Generator Grid Code Compliance Assessment Using Simulation Models

Jan-David Schmidt
j.d.schmidt@energynautics.com

Agenda

1. Background and Motivation
2. Comparison of Approaches for Compliance using Models
3. Comparison of Model Validation
4. Modelling experiences

Background

energynautics
solutions for sustainable development

European Grid Code: Requirements for Generators (RfG, Commission Regulation (EU) 2016/631)

- Common European grid code was introduced in 2016 for ENTSO-E
- Harmonization of requirements in all ENTSO-E countries
- But RfG only gives high level requirements

➢ Details are left to the countries

➢ Almost no information on how to prove compliance of generators

➢ Consequence: different approach in each country

- RfG is currently being revised

Motivation

energy**nautics**
solutions for sustainable development

- We have observed that the **approach** and the **effort** using simulation models to prove compliance can vary a lot in different European countries
- Differences in effort raises the question, which effort is necessary?

- Comparison of the approach for 4 countries:
  Germany, Italy, Belgium and Austria
- Focus is on synchronous generators connected to medium voltage

Approaches

Relevant Guidelines:

- Germany: **VDE-AR-N 4110/4120/4130** and **FGW TG 4, Annex E**
- Italy: **CEI 0-16, Annex Nter**
- Belgium: **"Compliance Simulation Procedure Type B SPGM"**
- Austria: **"TOR Erzeuger: Anschluss und Parallelbetrieb von Stromerzeugungsanlagen des Typs B" (TOR B)**

Approach in Germany and Italy

energynautics
solutions for sustainable development

Creation of power plant simulation model → Preliminary compliance study → Temporary approval and connection

→ Commissioning tests and measurement → Validation of simulation model → Final compliance study

→ Final approval

(Germany: For small machines a different approach using unit certificates is more efficient)

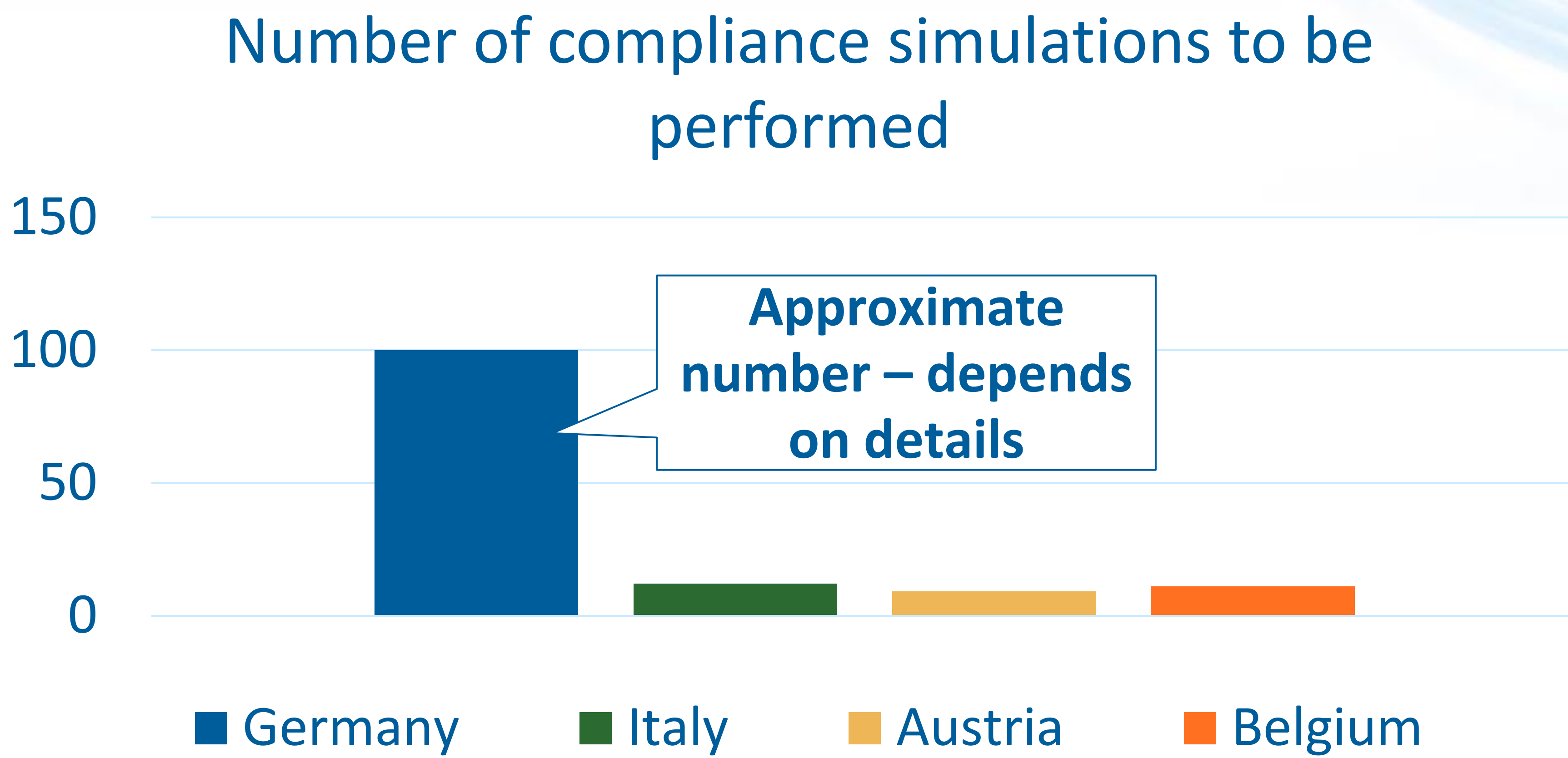
Approach in Austria and Belgium

Run compliance simulations → Evaluate the behavior, submit report → Final Approval

In Austria:

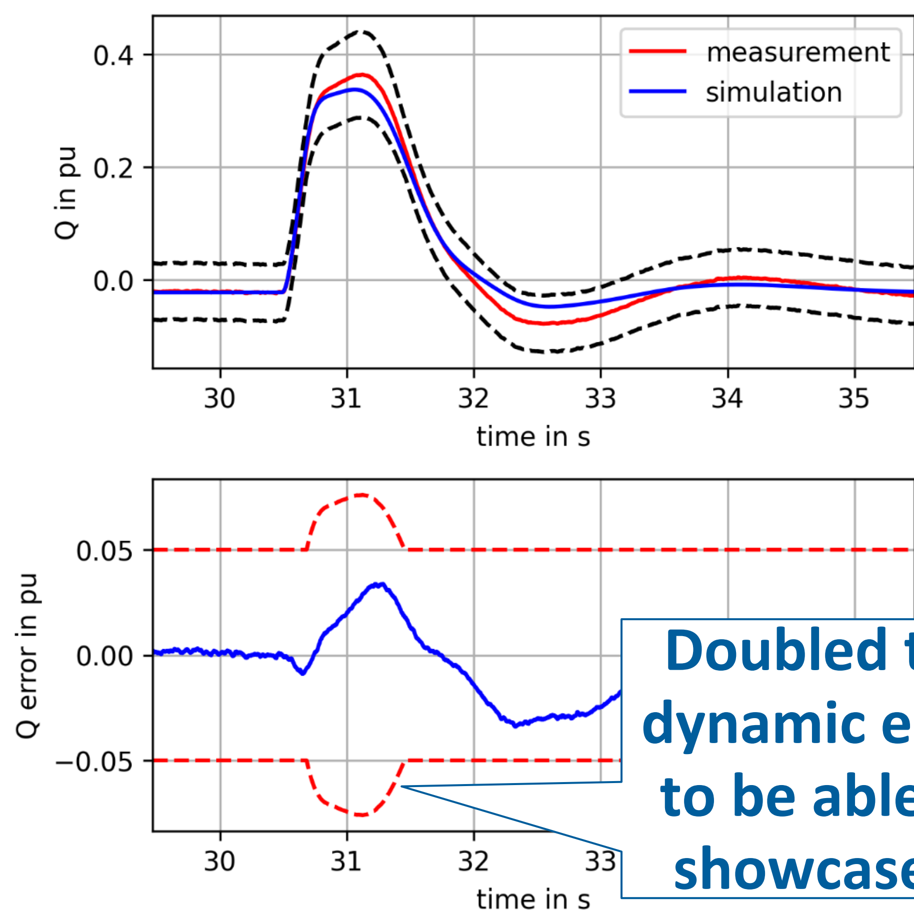
- Grid operator decides together with grid user, if compliance tests or simulations are done

Compliance Simulations



Model Validation in Germany

- Sophisticated (complex) formulas for allowed errors
- Partly very strict limits even during transients (5 % and sometimes 1.5 %)
- Evaluated quantities:
  - Active & reactive power
  - Excitation voltage and current
  - Intermediate signals



Doubled the dynamic error to be able to showcase it

Model Validation in Italy

- Allowed tolerances for measured and simulated quantities:

	Active Power Tests	Reactive Power/ Voltage Tests
Initial and final conditions	5%	5%
Oscillating transients	15%	15%
Transients	20%	25%

- Measured quantities: speed, terminal voltage, active power, reactive power, excitation voltage and excitation current
- Limit violations are allowed, if justified adequately

Comparison of Model Validation

energynautics
solutions for sustainable development

Italy

- Backdoor in validation procedure: “Models validated through procedures described in documents of recognised organisations (IEC, CENELEC, national standards bodies) can be used […]”

Austria/ Belgium

- No validation at all!

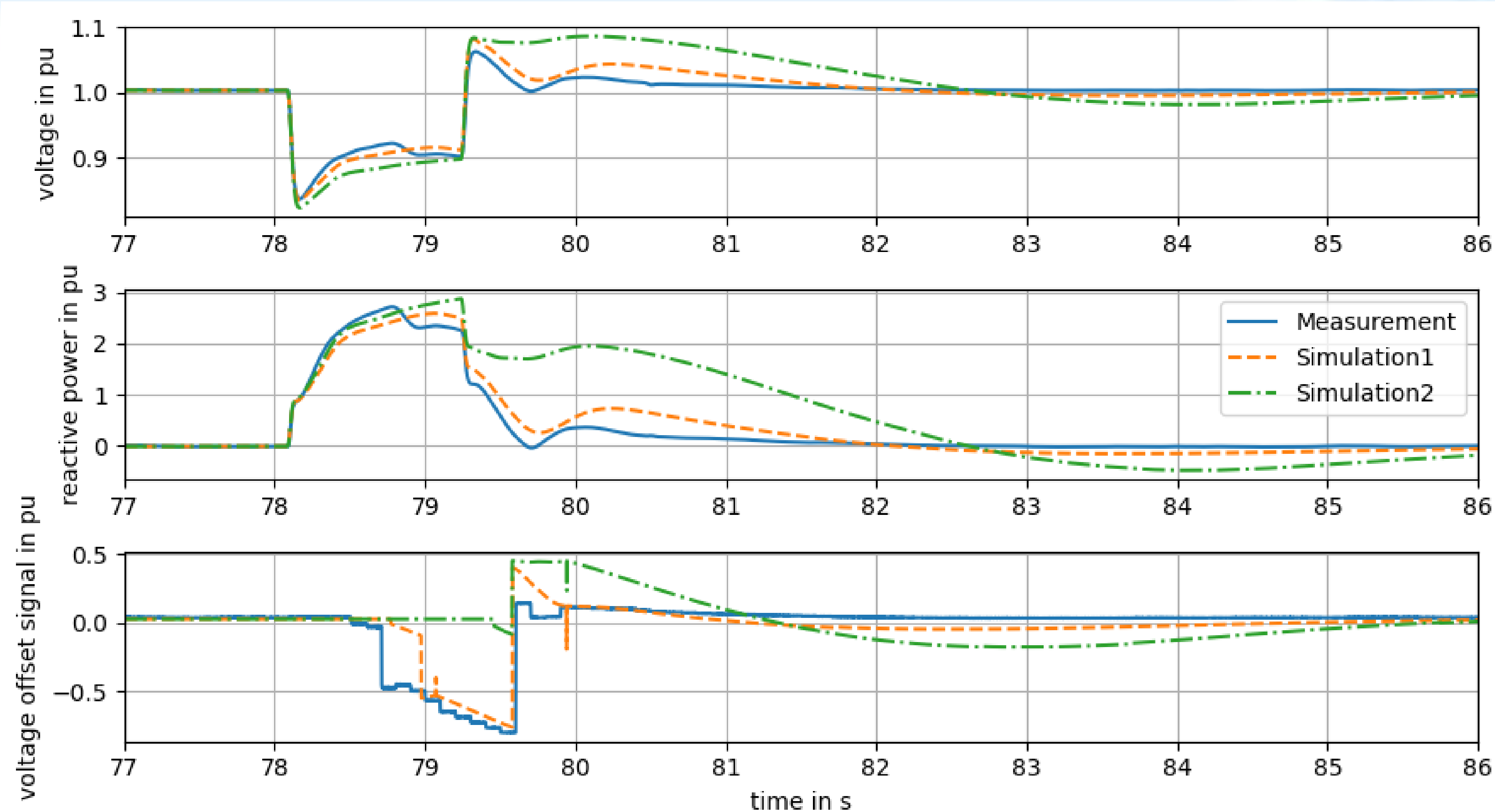
➢ In a recent project for Austria the customer asked us to use generic models with standard parameters
➢ In this case, the model will have nothing to do with reality!

➢ In a recent project we developed a model for the German market and used the same model for Italy, after the German certificate was issued

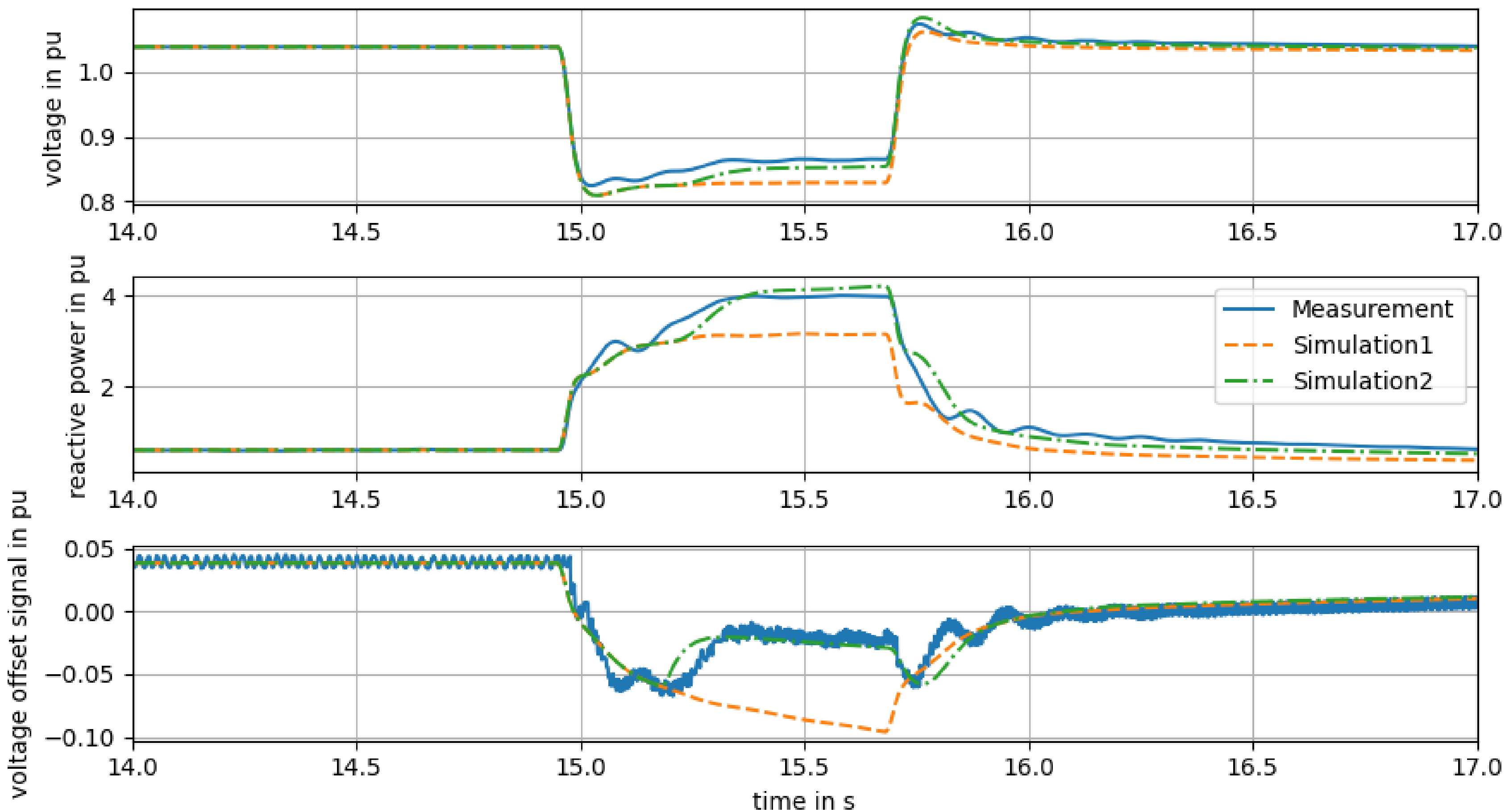
Regulation Mode Switching

- Grid codes keep evolving and manufacturers must adapt quickly
- Digital control implementations allow for quick development with lots of logical switching options
- Generic models have longer development time frames, and it is difficult to capture all possible implementations
- Difficult to accurately model and validate, small deviations can make a huge difference

Regulation Mode Switching

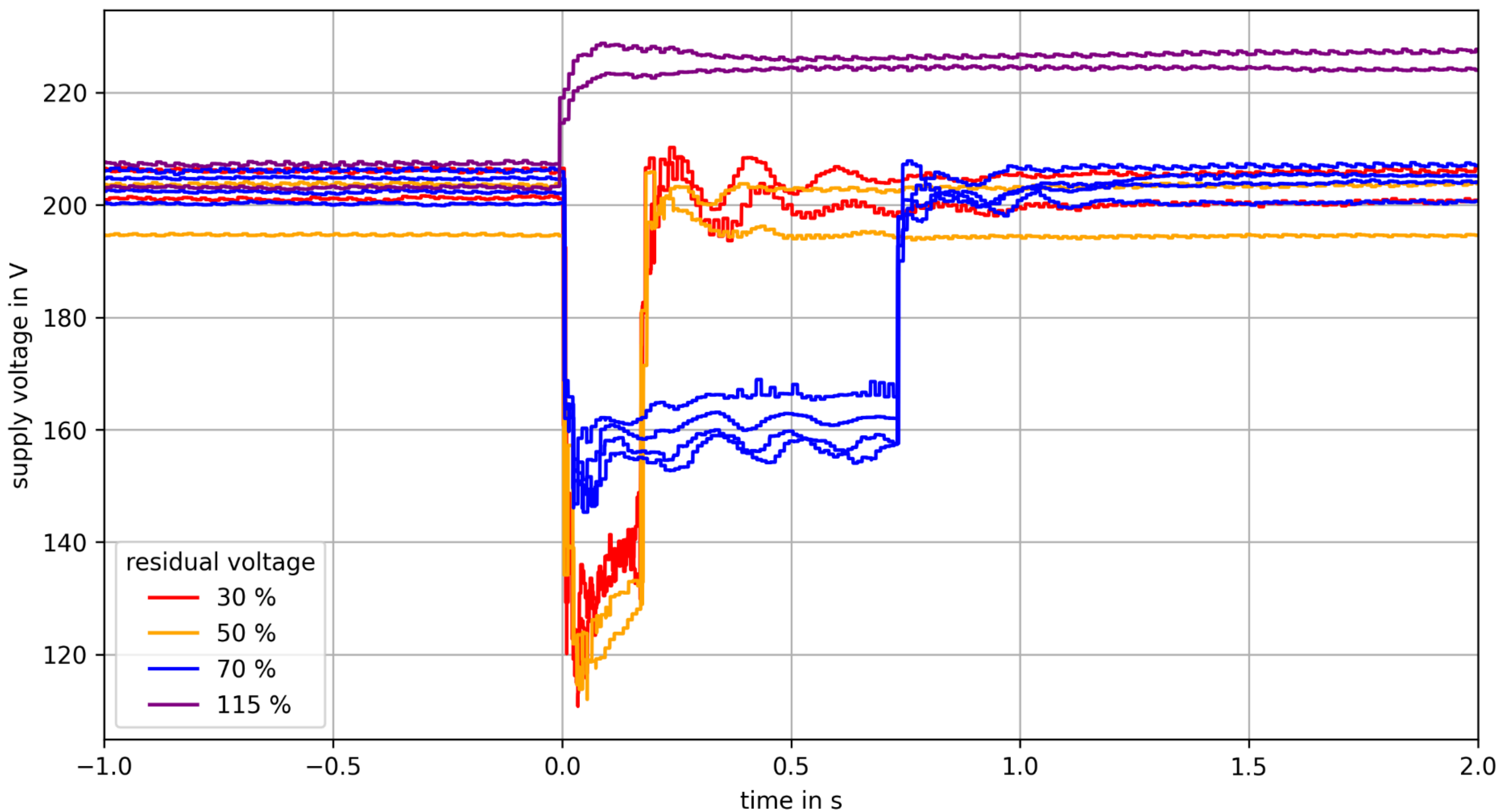


Reactive Power Control



Ceiling Voltage

energynautics
solutions for sustainable development



Conclusions

- **Any validation** is better than no validation!
- **Understanding** the cause and implications of **model deviations** should be more relevant than adhering to stricter validation limits, **but** this can be a **very fine line**
- If the actual event cannot be measured directly it is crucial to understand what **components** may be **affected by the event**
- Generic models for synchronous generators
  - can **lag behind fast** software **implementation cycles**
  - can sometimes be used as a base for models, but may have to be **augmented** during validation

Thank you for your attention!

Backup

Approach in Italy

Only required in case of field tests

Submission of simulation model → Simulation of FRT capability → Preliminary certificate of compliance

Measurements (laboratory or field tests) → Validation of Simulation model → Simulation of FRT capability

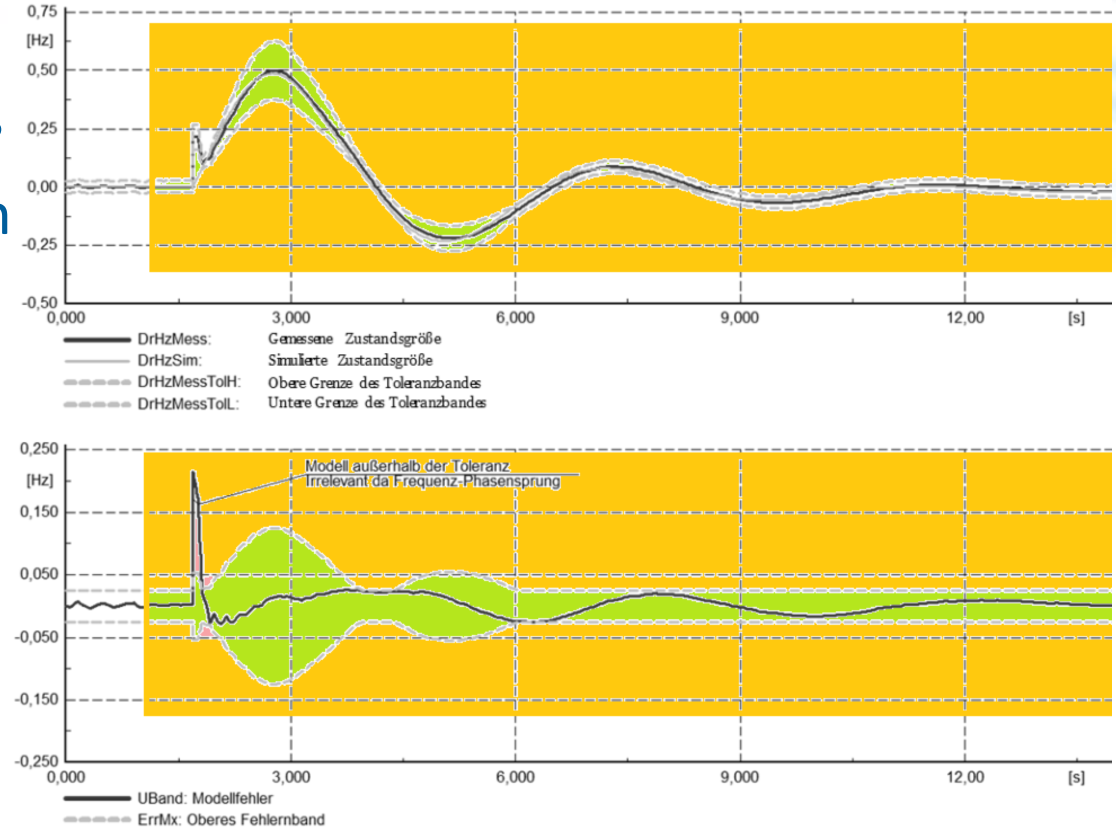
→ Final approval

Model Validation Measurements

<table>
<tr><th></th><th>Germany</th><th>Italy</th></tr>
<tr><td rowspan="6">Reactive power</td><td colspan="2">Main field saturation curve</td></tr>
<tr><td colspan="2">Step response of voltage regulator</td></tr>
<tr><td colspan="2">Over and under excitation limiter</td></tr>
<tr><td colspan="2">Verification of voltage regulator during emulated voltage dip,
Ceiling voltage</td></tr>
<tr><td colspan="2">Test of voltage control switch</td></tr>
<tr><td></td><td>Reactive power and power factor control loop</td></tr>
<tr><td rowspan="4">Active power</td><td colspan="2">Inertia time constant</td></tr>
<tr><td colspan="2">Stationary behavior of the prime mover</td></tr>
<tr><td colspan="2">Responsiveness of the control system</td></tr>
<tr><td colspan="2">Dynamic properties of the prime mover</td></tr>
</table>

Model Validation in Germany

- Sophisticated (complex) formulas for allowed errors
- Partly very strict limits even during transients (5 % and sometimes 1.5 %)
- Evaluated quantities:
  - Active & reactive power
  - Excitation voltage and current
  - Intermediate signals



Source: FGW TG4