Expert group: Interaction Studies and Simulation Models (EG ISSM) for PGM/HVDC

Approved by the GC ESC on 04 June 2020
Subject to possible updates on the list of members

Chair: ENTSO-E, Mario Ndreko

Vice-Chair: VGB, Ton Geraerds

Problem Statement

On 11 September 2019, the Grid Connection European Stakeholder Committee (GC ESC) has decided to establish an expert group on interaction studies (IS) for power generation modules (PGM), power park modules (PPM) and high voltage direct current (HVDC) transmission systems. The creation of this EG was proposed by ENTSO-E to elaborate further on connection network code (CNC) issues, which had been raised by stakeholders representing both generation and demand during the CNC implementation. The ENTSOE proposal was based on a stakeholder survey to identify priority topics.

Target (objectives)

The objective of the EG ISSM is to identify simulation methods, simulation models (black box, open source), model structures, the interfaces between the model blocks and the data necessary to be exchanged between the stakeholders in grid connection studies (including large system studies), with main focus on interactions for PGMs, for HVDC systems (including FACTs) and other grid users. The interaction studies under the scope of this EG refer to dynamic and controllers interactions. The EG shall take into account existing developments and propose the model interfaces needed for the purpose of interactions studies (for black box and open source modes). The EG shall develop use cases in order to define the amount of models, data and signals necessary to perform the IS efficiently. In addition, the process of exchanging the models (blocks and signal interfaces) shall be described. The boundaries of the interaction studies are defined in a wide frequency range (sub-synchronous, near-synchronous and higher order of harmonics). In addition, the EG shall assess the efficient use of simulation models to prove compliance with technical requirements (including the process and acceptability) in conjugation with the minimum information acceptable in the use of models.

Legislative background

NC HVDC, Article 51 (2) foresees that: *"The automatic controller of the HVDC system referred to in paragraph 1 shall be capable of sending the following signal types to the relevant system operator: (a) operational signals, providing at least the following: (i) start-up signals; (ii) AC and DC voltage measurements; (iii) AC and DC current measurements; (iv) active and reactive power measurements on the AC side; (v) DC power measurements; (vi) HVDC converter unit level operation in a multi-pole type HVDC converter; (vii) elements and topology status; and (viii) FSM, LFSM-O and LFSM-U active power ranges. (b) alarm signals, providing at least the following: (i) emergency blocking; (ii) ramp blocking; (iii) fast active power reversal. t*

NC HVDC, Article 52 foresees that: *"The parameters and settings of the main control functions of an HVDC system shall be agreed between the HVDC system owner and the relevant system operator, in coordination with the relevant TSO. The parameters and settings shall be implemented within such a control hierarchy that makes their modification possible if necessary. Those main control functions are at* *least: (a) synthetic inertia, if applicable as referred to in Articles 14 and 41; (b) frequency sensitive modes (FSM, LFSM-O, LFSM-U) referred to in Articles 15, 16 and 17; (c) frequency control, if applicable, referred to in Article 16; (d) reactive power control mode, if applicable as referred to in Article 22; (e) power oscillation damping capability, referred to Article 30; (f) sub-synchronous torsional interaction damping capability, referred to Article 31."*

NC HVDC, Article 53 foresees that: *"1. An HVDC system shall be equipped with a facility to provide fault recording and dynamic system behaviour monitoring of the following parameters for each of its HVDC converter stations: (a) AC and DC voltage; (b) AC and DC current; (c) active power; (d) reactive power; and (e) frequency. 2. The relevant system operator may specify quality of supply parameters to be complied with by the HVDC system, provided a reasonable prior notice is given. 3. The particulars of the fault recording equipment referred to in paragraph 1, including analogue and digital channels, the settings, including triggering criteria and the sampling rates, shall be agreed between the HVDC system owner, the relevant system operator and the relevant TSO. 4. All dynamic system behaviour monitoring equipment shall include an oscillation trigger, specified by the relevant system operator, in coordination with the relevant TSO, with the purpose of detecting poorly damped power oscillations. 5. The facilities for quality of supply and dynamic system behaviour monitoring shall include arrangements for the HVDC system owner and the relevant system operator to access the information electronically. The communications protocols for recorded."*

NC HVDC, Article 54 (1) foresees that: *"The relevant system operator in coordination with the relevant TSO may specify that an HVDC system owner deliver simulation models which properly reflect the behaviour of the HVDC system in both steady-state, dynamic simulations (fundamental frequency component) and in electromagnetic transient simulations. The format in which models shall be provided and the provision of documentation of models structure and block diagrams shall be specified by the relevant system operator in coordination with the relevant TSO."*

NC HVDC, Article *70 (1) and (2) foresees that: "1.The relevant system operator shall assess the compliance of an HVDC system, HVDC converter station and DC- connected power park module with the requirements under this Regulation throughout the lifetime of the HVDC system, HVDC converter station or DC-connected power park module. The HVDC system owner or DC-connected power park module owner shall be informed of the outcome of this assessment. 2.Where requested by the relevant system operator, the HVDC system owner or DC-connected power park module owner shall carry out compliance tests and simulations, not only during the operational notification procedures according to Title V, but repeatedly throughout the lifetime of the HVDC system, HVDC converter station or DC- connected power park module according to a plan or general scheme for repeated tests and specified simulations or after any failure, modification or replacement of any equipment that may have impact on the compliance with the requirements under this Regulation. The HVDC system owner or DC-connected power park module owner shall be informed of the outcome of these compliance tests and simulations.*

DCC, Article 21 (3) and (4) foresees that: *"3. Each TSO shall specify the content and format of those simulation models or equivalent information. The content and format shall include: (a) steady and dynamic states, including 50 Hz component; (b) electromagnetic transient simulations at the connection point; (c) structure and block diagrams. 4. For the purpose of dynamic simulations, the simulation model or equivalent information referred to in paragraph 3(a) shall contain the following sub-models or equivalent information: (a) power control; (b) voltage control; (c) transmission-connected demand facility and transmission-connected distribution system protection models; (d) the different types of demand, that is to say electro technical characteristics of the demand; and (e) converter models."*

RfG, Article 15 (6, c) foresees that: *"(i) At the request of the relevant system operator or the relevant TSO, the power-generating facility owner shall provide simulation models which properly reflect the behaviour of the power-generating module in both steady- state and dynamic simulations (50 Hz component) or in electromagnetic transient simulations. The power-generating facility owner shall ensure that the models provided have been verified against the results of compliance tests referred to in Chapters 2, 3 and 4 of*

Title IV, and shall notify the results of the verification to the relevant system operator or relevant TSO. Member States may require that such verification be carried out by an authorised certifier; (ii) the models provided by the power-generating facility owner shall contain the following sub-models, depending on the existence of the individual components: (1) alternator and prime mover, (2) speed and power control, (3) voltage control, including, if applicable, power system stabiliser ('PSS') function and excitation control system, (4) power-generating module protection models, as agreed between the relevant system operator and the power- generating facility owner, and (5) converter models for power park modules; (iii) the request by the relevant system operator referred to in point (i) shall be coordinated with the relevant TSO. It shall include: (1) the format in which models are to be provided, (2) the provision of documentation on a model's structure and block diagrams, (3) an estimate of the minimum and maximum short circuit capacity at the connection point, expressed in MVA, as an equivalent of the network; (iv) the power-generating facility owner shall provide recordings of the power-generating module's performance to the relevant system operator or relevant TSO if requested. The relevant system operator or relevant TSO may make such a request, in order to compare the response of the models with those recordings;"

RfG, Article 40 (1) foresees that: *"The power-generating facility owner shall ensure that each power-generating module complies with the requirements applicable under this Regulation throughout the lifetime of the facility. For type A power-generating modules, the power-generating facility owner may rely upon equipment certificates, issued as per Regulation (EC) No 765/2008. 2"*

Task description

Discussions with stakeholders and stakeholder interventions at the GC ESC have identified that the confidentiality between the exchanged models as well as the accuracy of generic models is an issue when performing interoperability studies for PGMs and HVDC systems. Moreover, the simulations model accuracy and validity with respect to the accurate representation of the installation is crucial for interaction studies. Under these boundary conditions the following tasks have been identified for the EG:

- With regard to NC HVDC, Article 51 and Article 53, the HVDC systems have the capability to enable fault recording and monitoring signal of key operation metrics such as voltages (AC, DC), currents (AC, DC) and power. The later shall be assessed on how it could be integrated in the validation of the models used in interaction studies as well as on how potential signal interfaces between various control blocks could be used to reproduce faults from the field.

- With regard to NC HVDC, Article 54 (1), the stakeholders have requested clarification on the type of model (black box or open source model) as well as clarification on the accuracy of the model and its capability to reflect the adequate real behaviour of the installation. The EG shall define the models needed, the model block layers as well as the relevant signal interfaces between the control layers in the models (black box, open source) in order to perform accurate, reproducible and validated interaction studies. The definition of control layers and interfaces in models (offline, real-time) could provide a platform on how signals and data could be exchanged in interactions and network code compliance studies. The model structure shall as well support NC HVDC Article 70 and the amendment of the model during lifetime. The model should be flexible for different studies always representing the exact control behaviour by having the real source code of all control layers included. Separation between physical hardware and control is essential in order to support all kind of interaction studies.

- NC HVDC, Article 70 requires the assessment of an HVDC system during lifetime. This article is relevant for interaction studies, as the required modelling accuracy to cover all potential interaction risks is not yet fully known. Furthermore, a consistent representation of power-electronic assets by separating physical hardware and control ensures interoperability in the long term beyond typical manufacturer warranty periods.

- With regard to DCC, Article 21 (3) stakeholders have requested to precisely define that the dynamic states of the model shall represent electromechanical phenomena based on root-mean-square (RMS) or positive sequence models. The phrase “including 50 Hz component” is unclear and suggests that the 50 Hz component is one of many components required in this type of dynamic studies. The content and format shall include "structure and block diagrams" is not a clear and coherence sentence. With regard to DCC, Article 21 (4), it is not clear, why simulation models do not consider frequency regulation despite the capability of the demand response system frequency control is determined in paragraph 29 or DS connected PGMs. The EG shall address the above mentioned issues and provide recommendations.

- With regard to RfG, Article 15 (6, c), the EG shall provide an overview of different types of dedicated models (black-box, open source, generic), representing the real plant (PGM) behaviour by implementing/embedding in the models the real source code. The EG shall recommend use cases for the demonstration of adverse interactions studies for AC and for DC connected PGMs. In the focus of the EG will be also SPGMs in the close electrical proximity of HVDC systems (where sub-synchronous torsional interactions become relevant). The EG shall define the process for model validation (potentially with field tests) and model layers in black-box models (covering control and physical layers). The EG shall propose well defined interfaces in the simulation models for the control and physical layer that need to be observable/accessible from stakeholders in grid connection and compliance verification studies. Separation between physical hardware and control is essential in order to support all kind of interaction studies and allow reproduction of faults/interactions from the field.

- With regard to the RfG article 40 and associated sub-articles, the EG shall discuss the way to use mathematical models representing the generating unit behaviour to prove compliance to the requirements. Discussion can include the different type of models and their minimum structure. The EG shall provide recommendations on model validation and associated process, including eventual field testing. The EG group shall discuss what the model shall include (or exclude). The EG shall identify applicable reference standards that can be used by manufacturers and on which they shall be based upon.

Deliverables

- Provide a report to the GC ESC with detailed recommendation and solution to the tasks defined above.
- Derive proposals for the potential revisions to:
    - NC RfG, NC HVDC and NC DCC along with justification; and
    - associated non-binding implementation guidance documents.

Timing

- estimated 6 months from June 2020.

Team (update 10.06.2020)

The following nominations to participate in EG ISSM have been received (name and association):

Name	*Organisation*	*Representation at GC ESC*
Mario Ndreko	TenneT DE	ENTSO-E
Macarena Martín Almenta	REE	ENTSO-E
Hani SAAD	RTE	ENTSO-E
Tobias Hennig	Amprion	ENTSO-E
Ioannis Theologitis	ENTSO-E	ENTSO-E
Jesus Bernal Lopez	Iberdrola	SolarPower Europe
Juan-Carlos Perez Campion	Iberdrola	SolarPower Europe
Daniel Premm	SMA	SolarPower Europe
Musa Shah	Lightsource BP	SolarPower Europe
Naomi Chevillard	SolarPower Europe	SolarPower Europe
Vasiliki Klonari	WindEurope	WindEurope
Patrick Alizon	Vestas	WindEurope
Ton Geraerds	RWE	VGB
Eric Dekinderen	VGB	VGB
Cedric Lehaire	Veolia	COGEN Europe
Luvigi Di Raimondo	Solar Turbines	COGEN Europe
Alexandra Tudoroiu	COGEN Europe	COGEN Europe
Mike Kay	ENA	GEODE
Luca Guenzi	Solar Turbines	EUTurbines
Kevin Chan	GE	EUTurbines
Magdalena Kurz	EUTurbines	EUTurbines
Vincenzo Trovato	ACER	ACER
Adolfo Anta	AIT	EASE

Estimated workload

- biweekly webinars;
- 3 physical meetings
- commitment of 25 days per member.

Target audience

- GC ESC
- Relevant and/or interested stakeholders on the Connection Network Codes