CIGRE Study Committee C4

PROPOSAL FOR THE CREATION OF A NEW JOINT WORKING GROUP (1)

JWG* C4/C6.35/CIRED WGa	**Name of Co-Convenor: Koji Yamashita** (JP) **E-mail address**: koji.japan@gmail.com/yama@criepi.denken.or.jp **Name of Co-Convenor: Alberto Cerretti** **E-mail address**: alberto.cerretti@enel.com
Technical Issues # (2): 3, 8	**Strategic Directions # (3): 1, 2**
The WG applies to distribution networks (4): Yes	
Title of the Group: Modelling and dynamic performance of inverter based generation in power system transmission and distribution studies	

Scope, deliverables and proposed time schedule of the Group:

Background: In recent years there has been much effort on the development of models for renewable generation sources (RES), primarily associated with wind generation[1]. However, further work is needed and some attention is now starting to be devoted to photovoltaic (PV) systems. Very little validation work has been done for the PV models up to this point. Thus, in general there is still a lack of validated and generally accepted dynamic electrical simulation models particularly for PV, for use in large system dynamic studies.

Current trends towards integration of an increasing range of generation technologies widely differing in size and number poses serious concerns in the industry on how to represent these new technologies in power system network simulations. In fact, not only is there a lack of validated dynamic computer models of individual generating technologies, such as photovoltaics, fuel cells, micro turbines and other inverter based sources, but also there is no agreed methodology on how to represent or aggregate the enormous generation in large system dynamic studies, focusing on both local (distribution level) and widespread (transmission level) disturbances. Furthermore, as the penetration of such inverter based generation technologies increases, various aspects of the power system stability and dynamic performance may change. For example in the extreme where for certain island systems there is the potential for the system to have nearly 100% penetration of inverter based generation, in certain future scenarios, a phenomena such as rotor angle stability is no longer relevant. Also protection systems are heavily impacted by high penetration of inverter based generators.

The abovementioned increased penetration of distributed energy resources (DER) also makes system operation more challenging than in the past, both for transmission system operators (TSOs) and distribution system operators (DSOs). Already in some areas the fulfillment of the consumers' need is mostly achieved by generation which is connected directly to the distribution system; in the near future, this may become the norm. From a technological viewpoint, as already mentioned, most of these new generators use power electronic converters to interface to the grid, with completely different dynamic characteristics compared to the classical synchronous generators.

TSOs routinely run dynamic time-domain simulations to assess the stability of the system. Models which are currently used to represent distribution systems are only based on a limited amount of information, generally related to the HV network, taking into account the lower voltage level

[1] A previous report by CIGRE WG C4.601 on Modeling and Dynamic Behavior of Wind Generation as it Relates to Power System Control and Dynamic Performance, August 2007. Furthermore, there is much on-going work by the IEC TC88 WG27 on Wind Turbine Modeling and the WECC Renewable Energy Modeling Task Force in the US. This JWG should take these previous, and on-going efforts, into consideration and complement this work instead of duplicating effort.

contribution through the power exchange which has been historically measured at the HV-MV boundary or through the installed transformation power in any given substation.

DSOs have a representation of their networks and have details about connected users and producers to some extent; however, this data is generally not suitable for dynamic simulations for either the distribution or transmission systems or, at least, has not been used for that purpose in the past, due to there being too high a level of detail.

From the point of view of DSOs dynamic simulations may also now be necessary to focused on assessment of protection system behavior, distribution network automation operation, uncontrolled islanding of part of distribution systems sustained by DER, voltage issues, etc. Time-domain domain simulations may be needed for this purpose but, in order to run them, extremely accurate models of loads and generators, based on the features of real components, must be available.

Being able to define detailed models for time domain simulations and, starting from these, simplified and reduced models would support the need of DSOs for representation of dynamic behavior of individual distribution systems (or parts of it), including embedded generation and load in a schematic and conventional way with acceptable adherence to the reality, as well as TSOs needs of managing a more complicated system than they were used to, also increasing the awareness of DSOs and single network users about the impact of distribution network design and of the dissemination of resources and consumption.

Scope:

Based on the aforementioned background, the aim of this WG is to address the following issues:

1. Provide critical overview of existing RES dynamic electrical simulation models and modeling methodologies, focusing primarily on photovoltaics and some other inverter-based sources, and their relevant parameters for both distribution and transmission system studies. Generation technologies for which adequate dynamic electrical simulation models are presently missing or not completely appropriate for the expected purposes will be identified. Reference will be made, and coordination done, with existing groups such as the IEC and WECC groups in an effort to briefly summarize, with reference, such working already in process to avoid duplication of effort. Suggestion will be made on improvements to the models and modeling methods as appropriate.
2. Develop a set of recommendations and step-by-step procedures for RES dynamic electrical simulation model development and validation for different types of large system dynamic studies (mainly small and large disturbance studies).
3. Provide recommendations on developing equivalent dynamic electrical simulation models of clusters of same and different types of RES technologies.
4. Provide an overview of potential new system performance issues that may arise as a result of very large penetration of inverter based generation (and load) technologies.

Also, note that the models for distributed generation will be aggregated models as seen at the MV-LV and HV-MV transformations and should try to take into account:

- extension, configuration and composition (bare conductors, cables, etc.) of the LV and MV networks;
- contribution of embedded generation (type of plants, installed capacity, built-in protective relays, regulation capabilities and settings, etc.);
- automated operation and/or protection systems such as load-shedding functionalities, self-healing characteristics, etc.
- islanded operation on MV network.

The characterization of loads is also important in these activities, but much of this work has already been done and soon to be completed by the WG C4.605 Modelling and aggregation of loads in flexible power networks. Therefore, any additional work done in this regard should be minimal and with reference primarily to the WG C4.605 work.

The above scope is perhaps too large for a single Technical Brochure (CIGRE TBs are to be generally kept to around 100 pages). Therefore, the co-conveners will at the outset of the work identify the breakdown of the work into two subgroups which will each be responsible for one of the two Technical Brochures. The two documents should be complementary and the groups should work together to ensure consistency and to merge the experiences of transmission and distribution experts.

Deliverables: A summary paper that will be published in Electra as well as two (2) detailed Technical Brochures to be published by CIGRE. It is anticipated that the above scope is too much to be published in a single Technical Brochure. The co-conveners are responsible for keeping CIGRE SC C4, SC C6 and CIRED informed of the work and to submit all completed documents to the three groups for final approval. SC C4 will then send the finished products, once approved by SC C4, SC C6 and CIRED, to the CIGRE head office for publication.

Time Schedule: October 2013 **Final report**: March 2017

Comments from Chairmen of SCs concerned: The three entities (CIGRE SC C4, SC C6 and CIRED) have agreed through a series of emails to this joint venture.

Approval by CIGRE Technical Committee Chairman:
Date: 28/10/2013

Approval by CIRED Technical Committee Chairman:

Date: 19/11/2013

(1) Joint Working Group (JWG) - (2) See attached table 1 – (3) See attached table 2
(4) Delete as appropriate

Table 1: Technical Issues of the TC project "Network of the Future" (cf. Electra 256 June 2011)

1	Active Distribution Networks resulting in bidirectional flows within distribution level and to the upstream network.
2	The application of advanced metering and resulting massive need for exchange of information.
3	The growth in the application of HVDC and power electronics at all voltage levels and its impact on power quality, system control, and system security, and standardisation.
4	The need for the development and massive installation of energy storage systems, and the impact this can have on the power system development and operation.
5	New concepts for system operation and control to take account of active customer interactions and different generation types.
6	New concepts for protection to respond to the developing grid and different characteristics of generation.
7	New concepts in planning to take into account increasing environmental constraints, and new technology solutions for active and reactive power flow control.
8	New tools for system technical performance assessment, because of new Customer, Generator and Network characteristics.
9	Increase of right of way capacity and use of overhead, underground and subsea infrastructure, and its consequence on the technical performance and reliability of the network.
10	An increasing need for keeping Stakeholders aware of the technical and commercial consequences and keeping them engaged during the development of the network of the future.

Table 2: Strategic directions of the TC (cf. Electra 249 April 2010)

1	The electrical power system of the future
2	Making the best use of the existing system
3	Focus on the environment and sustainability
4	Preparation of material readable for non technical audience