# Expert Group Interaction Studies and Simulation Models (EG ISSM) for PGMs/HVDC

- Timeline
- Report Structure and content
- Next steps and risks

**Presentation to GC ESC on behalf of the EG ISSM**

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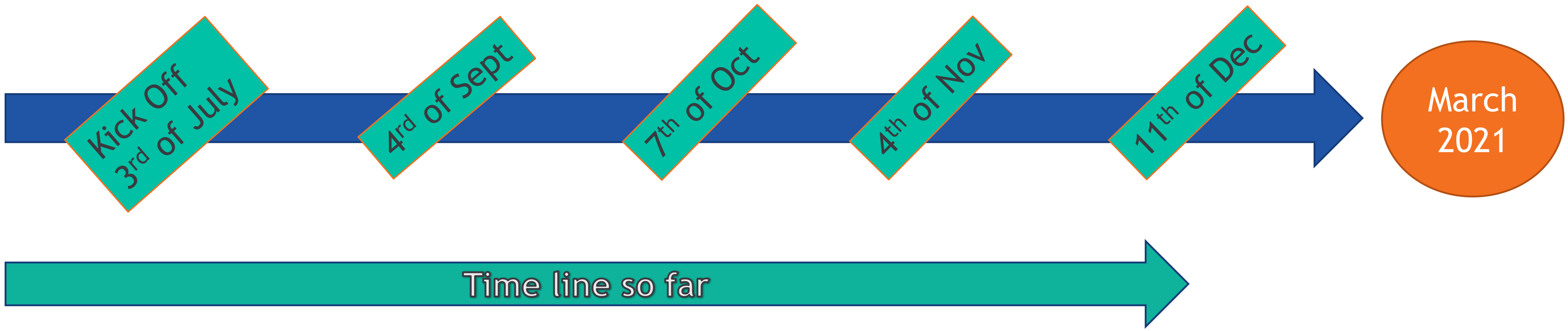
# Time line of the EG ISSM

**Estimated workload**

- 5 webinars
- commitment of 25 days per member



# Report Outline

## Expert Group Interaction Studies and Simulation Models (EG ISSM)

FINAL REPORT

In Progress

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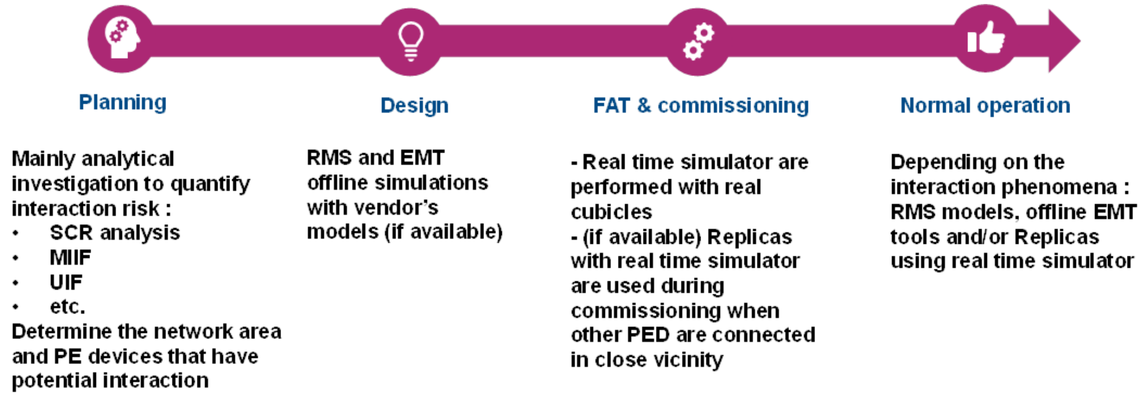
# Chapter 3: Interaction Studies

- The increasing penetration of Power Electronic Devices (PED) within the AC network leads to higher risk of interaction of such systems between PED, network elements and/or conventional power plants.

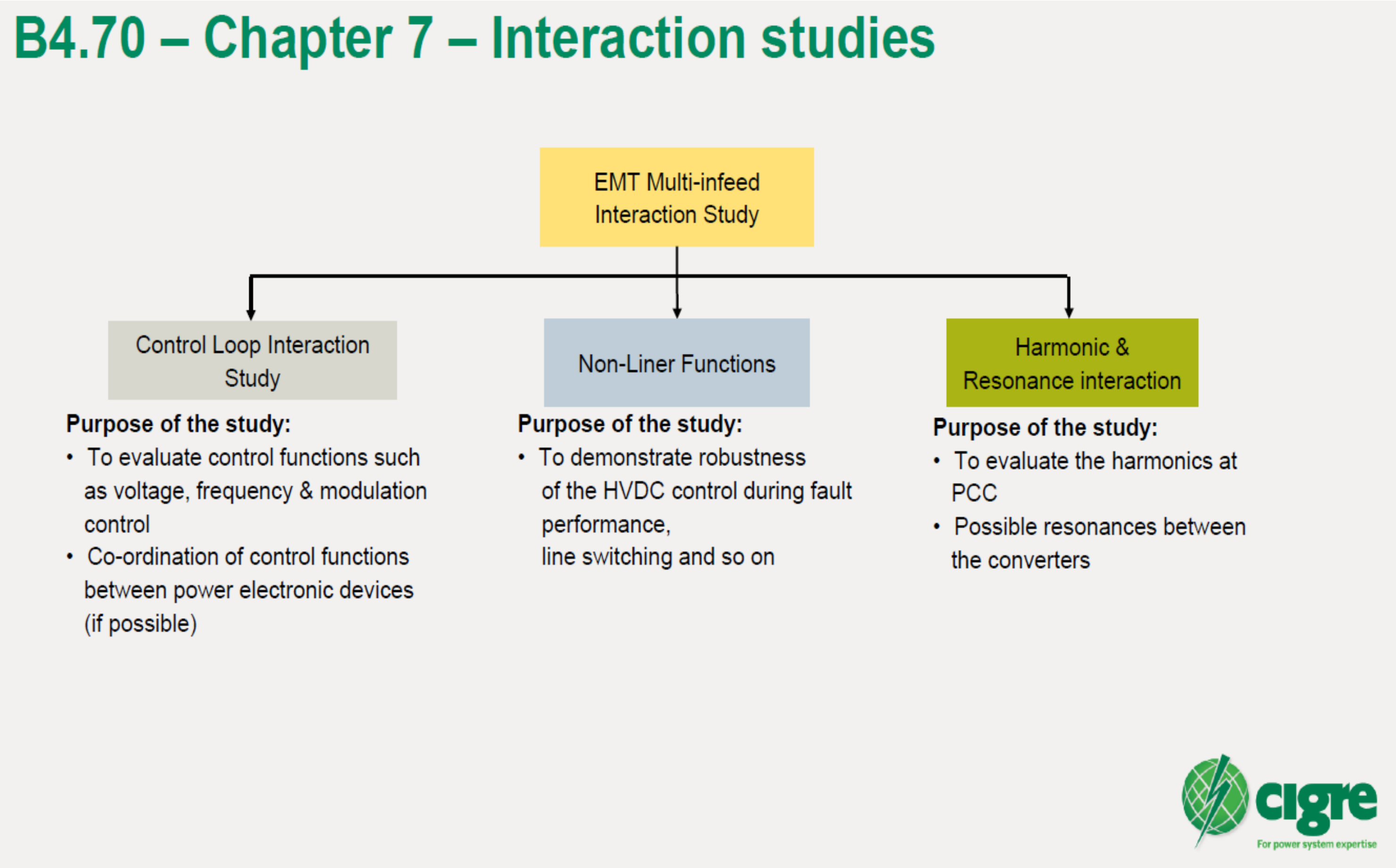
- **Performing interaction studies with high PED is challenging due to:**
  I. The complexity of their control and protection system
  II. The high influence of PED on the power system
  III. Confidentiality and IP issues with the C&P algorithms
  IV. The different software tools, versions, and simulation parameters in which the model is provided
  V. The model maintenance through the lifetime of the project

- For each project phases, several studies are performed. To detect potential interaction issues between PEDs, a different type of tool is used, as shown



# Chapter 4: Interaction Phenomena

Interaction phenomena – Reference: CIGRE B4. 70



# Chapter 5: Definition of simulation models for interaction studies (EMT, RMS)

- **For SPGMs (description of RMS and EMT models)**
  - Dynamic model of turbine-governor
  - 2-axis model of synchronous alternator
  - Mass-spring model of turbine and alternator shaft (multi-mass)
  - Dynamic RMS model of AVR
  - Dynamic SSTI model of AVR (NC HVDC Art. 29.3 and 31.3)
  - Dynamic RMS model of PSS
  - more in the report…

- **For HVDC systems (description of RMS and EMT models)**
  - be valid for all specific operating points and all control modes of the HVDC system;
  - include representation of HVDC converter unit and its control systems that influence the dynamic behaviour of the HVDC transmission system in the specified time frame;
  - include the protection function models as agreed between the relevant TSO and the HVDC system owner;
  - more in the report…
- **For PPMs**
  - reproduce the detailed response of the PPM and its control blocks during balanced and unbalanced AC network faults in the valid frequency range;
  - work in progress..

# Chapter 5: Discussion of frequency dependent models

ENTSO-E has proposed new impedance based model requirement besides EMT and RMS as follows:

## Frequency-Dependent Impedance model requirements (related to NC HVDC Art 54)

For the purpose of the risk assessment of the resonance stability of the HVDC convert station, the relevant TSO shall have the right to request from the HVDC system owner the frequency dependent impedance model of the HVDC converter station at the AC side. In that case, the following requirements shall apply:

(a) The impedance model of the HVDC converter station shall be requested at least in the range 10-2500Hz;
(b) The relevant TSO shall have the right to request the calculation of the impedance model of the HVDC converter station either numerically (using the EMT model) or analytically (using transfer function);
(c) The relevant TSO shall have the right to request the impedance model of the HVDC station through the whole operating range and control modes of operation;
(d) The impedance model of the HVDC converter station shall be provided for both the positive and for the negative phase sequence;
(e) The HVDC system owner shall take into account the influence of the whole HVDC unit control and measurement system as well as other parts of the HVDC unit which influences the output impedance in the specified frequency range;
(f) The HVDC system owner shall specify and justify simplifications made in the calculation of the impedance model;

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# Model Validation (for PPMs)

- **Validation is mainly driven by grid compliance** with FRT requirements

- Higher penetration of renewable on power system means:
  - Increased focus on grid compliance which is also driving model validation, e.g. FRT, etc...

- To comply with grid requirements:
  - Measurements done on a test sites
  - Models validated against site measurements

- **Interaction studies is a wide topic and validating models on all corners can be challenging**
  - examples: unstable system modes, weak interconnection instability, interaction with active system components, operation condition dependency

- **Clear definition of specific tests** and validation for interaction studies purpose is necessary
  - purpose specific
    - e.g. transients, sub/super synchronous, frequency, etc...
  - plant control and wind turbine level control

- Flexibility of model use: driven by project specific phenomenon to be investigated
  - EMT vs RMS, time domain v frequency domain, model features
  - like time steps etc...

# Model Validity (for PPMs)

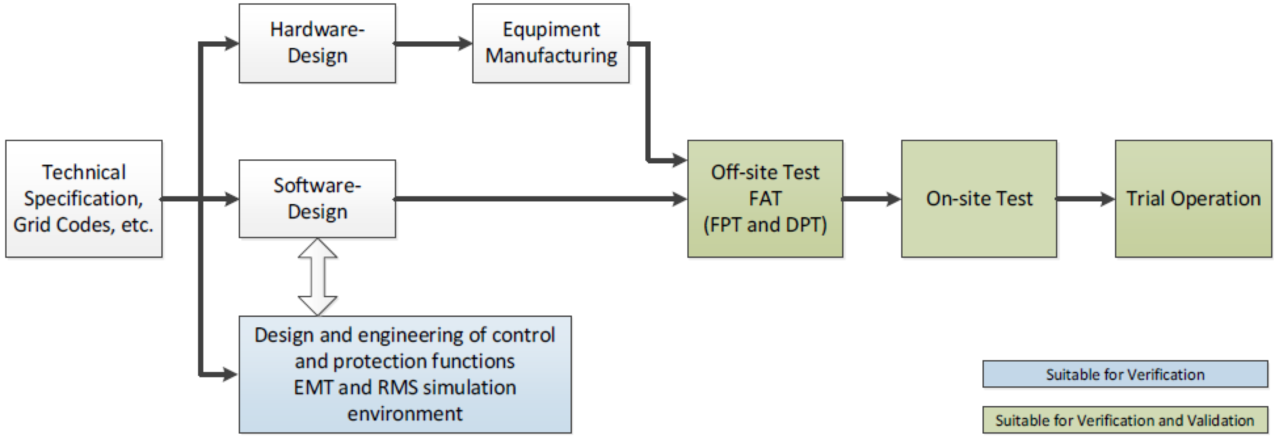
| Phenomena | Phenomena (Grid Code) | Model validity |
|---|---|---|
| FRT | FRT | Model is valid for voltage dip simulations incl. all relevant operation modes and thermal / mechanical limitations |
| Control functions<br>Active power<br>Reactive power<br>P(f) control<br>Inertia emulation | LFSM-O<br>LFSM-U<br>FSM<br>Reactive power capability | Model is valid for all relevant control modes incl. active / reactive power steps, voltage and frequency control |
| Low frequency oscillations | Active power oscillation damping<br>Torsional oscillations | Model is valid regarding the reaction to voltage and frequency oscillations |
| Behavior under weak grid conditions<br>(considering inner control loops) | Island operation<br>Restoration? | Model is valid regarding the behavior in weak grid conditions, relevant inner control loops are considered.<br>Allowed simplifications are proved by tests |
| Harmonic model<br>(Example IEC 61400-21/3) | - | Model is valid for a specified frequency range and different operation points |
| Protection | Part of all | All relevant protection systems shall be represented in the model with correct time delays |
| Transient stress | - | Model is valid for transient switching situations |

# Model Validity (for HVDC)

## Network Code HVDC Article 54 (3)

### Model Verification and Validation – HVDC Design and Engineering Phase

SIEMENS energy




Grid code and technical specification compliance is verified in:

- Studies (such as RMS Stability Study, EMT Dynamic Performance Study, EMT Interaction Study
- Factory Acceptance Test (Real-Time and Non-Real Time)
- On-Site Tests during the commissioning phase

Based on these internal study and testing models, the customer models with verified electrical component, and control & protection system representation are developed.

The On-site tests and the trial operation, as well as commercial operation, provide also information for model validation. This is also related to NC HVDC Articles 54(4) and 54(5).

# Next steps & Risks

1. The time line of the work is too short for the amount of work
   - Many tasks to be completed in very short time
   - Big time constant to draft the needed report
2. Engagement of the Stakeholders by providing contribution is important
   - Stakeholders and contributors are engaged

- Request for extension till June 2021