SIMULATION FRAMEWORK FOR ANALYSIS OF THE EUROPEAN TRANSMISSION SYSTEM UNDER A WIDE RANGE OF OPERATING CONDITIONS

Irina BOIARCHUK[1], Dominic HEWES[1], Sascha ALTSCHÄFFL[1], Rolf WITZMANN[1]

Problem Statement

Current challenges in the field of system stability, such as the balancing of load and generation in a predominantly renewable-based energy system or the incorporation of HVDC links in the European Transmission System (ETS), provide a large research area for power engineers and scientists. These issues require system behavior to be examined under a wide range of operating conditions, which correspond to execution of system analysis on DC, AC and dynamic levels with a possibility to examine the influence of different factors (e.g. weather conditions).

To conduct system simulations, multiple models of the ETS and its regions have been published in the literature during recent years. However, their applications are usually limited by the scope of the projects for which they were established.

In this paper, a flexible simulation framework for assessment of the ETS under a wide range of both normal and abnormal conditions is presented.

Method

The modelling framework is based primarily on the development of a quasi-stationary AC load-flow model (QS AC LF) of the ETS, as presented in [1]. The method of the ETS model creation is extended and set up as an automatic process within the simulation framework. As a result, the following four representations of the ETS can be generated and analyzed (Fig. 1): base model, market model, QS AC LF model with convergent AC load-flow results, and dynamic model. A stepwise transition between system representations is accomplished within the framework. To implement this feature, a set of necessary parameters is defined for each model type. The models are grouped according to the simulation type possible with them (quasi-stationary and dynamic), and subdivided into two modules.

Module 1 is responsible for the generation of system models for analysis under normal conditions. We define a scenario as an elementary system representation, which includes topology, power plant fleet, peak loads and installed capacities of known equipment (synchronous generators, renewable sources). Starting with a scenario, a desired complexity of a system representation can be achieved. To implement this, the profiles for load (1), PV (1), wind (1), storage capacities (2), representation of distribution systems in the simulation (2), load power factor (3), reactive power control strategies (3) are defined for a corresponding stage of the model generation process (stages 1 to 3 on Fig. 1). Different values can be assigned to these parameters such that the framework maintains maximum flexibility for simulation of different scenarios. Another advantage of the developed procedure is that both economical and technical limitations are taken into account in the simulation processes.

Module 2 incorporates functionalities for analysis of dynamic system behavior and can serve as a continuation of the module 1. Firstly, a desired operating point is selected from calculated AC load-flow results of a QS AC LF model of interest. Then, dynamic machine models are added to the stationary system representation. Finally, dynamic properties like frequency behavior of the system can be evaluated in corresponding simulations (short circuit analysis, eigenvalue analysis, transient stability, synchronous machine dynamics).

[1] Technische Universität München, Arcisstraße 21, 80290 München, Fax: +49 89 289 25089,
{Tel.: +49 89 289 25098, {irina.boiarchuk|dominic.hewes|sascha.altschaeffl}@tum.de},
{Tel.: +49 89 289 22004, rolf.witzmann@tum.de},
www.een.ei.tum.de

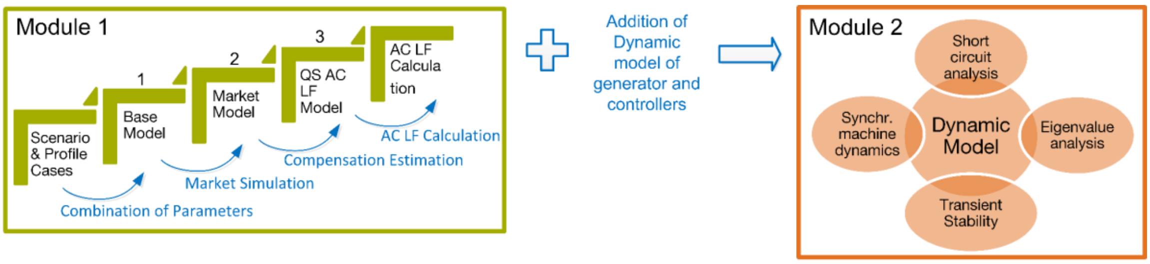

Figure 1: Functionalities of the Simulation Tool.

Results

The presented simulation framework is a generic tool with potential application for ETS development studies. A great variety of demand (active and reactive power), weather and economic cases can be simulated using the framework. The influence of changes in static system parameters or economic factors can be investigated and assessed in dynamic simulations. An example of results obtained from the simulation framework is presented on Figure 2.

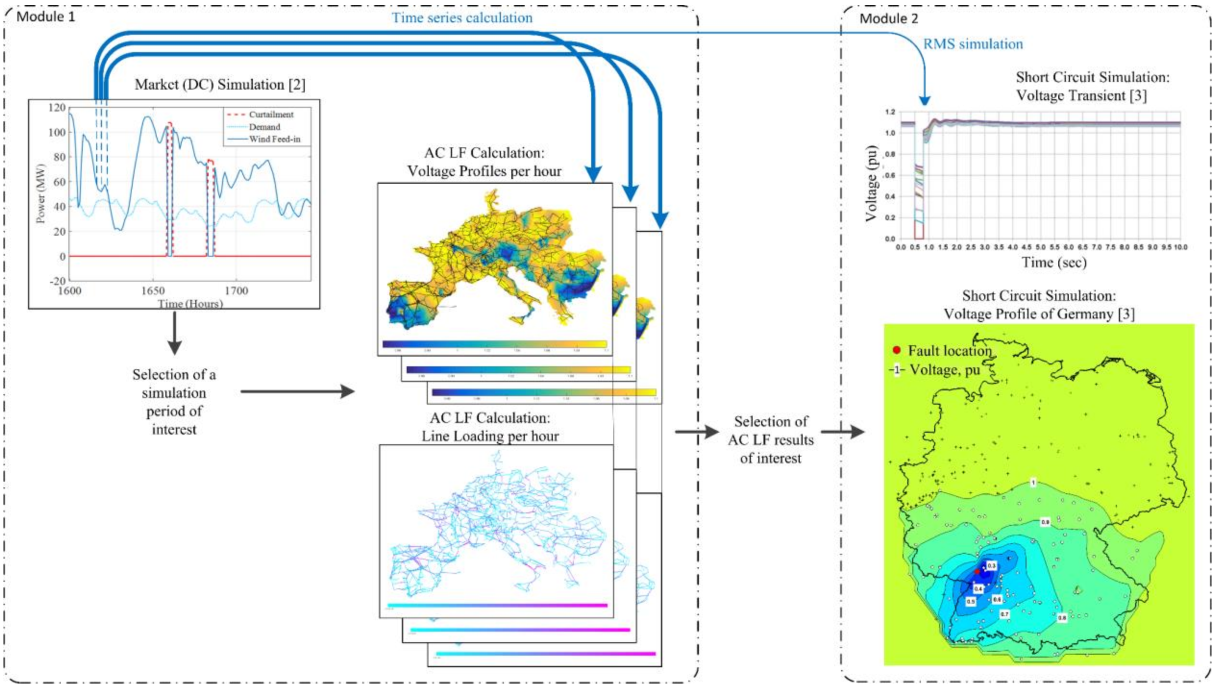

Figure 2: Example results of the Simulation Framework: DC, AC and dynamic simulations of the ETS.

References

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