Quirinus Control

Power quality assurance in the structural change of the Rhenish mining area

Supported by:

Federal Ministry
for Economic Affairs
and Climate Action

on the basis of a decision
by the German Bundestag

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IAEW High Voltage Equipment & Grids, Digitalization & Energy Economics | RWTH AACHEN UNIVERSITY

Brief Introduction of the Institute

Institute for High Voltage Equipment and Grids, Digitalization and Energy Economics (IAEW)
Chair Active Energy Distribution Grids

Research Topics:

- Analysis and evaluation of power and gas distribution grids as well as heating networks
- Integration of renewable energies and sector coupling assets
- Development of system planning and operation methods
- Economic, grid- and system-oriented coordination of distributed flexibility
- Power grid economics and regulation
- Strategies for digitalisation, automation and IT security in resilient distribution grids
- Assessment of the stability in active distribution grids including concepts for temporary islanded operation and grid restoration
- Development and conduct of testing methods at the Center for Grid Integration and Storage Technologies

Head of Chair
Univ. Prof. Dr.-sc. Andreas Ulbig

Research Associate
Florian Schmidtke

Motivation and Goals

Initial Situation

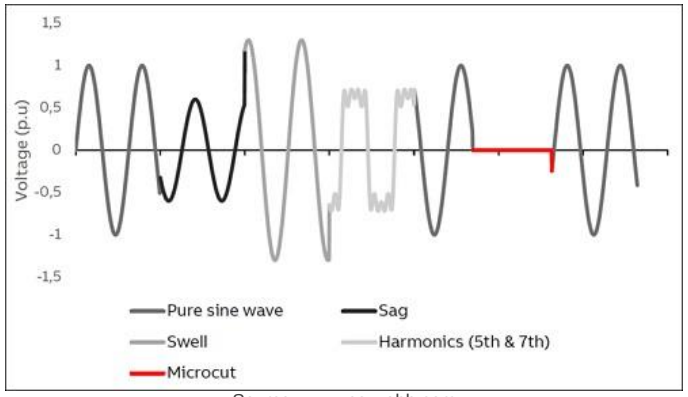
- Ensuring the reliability of the electricity supply system (due to the EnWG)
- Special focus of grid operators on power quality - contractually assured

Challenges

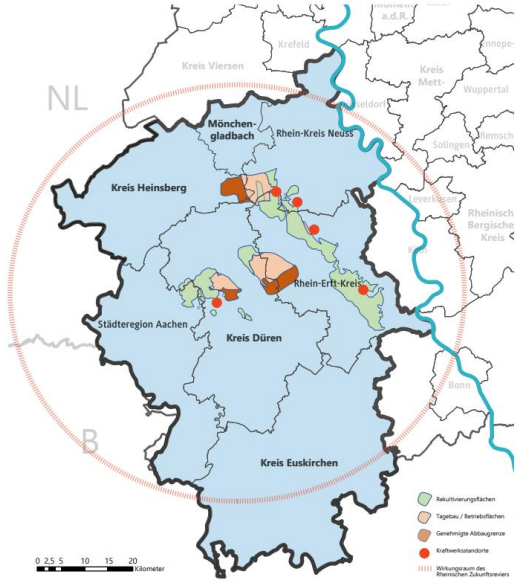
- Voltage quality affected by consumers and generators
  - Negative impacts: Harmonics, flicker or asymmetries
- “Kohleausstiegsgesetz„ - Removal of conventional power plant
- Increase in inverter-based, volatile generation units
  - Increase in power electronic components

Problem

- Negative impact on energy-sensitive industrial and commercial enterprises in the Rhenish mining area
  - E.g. failure of the control electronics due to losses in power quality



Source: www.new.abb.com



Source: Zukunftsagentur Rheinisches Revier 2018, S. 19

Motivation and Goals

Quirinus Control - Main Questions

- Impact of the shutdown of conventional generation capacities in the model region Rhenish mining area …
  - … in general on the reliability of the electricity supply
  - … in particular on the power quality

Quirinus Control - Objectives

- Effective and efficient metrological recording, analysis and evaluation of changes in the electricity supply reliability
  - Focus: Short-term power quality (< 3min) for grid and customers
- Development and setup of a Wide Area Monitoring System (WAMS)
  - Distributed measuring system
  - Secure processes and information and communication infrastructure
  - Evaluation of regulatory framework and business models

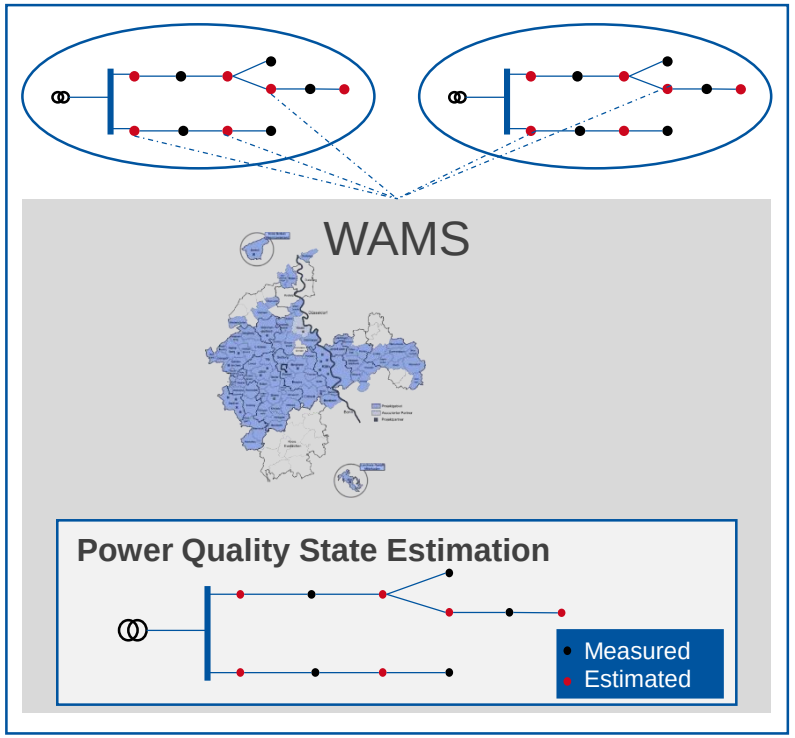
➢ Following the Quirinus project (Funded project between 2017 and 2020)

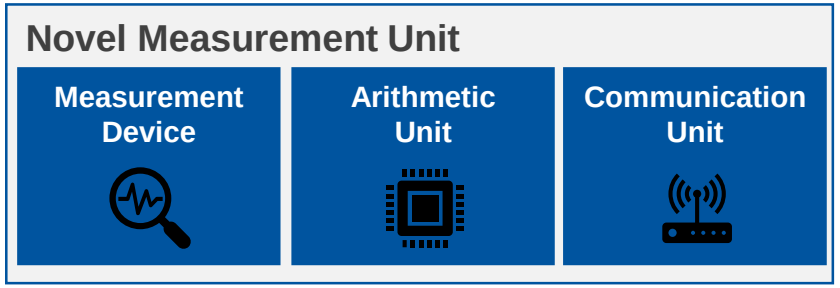
PROJEKTPARTNER	LOGO	PROJEKTPARTNER	LOGO
Forschungsgemeinschaft für Elektrische Anlagen und Stromwirtschaft e.V.	FGH	SME Management GmbH	SME
envelio GmbH	envelio	Stadtwerke Bühl GmbH	Stadtwerke Bühl
Rheinische NETZGesellschaft mbH	RNG Rheinische NETZGesellschaft	SOPTIM AG	SOPTIM
Energiewirtschaftliches Institut an der Universität zu Köln gGmbH	ewi	RWTH Aachen University	RWTH AACHEN UNIVERSITY
Leitungspartner GmbH	LEITUNGSPARTNER Lebensadern Deiner Stadt.	Technische Hochschule Köln	Technology Arts Sciences TH Köln
Gridhound GmbH	GRIDHOUND Smart Solutions for Smart Grids	RWE Power AG	RWE
Fraunhofer-Einrichtung für Energieinfrastrukturen und Geothermie IEG	Fraunhofer IEG	Bocholter Energie- und Wasserversorgung GmbH	BEW Bocholter Energie- und Wasserversorgung GmbH
Regionetz GmbH	Regionetz STAWAG EWV	Stadtwerke Brühl GmbH	Stadtwerke Brühl

Project Period: June 22 – May 26 (4 Years)
Project Volume: 10Mio €

Overall Project

- **Step 1:** Rollout of measurement devices by participating grid operators
  - Specification of the measurement devices
  - Identification of suitable locations
- **Step 2:** Design and development of a Wide Area Monitoring System (WAMS)
  - Connection of the measurement devices to the WAMS
  - Investigation of information security
- **Step 3:** Development of data processing algorithms
  - Centralized vs. decentralized data processing
    - Centralized: “Power Quality State Estimation”
    - Decentralized: Automated local filtering and forwarding of pre-processed data
- **Step 4:** Further development of measurement devices adapted to new challenges
- **Step 5:** Preparation of network data for WAMS
  - Grid models of the grid operators
  - Synthetic grid data extension
- **Step 6:** Derivation of business models, solution measures and recommendations

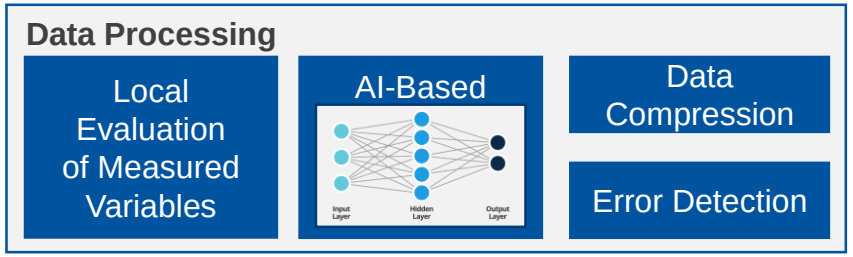




RWTH Tasks and Goals

Sub-project:

- Dynamic Grid Models, AI-Based Data Processing and Information Security



Objective:

- Development of novel methods for measuring and evaluating the security of supply
- Development of measurement systems for the local acquisition and processing of electrotechnical measured variables
- Central instance for processing, correlating and interpreting the measurement data and indicators

Challenges:

- Data-saving information processing
- Limited transmission and storage capacity
- Assessment of the local network status based on reduced data volume

Solution approaches and methods:

- AI-based approach for local assessment of measured variables "On the Edge”
- State estimation of quality of supply with incomplete measurement data
- Simulative verification of developed algorithms in preparation for Control Center
- Transfer of algorithms to the prototype measurement system
- Verification and optimization of the prototype in a laboratory environment

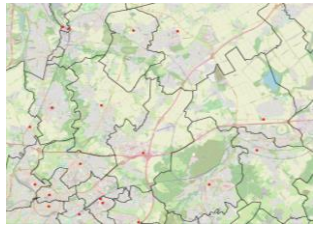
RWTH Tasks and Goals – Dynamic Grid Models

Clustering

- Investigation region:
  Rhenisch mining area is divided into PLZ5 regions
- Categorization using cluster analysis based on structural parameters
  - e.g. population density, building density, building area, installed capacity of PV and wind, “Marktstammdatenregister”
  - ➢ Selection of supply areas near the cluster centers

Definition of the research region and pre-grouping (PLZ5)

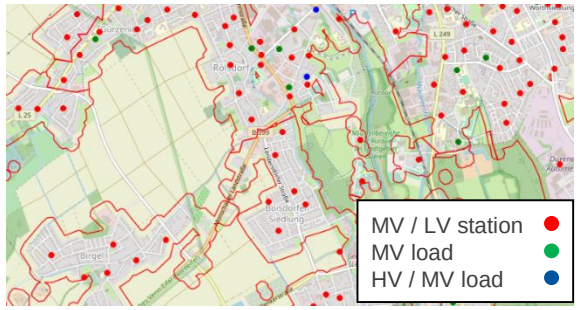
Clustering based on structural parameters



Grid Modelling

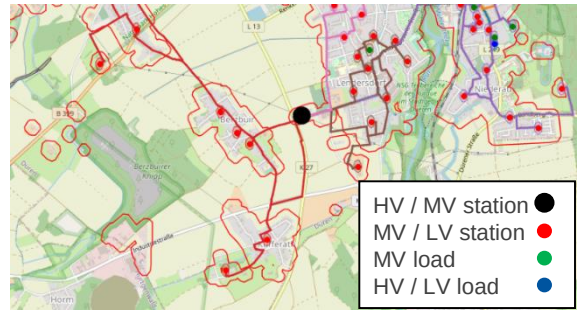
Graph Model

- Use roads or overhead lines in OSM as a possible route
- Determination of voltage level and connection objects and types

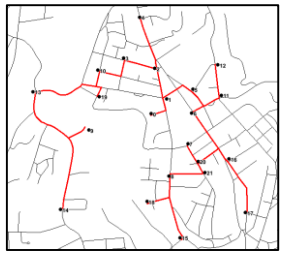


Electric Model

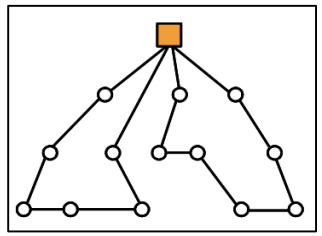
- Grid design taking into account load, number of stations and length
- Conversion into computational MV / LV grid model



Low Voltage
Modelling of radial grid topologies through minimal spanning trees



Medium Voltage
Modelling ring topologies using capacitated vehicle routing approach



RWTH Tasks and Goals – Evaluation of Prototypes in a Laboratory Environment

- Prototype development of a measurement unit

Measurment Unit

Measurement Device
- Three-phase current and voltage measurements
- High temporal resolution

Arithmetic Unit
- Processing of measured values
- Application of developed algorithms for data processing

Communication Unit
- Forwarding of compressed measured values and indicators
- Consideration of safety aspects and max. throughput

- Testing the measurement unit and the algorithms in a laboratory environment (*TH Köln, RWTH*)
  - Verification of the grid state estimation procedure in the test microgrid of the TH Köln
  - Simulation of disturbances of the quality of supply with the help of a grid simulator of the RWTH
  - Optimization and further development of the procedures and the measurement system with the help of the findings from the laboratory environment

Center for Grid Integration and Storage Technologies @RWTH

RWTH Tasks and Goals – Evaluation of Prototypes in a Laboratory Environment

Grid simulator

Multiple inverters and loads

Variable LV topologies

ICT, Cyber-Resilience and grid control center

Thank you for your attention!

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More information:

https://www.quirinus-control.de/

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