Towards a Smart City Playground for Research and Experimentation of Energy Use Cases in a University Campus Setting

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Abstract: The current paper describes our planned activities towards establishing an experimentation platform for energy management as part of our research and teaching activities at the RheinMain University of Applied Sciences (UAS) in Wiesbaden, Germany. Our vision is to establish a data platform that gathers energy related data and information from various sources, including sensors, weather data, existing energy management systems, open data platforms and different research data sets available for the community. In order to transfer the data to the data platform, different communication protocols (e.g. MQTT, 5G/6G, LoRaWAN, WiFi, CoAP, 6LoWPAN …) and data models/formats (NGSI-LD, XML, JSON, SensorThings …) should be put in place and utilized in a campus setting, such that data and information can flow into the logically centralized data platform. Our vision is to follow established smart city (pre-)standards for Open Urban Platforms, such as the DIN SPEC 91357, DIN SPEC 91397 and DIN SPEC 91377. By following such open modular approaches, we want to enable a framework of different software and hardware components as well as datasets, which can be used for teaching (e.g. in seminars and lectures) as well as for research activities in the course of PhD projects.

1 INTRODUCTION

The recent years were marked by intensive developments in the areas of Smart City, Smart Country and Smart Region. All across the world, one can observe the increased introduction of smart digital solutions in public spaces and at the interface between administration and citizens (IMD, 2024) (BITKOM, 2024).

The core of the Smart City/Region in this context is constituted by the use of information and communication technology (ICT) to collect data about a city/region and derive intelligent (real-time) decisions and measures. These decisions can either happen on city/region management level or on personal level, in cases like personal energy consumption and mobility. This vision has been facilitated by the fast recent developments in the areas of telecommunications, distributed systems, the Internet of Things, cyber-physical systems, big data and artificial intelligence. In this context, one can observe the following key enablers:

- **Enabler 1 – all-IP:** The establishment of the Internet Protocol (IP) and the Internet as the all-encompassing communication medium with connections to sensors, control systems, public data and many other types of information and objects has made it possible to merge the virtual and physical worlds in line with the notion of cyber-physical systems (Mikusz et. al., 2014). This interaction between physical and digital solutions facilitates that (real-time) data about the (urban) environment and developments in the city/region is transmitted to corresponding data platforms for further analysis (Schieferdecker et. al., 2016) (Tcholtchev et. al., 2021) (Schieferdecker, Bruns et. al., 2019) (Tcholtchev, Lämmel et. al., 2018).
- **Enabler 2 - XG:** The rapid development of mobile network architectures (4G/5G/6G), which is to a large extend enabled through the utilization of IP technology, offers the possibility for the (dynamic) placement of various sensors and actuators in the smart city and region.
- **Enabler 3 – IoT:** Additional possible complementary technologies in this context are given by various IoT devices and belonging wireless communication protocols, such as WiFi,

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LoRaWAN, IEEE 802.15.4 and 6LoWPAN, to mention a few.

- **Enabler 4 – AI/ML:** Advances in artificial intelligence and machine learning, which were unimaginable some years ago, enable efficient analysis, pattern recognition and measure identification with the aim of improving the quality of life and optimizing processes in an intelligent (urban) environment.

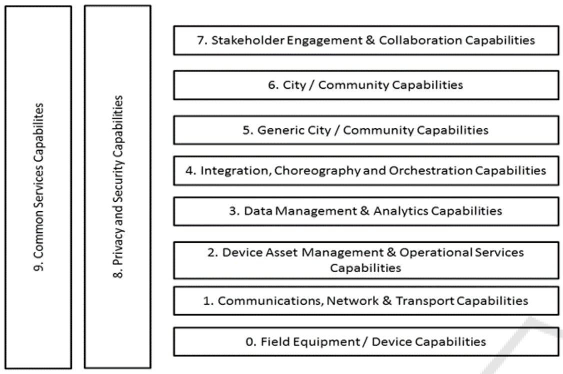

Figure 1: Simplified Illustration of the DIN OUP ICT Reference Architecture for Smart Cities (Tcholtchev et. al., 2021) (Schieferdecker, Bruns et. al., 2019) (Tcholtchev, Lämmel et. al., 2018).

Enabler 5 – Big Data: A smart city/region is built around an (urban) data platform that brings together different data sources in an urban ecosystem. The data sources can be versatile and include both static data (e.g. government data, open data in general, and any kind of urban data and information whose value/parameters are not constantly changing) and dynamic data (like continuous real-time data such as sensor/Internet-of-Things data, global positioning information …).

To enable the above drafted approach, different components, network segments and computing nodes from various silos and domains need to work together efficiently to enable a data-driven Smart City/Region. This type of architectural Smart City/Region approach can also be applied to the energy domain, especially in the increasingly importance-gaining demand-response model in the scope of renewable energy transition settings as implied by the EU Green Deal and the "Energie-wende" in Germany. The basic idea is to break the energy data silos and to compile a logically centralized one-stop shop for various energy related data streams and datasets, in order to facilitate the AI based analysis and interplay of cross-domain use cases and solutions towards the end user.

In order to enable the above setting, we plan to develop an integrative architecture according to the principles of Open Urban Platforms (i.e. DIN SPEC 91357) thereby mapping and identifying key technologies to the main pillars and layers of reference structure. Within this architecture, different types of energy related data and sensors should flow together, such that AI based analysis and correlations of datasets are enabled. In this setting, we envision to teach and research in the scope/context/environment of the RheinMain University campus.

The rest of this paper is organized as follows: Section 2 presents related work. Section 3 gives an introduction to the concept of Open Urban Platforms (OUP) and relevant German DIN standards. The following section 4 identifies and exemplifies key technologies and components fitting into the planned energy related OUP, while section 5 puts the pieces together and outlines our technological blueprint. Section 6 and 7 discuss the next steps and draw appropriate conclusions.

2 RELATED WORK

The utilization of Open Urban Platforms and collaborative Smart City data approaches has been researched in many projects during the past years. The WindNode project (Graebig, 2017) on German national level has developed various solutions and simulations for collaborative demand-response energy load balancing (Boerger, Lämmel, et. al., 2022) (Rangelov, Subudhi, et. al., 2021) (Rangelov, Boerger, et. al., 2023), including blockchain-based solutions and centralized open data platforms. Smart City EU projects such as Triangulum (Fernandez et. al., 2023) and RemoUrban (de Torre et. al., 2021), in which energy use cases were considered as an area for smart city development viewing data platforms as a facilitator. It is important to remark that the mentioned projects are just examples for the large number of activities executed within the last decade in the domain.

In addition, solid and innovative research was conducted on the topic of digitalization of energy infrastructure and markets, with (Baidya et. al., 2021) (Di Silvestre et. al., 2018) and (Zein et.al., 2024) being some relevant examples. Especially, the problem of asynchronous demand-response energy production and generation has been widely discussed in literature and in the scope of introducing renewable energy sources (Rangelov, Boerger, et. al., 2023) (Akhter et. al., 2019). Thereby, methods from the domains of AI and Machine Learning have been extensively applied, in order to align the energy demand and generation predictions and to increase the efficiency of the overall system.

The aspects of cybersecurity and ICT management of the digital infrastructure are also crucial for the success of such use cases, approached through the concept of Open Urban Platforms. In this context, various research activities address the domains of penetration testing (Zhukabayeva et. al., 2024), risk assessment (Lupton et. al., 2022), vulnerability assessment (Tariq et.al., 2020) and the overall establishment of security operation centers for such critical infrastructures (Mohammad, 2019). Hence, we hope that with our envisioned experimentation platform future engineers in the domain will be also trained and sensitized regarding the imminent threats in this area of digitization.

3 OPEN URBAN PLATFORMS

The Smart City/Region introduction of critical digital solutions is of particular importance, because the associated ICT components are becoming increasingly relevant as the technical backbone of digital societies in cities and municipalities. On the one hand, it is of the utmost importance that these ICT infrastructures are of particular quality and reliability - e.g. secured by intensive quality measures and protection against cyber-attacks. At the same time, it is essential that potential dependencies of the municipal and administrative infrastructure on individual providers/manufacturers are avoided, in order to ensure a higher level of digital and technological sovereignty. This technological sovereignty is made possible by the establishment and use of standards for the ICT infrastructure in smart cities/regions. Recent years have been characterized by the introduction of a number of bodies working on standards in the field - e.g. (ISO/CD 37173) (ISO/DIS 37170) (ISO/DTS 37172) and (ISO 37166:2022) as well as cooperation within initiatives such as FI-WARE (Torrepadula et. al, 2024), Living-in.eu (Living-in.EU, 2024) and Open Agile Smart Cities (OASC) (OASC, 2024). For Germany and Europe, the activities within the DIN standardization body are of particular importance, with the DIN SPEC 913X7 series as the main pillar of standardization for Smart City/Region ICT in Germany (DIN DKE Smart City, 2024). The DIN SPEC 913X7 series consists of various specifications that describe key aspects and use cases. DIN SPECs have a special role in the standardization landscape by constituting a kind of pre-standard, which is particularly suitable for dynamic new areas such as ICT, in order to publish current results in the short term and make it possible to update them in 2-3 years, while in parallel they can be put on the path to international standardization at CEN/CENELEC or ISO. The main specifications of the DIN SPEC 913X7 series are briefly presented below.

DIN SPEC 91357 (Heuser et. al., 2017): This DIN SPEC defines a reference architecture for Open Urban Platforms. In this context, it is assumed that the main difference between a city/municipality and classical organizations (e.g. companies) is that municipalities are not monolithic entities and even the administration - as an interface and service provider for citizens - is only part of a much larger ecosystem in the urban and municipal context. Therefore, a collaborative approach involving the various local actors, stakeholders and organizations is required to provide efficient and beneficial digital solutions and infrastructure. In this context, municipal data is a resource and basis for a number of use cases, e.g. mobility, energy optimization and public safety. The challenge for German (and European) cities/municipalities/regions is to identify and acquire scalable solutions that can be adapted to their needs and to draw from a variety of potential services/components/providers that can also be provided by local providers, SMEs, academia, open-source initiatives, and start-ups. The key question here is how these services and data are organized, managed and provided. Municipalities therefore need an architectural digital framework in the form of an *"urban platform"* that brings together all the different services and integrates the resulting data. Such an abstract reference architecture for Open Urban Platforms (OUP) is provided within the framework of DIN SPEC 91357 and illustrated in Figure 1.

The DIN OUP ICT reference architecture consists of eight layers and two pillars. Each layer/pillar is characterized by a series of capabilities, which are logically placed/located within this framework. The bottom layer 0 in Figure 1 represents the data sources within a municipality/city/region. Various sensors and measuring stations are located there, which generate data for intelligent urban development and management. Layer 1, which builds on this, is responsible for networking individual devices to a communication infrastructure, e.g. via a telecommunications network or the Internet. The devices and sensors in the layer with the data sources as well as the communication infrastructure are controlled via protocols and components that are logically assigned to the layer called *"2. Device Asset Management & Operational Services Capabilities"*. Based on this basic infrastructure, the data from data sources is fed into the data platforms in the third layer above. This includes, for example, databases, open data portals, cloud platforms, event-based data processing systems and metadata catalogues. The data from the sources is prepared and offered for further services and applications in the urban, municipal and regional environment. Layer 4 *"Integration, Choreography and Orchestration Capabilities"* contains various services that - based on the interoperable use of data and information from the underlying layers - offer the possibility of implementing new types of application scenarios. Layers 5 and 6 contain the variety of urban and municipal administrative processes, planning processes and general innovations that are made possible on the basis of the ICT infrastructure and data from DIN OUP. The two pillars in the reference model are responsible for data protection and security and the general network and system management for the integrative ICT solutions in the urban/municipal context. They relate (vertically) to all layers and contain capabilities for IT security and for the efficient operation of the Open Urban Platform.

DIN SPEC 91397 (Heuser, Dickgießer et. al., 2022): DIN SPEC 91397 builds on DIN SPEC 91357 and provides guidelines for the implementation of digital district management systems in the context of a Smart City/Region. According to DIN SPEC 91377, in a modern district, many different pieces of information/data should flow together and be analyzed as part of an OUP architecture and operation. By integrating various data-generating systems, added value can be offered in the form of new services for local residents. Such approaches for the digitalization of neighborhoods can provide a conceptual basis that can then be extended and scaled to the broader smart city/region level. The basis for digitally integrated district management should be a secure and networked data infrastructure that meets current demands - particularly regarding the geopolitical situation - for digital sovereignty.

Figure 2: The IoT Weather Station at the RheinMain University of Applied Sciences

DIN SPEC 91377 (DIN SPEC 91377, 2025): A few years after the provision of DIN SPEC 91357, it was observed that a technological "patchwork" had emerged in German and European municipalities. This was especially shaped by the individual solution approaches of different cities and regions in the EU. For this reason, DIN SPEC 91377 addresses the challenge of specifying and identifying data models and protocols in Open Urban Platforms as a further development of the activities in DIN SPEC 91357 and DIN SPEC 91397. This is intended to help smaller municipalities in particular, enabling them to communicate specific requirements to the manufacturers and providers of ICT components for Open Urban Platforms. In order to achieve the aforementioned goals, work is being carried out on the classification of existing standards, the identification of relevant interfaces for interoperability and abstract interfaces for the interaction of ICT solutions within OUP instances. Other important topics include platform security, critical data and data governance as well as the identification of new architectural concepts as extensions to DIN SPEC 91357.

4 RELEVANT TECHNOLOGIES

Having described the overall standardized reference architecture, in the following sections we point to some key technological aspects, which are to be considered for the envisioned energy use case experimentation platform. Based on these technologies, we plan to draft a simplified reference architecture (in comparison to DIN SPEC 91357), which is on one hand fully aligned to the principles of an Open Urban Platform and on the other hand capable of accommodating the needed hardware components and software stacks.

4.1 Internet-of-Things and Communication Protocols

IoT sensors can measure parameters such as temperature, humidity and infrared radiation and transmit the measured values to an IoT platform. In order for the IoT sensors and actuators to work together with the associated IoT platform (in the backend/cloud), it is necessary to establish communication channels. Typical protocols in this domain are CoAP, MQTT, LoRaWAN, ZigBee, IEEE 802.15.4, NB-IoT, Sigfox and 6LoWPAN.

5G is the fifth generation of standards for cellular wireless communication, illustrated with its basic structure and antenna examples in Figure 3. The 5G infrastructure increases data transmission rates by a factor of 100. Network latency times improve to 1-10 ms, while the cost of mobile data transmission is reduced by a factor of 10 compared to 4G networks. The development of 6G, the sixth generation of mobile communication, has begun and will also bring new functions for smart city solutions.

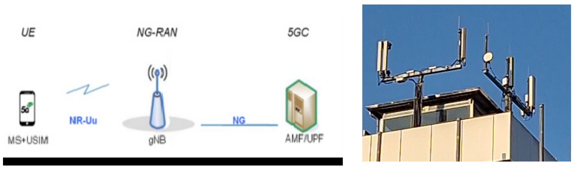

Figure 3: 5G Architectural Sketch according to (5G, 2025) and typical gNode-B-Antennas.

Public WiFi is a service where cities offer free wireless Internet access to their citizens including the possibility to attach sensor and actuator devices. Hence, WiFi also provides the city with a platform to disseminate various information and facilitate connectivity and relevant use cases. In the following, we continue with showing an example of existing IoT and communication infrastructure at our premises.

Example of an IoT-Infrastructure at the RheinMain university campus: A potential source of weather data - in the form of an IoT weather sensor station – is already installed at our university campus and is connected to a corresponding cloud backend. The weather station – shown in Figure 2 - consists of two poles that are placed next to each other and fixed to the ground using anchors. The sensors and two metal boxes below are mounted on one pole at a height of around 2 m, while a solar panel is located on the other pole. A *Victron Energy Lithium SuperPack* battery is located in the lower box of the weather station. The upper box contains the data logger and a data terminal for communication with the Internet. The installed router is a TP-Link model TV-MR1043ND, which requires a power supply of 12V and 1.5A. It acts as a WiFi bridge between the weather station and the provided university network. An outdoor WiFi antenna was attached to the weather station for this purpose. The router runs under the Linux-based open-source operating system OpenWrt.

Regarding available sensors, the weather station utilizes various data sources such as temperature, humidity, wind velocity and further attached sensor devices, all of which are listed in Table 1.

Table 1: Installed Sensors and Belonging Parameters.

Measurement	Sensor	Range	Precision	A/D[a]	Power
Temperature	PT-100 sensor	-20°C to 70°C	± 0,2 °C	A	0,84W
Humidity	Capacitive sensor	5% to 100%	± 1,5 %	D	0,01W
Rainfall	Tipping scale	0-8 mm/min	± 2 %	D	6W
Floor temperature	PT-100	-20°C to 70°C	± 0,2 °C	A	0W
Leaf wet sensor	Capacitive sensor	0% to 100%	-	A	-
Global radiation	Pyranometer	0 to 2000 W/m²	-	A	-
Wind velocity	ACRO-Serial Wind Sensor	0,3 to 75 m / s	± 2 %	D	0,48W
Wind direction	ACRO-Serial Wind Sensor	0° to 360°	± 1 °C	D	-

4.2 Fog-Edge-Cloud Computing

Cloud computing is a paradigm that enables the automatic provision of various computing resources such as computing power and storage space on demand. In cloud computing, the resources are physically housed and maintained in large data centers. Edge computing, on the other hand, is a distributed computing paradigm in which computations are performed at or closer to the data source – the latter pertains to the specialized term Fog Computing. Edge computing is of great importance in the context of IoT and 5G. The advantages of this approach are bandwidth savings, privacy preservation (e.g. in the scope of federated learning) and improved response times.

4.3 Data Platforms

The data platforms can encompass various types of data, such as Open Data and big amounts of data in general. According to the European Open Data Portal, *"open data is data that anyone can access, use and share."* (Open Data, 2025). The main sources of Open Data include scientific communities, governments, and non-profit organizations. Typical Open Data platforms include meta-data catalogues such as CKAN and *piveu* as well as semantic datastores like Virtuoso. Big data are extremely large data sets that can be analyzed by computers (going beyond Open Data). Big data is

[a] A=Analog, D=Digital

the basis for a wide range of intelligent analyses, services and applications in Smart Cities, Smart Country and Smart Regions.

4.4 Data Analysis and AI/ML

Data analysis is the process of cleansing, transforming, examining, and visualizing datasets, usually with the aim of gaining insights that help in decision-making and establishing a correlation between the various factors involved. Artificial intelligence (AI) and Machine Learning (ML) is an area of computer science, in which machines react to input from their environment by simulating human intelligence and learning step-by-step from the interpretation of the input values.

Typical Applications of AI in the field of IoT: predicting maintenance work, automation failures, connectivity problems and the intelligent orchestration of tasks in a complex IoT system.

4.5 Dashboards and end User Interfaces

City dashboards – as exemplified in Figure 4 - offer the possibility to get an overall view of certain aspects of a Smart City (area). Typically, city dashboards aggregate data from various sources, including city data platforms, open data portals, GIS (Geographic Information System) systems, IoT platforms and data from commercial data providers (e.g. mobile network operators).

Figure 4: Example of a City Dashboard by the City of Bad Hersfeld (Urban Cockpit, 2025).

Having outlined the key technological aspects to consider, the following section compiles an overall reference architecture with complete technology to be integrated over the different layers and pillars of an Open Urban Platform for experimentation with energy use cases at the RheinMain UAS.

5 PUTTING THE PIECES TOGETHER

Within this section, we put all the pieces together and aim at defining an abstract reference architecture aligned with the DIN SPEC 91357 Open Urban Platform. This abstract reference architecture will encompass the various tools and processes, in order to enable research and teaching for IT in smart energy use cases at the RheinMain university campus.

The overall reference architecture is presented in Figure 5. Starting from the bottom, one can observe the various data sources, which will ingest input for the data platform over the provided communication network in the layer above. All the data is consolidated in the logically centralized data platform, which would be managing the various types of data. On top of the data platform, we can observe a layer of distributed cloud/edge services operating on the consolidated data and implementing different monitoring capabilities, data analytics, dynamic energy price models and further procedures in the scope of smart energy. This is also the layer where AI/ML methods will be accommodated. Finally, on top, we see the layer of end-user applications and services that is meant to provide data visualizations and innovative interfaces for customers and operators. The pillars for network and systems management, including cyber security aspects, as well as data quality processes are visualized on the left and right of the layered structure in the middle. These pillars are meant to accommodate the typical tasks of network planning, risk/vulnerability assessment, network-/system-monitoring and -configuration in addition to ensuring the quality of the obtained data and the proper functioning of the devices involved in data acquisition (i.e. IoT sensor nodes).

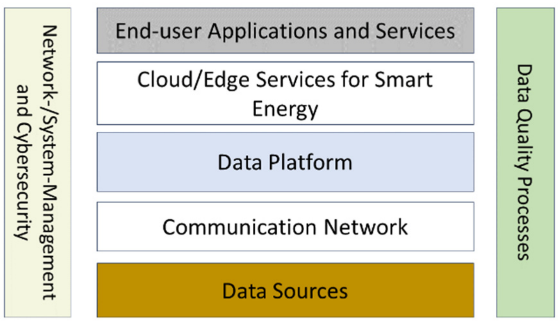

Figure 5: Overall Reference Architecture derived from the DIN SPEC 91357 Open Urban Platform.

In the following, key technological aspects for each layer/pillar are presented towards the prototypical implementation for research and teaching at the RheinMain university campus.

- **Data Sources:** Possible data sources at the RheinMain university campus include our IoT weather station, additional IoT sensors, exports from the campus-wide energy management system (Sauter EMS (Sauter, 2025)), data from charging stations as well as external research datasets.
- **Communication Network:** As a communication network, we plan to utilize the campus-wide WiFi and LAN, which would serve as a backhaul for various IoT-gateways (e.g. LoRaWAN, IEEE 802.15.4, SigFox …). Furthermore, we are in the process of acquiring an Open Source 5G implementation that we plan to use for realizing wireless (mobile) connectivity in a sandbox setting, in order to connect over existing 5G and (upcoming) beyond 5G communication standards.

- **Data Platform:** On this layer, we utilize a NextCloud offer established by the local public IT-service provider in the state of Hesse. Furthermore, we plan to realize connectors to service/cloud platforms such as Hadoop, HDFS and Apache Kafka.

- **Cloud/Edge Services:** The cloud/edge services will be implemented based on microservices (e.g. docker and Kubernetes) and API/orchestration management frameworks like Node-RED. The microservices will be distributed on the various available computing resource including IoT-devices and back-end servers. For processing the data, the standard AI/ML and data analytics packages such as TensorFlow, PyTorch, scikit-learn and RDF/OWL/SPARQL with corresponding processing frameworks, such as Jena, will be put in place.

- **End-user Interfaces:** The End-user interfaces layer will provide the possibility to experiment with various frameworks (e.g. React, Vue.js, responsive design ...) as well as devices such as AR/VR-interfaces, tablets and smart phones. In addition, information visualization dashboards can be developed in the context of the curriculum of the university, including the utilization of frameworks such as D3.js and open-source dashboard software like Grafana.

- **Management:** This pillar will allow us to plan our network (e.g. 5G back-bone and backhauling) and available resources. This can also include network simulations such as the OMNET++ one presented in Figure 6 and being used in our courses on smart cities. In addition, it is planned to establish NMS (Network Management Systems) such as Nagios, in order to observe the overall status of the infrastructure and be able to take corrective actions when required. We also envision to experiments with aspects, such as security monitoring, penetration testing, vulnerability, and risk assessment, in order to train new experts and experiment with cyber security challenges in the scope of energy critical infrastructure.

- **Data Quality:** We perceive the data quality as a key challenge for future smart energy use cases. This includes the data curation and improvement for input coming from external data sources, energy management systems and especially from (potbe entially erratic) IoT sensors. Hence, we plan to experimentally realize processes (e.g. described in BPMN) for the automated checks and verification of data properties (e.g. format, completeness, timeliness, and semantic checks), which have the potential to increase the trust and quality of the data-driven smart energy services.

Having derived and outlined the overall reference architecture and technological aspects, the following section continues with presenting the next steps for research in the course of PhD projects and advanced studies (e.g. master courses, projects and theses).

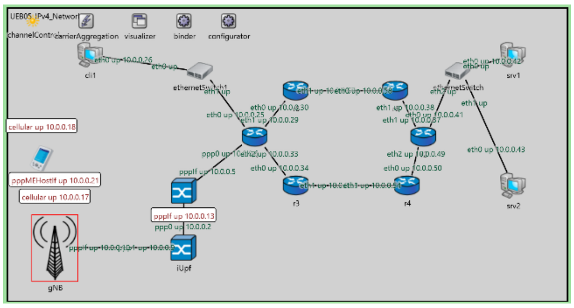

Figure 6: An OMNET++ Simulation of a 5G Network including Backbone.

6 NEXT STEPS – A RESEARCH AGENDA

From an information technology perspective, our research agenda deals with four problem areas (PA):

(PA1) What do AI-supported management and control elements look like for solving the asynchrony problem and optimizing the energy system?

(PA2) How must the simulation models of the future be designed, in order to interlink the interaction of different application, energy storage and energy generation contexts in terms of information technology?

(PA3) How can the cyber security of AI-supported energy systems be increased?

(PA4) How must the user interfaces be designed so that they not only increase transparency but also the acceptance of the overall systems?

(PA5) How can we systematically ensure the data quality required to make reliable decisions in the scope of Energy Data management?

To address the above formulated problem areas, we plan to pursue the following research objectives (RO):

(RO1) For solving asynchrony problem, (1) AI approaches for controlling load management must be researched that address the predictive modeling of power flows.

(RO2) The development and integration of a simulation platform should make the interaction of heterogeneous interfaces (e.g. HVAC and PV systems) accessible for simulations and be tested and evaluated in apartment buildings in particular.

(RO3) Cyber security plays a central role in the operation and acceptance of integrated, sustainable energy systems. With the installation of security modules, the resilience of the applications implemented in the microgrid is to be tested by penetration and security tests and increased by appropriate solutions.

(RO4) Prototype user interfaces for price modeling will be researched to increase user acceptance of AI-based control of the energy system.

The above research objectives require the following methodological approach:

Step 1: The project pursues an iterative, research-led development approach that combines design science research and agile software development.

Step 2: First, a simulation environment is developed as an experimental field and for the validation of AI-supported prediction models and control algorithms.

Step 3: To validate real use cases, an existing Tinyhouse with an existing smart home infrastructure that still needs to be expanded and, if necessary, and an energy storage system already in operation at RheinMain University of Applied Sciences will be used. The Tinyhouse will initially represent a single household, be replicated via digital twins and integrated into a higher-level "virtual" multi-family house system architecture.

Step 4: In this simulation environment, modules for energy flow visualization and control automation can already be developed and tested under controlled conditions, e.g. to identify potential for AI-based optimizations.

Step 5: The corresponding iterative development is supported by agile methods that ensure regular feedback loops with users and stakeholders.

Step 6: In the second phase, the platform is increasingly linked to real data sources. In addition to the physical connection of the Tinyhouse infrastructure, an existing energy storage system is included in order to achieve the proof of concept at the level of a virtual multi-family house energy management system.

Step 7: Finally, a prototype implementation in the real environment of an apartment building will be sought, provided that suitable implementation environments and partners for co-financing can be found.

Step 8: On this basis, a long-term study will be prepared to analyze the effects of the system on energy efficiency, user behavior and grid stability.

This methodological approach combines theoretical modeling with practical validation, in order to achieve robust and transferable results.

7 CONCLUSIONS

Within this paper, we presented our vision for establishing an experimentation platform for energy use cases at the campus of the RheinMain university of applied sciences. We plan to follow established Smart City standards and to create an open urban platform integrating various data sources, communication capabilities (5G/6G, WiFi, …) as well as IoT devices and data platforms (e.g. including open/big data aspects). Thereby, the idea is to tap on existing information and datasets in order to create an overall playground for applying AI/ML algorithms towards the efficient analysis of energy related use cases (e.g. asynchrony demand-response) as well as to provide the capabilities to train students in topics related to network management and cybersecurity.

The envisioned playground should provide the basis for investigating (e.g. in the course of PhD projects) various problems areas thereby answering clear research questions and outlining an interative development strategy. Taking on the energy synchronization challenge will provide the possibility to experiment and teach various technologies of relevance for the domain of Smart City, Smart Country and Smart Region, which is a key development area for the RheinMain UAS.

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