Distributed Energy Resources and Power System Stability

A. Svalovs, I. Svalova
Parsons Brinckerhoff Ltd (PB Power)
Amber Court, William Armstrong Drive
Newcastle upon Tyne, NE4 7YQ, UK
E-mail: svalovsa@pbworld.com

A. Sauhats, J. Kucajevs, N. Halilova
Power Energy Institute,
Riga Technical University
Kronvalda bulv. 1, LV-1010, Rīga, Latvia
E-mail: sauhatas@eef.rtu.lv

***Abstract* — Future power systems will contain a considerable portion of distributed energy resources. To accommodate this, well established requirements are applied both at the system development and operation stages. One of the main requirements is the existence of a dynamic stability reserve that is capable of providing sufficient support to the system during transients. However, the future dynamic characteristics of power systems are unknown and in this respect appropriate modelling and uncertainty handling techniques are required. To provide this, automation procedures have been developed to estimate future stability reserves for the systems under consideration.**

I. FUTURE POWER SYSTEMS INVESTIGESTIONS

The poster presents the results of investigations into future power systems (FPSs) that contain a considerable volume of DER including both synchronously and asynchronously operated generation. One of the main requirements for system development and operation is the existence of sufficient dynamic stability reserve, which ensures the system viability and prevents large-scale incidents.

For FPS it is not easy to make a priori clear assumptions about the network development and generation planning at the DER level. It is impossible to predict exactly the structure, composition, and parameters of such systems. For this, it is necessary to perform calculations that would correspond to various combinations of the types of DERs used, their connection points, and disturbances that may cause a loss of dynamic stability.

To do this, we propose to use industrial (commercially available) software that simulates the electromechanical transient processes in the systems containing both traditional and DER generators, complimented with:

- a block (procedure) that automatically predicts possible future states of FPS, including load-flow conditions, and a dynamic description of equipment and events;
- a block (procedure) that estimates states as being acceptable or non-acceptable from the angle stability point of view.

The above theories require numerical solutions considering the future events. If properly selected, uncertainty modelling approaches will enable us to handle the restriction problem in FPS.

The algorithm considered here is aimed at classifying all possible states of FPS as acceptable or non-acceptable from the angle stability point of view. More precisely the limit states are found by posing additionally a sub-task as shown below.

A. Sufficiency stability criterion

Classification of FPS states as acceptable or non-acceptable is based on the sufficiency of stability reserve for a transmission grid. As the sufficiency criterion, the allowable limit for short-circuit critical clearing time (CCT) has been assumed.

CCT is defined as the maximum duration of a fault which will not lead to the loss of synchronism of one or more generators. The minimum value of CCT (CCT limit) is limited by operation times of the relay protection and circuit-breakers. Acceptable states are the states at which the CCT value exceeds that of the CCT limit. Non-acceptable states are the states at which the CCT value is below the CCT limit.

The group of acceptable FPS states is additionally divided into limiting and non-limiting. The limiting state group is denoted as DERmax range, which corresponds to the CCT values close to the CCT limit (see Figure 1).

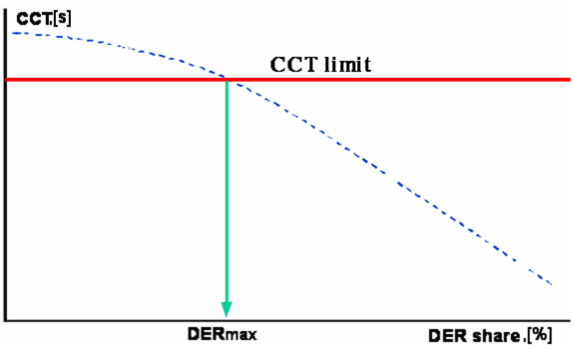

Figure 1. Definition of the maximum DER share concept.

The presented approaches for modelling and classification of FPS states were used to study a system based on the existing interconnection of the power systems of the Baltics (Estonia, Latvia, and Lithuania) with the Northwest of Russia and Belarus.

The interaction of transient processes in transmission and distribution networks can affect both positively and negatively the transmission system's stability. Tripping of DER generators can increase - or decrease as well - the power flows in a transmission thus leading to the stabilisation or destabilisation of the angle position.

In the positive case DER are located mainly at the importing side of a transmission corridor.

The negative effect of CCT decreasing was found in our other simulations. This happens in two cases: when DER are located mainly at the exporting side of a transmission corridor, and when they are evenly distributed throughout the whole system. To comment on this, one should consider the dynamic behaviour of DER synchronous generators following a fault in the transmission system.

DER units are very sensitive to the faults originating in transmission systems. Two types of DER response exist affecting the CCT values:

- Tripping of DER by their own protection following repeated voltage falls (swings) in the high-voltage system, and
- DER generators losing synchronism after large and sudden changes of the operating conditions in transmission networks. In this case, large generators remain in synchronism.

To this end, all DER synchronous generators in our simulations were supplied with automatic protection for asynchronous operating conditions.

A boundary between acceptable and non-acceptable states may be extended by introducing one or more of the following:

- implementation of faster acting relay protection and circuit-breakers in the transmission grid;
- application of new requirements for keeping the DER in operation under decreased and increased voltage and frequency conditions.

The last point also provides a basis for maintenance of the operational integrity of a distribution network when it is separated from the transmission network.