Instruction manual

Dynamic Study Model
Range of Applications and Modelling Basis

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Contents

1 The concept of the Dynamic Study Model

1.1 Introduction

Aim of the document is to illustrate the preparation of a reference model for the Continental Europe (CE), power system suitable for studies and dynamic evaluations performed by TSOs and external parties. The model was prepared by ENTSO-E System Protection and Dynamics (SPD) experts based on physical considerations and expert knowledge for the European power system dynamic behaviour. The internal/external use of this model is recommended exclusively under the supervision/support of a SPD group expert.

The main target of the Dynamic Study Model was to setup a robust, simple, transparent and easily transferable dynamic model able to reproduce the same results with a high variety of dynamic simulation tools available and in use at the different CE TSOs.

For this purpose a load-flow model of the CE-system was expanded with standard models for generators and appropriate controller models in order to represent the dynamics of the interconnected CE power system. With defined criteria it is possible to choose, which generators should be taken into account for dynamic analysis. The following **Figure 1.1** shows the concept of the Dynamic Study Model.
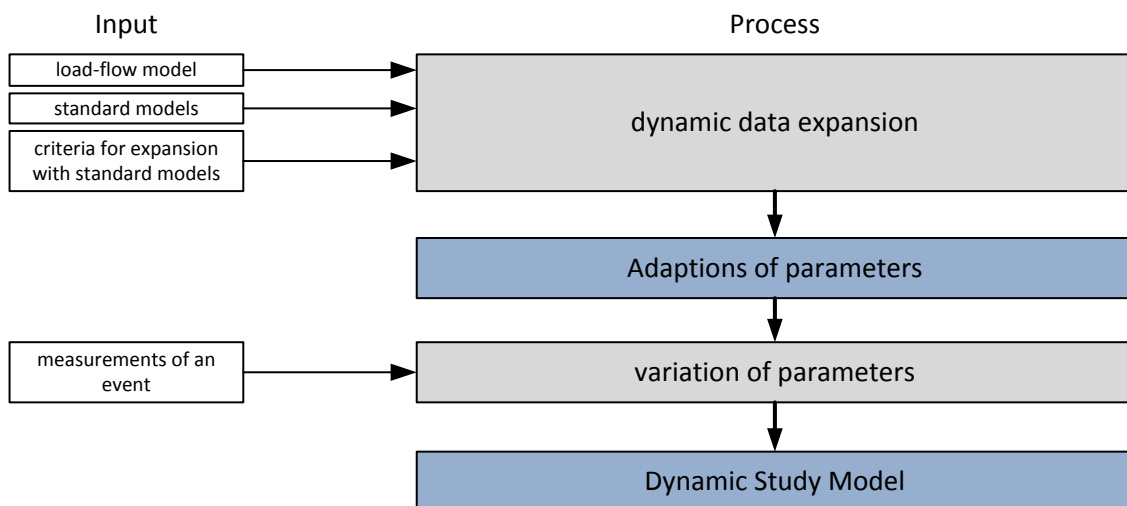
Fig. 1.1: The concept of the Dynamic Study Model

After the expansion with dynamic data a dynamic model with initial parameters is set up. Subsequently the model is systematically tuned with the help of measurements of an event by adjusting parameters of the standard models.

The resulting model describes the general dynamic behaviour and allows investigating frequency transients and general oscillatory behaviour. This model can also be used for detailed investigations e.g. local voltage transients. However, for this purpose the TSOs have to replace the affected area with a more detailed model (area and model accuracy depends on investigation issue). Detailed investigation within a specific local area is then possible by using the Dynamic Study Model and substitute the model of the local area by a more detailed representation.

As previously reported, the parameters and settings described below, are a result of the study of the European grid behaviour and complex evaluation of dynamic clusters of this system; so these settings

can differ from "classical" literature typical numbers. Consequently the following reference dynamic standard models were set up:

- standard synchronous machine with round rotor
- automatic voltage regulator (AVR),
- power system stabilizer (PSS) and
- prime mover (GOV) representation.

Test and comparison of the standard models in different simulation tools was already published on the ENTSO-E website [1].

1.2 Scope of application

The Dynamic Study Model is suitable for representing:

- Mean frequency transients (spinning reserve, primary regulation)
- General oscillatory behaviour (i.e. modal analysis)

Therefore this model should be able to reflect the typical "mean" dynamic behaviour for the whole CE interconnected power system. On the other hand, the model does not take account of:

- local phenomena such as voltage transients,
- system protection of lines, generators and other devices,
- special protection schemes and defense plans,
- specific particular control schemes (AGC, islanding regulation, emergency overfrequency control, overfrequency control, under/overexcitation controls, etc.), and
- dynamic load behaviour and
- specific models of devices connected through a power electronic interface

This means, if specific studies have to be performed, a correct "local" configuration of the power system must be done, with corresponding detailed models and settings; this should be performed in consultation with the SPD group.

2 Data Adjustments

In order to simplify the model and be able to make the network data available to third parties a few simplification and anonymisation steps were performed as e.g.:

- reduce parallel lines
- reduce coupled busbars to single busbar
- unify line and transformer limits
- anonymise geographical names
- aggregate loads

However, all this adjustments were done in such a way that the TSOs as single entities together with their dedicated tie lines can be identified and the dynamic behaviour of the power system is not affected.

3 Dynamic Data Expansion

As described in chapter 1.1 the load-flow model is expanded by additional information to make dynamic calculations possible. The additional information covers the standard dynamic models of the generators, the voltage controllers (AVR), the power system stabilizers (PSS) and the governors (GOV). In [1] detailed modelling and initial parameters of the standard models can be seen. The mentioned models have to be inserted in the adjusted load flow model in the corresponding dynamic simulation tool. There are some points to be considered:

- no controller shall be at limit, e.g. Pmax=1.05 p.u.
- in order to create a fully transparent, robust and simple handling only generation infeed with maximum active power higher than 250 MW is considered to be equipped with synchronous machines and related control equipment with the parameter and settings as described in [1]. By this rule the not considered infeed is modelled as negative constant impedance.
- standard governors of pump storage units (Pgen < 0) are deactivated. Otherwise the controllers would reach the limits in the time domain directly.
- due to the loss of the information for the fuel type there are some infeeds e.g. wind farms or HVDC converters which have to be identified. These units, even if their maximum active power is greater than 250 MW, are modelled as constant impedance without dynamic generator data and without inertia.
- loads are modelled as constant impedances, so that only squared dependency of voltage is given. No frequency dependency in load models is taken into consideration.
- Network elements are modelled frequency independent, related to nominal frequency.

4 Validation of the Dynamic Study Model

Based on expert experience and knowledge a subsequent process of parameter adaption have taken place which have finally end with slightly adapted parameters in comparison with the standard settings documented in [1]. The comparison between measurement and simulation is depicted in **Fig. 4.1.**
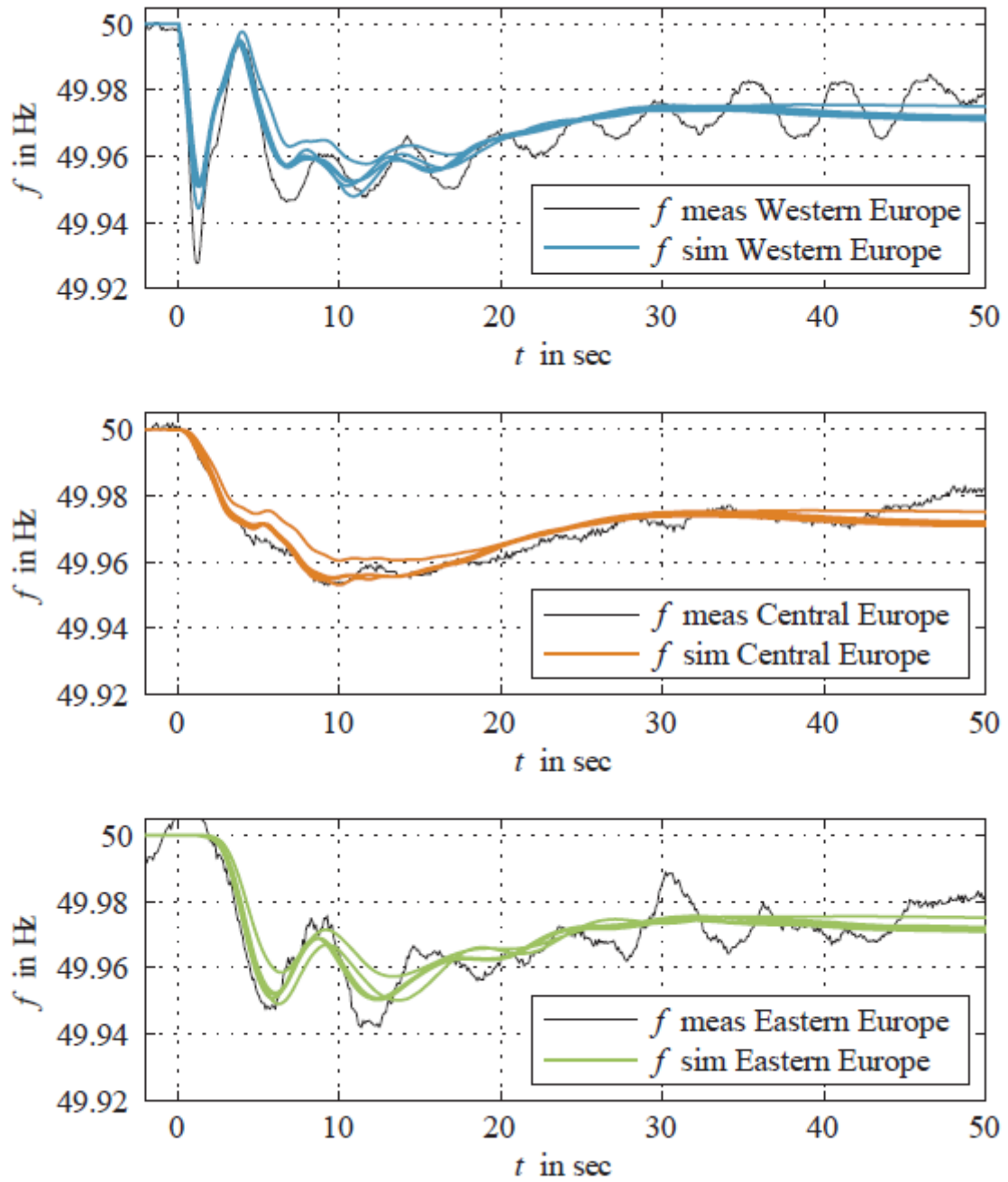
Fig. 4.1: Measured and simulated frequency after a plant outage in Spain

5 References

[1] ENTSO-E WG SPD, „Documentation on controller tests in test grid configurations," ENTSO-E, Brussels, 2013.