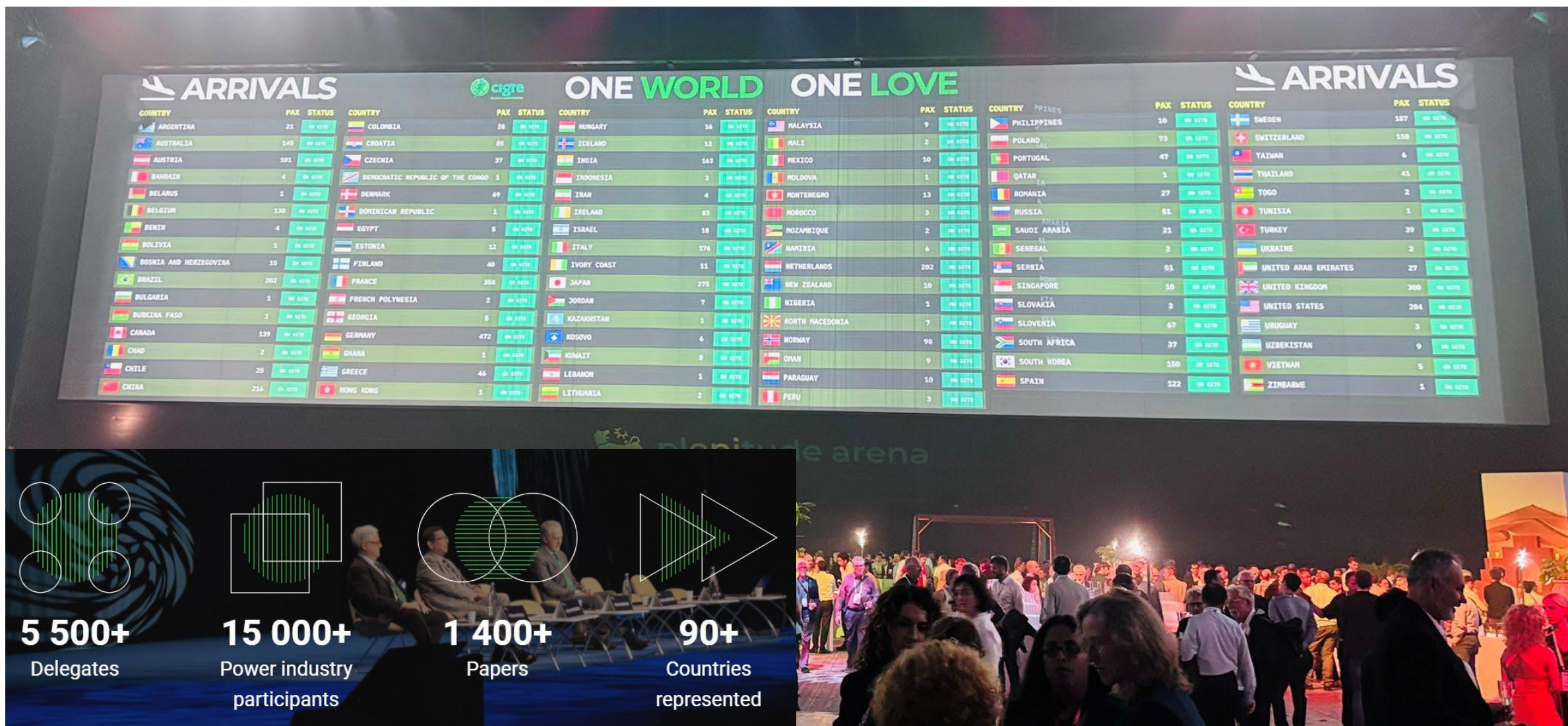
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PS1, PS2 and PS3

Key Takeaways

Implications for the Netherlands

For each topic: what was discussed → what stood out → why it matters.



Inaugural ceremony

Panel 1: Technical path and solutions for a green resilient grid



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Four perspectives on a resilient grid

System Needs	Technology	Operations	Sustainability
• Frequency and voltage stability • System strength and damping • Restoration and black start	• Grid-forming solutions • Performance requirements • Deployment conditions • Artificial intelligence and Digital Twin	• Real-time planning • Restoration processes • Tools and workforce	• Resilient infrastructure • Lifecycle thinking • Value-chain cooperation

Session takeaway: resilience is created by designing these four perspectives together.

Power System Needs Perspective



Focus on System Needs

- Frequency stability
- Voltage stability / System strength
- Oscillation damping
- Fault response
- Black Start and Restoration capability

Technology-neutral performance requirements

Technology Gap is Real

From identifying need to having capable resources takes 3-5 years



Waiting until the need becomes critical may result in a fleet incapable meeting system needs

The Way Forward: System Needs + Technology

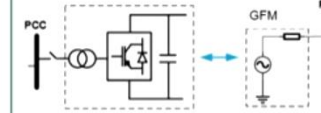
- Define system needs in a technology-neutral manner
- Require critical capabilities from generation resources
- Monitor resource performance
- Evolve system needs and tech capabilities as the system evolves

Tech neutrality guides system needs. Tech readiness ensures availability

Grid-Forming Technology Perspective

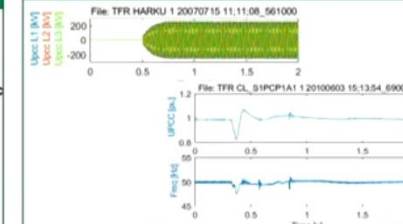


How it works



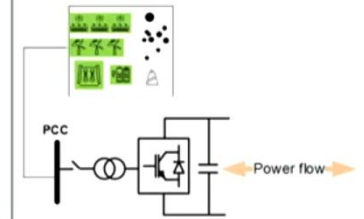
A converter with Grid-forming control acts as a controlled voltage source behind an impedance

What it can do



It can form an AC voltage for a blackout grid; strengthen weak AC grids; and it can compensate the losses of nature characteristics such as Inertia, network strength, Frequency & Voltage stability due to displacement of traditional synchronous generators

Dependency



The performance depends on the connected AC system conditions, the available energy source, and the hardware limits

Sustainability Perspective



GREEN

- Power systems are enablers of decarbonization. Therefore, they must also become **sustainable infrastructures** themselves.

RESILIENT

- Power systems must be designed and **adapted** to evolving climate conditions.

Technology provides the solutions. Cooperation across the entire value chain is needed to develop, scale and turn those solutions into reality

Power System Operator Perspective



Risk-Based Operational Planning

Shift from deterministic to probabilistic, risk-based operations

Quantify uncertainty from renewables and emerging load patterns

Prioritize decisions using risk metrics for commitment, reserves, and contingencies

Establish resilience benchmarks and operator-focused performance metrics

Real-Time Operations & Restoration

Improve wide-area visibility and TSO/DSO coordination

Modernize protection and automation

Strengthen restoration readiness (blackstart + post-event drills)

Embed cyber-physical resilience in control-center tools

People & Process New Resilience Era

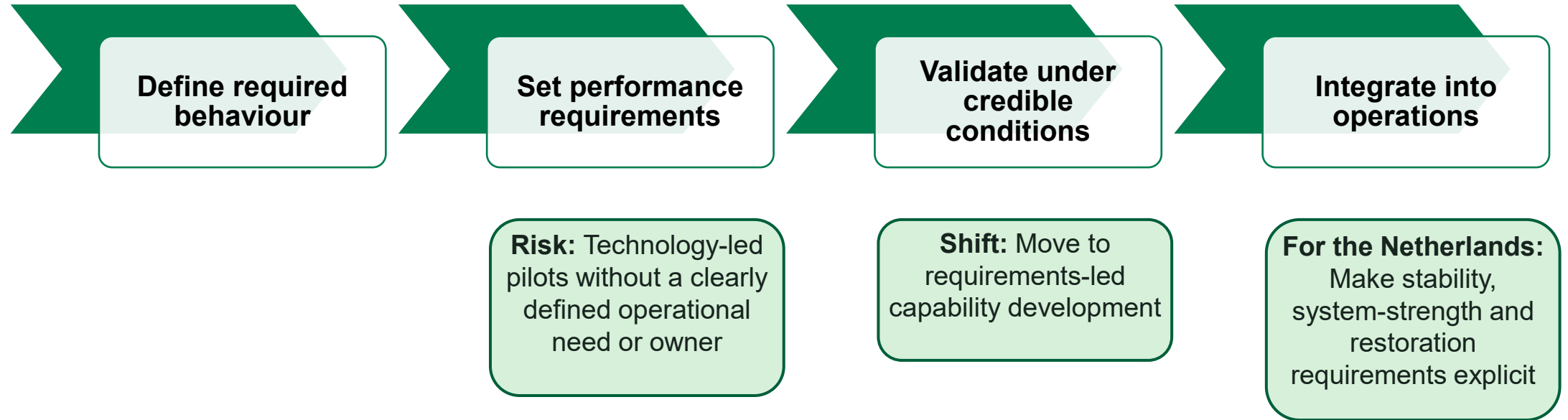
Expand operator training and simulation, including joint TSO/DSO exercises

Enhance situational awareness and decision support (digital twins, workflows)

Build organizational and control-center resilience

Align incentives and metrics with reliability outcomes

Key takeaway



Start with the system need, not the technology

Tutorial C2

International examples of System Integrity Protection Schemes (SIPS) deployment



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SIPS – an umbrella term



Definition proposed by JWG C2/B5.46



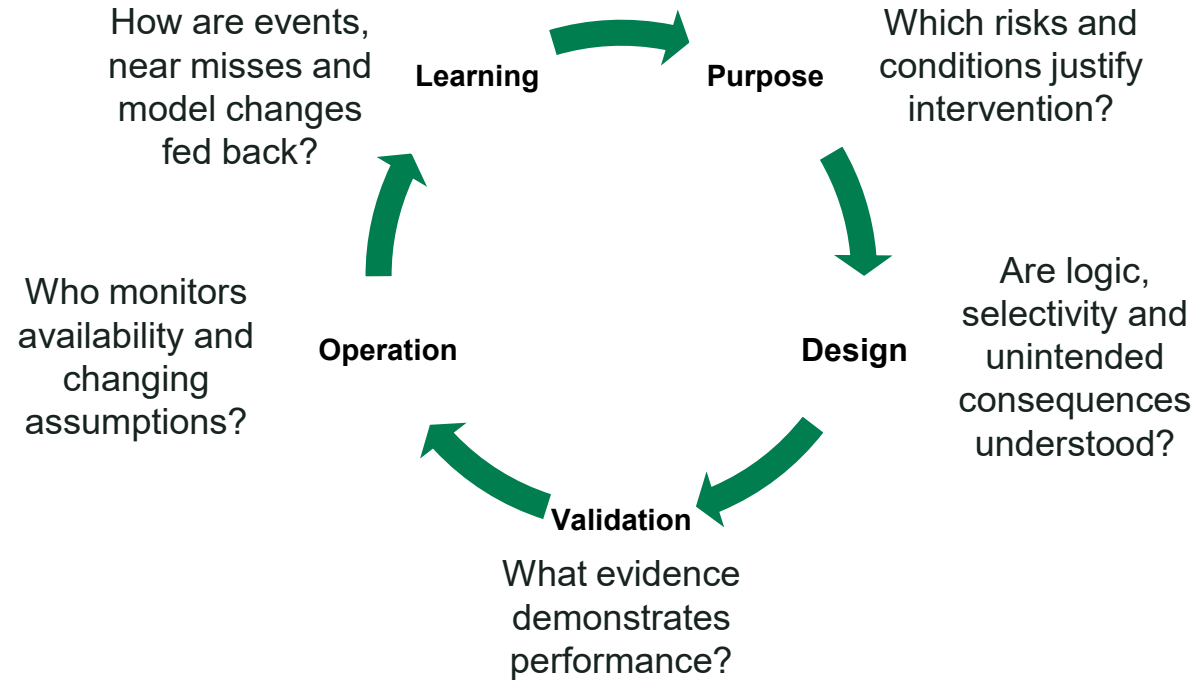
System Integrity Protection Schemes (SIPS) can be defined as:
automatic systems which apply **curative** control actions
as the response to a **critical condition**,
in order to increase the power system **reliability**
and/or **available capacity**.

Examples from real world SIPS implementations



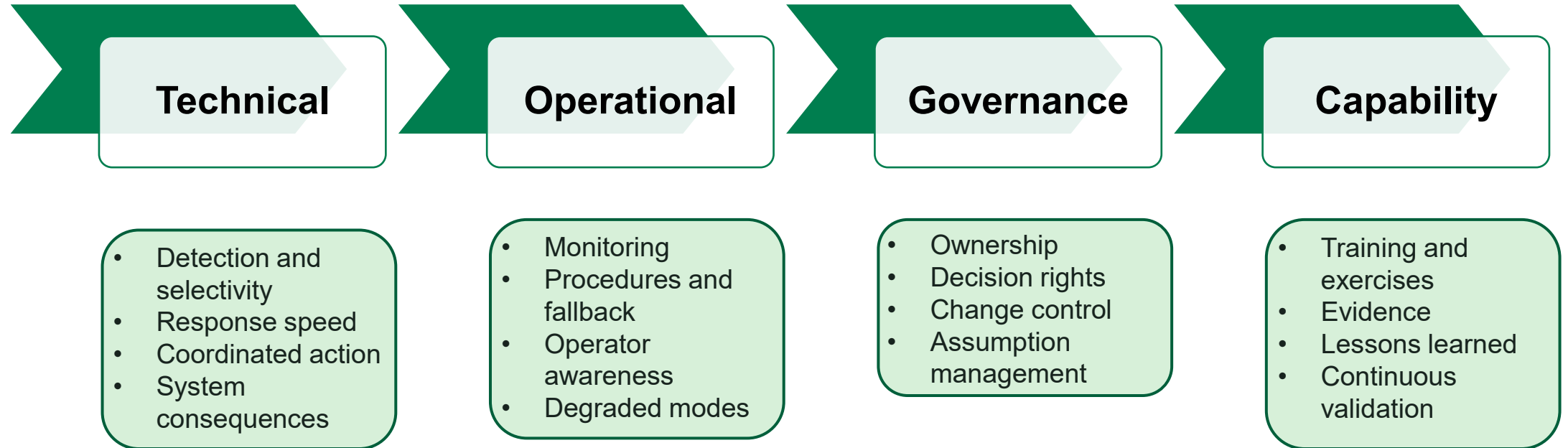
	Aim	Main goal	Particularities
NO	Grid capacity	Enable utilization of existing grid above N-1 criterion	Many SIPS managed as part of operators' daily work
BR	Reliability	Prevent blackout from extreme weather events	Communication over large distances to enable inter-tripping solution
ES	Grid capacity	Increased integration of Renewable Energy Sources	Large amount of distributed resources used with centralized coordination
AU	Reliability	Prevent uncontrolled islanding	Multi-stage hybrid scheme utilizing PMUs

International SIPS examples highlighted a full lifecycle



**SIPS is a continuously validated operational capability,
not a one-time implementation.**

Key takeaway



NL relevance: lifecycle governance must keep pace with increasing automation.

Workshop

C2 and C5: Large disturbance



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C2 & C5: Large disturbance

- **Purpose of the workshop:** To share experiences of significant technical and market disturbances that have occurred in the past 12-24 months.
- What happened? Type of disturbance?
- How did power systems, participants & institutions respond?
- How did markets and regulatory policy and settings perform?
- What observations/lessons learned?

Five recent disturbance cases presented

Workshop lens: technical, market and institutional response, followed by lessons learned

Georgia
19 Apr 2025

Spain and Portugal
28 Apr 2025

**China South
Western Grid**

India load reduction
17 Jun 2024

Chile
28 Feb 2025

**Cyber-physical
disturbance and
asset loss [Sergi-
Energy]**

North Hyde / Heathrow
20 Mar 2025

**Different events exposed recurring gaps in visibility, compliance,
coordination and recovery.**

Cross-case takeaway

How to prevent?

- Accurate models
- Settings and compliance
- Control-interaction studies
- Asset and cyber resilience

How to contain?

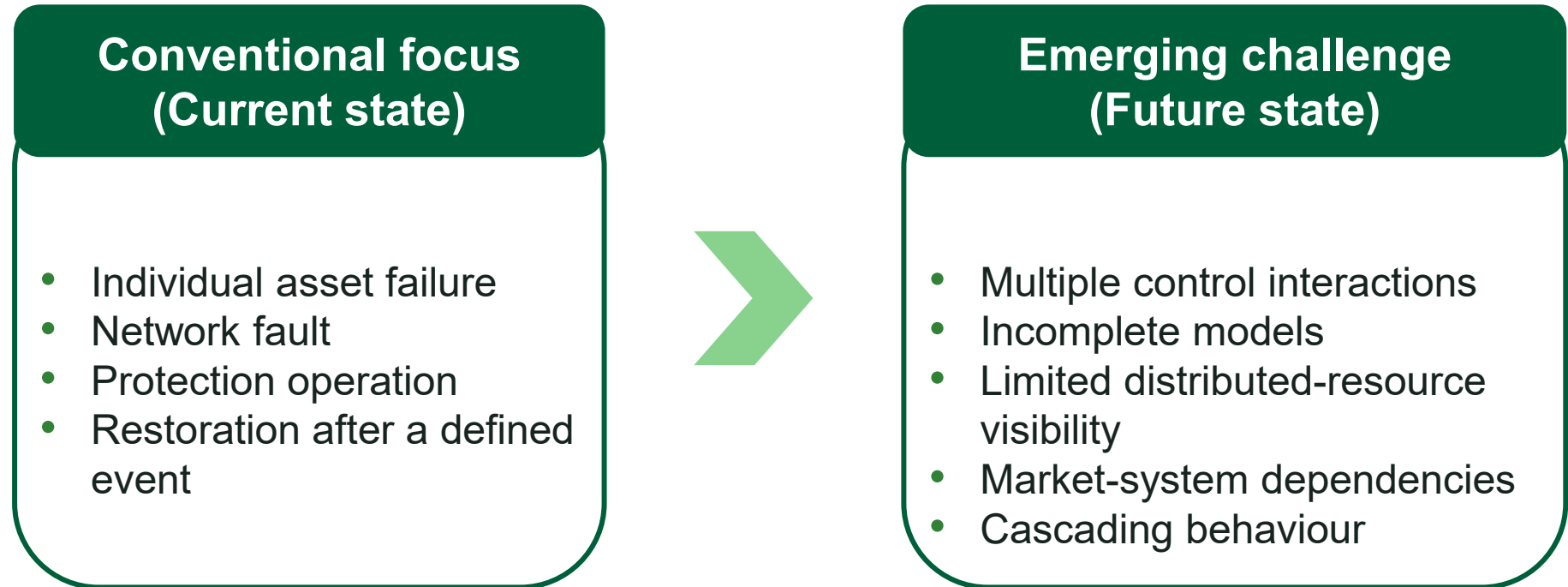
- Real-time visibility
- Protection and automation
- Decision rights
- Technical-market coordination

How to recover?

- Restoration and black start
- Islanding where appropriate
- Fallback procedures
- Joint exercises

Resilience is the combined quality of prevention, containment and recovery.

Key takeaway



Conventional risks remain, while interaction-driven risks are becoming more significant.

Study Committee C2 Meeting



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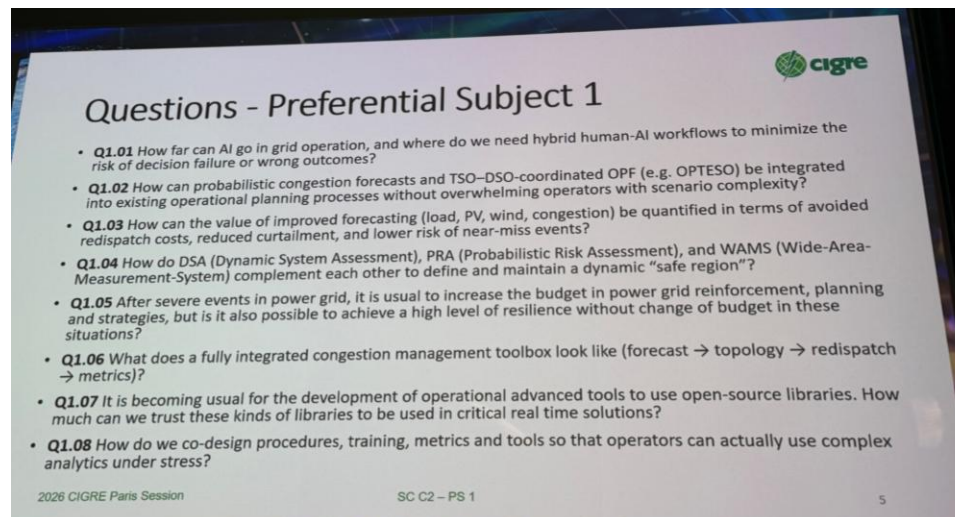
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Introduction

- Discussions focused on evolving operator skill needs, increasing digitalization, flexibility in system operation, and the growing complexity of managing dynamic grid behavior
- **48 contributions** addressing the 3 Preferential Subjects (PS), **16 for PS1**, **14 for PS2**, and **18 for PS3**
- Contributions were received from over 17 different countries

PS1 – Advanced decision support, training and skills for control room personnel

- **Sub-topics**
 - New requirements for personnel skills, procedures and tools
 - Digitalization and use of artificial intelligence for enhancing decision support
 - Operational procedures, tools and processes for operating grids during extreme events
- Eight questions were proposed in the Special Report to which there were 16 prepared contributions



PS1 – Advanced decision support, training and skills for control room personnel

What was discussed

- New skill requirements
- AI decision support
- Digital control rooms
- Extreme-event procedures
- Wide-area monitoring
- Retention of expertise

Session takeaway

- AI can prioritize information, detect patterns and explore scenarios.
- Operators retain judgment, challenge and accountability.

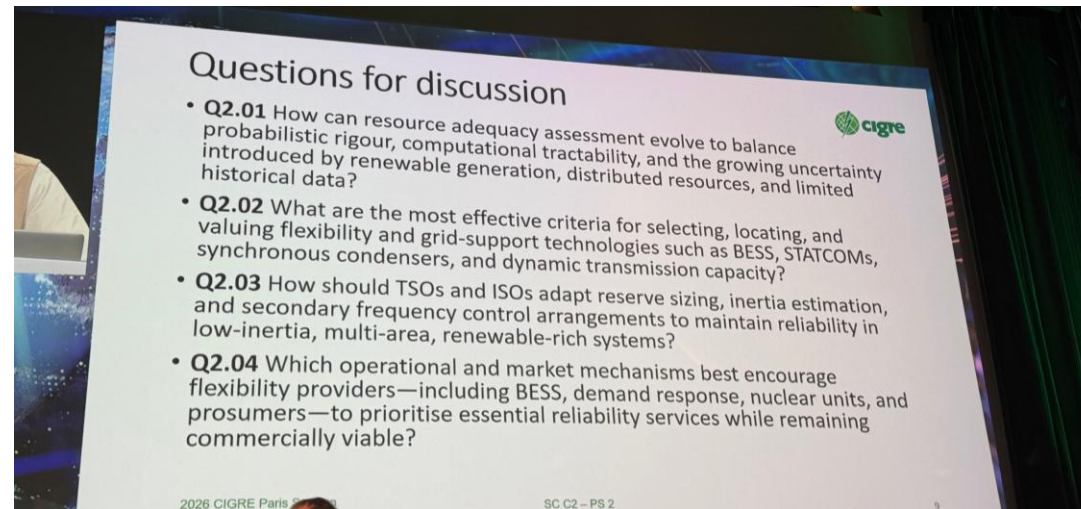
NL Relevance

Train for unusual conditions, uncertainty, degraded modes and human-machine coordination.

AI changes the operator role, but does not remove operator accountability.

PS2 – Maintaining operational reliability through flexibility

- Sub-topics
 - Methods to identify and quantify system services in response to the energy transition
 - Operational experience with flexibility services, including demand side response, topology changes, sector coupling and results from pilots
- Seven questions were asked in the Special Report to which there were 14 prepared contributions.



PS2 – Maintaining operational reliability through flexibility

What was discussed

- Demand response and storage
- Topology changes
- Sector coupling
- Flexibility pilots
- Declining inertia
- Distributed-resource visibility

Session takeaway

Flexibility adds operational value when location, speed, limits and current availability are known and dependable.

NL Relevance

Understand not only how much flexibility exists, but where, when and under which network constraints.

Dependable flexibility is a reliability capability, not only a market product.

PS3 – Power system dynamics and control in operations

- Sub-topics
 - Operational experience with managing power system stability, including oscillations
 - Monitoring and control of power system dynamics in the control room, including wide area systems
 - Impact of adverse interactions between power electronics interfaced devices on system operations
- Ten questions were asked in the Special Report to which there were 18 prepared contributions.

PS3 – Power system dynamics and control in operations

What was discussed

- Variable inertia
- Oscillations
- Voltage stability
- Wide-area measurement
- Inverter interactions
- Restoration and simulation

Session takeaway

Dynamic behaviour requires alignment of models, measurements, control strategies and real-time decisions.

NL Relevance

Test model accuracy, early detection, operational criteria and cross-asset control interactions.

**The system must not only be secure now;
changing risk must be visible early enough.**

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Conclusion

- Wide range of contributions demonstrated strong global engagement and a shared commitment to advancing reliable and efficient system operations.
- Diverse insights on operator readiness, flexibility, and dynamic grid behavior, highlighting both common challenges and innovative approaches emerging worldwide.
- These perspectives reinforce the value of international collaboration in navigating the evolving demands of modern power systems.

**Secure operation aligns risk insight, people,
flexible resources and dynamic control.**

Key takeaways

Define future system-behaviour requirements

Panel 1 + PS3

Build risk-based, forward-looking security assessment

PS1 best paper + PS3

Strengthen end-to-end visibility and compliance

Workshop + PS2

Govern automated schemes through their lifecycle

SIPS + PS1

Test resilience and competence across organizations

Workshop + PS1

Thank you!

Kind regards / Met vriendelijke groeten / Mit freundlichen Grüßen,

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