Bericht des Zukunftslabor Energie über das AP 1.2 des Teilprojekts 1

ZDIN
Zentrum für digitale Innovationen Niedersachsen

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Im vorliegenden Dokument wird der Zeitraum von 01.04.2020 bis 30.06.2021 dargestellt.
Der vorliegende Bericht gehört zum Teilprojekt „TP1: Erforschung von IKT-Abhängigkeiten in Quartiersversorgungssystemen“

Inhaltsverzeichnis

Abbildungsverzeichnis

1 Generelle Informationen

Dieser Bericht sammelt die Ergebnisse von AP1.2 von April 2020 bis Juni 2021. Die Ergebnisse werden entsprechend ihrer Ausarbeitungsform sowohl in textlicher Form als auch in Visualisierungen dargestellt.

In dem Arbeitspaket AP1.2 „Identifikation und Anforderungserhebung relevanter Modelle zur Simulation und Analyse der Quartiersversorgungsszenarien“ werden zunächst Anforderungs-spezifikationen für die Modelle und deren Co-Simulation in den in AP1.1 herausgearbeiteten Anwendungsfällen erstellt. Darüber hinaus sind geeignete Referenzszenarien zu entwickeln und geeignet zu modellieren.

AP1.2	**Verantwortlich: UOL/OFFIS**
Kurzbeschreibung	
Je nach Fokus des vorliegenden Anwendungsfalls (technisch, ökonomisch) ergeben sich unterschiedliche funktionale (welche Ein- und Ausgaben, welches Verhalten etc.) sowie nichtfunktionale Anforderungen (welche Auflösung/Qualität, welche technischen/fachlichen Schnittstellen, wie können Technologieakzeptanz, Finanzierbarkeit und Nutzungsbereitschaft gefördert werden) an die Modelle. Für diese Anforderungen, die in enger Abstimmung mit den industriellen Praxispartnern ermittelt werden, sind geeignete Simulationsmodelle zu identifizieren. Darüber hinaus besteht die Möglichkeit, Teile des Szenarios experimentell über die Laborinfrastrukturen der ProjektpartnerInnen nachzubilden und zu koppeln, falls hierdurch Vorteile für den jeweiligen Anwendungsfall zu erwarten sind. Die Referenzszenarien für die Quartierversorgungsanwendungsfälle können vergleichbar zu Stark-/Schwachlastszenarien in der Netzplanung entwickelt und über Szenario-/ Modellparametrierungen, Zeitreihen etc. modelliert werden.	
Start	**Ende**
M7	M21
Erforderliche Inputs	**Outputs**
Ergebnisse aus AP1.1: Quartiersszenarienentwürfe, Datenstrukturen, Aufbereitung Flexibilitätsansätze, IKT-Modellierungsansätze	D1.2, M1.2

2 Erforschung von IKT-Abhängigkeiten in Quartiersversorgungssystemen

2.1 Einleitung und Zielsetzung

Ziel des Teilprojekts 1 ist die „Erforschung von IKT-Abhängigkeiten in Quartiersversorgungssystemen“. Gegenstand der Untersuchung bilden die Informations- und Kommunikationstechnologien und die Energieversorgungsinfrastruktur in digitalisierten Wohnquartieren.

Das dem Teilprojekt untergeordnete Arbeitspaket 1.2 fokussiert im Wesentlichen die Identifikation und Anforderungserhebung relevanter Modelle zur Co-Simulation und Analyse der Quartiers-versorgungsszenarien. Hierfür wurden unter Einbezug der Anwendungsfälle aus AP1.1 geeignete Durchstichszenarien entwickelt und modelliert.

2.2 Durchstichszenarien

Es wurden insgesamt fünf Durchstichszenarien definiert, die sich mit unterschiedlichen Themen-schwerpunkten und Problemstellungen sowie dazugehörige Forschungsfragen beschäftigen: Flexibilität, IKT-Störungen, E-Mobilität, Gebäude und Netzbetrieb.

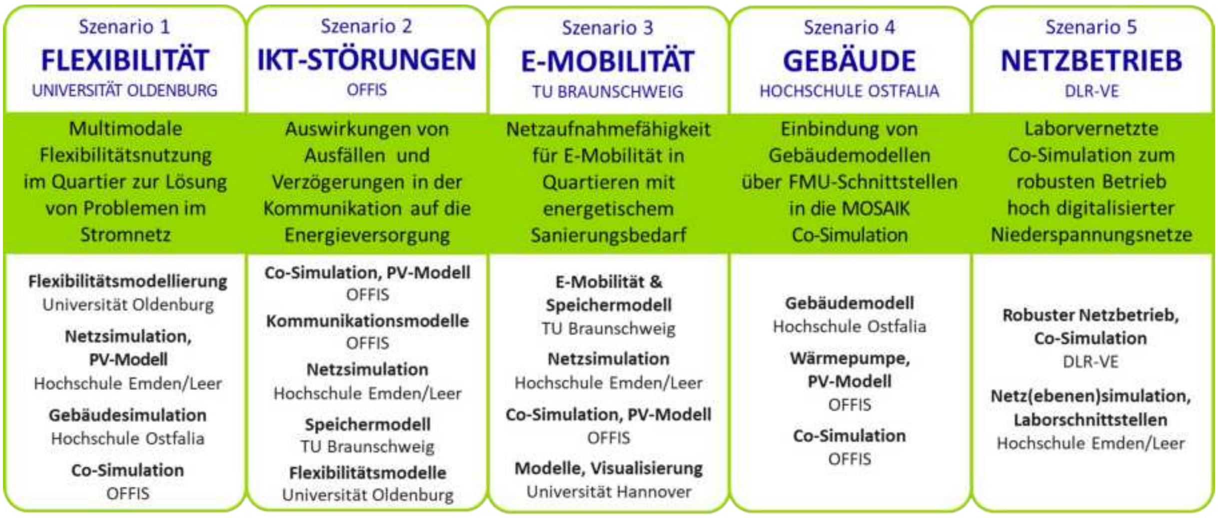

Figure 1: Übersicht der fünf Durchstichszenarien

2.2.1 Multimodal Use of Flexibility in a District Grid

Stephan Ferenz (DES@UOL)

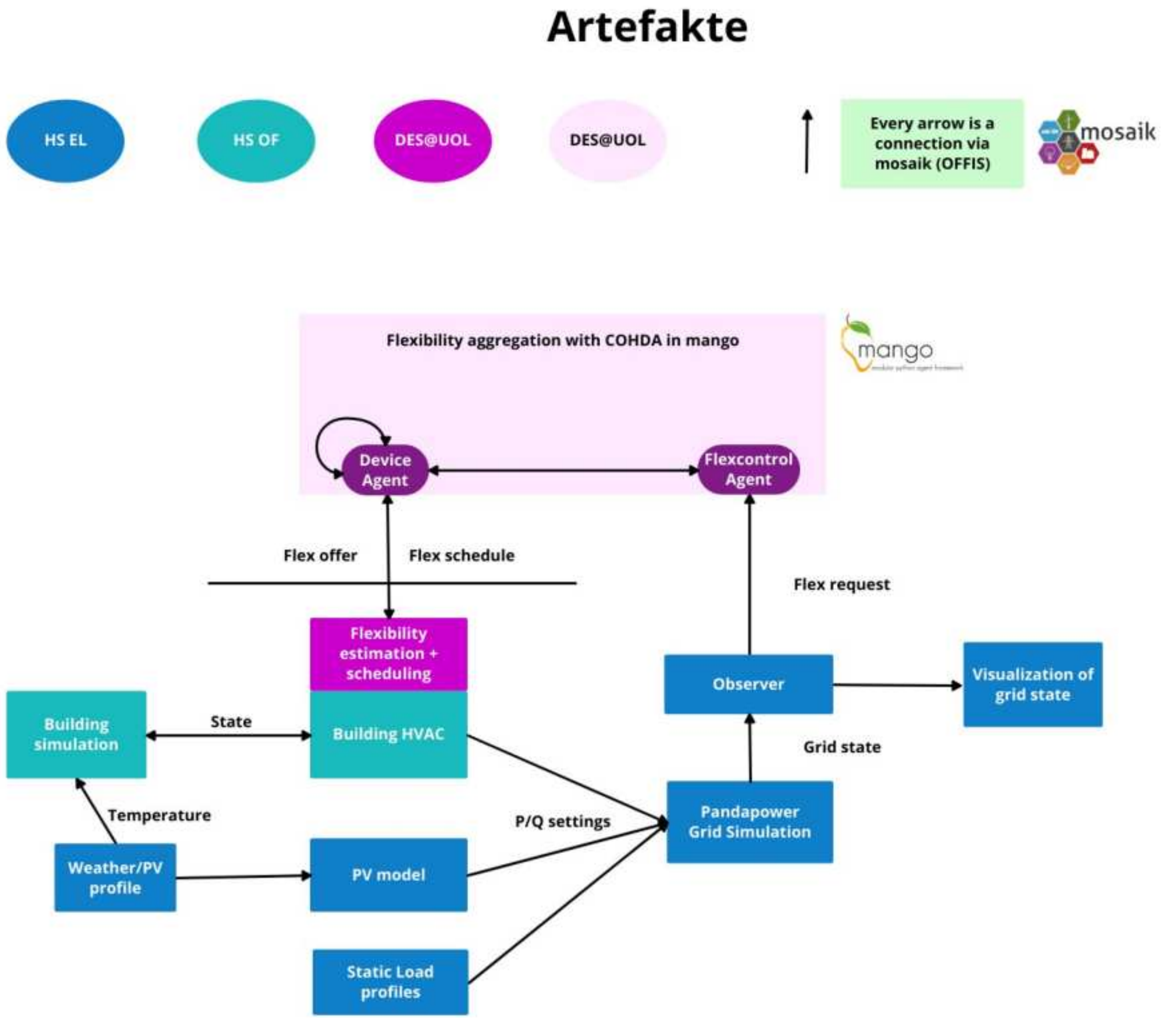

Figure 2: Overview of the scenario with flexibility aggregation

Scenario Description

Within the scenario, flexibility of a heating, ventilation, and air conditioning (HVAC) system is used to solve problems in the electric grid. Therefore, buildings including their HVAC are simulated. The flexibility of their HVAC is determined and translated in a uniform flexibility description. The flexibility of multiple buildings is aggregated and used when the grid simulation announces grid problems (e.g. voltage or current violations). The grid simulation includes load profiles of PV systems and households.

The grid simulation is performed using pandapower. COHDA is used for the aggregation of flexibility. Mango is used as multiagent environment for COHDA. All simulators will be coupled using the co-simulation tool mosaik.

The scenario can be extended later on by adding electromobility, storage systems, marketing of flexibility and/or heat networks.

Participating Partners and their Competences

OFFIS: Annika Ofenloch	- Co-Simulation - FMI-Adapter & Mango-Adapter for mosaik
HS OF: Tobias Lege	- HVAC and building simulation - Building model to estimate flexibility from heating system for the power grid
HS EL: Sarah Fayed	- Grid simulation with pandapower incl. PV models, load profiles etc. - Within the grid simulation problems in the power grid exist
DES@UOL: Stephan Ferenz	- Modelling of flexibility - Aggregation of flexibility

2.2.2 Investigation of the Effects of Delays and Failures in Communication on the Energy Supply

Fernando Peñaherrera V. (EI@UOL/OFFIS)

Scenario Description

The objective of this scenario is to develop and test a model to investigate the effects of the performance of the ICT system on the digitalized energy system for a district.

Motivation

On parallel to the increasing implementation of decentralized energy supply systems for local energy production in districts, the increasing integration of ICT systems for the management of energy supply allows monitoring, control, and optimization of the energy system. The accompanying complexity of these ICT systems and the related potential failures and errors in the communication may affect the energy supply. Due to the early stages of research on ICT systems, part of the motivation is to develop and test a model that incorporates aspects of these systems in the modelling of energy supply, so that the possible cascading effects of the performance of ICT are analyzed. The goal is then to develop an artifact that can serve as experimentation object to conduct simulation studies to evaluate the performance of such complex systems.

Graphical Description

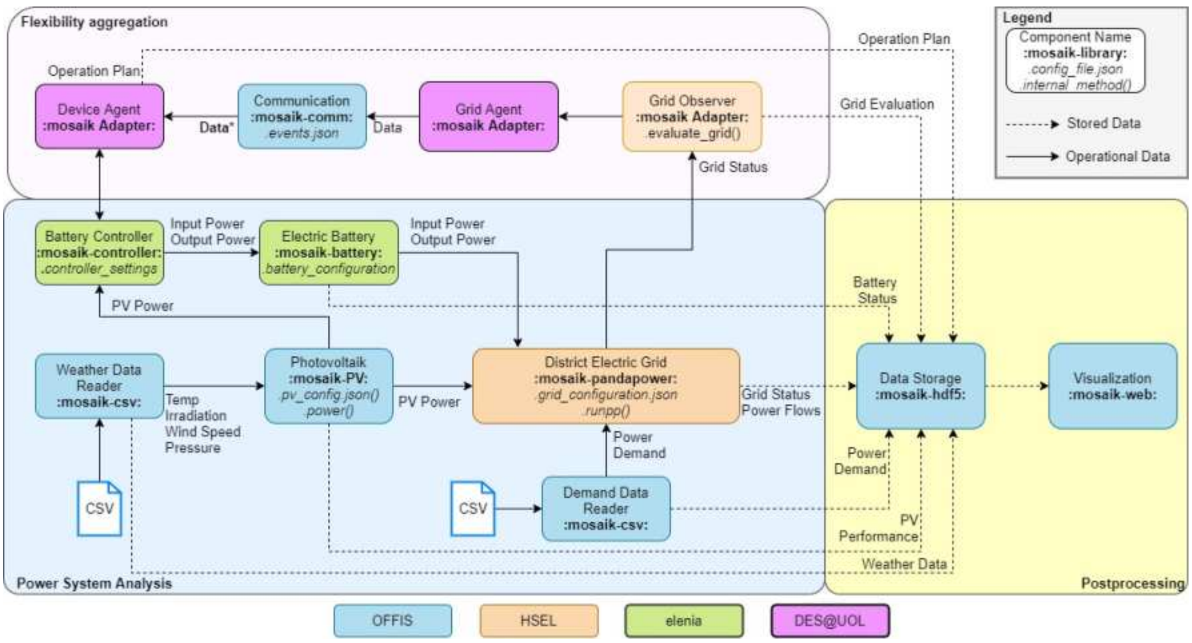

Figure 3: Graphical description of the scenario with a communication model

Methodology

A model of the energy system for a district is to be developed by coupling different tools and models representing the components of the system. Local generation is to be modelled through models of photovoltaic facilities based on weather and location data. Local storage is to be represented through electric battery storage models. A model for the local power grid is to be developed using pandapower for the low voltage grid. Electric demands of the residents are generated based on load profiles and included as csv files.

Flexibility aggregated from different devices is used to solve bottlenecks in the electricity grid. The optimal aggregation is achieved by using COHDA in mango. The communication system is to be first incorporated using a Black-Box model and through the creation of events representing issues in the system (delays, value-errors, disconnection, etc.). The components are to be synchronized using the co-simulation framework mosaik and existing or self-developed adapters.

The scalability of the model is to be tested later through incorporation of further components or expanding the functionalities of the existing ones. Examples of these are a district aggregator with connection to the power grid, future options for the operation of the battery system (multi-use concepts) or further energy supply components (wind power plants).

Results Analysis

Apart from testing the functionalities of the scenario and its components, the model is to be used as experimentation object to analyze the impacts of communication performance on the energy system through sensibility analysis for the evaluation of Key Performance Indicators (greenhouse gas emissions, costs, self-sufficiency, self-consumption) based on the events modelled. Results are to be stored and then presented in visualization tools, such as knot diagrams, HTML objects or dashboards.

Participating Partners and their Competences

EI@UOL/OFFIS: Fernando Peñaherrera V.	- Modelling of energy system, photovoltaic components, energy demand profiles
elenia: Henrik Wagner	- Electric battery storage and controller
HS EL: Sarah Fayed	- Power grids
OFFIS: Annika Ofenloch	- Communication models, Co-Simulation (mosaik)
DES@UOL: Stephan Ferenz	- Operation plan based on aggregation of flexibilities

2.2.3 Analysis of the Grid Capacity for Electric Mobility in Existing Districts with a Major Need for Energy Refurbishment

Henrik Wagner (elenia)

Scenario Description

The objective of this scenario is the analysis of the effects of the increasing number of electric vehicles on the local low-voltage grid in existing districts.

Motivation

The demand for charging facilities is growing in parallel to the number of electric vehicles. It is expected that this demand will be predominantly covered by private charging points connected to the low-voltage grid. The increased load resulting from these charging processes may cause high load peaks and voltage range breaches depending on the coincidence factor, the penetration factor and the respective charging behaviour. These high load cases were unknown while planning the grid of existing districts and therefore have not been considered. Therefore, critical grid situations can occur resulting from high penetration rates of electric mobility.

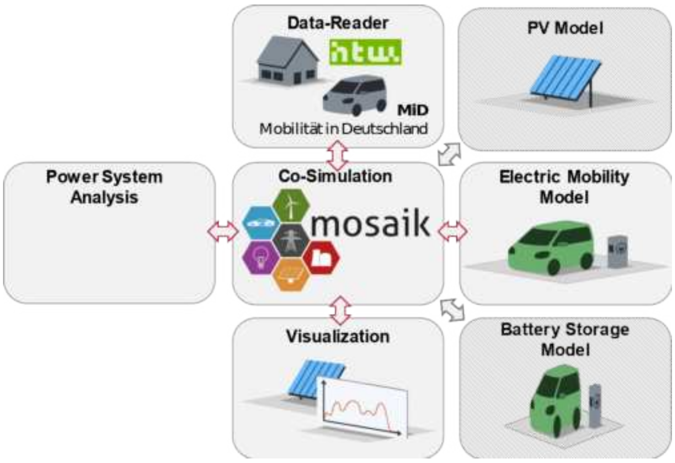

Figure 4: Coupling of the models, data and visualisation of the e-mobility scenario with mosaik

Methodology

As shown in Figure 1, a model for mapping the user-dependent grid load caused by electric mobility is coupled with the grid calculation tool pandapower through the co-simulation platform mosaik. The electric mobility model provides time-dependent power values of the charging processes occurring in the district. The user-specific behaviour (charging frequency, charging time), current penetration rates and common charging capacities, coincidence factors and the region-specific typical path lengths are considered. Pandapower can be used to determine the loads on the local low-voltage grid in the neighbourhood. For this purpose, a load flow calculation on an annual basis, e.g. using type days, is planned. The required household and charging load profiles are imported using mosaik's CSV reader. The final visualisation will illustrate relevant technical key figures. In addition, the impact of electric mobility in the district on the electricity grid will be presented in a suitable format for interested stakeholders.

Expansion Stages of the Scenario

- Expansion of the key figures to include economic and ecological factors (e.g. CO_2 emissions).
- Inclusion of photovoltaic systems and battery storage systems.
- Upgrading the battery storage model to include multi-use concepts.
- Increasing the level of detail of the visualisation (e.g. by a coloured representation of possible overloads on the grid map during the simulation timeframe).

Participating Partners and their Competences

HS EL: Sarah Fayed	- Grid simulation in pandapower - Electrical load profiles - Photovoltaic model
elenia: Henrik Wagner	- EMOB Model - Economic analysis - Storage model / Multi-use concepts
IWI@: Oliver Werth Sarah Eckhoff	- EMOB Model - Economic analysis - Web browser visualisation via HTML
EI@UOL/OFFIS: Fernando Peñaherrera V.	- Support at model coupling in mosaik - Coupling of pvlib library (Photovoltaic model)

Annika Ofenloch	

2.2.4 Integration of building models via FMI into the mosaik co-simulation

Tobias Lege (HS OF)

Scenario Description

In this scenario, a model of a multi-family building is created with the software Dymola and linked together with other Python models for the plant technology in the co-simulation platform mosaik. The basis for the building model is the AixLib-library of the RWTH Aachen. The integration into the co-simulation is done via a FMI-port. The goal is to simulate load profiles for one year, plot the results in graphs and check them for plausibility. Furthermore, necessary interfaces in the co-simulation are to be tested, optimized and standardized.

Scenario Goal

- A building model will be coupled to the co-simulation platform mosaik via FMI (functional mock-up interface).
- Weather data will be forwarded to the building model via mosaik.
- The heating requirement is calculated by a heat balance.
- As a heating supply system a heat pump will be modeled and implemented.
- The courses of temperature as well as power and heat consumption are presented throughout the year at defined time steps.
- The CO2-emission due to heat pump operation are calculated each time step via emission factors and returned to the co-simulation.

Motivation

- Integration of building models in the co-simulation
- Implementation of a FMI-Adapter for mosaik
- Modeling of regenerative supply scenarios
- Determination and optimization of CO_2-emissions

Basic Setup

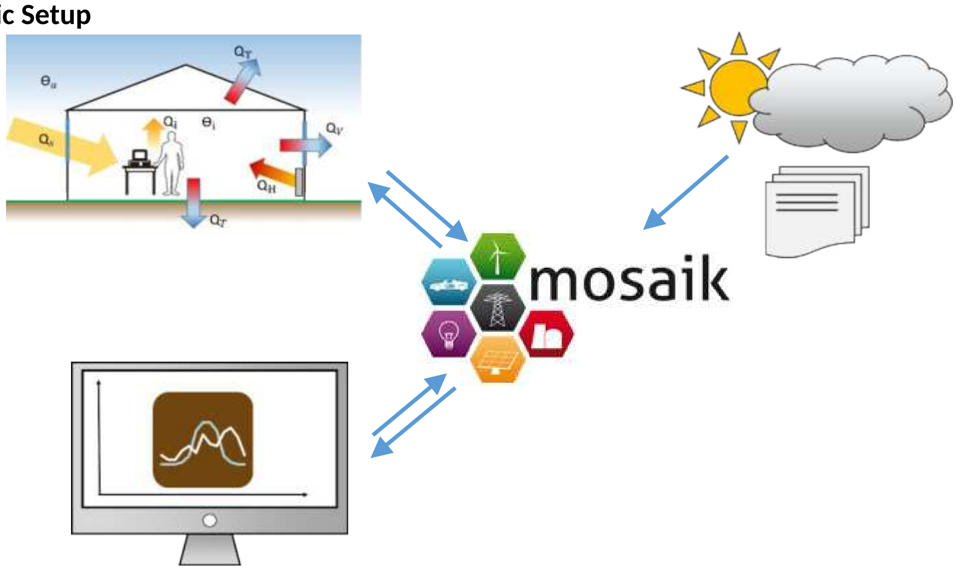

Figure 5: Overview of the scenario with the integration of building models

Necessary Artifacts (models, data, components)

- Building model as a FMU

- Weather, load and price forecasts
- Load forecasts based on user behavior

Participating Partners and their Competences

HS OF: Tobias Lege	- Building model
EI@UOL/OFFIS: Fernando Peñaherrera V.	- Heat pump, PV-model
OFFIS: Annika Ofenloch	- Co-Simulation with mosaik

2.2.5 Laboratory networked co-simulation for the robust operation of highly digitized low-voltage networks

Jan Petznik (DLR)

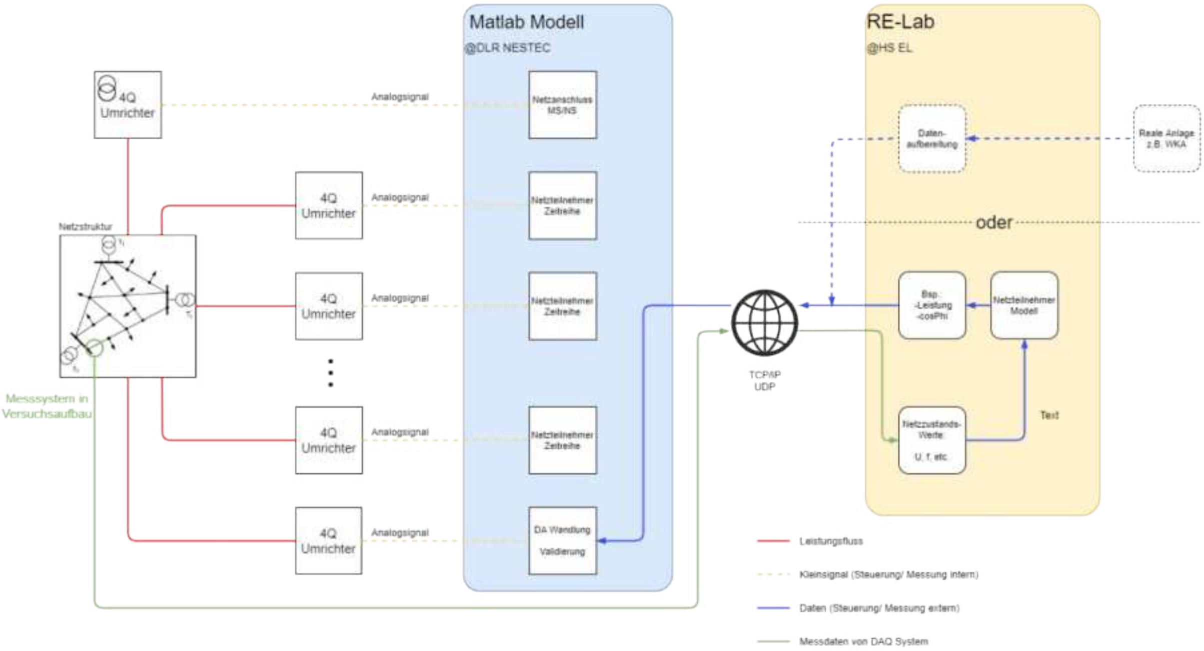

Figure 6: Overview of the laboratory coupling

Scenario Description

Within the scenario, the use flexibility as a contribution to system stability will be researched. For this, the laboratories of the HS EL and DLR will be coupled to operate in a co-simulation environment. This will be done in two phases: **Phase 1 - Flexibility Provision** (months 1-6): • Use of flexibility to ensure system stability • Coupling of two low-voltage networks or spin-off of network sections in the RE@HS-EL and NESTEC@DLR laboratories. • Hardware in the Loop connection via the Internet • Development of safety mechanisms for tests with hardware • Elaboration of the requirements for a special coupling software for real-time operation (Mosaik, Villas or similar)   Methodology / Procedure

- Stage 1: Transmission of a unidirectional data stream for remote control of an inverter in the NESTEC.
- Stage 2: bidirectional coupling with closed loop control -> virtual hardware in the loop
- Stage 3: Mapping of two network strings and coupling via a virtual busbar
- Stage 4: (if enough time remains) mapping of two LV network districts and virtual coupling via a simulated MV link.

Phase 2 - **Resilience of digital network structures** (months 6 - end)**:**
Investigations into the influence of digitization on the operation of electrical networks. The laboratory simulations are intended to show whether digitization:

1. Supporting a robust network operation
2. Is rather insignificant for robust network operation because the system is inherently resilient
3. has a negative influence on stability (e.g., competing use cases with opposing interests or multi-regulator systems with instabilities).

Research questions

- What are the requirements of expanded energy management and energy industry interests for robust system management?
- What advanced protection mechanisms are required to maintain stable network operations?
- What measures / rules are useful for robust grid operation in area grids when intermittent islanding is the goal?
- What influence does the increasing use of power electronics in distribution networks have on e.g. voltage maintenance, grid protection and unwanted interactions of controls
- Allow co-existence or cooperation with classical system service models.
- What influence does the changed grid usage situation (behavior of grid participants, changed simultaneity factors, more fluctuating feed-in) have on the measures for robust system management?

Participating Partners and their Competences

HS EL: Sarah Fayed	- Power grid simulation - Integration of generation (WKA) and load time series
DLR-VE: Jan Petznik, Thomas Poppinga, Alejandro Rubio	- Power grid simulation - Laboratory Hardware - Measurement systems, laboratory safety - Simulation of energy systems - Integration of EE