1 Workshop on „Power System Testing“

DERlab/ SIRFN, 19 March 2015, 9:00 – 12:00

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1.1 Motivation

Our society has become highly dependent on a reliable electric energy supply due to the ever increasing networking and electronic information exchange developments. This dependency will further increase due to the shift in the fuel mix – substitution of other energy sources to electricity - and the growing share of variable renewables. Investors, generators, owners and operators of electrical power systems are increasingly uncertain if the system is adequate for the task and performs as intended now and in the future. There are also concerns about the reliability and safety and whether it is robust enough and allows for stable operation. Maintainability, expandability and the capability of fast recovering after failures and outages as well as societal acceptability are issues too.

New territories are covered in power systems, e.g. offshore (wind) generation, distributed solar PV and new technology and markets are being introduced, advanced control functionality is added and more and more interdependencies with other systems (e.g. IT and telecom) are created. Power systems develop from a "passive stable" highly predictable system to a hugely complex "actively held stable" integrated system, evolving over time.
This raises the question how to verify that:

"the power system functions correctly in this wider/bigger environment and its functionality is adequate over time" (e.g. does it still functions as intended after updating with new equipment or software)

Power system testing is one of the verification tools to answer this question.

1.2 Approach

A definition of power system testing/ verification will be introduced and discussed. A set of use cases will be classified and testing requirements will be specified. Requirements and available testing/ verification methods will be compared.

1.2.1 Possible classification of use cases

Classification can be based on operation mode and technical constraints, like

- normal operation,
- abnormal or degraded operation,
- recovery,

and

- power rating/ grid level,
- time scale (dynamics),
- interoperability (technical/communication/interference).

1.2.2 Mapping to testing methodologies

Testing requirements of use cases will be mapped to a matrix of testing methodologies to identify the best available testing frame and possible gaps. An example of such a matrix is given below.

Use case XY	Simulation	Laboratory	Simulator	Field test
Performance				
Require-ments				
System				
Subsystem				
Component				

1.3 Power system testing and/or verification

Definition: a power system is a complex assemblage of equipment and circuits for generating, transmitting, transforming, distributing and use of electrical energy.

Testing is one of the verification methods. Verification refers to the confirmation, through the provision of objective evidence, that specified requirements have been fulfilled (ISO 9000:2005). Verification can comprise activities such as:

- Performing an independent review/assessment to confirm the reported results of a design analysis;
- Witnessing activities such as manufacturing, testing, installation and commissioning to confirm compliance with specified procedures;
- Document review;
- Testing/Inspecting components or products to conform compliance to applicable specifications.

Testing and certification guarantees that the equipment used for the project fulfills the relevant requirements, rules and standards.

1.4 Use cases

Following the online workshop in June and the Kyoto workshop in November 2014 the currently proposed use cases are:

1. Provision of flexibility to the grid (voltage/ frequency)
2. Massive deployment of automated OLTC MV/LV substations
3. Dynamic grid support (voltage, frequency)
4. Systems with high penetration of power electronics (e.g. quality of supply, network stability and protection)

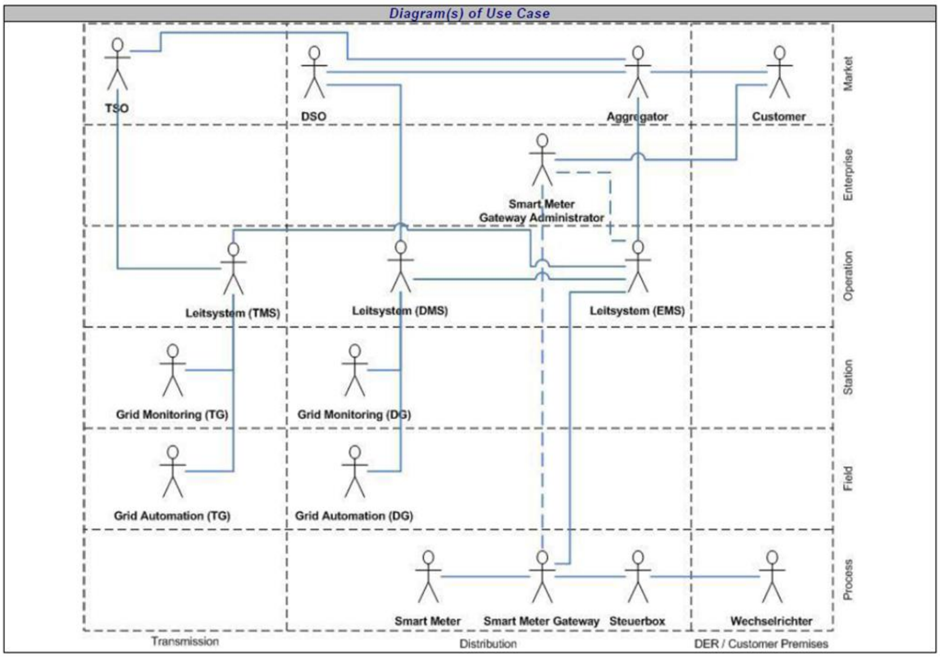
The objective of the workshop is to elaborate the use cases, their testing requirements and to start the mapping to existing testing methodologies.

1.5 Use case description

1.5.1 Provision of flexibility to the grid (voltage/ frequency)

Provision of flexibility to the grid by generation or consumption or storage units is a smart grid use case discussed and investigated in a number of studies and projects. Examples are from Flexibility Clearing House FLECH from DTU or RegioFlex a description of a regional market for flexibility as a service.

Use case description according to IEC 62559-2 "RegioFlex – market based usage of regional flexibility options" taken from VDE-Study "Regionale Flexibilitätsmärkte".



Example from FNN Use Case Grid Supporting Control (non-regulated)

Complete description

The different scenarios of this use case are describing the interaction of the main stakeholders for the implementation of a regional energy flexibility market, where prosumers may offer energy flexibilities to the distribution grid operator to help him to mitigate critical grid situations. The used stakeholders are Prosumer, Smart Meter gateway administrator, Aggregator / Balancing responsible, Distribution grid operator, Data access manager and RegioFlex.

Master data

With the installation, removal or modification of a distributed energy resources device, identified by an assets code, by the PROSU, technical information are transferred via the SMGW-A and tagged with a metering point-ID to the DSO. The DSO adds information to the DAM about the assignment of the DER to a network aggregation area. Additionally the PROSU will conclude a contract with an AGG/BRP to be able to participate in appropriate and reliable ways with the contracted distributed energy resources in the REGIOFLEX. The contract will allow the AGG/BRP to retrieve all necessary information about the PROSU's distributed
energy resources from the DAM. The SMGW-A and DSO receives information about the assignment of the distributed energy resources, the assets code, the technical information, the metering point-ID, network aggregation area and the responsible AGG/ BRP from the DAM.

Day ahead planning

As soon as relevant weather data is available the DSO calculates the expected infeed forecast from renewable energy production. Together with his load forecast and taking into account the actual grid topology the DSO calculates whether there will probably be any critical grid situations in the distribution grid during the next day (0-24h). The DSO checks, whether technical measures could mitigate the critical grid situation and to what extent. In a second step – if necessary - the DSO conceives flexibility products in the relevant aggregation zone and places these flexibility demands on the REGIOFLEX. UC Contracting starts.

Flexibility offering

The AGG/BRP subscribes at the REGIOFLEX via internet services to receive all offers which might be of interest for him. Selection criteria might be geographical location, flexibility types, delivery duration, Delivery response time, etc., After subscription the AGG/ BRP get informed about any change for offers at the REGIOFLEX which fit to the selection criteria. In parallel the AGG/BRP supervises all energy resources which are under contracted control regarding their flexibility capabilities and flexibility costs. Additional information for this supervision might be weather forecast, load and renewable generation forecast, etc. The AGG/BRP compares flexibility demand at the market and available flexibility within its portfolio and if he can sell flexibility with positive margin he signals a corresponding offer to REGIOFLEX specifying the details of offered flexibility [Power, duration, means to activate, …] and its price.

Flexibility contracting

Based on his updated load and infeed forecast calculation the DSO calculates whether there will be any congestion in the distribution grid during the forecasted period. The DSO checks, whether he could use existing flexibility offers from REGIOFLEX to mitigate the problem if it really occurs. If a REGIOFLEX offer helps to mitigate upcoming problems, the DSO decides, if he wants to contract this flexibility to be able to use it in case the problem occurs. In this case he decides to contract a certain flexibility he informs the corresponding provider via REGIOFLEX about the award. Flexibility offers which are not selected by the DSO will automatically be deleted after a deadline and the corresponding provider gets informed about this too.

Using flexibility (yellow)

The DSO continuously monitors the grid situation for all its network aggregation levels. In case he identifies a critical grid situation he checks the contracted flexibilities and calls up those helpful for solving the critical situation at the relevant AGG/BRP. The AGG/BRP selects with his internal methodologies the most suitable prosumers under contract and sends the related control signals. In parallel the DSO sets the traffic light at RegioFlex for the concerned network aggregation level to "yellow" when he expects the solution of the critical grid situation. After this, he monitors the grid to detect the point in time when the critical grid situation is relieved and he can end using the flexibility and changes the traffic light back to green. In case the DSO is not able to solve the critical grid situation he switches the traffic light at RegioFlex to "red" and the UC Critical Grid Situation starts.

Using Ultima Ratio (red)

The continuous monitoring by the DSO detects critical grid situations in a network aggregation area which could not be mitigated by activating the contracted flexibility. Therefore the signal red of the grid capacity indicator is transmitted to and published for the affected network aggregation area on the REGIOFLEX. As an internal process the DSO choses an appropriate PROSU to antagonize the critical grid situation. With information out of the master data the DSO informs the chosen PROSU via the SMGW-A about the required Ultima Ratio action. At the same time the DSO informs the corresponding AGG/BKV about the Ultima Ratio action. The DSO monitors the grid situation regarding the necessity of the Ultima Ratio action. As soon as critical grid situation in the network aggregation area can be mitigated without the Ultima Ratio action the DSO informs the PROSU via the MGW-A about the ending of the Ultima Ratio and turns the signal of the grid capacity indicator yellow for the specific network aggregation area. The DSO informs the AGG/BRP about the changed signal of the grid capacity indicator. The signal is published on the REGIOFLEX.

How can different scenarios of this use case be classified?

What has to be tested? What are the requirements?

- Completeness and updates of "Master data"

- Technical communication between stakeholders
- Monitoring grid status
- Response to requested action
- Interdependencies between regional markets (e.g. Regioflex, FLECH) and global markets (e.g. reserve capacities requested by TSO)
- …more?

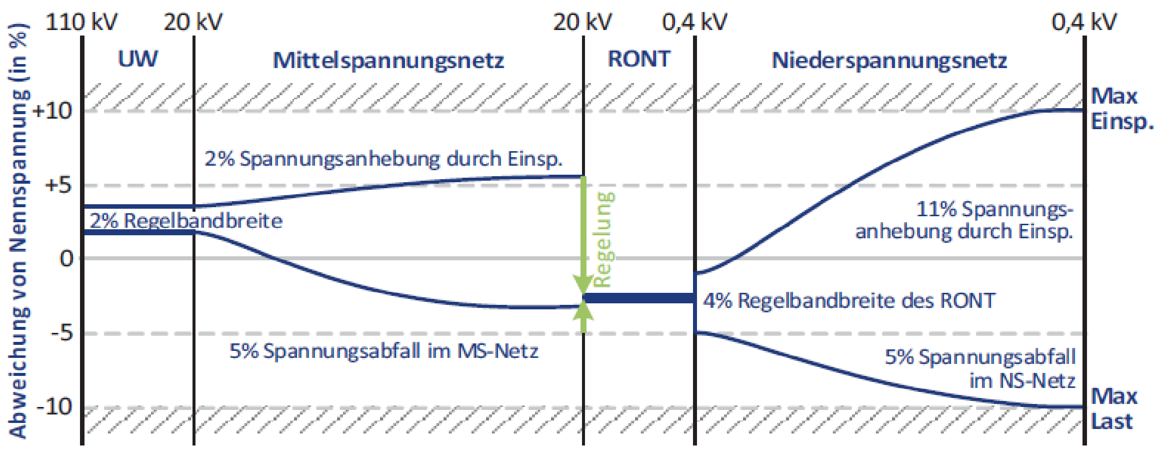
Which testing methodologies should be recommended?

1.5.2 Massive deployment of automated OLTC MV/LV substations

Background information and diagrams taken from the German distribution grid study regadring network extension and re-inforcement requirements („Moderne Verteilernetze für Deutschland" (Verteilernetzstudie), E-Bridge, IAEW, Offis, September 2014).

The time horizon of the study is the development until 2032. The political aim for 2032 in Germany is to generate 50% of electricity by renewables. The scenarios for the installed PV capacity range from 59 to 85 GW, connected mainly to MV and LV.

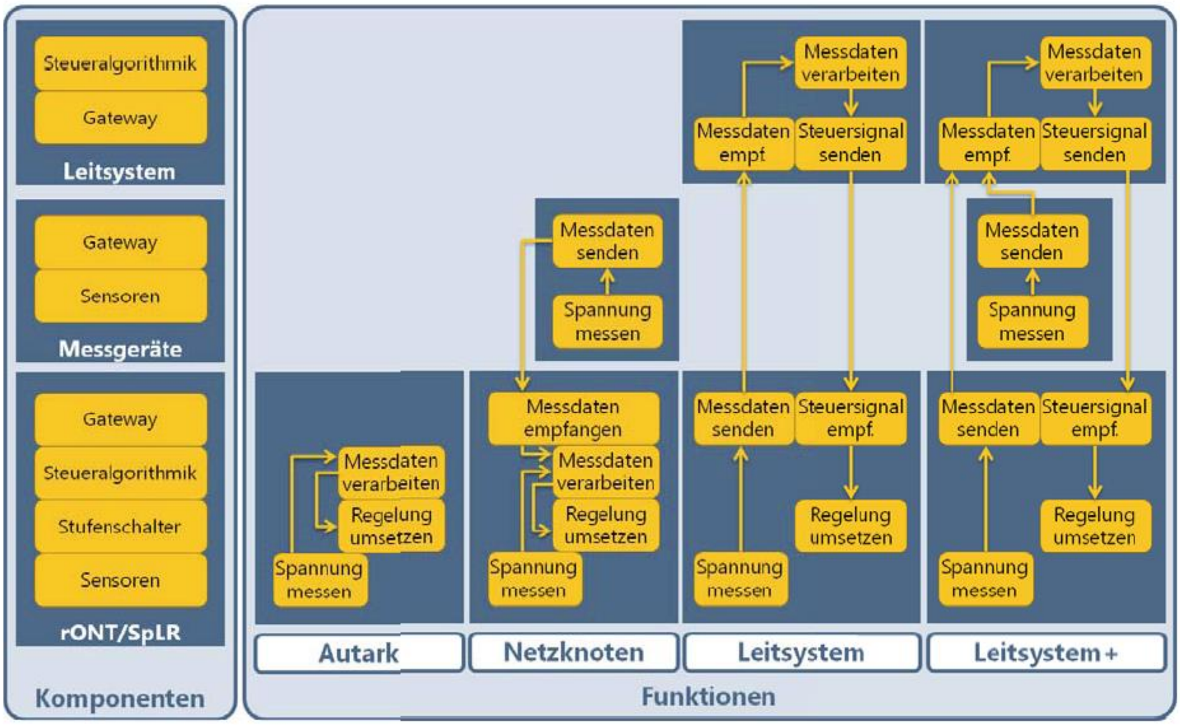
According to the study deployment of OLTC MV/LV substations has for the German boundaries the capability to avoid 38% of the network extension in length of LV cable (about 49 000 km) compared to conventional methods. This would need an installation of about 46 000 units (total penetration about 8%, but regional differentiated distribution). High shares are expected in rural areas/ villages with high PV penetration.



Three different control strategies are envisaged:

1) Busbar control reference (*autark*)
2) Remote LV node control reference (*Netzknoten*)
3) Central control (dispatch center)
   a) busbar reference (*Leitsystem*)
   b) LV node reference (*Leitsystem* +)

Control path and functions of the different strategies:



How can different scenarios of this use case be classified?

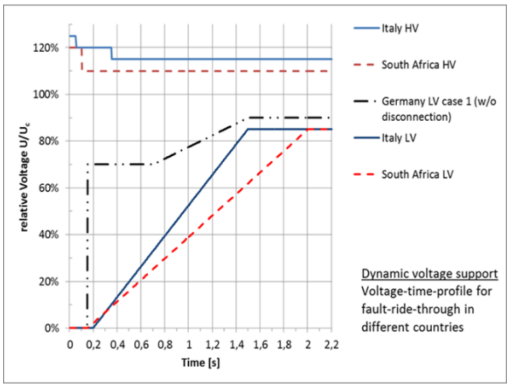
What has to be tested? What are the requirements?

- Technical communication between components/ despatch
- Monitoring grid status
- Response to requested action
- Interdependencies, (de-)coupling, voltage swing using diverse manufacturers/ control algorithms, (also using one manufacturer/ control algorithm?)
- Interdependencies between OLTC use on MV/ LV and HV/MV substations
- Behavior in emergency and alert situations like voltage collapse or restoration
- …more?

Which testing methodologies should be recommended?

1.5.3 Dynamic grid support (voltage, frequency)

Examples for dynamic voltage support (FRT) as defined in German, Italian and South African grid codes:



Detailed description of test scenarios?

How can different scenarios of this use case be classified?

What has to be tested? What are the requirements?

- Interdependencies with network protection, unintentional islanding?
- …more?

Which testing methodologies should be recommended?

1.5.4 Systems with high penetration of power electronics (e.g. quality of supply, network stability and protection)

Detailed description of test scenarios?

How can different scenarios of this use case be classified?

What has to be tested? What are the requirements?

Which testing methodologies should be recommended?