

Integrated Data and Service Platforms for Smart Energy Networks as a Key Component for Smart Cities

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Abstract. In the light of the German national energy system transformation, the so-called "Energiewende", the requirements for a sustainable energy supply based on renewables are very complex. To address this topic, the project Designetz develops approaches to test how decentralized renewable energy sources and the need for electrical energy can affect the respective network infrastructure levels and how an intelligent information communication technology (ICT) infrastructure can look like, to meet the demands of the energy network of the future, also in the context of smart cities. First results indicate that a transformation towards an increasingly decentralized energy supply is necessary and, particularly in view of the volatility, demands corresponding requirements of the ICT infrastructure. It will be shown how the classic producer-consumer constellation is changed and a multitude of prosumers, i.e. actors, who are both producers and consumers of electricity, arise, and how they can be integrated into the grid structure. Core functionalities will be demonstrated with an integrated data and service platform which also allows the possible integration of supplementary services. In addition, the potential interdependencies from a more decentralized energy network towards regional and urban planning patterns will be assessed.

Keywords: Renewable energies · Smart grid · Smart cities · Data and service platform

1 Introduction

The share of renewable energies in Germany was growing permanently in the last decades due to technological developments, but the national "Energiewende" (energy system transformation) [12] defined a new relevance of this topic.

© Springer Nature Switzerland AG 2020
O. Gervasi et al. (Eds.): ICCSA 2020, LNCS 12253, pp. 468–483, 2020.
https://doi.org/10.1007/978-3-030-58814-4_33

On June 6, 2011, the German Federal Government decided to shut down eight nuclear power plants immediately and to phase out nuclear energy gradually until 2022 due to a change in perception of Nuclear energy. In General, the political goal is to move away from nuclear energy and fossil fuels towards renewables-in the next decades.

The transformation from central to decentralized energy supply in the course of decarbonizing energy production and the phase-out of nuclear energy, imposes major challenges for the energy supply in Germany. These challenges can't only be overcome by installing hardware. According to the Federal Ministry of Economics and Energy, who started the SINTEG (National Smart Energy Showcases) projects in 2016, digitization approaches are seen as necessary development, to utilize efficiency potential and to develop a blueprint for a functioning, safe and efficient energy system of the future. One of the five SINTEG projects is Designetz. This focuses on an energy system transformation kit that contributes to the efficient system of the future with individual solutions [9]. The broad consideration of these topics also reflects the complex interactions towards other sectors such as mobility and urban planning. The greater the amount of energy fed to the grid from low-voltage levels by ordinary citizens, the more integrated concepts such as smart cities should be taken into account.

The paper is organized as follows: Sect. 2 presents the theoretical framework for a global decentralized energy system based on renewable energies. Section 3 exemplifies some of the Designetz approaches. Section 4 focusses on the interactions between the various scales of regional and urban planning and defines necessary points for further research by the integration into the real world. Finally, Sect. 5 concludes and provides some highlights.

2 Theoretical Framework

In order to achieve the primary goals of the national energy transformation, it is crucial to establish a subsidiarity of energy production and consumption, a flexible and adaptable infrastructure, as well as a secure and safe distribution. This embraces the conceptual goals of the project, the future composition of the energy network as well as the appearance of prosumers and the respective security issues. In previous decades, electrical energy in Germany was mainly generated by central power plants based on fossil fuels and has so far been primarily centralized by some large producers such as nuclear or coal-fired power plants. With the introduction of the German energy transition and the emergence of more renewable energies, electricity generation is becoming more heterogeneous, decentralized and dynamic [1,21]. Hence, the classic producer-consumer constellation changes towards a multitude of prosumers, i.e. actors who simultaneously are producers and consumers of electricity. The use of renewable energies also leads to strong weather-related fluctuations in electricity production [21]. This means that the impact on the energy network infrastructure is inevitable, and the fundamental question must be, how the networks can be kept stable in the event of dynamic feed-in. In addition to conventional energy network expansion, the focus is on IT-based management of the available flexibility in the energy

system. The power feed-in of distributed renewables and the demand of electrical power increase on the distribution level confront low-voltage grids by challenges ranging from unmonitored overloads over violations of the voltage range to back-feeding of electrical energy. Additionally, the volatility of loads and renewable energies makes it difficult to predict future grid states, to plan preventive measures, and to apply them if needed. These factors have a particular impact on the energy network infrastructure and raising the question, how the networks could remain stable. In order to address these points, one can physically expand the electrical grid and storage infrastructure, the power grid or by the means of digitization, make the existing grid smarter and more efficient. This paper exemplifies how to design the ICT backbone for the German energy network in 2035 with IT-supported management of the available flexibilities in the energy system. The results were achieved in the project Designetz, which is funded by the Federal Ministry of Economics and Technology and is one of the largest German research projects on energy system transformation.

2.1 Conceptual Goal of Designetz

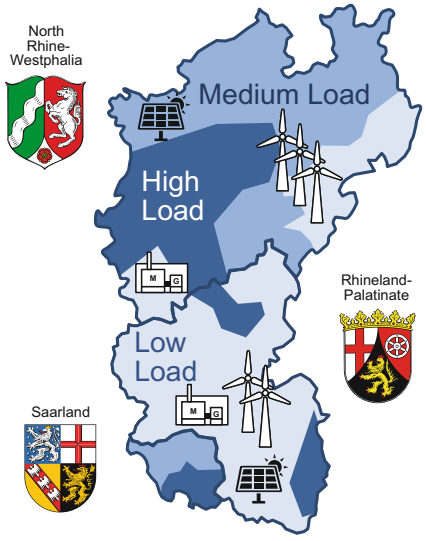

Fig. 1. Project area Designetz

The project area of Designetz embraces an exemplary mixed region with photovoltaic and wind facilities and areas, which have partly high renewable surpluses and nearby load centers (see Fig. 1). The project faces many individual solutions in twenty new demonstration projects as well as in eleven already existing projects, that are to be combined in a joint solution. Designetz develops technologies to balance the production and the usage of electricity between the regions by leveraging the flexibility of the aforementioned demonstration projects.

The project showcases the use of digital technologies to master the technical and economic challenges of the energy transition. It develops secure and efficient processes that are suitable for mass business and tests innovative technologies and market mechanisms for flexible and intelligent networks and markets. In order to successfully roll out the energy transition, there must be an interaction between the countries and technology-open standardized technological solutions in order to ensure penetration not only across Germany, but also at an international level. To develop these solutions, it makes sense to learn from pioneering regions that are already facing the challenges of integrating a high proportion of renewable energy. SINTEG promotes the learning process of complex interaction in so-called project showcases.

The goal of the SINTEG program is also to gain practical experience for the future development of the legal framework. For this purpose, the Federal Government has passed a regulation with "experiment options". The regulation gives the project showcases the opportunity to test new technologies, processes and business models without economic disadvantages, for example, the digitization and the coupling of electricity and heat. This enables innovations to get from the laboratory to the practical test and finally to the market more quickly. With SINTEG, a "real laboratory" is created for the intelligent energy supply of the future.

2.2 The Value of Flexibility in the Smart Grid

In a power grid, generation and consumption must be in balance. This also applies to a sustainable and decentralized grid and an appropriate ICT system for a sustainable grid must therefore have a local, decentralized optimization of flexibility to make this possible. The transforming energy system will lead to an increasing number of prosumers and more and more actors will show flexible generation and consumption behavior. Hence, the development of a flexibility management scheme is essential. In addition, it will be the task of network operators to assess the effects of generation and consumption behavior, to keep the network stable and, if necessary, to compensate for network bottlenecks. At the same time, market participants such as aggregators and traders must also be considered. An ICT system for energy flexibility management must therefore enable existing and potentially new stakeholders to be dynamically linked [7]. Flexibility in the energy market is defined as follows: It is the change of feed or withdrawal in response to an external signal (price signal or activation) with the aim of providing a service in the energy system [6].

As the share of renewable energies in electricity generation increases, the residual load approaches zero on many days, in many hours and then increases significantly within a short period of time. It is therefore necessary to make the participants in the system more flexible in order to be able to efficiently guarantee a reliable power supply. This is especially important in terms of the growing number of prosumers. A prosumer [10] can simultaneously draw electricity and, for example, also produce it via the solar system on the roof and feed it into the grid. Hence, the energy system transformation overcomes the old separation into producer and consumer of electricity or heat. They can increasingly help to keep the entire electricity system stable and thus contribute to a reliable power supply. This can also be lucrative for every participant, if utilities offer electricity prices that reflect the changed electricity supply.

3 Implementation in the Context of Designetz

Flexibility describes the relative potential that the consumption behavior of installation dynamics generates according to the requirements of the network or the market. Due to the dynamic development of the energy sector and the increasing influence of digitization, the effects on business models and the new

players in this area are becoming visible. The requirements for corresponding ICT infrastructure are examined in the officially financed SINTEG project named Designetz and are used as a blueprint for Germany's energy network in 2035. In this project the IT system plays a central role in the realization of the backbone of a future energy system. Hence, this one must be flexible, adaptable and expandable, and be able to integrate previously unknown actors and services to be able to do that. One of the key elements in this way is the development of an integrated data and service platform.

3.1 Integrated Data and Service Platform

In Designetz, the requirements for the ICT infrastructure are realized in an exemplary manner. Several data nodes (servers) will be connected to each other from local to regional to supra-regional level in terms of communication technology, taking the necessary decentralization of the solution into account. On each of these data nodes, a data and service platform is implemented as a service-oriented architecture. The advantage of this architecture lies in the combination of its modularity in order to offer the possibility of a needs-based design, combined with services for the basic functions such as data management and simple additional options for the current and future added value of services and functions. In addition, dedicated security frameworks are used to monitor and control communication between data nodes and between individual services, thus ensuring secure data exchange at all levels.

We have data *about* the power grid (so-called master data, like network topology and electricity equipment) and *from* the power grid (measurement data with different granularity and coverage). Both master data and measurement data are processed, aggregated, stored in and, as necessary, distributed to other databases. Furthermore, processes were also digitized (e.g., for booking and requesting flexibility options). Based on these data and processes, different services were developed: (i) "models" and "simulations" as a service, (ii) AI-based prediction methods for generation from photovoltaics and wind, peak-maintaining load curve forecasts for private households and at the local network transformer level, (iii) analysis methods such as for anomaly detection or network analysis, (iv) a power system simulation service with which, among other things, the current network status or resource loads (as a virtual sensor for non-existent sensors) can be calculated, (v) the Flex-Management System for evaluation, reservation, retrieval and visualization of flexibility options.

For these services to work, a data and service platform is required that enables services to access data, to communicate with each other and for the transparent integration of new data sources.

To meet these requirements, an integrated data and service platform has been developed that follows Industrie 4.0 guidelines [15]. In other words, the data and service platform is divided into two platforms: the software-defined platform, through which data sources such as sensors, actuators and existing data nodes can be integrated, and the service-oriented platform based on this,

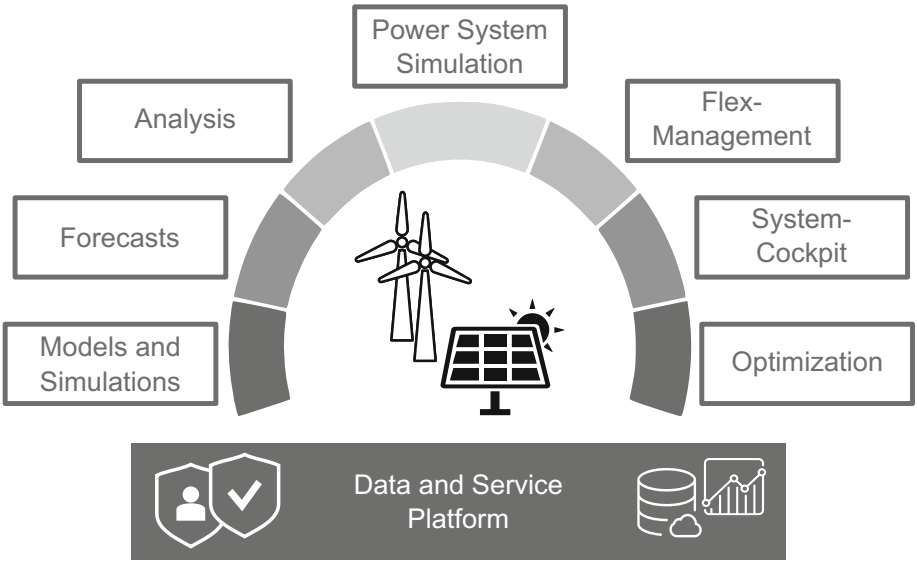

Fig. 2. Concept of the integrated data and service platform in the project

which provides the basis for the services mentioned before. Services must only be developed against this service-oriented platform (Fig. 2).

The service-oriented platform allows the flexible combination of services (service mashup) and thus an adaptation to different application scenarios in energy supply. This kind of data and service platform could also be a potential component of an urban platform for smart cities in the future. In addition to the privacy/data protection aspect, the possibilities of pseudonymization, anonymization and aggregation of data were investigated. The data and service platform transparently provides a security architecture and corresponding security mechanisms not only for itself but also for the data and services.

3.2 Data Infrastructure

The decentralized energy system of the future based on renewable energies and the increased use of flexibility leads to specific requirements. The involvement of numerous stakeholders with different interests and functions in such a system requires the definition of standardized processes and data formats. They will be based on clear and structured rules, which include specifications, how flexibility is offered, visualized and can be traded, i.e. in the context of the consideration, regarding for instance reservation or cancellation processes of flexibility products. These functions must be supported by an IT system that is scalable and implemented with uniform data technology.

Data Hub. Originally, the energy distribution in Germany was organized centrally which distributes the data hierarchically from high voltage to local low voltage networks. With the emergence of more decentralized bottom-up based energy generation and with more prosumers on the network, the classic data cascade must be understood as a data hub. In Designetz, this is where all the basic databases containing the master data and the transaction data of the so-called demonstration projects are combined. It consists of several data nodes that are connected from the national level to the regional and local levels. The regional data nodes for instance are designed and realized for the exchange of flexibility and measurement data between the involved actors and the demonstration projects, whereas the regional data nodes merge the information towards a central and intelligent controlling unit.

Data Distribution Service. With the increasing amount of renewable energy plants and to ensure the best use of flexibility, greater emphasis is exerted on intelligent networking and the exchange of energy-related data. The focus on open, flexible and secure IT infrastructure facilitates the easy exchange of data and the integration of new stakeholders and facilities. Therefore, the working group for Designetz implemented a uniform, open and secure integrated data and service platform. The platform fulfils the following three objectives: (1) an efficient, regulatory compliant data management, and (2) the cascading data hubs for flexibility options, network and meter data (the monitoring of the flexibility options is implemented prototypically within the framework of the Flex-Monitoring) and finally (3) a holistic security and data protection concept.

3.3 Services

In the following we want to present in more detail the services for monitoring and management of flexibility and various AI-based forecast services.

Monitoring and Management of Flexibilities. In Designetz, the demonstration projects are connected to the data nodes via appropriate interfaces. Relevant flexibility data can be exchanged using a uniform data model and structured processes that meet the requirements of all stakeholders. The necessary flexibility when expanding the data model can be ensured via document-oriented database structures. A central service in the Designetz-ICT system is a flexibility management component. This component coordinates the standard processes in the background, from the offer to the reservation to the call for flexibility. At the same time, the demonstration projects can use a monitoring function that provides a permanent overview of their own status as well as the overall system view and the retrieval of the processes involved. The flexibility management component also offers aggregation functions that support the creation of portfolios with various demonstration projects and enable their use as flexibility products in a future flexibility market. Initially, no such market is implemented in Designetz, but a network-related call for flexibility is realized through higher-level software.

Besides the passive monitoring, management of flexibilities offers further features. For instance, through an optimized combination of external procurement, generation, storage and consumption, it will be possible to generate business models for actors offering these necessary flexibilities as well as managers in terms of the net stability. By shifting loads or selling decentralized electricity flexibility, companies can react to the opportunities that arise on various energy markets. This means that operators trade their flexibility in line with the price signals on the energy trading markets.

Forecast. Various AI-based forecasting algorithms are available to predict the electrical behavior (power supply or consumption) of photovoltaic systems, and private households. 1) *Photovoltaic production*: Several methods for the prediction of the power output of photovoltaic systems are applied and combined in a meta-model for both day-ahead and intraday forecasts (see Fig. 3). A data set that consists of meteorological data (e.g., global radiation, temperature and humidity) and the measured power output of the photovoltaic systems over some years is used to create the models. The approaches considered include artificial neural networks, random forest, and case-based reasoning. 2) *Individual fine-grained load profiles of private households*: a peak-conserving forecast algorithm is available that tries to maintain peaks in order to achieve a forecast of a meaningful load profile. The forecast algorithm was initially developed and used in the project "Peer Energy Cloud" [7] for individual fine-grained load profiles of private households and was gradually improved in subsequent projects; it is resource-efficient in terms of data and computing requirements and thus suitable for embedded systems.

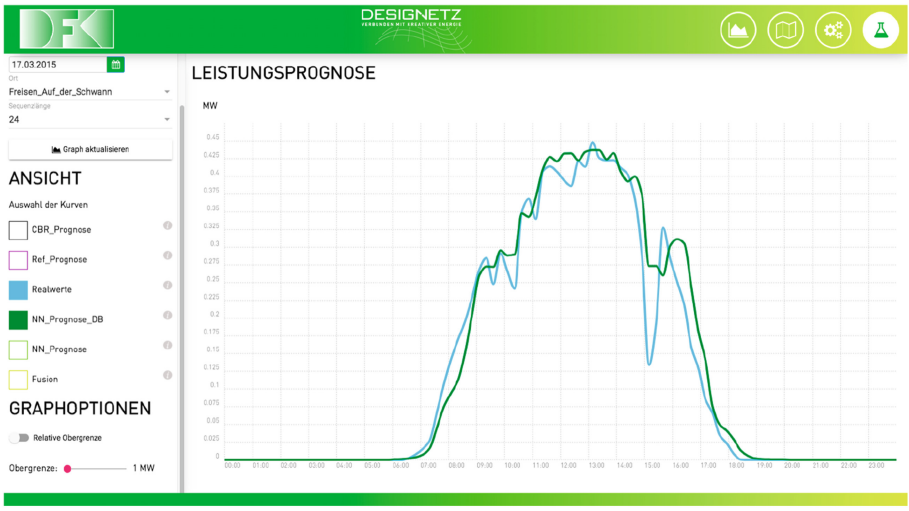

Fig. 3. Example of a forecast (in green) for the power generation of a photovoltaic system (day-ahead) and its subsequently measured values (in blue). On the left side of the dashboard other forecasts such as Case-based Reasoning and their combinations can be selected. (Color figure online)

3.4 Security and Privacy

The data and service platform itself was developed in a structured way according to Common Criteria (CC) – Evaluation Assurance Level (EAL) 4, taking into account BSI (German Federal Office for Information Security) conformity (security-by-design, privacy-by-design, resilience-by-design) [8]. The data and service platform is developed on the same evaluation assurance level as the smart meter in Germany. However, the smart meter is a monolithic system in contrast to the modular approach of the data and service platform. In addition to the privacy/data protection aspect, partners from Saarland University and CISPA (Helmholtz Center for Information Security) investigated the possibilities of pseudonymization, anonymization and aggregation of data. The data and service platform transparently implements a security architecture and corresponding security mechanisms not only for itself but also for the data and services. This includes, among other things, an innovative role and rights management as well as a comprehensive data usage control solution from Fraunhofer IESE for the (also downstream) usage control of data and services [14]. Due to the gateway character of the security components developed by the DFKI, a service no longer needs to implement corresponding security mechanisms itself.

3.5 Potential New Business Models

Due to the dynamic development of the energy sector and the increasing influence of digitization, there is already enormous growth in new players and business models. An IT system that plays a central role in realizing the backbone of a future energy system must therefore be able to be flexible, adaptable and expandable in order to be able to integrate previously unknown actors and services to do this. There are new opportunities for providers and end customers when it comes to using flexibility. The main source of income that new business models can generate is savings on network charges. Compared to the completely unconditional use of the network, considerable savings are possible, since the conditional and therefore cheaper use of the network can be selected for flexibly controllable consumer devices or manufacturers. This savings potential can be achieved through network users or with the involvement of third parties (e.g., supplier, aggregator).

If the ratio of labor and performance price shifts in favor of the performance price, there is another source of income. Above all, electricity-intensive applications such as electric heating or charging infrastructures for electric vehicles benefit from a higher performance price or the flexibly controllable shift in performance. According to a study by the German Federal Ministry for Economic Affairs and Energy, the target groups of new business models are primarily owners of controllable and flexibly usable consumption/generation facilities. New opportunities thus arise especially for, among other things, household customers who have controllable consumption, generation and/or storage facilities as prosumers, but also for mobility providers who can adapt the control of the unloading and loading of vehicles [21]. Smart meters are used to ensure the transparency

of energy consumption and the timely monitoring of the utilization of the power grids [1]. This new field also gives rise to further new business models.

The companies provide CC certified services for the operation of smart meter gateways and not only in their entirety, but also some as "software as a service" or as a pure IT infrastructure. This range of offers enables the measuring point operators to buy the required services on the market. Overall, it can be said that lively competition and a wide range of services have arisen around the Smart Meter Gateway Administration. This enables flexible tariffs and complex delivery products (e.g., tenant electricity) as well as value-added services in the field of sub-metering (heat cost allocators, sensors, actuators). There are already a few offers for end consumers that combine a time-variable electricity tariff with the provision of an intelligent measuring system [11]. Cellular energy systems, so called Microgrids, are also seen as a promising future solution. Microgrids use all generation, consumption and flexibility capacities and only draw energy from the higher-level network at certain points [12]. Potential further thoughts are indicating connected marketplaces as well as different possibilities to monetize data from the service platforms. These aspects are especially important in the understanding of urban platforms also as service platforms. Shipworth for instance points out the potential peer-to-peer trading in accordance with blockchain and its disruptive nature [25]. In bringing these platforms and services together, the relevance of such connected urban platforms will grow significantly.

4 Further Implications on Energy Distribution and for Urban Planning

The upcoming section reflects the mentioned aspects in the light of regional and urban planning. With the use of a modular and integrated data and service platform, further development towards a more decentralized and bottom-up based energy network which offers the ability to attach services will be supported. The existing top-down oriented system will begin to disappear and the new situation will have flow-on effects to the way we plan our cites. In this way, the necessary interdisciplinary understanding of the issues will be more crucial in the future, especially at the local level, where district and housing energy grids are an essential part of every smart city concept.

4.1 Requirements for Creating a Smart, Effective and Resilient Grid

The previously mentioned aspects indicated that the classical distinction between producer and consumer will disappear and, in this way, every prosumer must be understood as an active part of the network. Whereas data and service platforms theoretically enable every household to act like a "little" powerplant within the network on a much smaller scale. The consequence is, that the complexity regarding the design of smart grids will also grow. Hence, in the light of the given requirements, there are some major challenges for realizing a smart

energy grid for Germany in the future. First of all is the physical hardware site. Investments in the net infrastructure will be inevitable, because large, central fossil fuel power stations will be replaced increasingly with decentralized and unpredictable/volatile/uncertain/unreliable production. This raises questions regarding conventional storage capabilities as well as power-to-x approaches and innovative solutions (e.g., swarm batteries).

The second challenge concerns the distribution networks and their control infrastructure which will also face a serious transformation in terms of the need for digitization. The design of the infrastructure needs to fulfill reasonable control and adaptation functionalities and resist fluctuations at all levels as a resilient backbone on every level.

The last transformative challenge will be based on the fact that a digitized and decentralized electricity network with lots of prosumers will lead to the foundation of respective platforms and marketplaces [7]. The need to handle and manage flexibilities will be indispensable for the electricity grid to remain as stable and efficient as possible. The more effectively this smart optimization of the network works, the more cost savings regarding conventional structures can be achieved [2,13]. While the intelligence within the networks is at present not on the same quality level at all levels (for instance currently mainly on level of transmission grids and on the house level), this must be improved also for local grids.

In addition, ongoing trends such as the convergence with e-mobility will have an effect. The concept of smart cities for instance [4,19,22,24] differs by definition, but always, the convergence of all relevant urban sectors and the interdependencies to the power grid are crucial. Further, the market penetration of the transport sector with electric vehicles' both in individual, freight transport as well as public transport, requires a respective charging infrastructure that will affect the local grids. Besides the necessary investments in the local electricity distribution network, the traffic sector itself is very important. With a growing number of e-vehicles as part of the mobility system, their batteries could play their role as part of a decentralized storage unit for electricity in general and locally produced electricity based on renewable energies, especially for the charging supply network. In this light, the importance of flexibility, which allow dynamic pricing, is growing as well as their role as a crucial part of the energy network [23]. Though, the effects are not limited only on the individual transport, but also local public transport and the interdependencies between long-distance and freight transport will have to be taken into consideration. In addition, totally new approaches like mobile charging stations [26] could set the guidelines for highly complex requirements for urban infrastructure, in terms of modularity, granularity and flexibility. General questions will arise, such as the existing gas station network's suitability for large scale electric charging. The position of the charging stations and the associated parking facilities will also play a significant role in shaping the future street scene. In order to find suitable locations for local mobility points for car sharing, this is of great importance. More than that, the whole process of charging has to be scrutinized. In addition, further questions will emerge such as re-use of old petrol stations or the

different space requirements for charging queues for traditional and e-vehicles. The batteries in e-vehicles could be used as decentralized storage, especially for locally generated electricity from renewables and thus play an important role in the charging grid on a local level in urban districts. The development of areas and districts requires a new, innovative, flexible and digitized energy supply, that can be implemented by integrating renewables, storage options and e-mobility equipment.

This raises the issue on how these approaches could be integrated organizationally. In the light of the development of integrated smart city solutions, cities face the challenge of the provision of urban data by city administrations and other members by respective portals (e.g., open data portals) [17]. For urban services and data, the question therefore arises how they can be efficiently provided, managed and controlled. This topic raised significant awareness in the last decade [16] focusing predominantly on aspects such as public services, governance [20] but not specifically in the light of energy purposes. In this way, these urban dashboards could evolve in the future from a passive component for just monitoring the urban environment towards an active component by integrating the functionalities of a data and service platform.

4.2 Influences on Various Regional and Urban Planning

Considered from a regional and urban planning perspective, the effects will also be significant. The relevant planning procedures were considered in the following section. One basic aspect is the uneven geographical distribution of areas which will produce renewable energies and those which will merely consume it. In Germany, the BauGB (Federal Building Code) sets the formal guidelines for type, degree of building, land use, and it further defines strategic goals for regional and urban planners. In this way, BauGB §1 paragraph 5 states, that urban planning should "contribute to ensuring a decent environment, [...] promote climate protection and adaptation, especially in urban development" [5]. Besides the standards from a formal point of view, the planning solutions comply with the requirements for the integration into the urban environment, especially in the light of design aesthetics.

In fact, the increased use of renewable energies will thus cause a demand for energy transport lines. If energy will be transported from regions with greater production capacity (e.g., offshore wind farms) towards regions with a locally high demand (e.g., industrial areas), the respective hard infrastructure must be installed. For instance, as shown by scientific debate wind energy has a tremendous potential – especially offshore farms [27] – for a fast and cost-efficient nationwide development of the electricity grid. Hence, the great wind potential is primarily found in mountainous and coastal areas, wind turbines are most profitable in these regions while being the most sparsely populated areas in Germany. Therefore, not only must the general question of the legitimacy of the construction be answered, but also the transport structures for energy have to be built. High voltage lines that have not yet been realized are still required, especially from industrialized north, such as Schleswig-Holstein, to the urban sprawl

of consumers in the south, for example Bavaria or Baden-Württemberg. The formal obligations for the respective approval procedures and strategic development plans are inevitable and they will be a guideline for further plans on lower planning scales. The political debate in Germany showed [18] that determining the route for the new power lines in a consensus-oriented democratic system could be difficult. From a regional planning perspective, the focus on the provision of services is of public interest. However, this could include investments in the entire power grid, such as conventional grid extensions and the strategic planning of power plants. The resulting requirements will subsequently have an impact on the planning objects at local levels, e.g., traces or transformer substations, either for new locations or for retrofitting of existing ones.

Relevant aspects in this perspective are for instance the potential location finding process, the formal approval of combined heat and power plants and district-based energy storage on a more local level. This is particularly important since the focus on district-based considerations increases in many cities. This also includes the energy perspective, even towards concepts such as self-sufficiency. Other aspects must also be considered at the local level, which is mainly linked to the respective urban planning procedures and the building permit procedures at the district and housing levels. These are requirements for urban land use planning that will procure the installation of multimodal system stabilizers in urban areas, such as power-to-x systems for public utilities. This is of high relevance because the avoidance of emissions is now seen as an essential part of urban planning. In addition, the respective security issues and constraints, like the location in a district perspective for numerous power-to-x facilities or the effects of power chargers on local grid levels are still open questions. The effects in the local scale in terms of the building perspective will also be fundamental. In this perspective, the understanding of a smart city begins with the advent of smart and connected homes. Crucial parts in this perspective are the integration of battery storages in buildings or the respective voltage lines to charge e-mobility cars to fit the demands of in-house charging for e-vehicles [13]. Hence, a data and service platform based on flexibility as a key element for smart city or also smart home solutions. These should bring more adaptability for their users, and consequently, this does not only mean comfort in controlling the house but also to be an active part of the power grid network as a prosumer. This potential could be monetarized by emerging business models, focused also on prosumers.

5 Conclusion

The vision for a smart and secure energy grid of the future in Germany is decentralized, digitalized and decarbonized. In order to address these fields, the underlying architecture has to be adaptable, flexible and should use concepts such as data and services platforms as central components. Only with this focus, the digital net expansion will realize its potential. This is especially important in the light of the bigger share of renewable energies, because they will be unstable and the only way to handle this complexity comes along with the use of flexibilities, which need an almost totally digitized power grid network.

The vision in the project Designetz, which will achieve all of its results by 2021, is to take a look at the year 2035. It clarifies that, in addition to the pure IT-side and infrastructure consideration of requirements, that the business conditions will change for future networks. In the context of digitization, digitalization and digital transformation, this also means that the development of new business models based on new market mechanisms will emerge. The increasing number of actors and transactions, the resilience and high safety requirements for critical infrastructures, decentralized energy and IT infrastructures, as well as decentralized organization structures, such as contract processing, drastically increases the complexity of the energy network of the future. In the course of these complex requirements, blockchain-based solutions can also be a promising alternative through the use of smart contracts, especially in respective integration approaches in the urban platform.

In general, however, it should be noted that the network of the future needs to be as flexible as possible and must have a modular structure. The respective needs – considered in the light of an increasing share of renewable energies, will tend to increase in their complexity. There will always be a correlation between energy production and energy use, the more supply on local levels, the more complex the networks will be. The more tools such as data and service platforms will come to every household, the more it will be used and the more important it will be that these trends and developments has to be considered from planners from the energy side, as well as from urban planners or even architects. Consequently, new emerging trends, such as e-vehicles or new consumer-based business models in smart homes with smart meters will have to be part of every consideration and defining the necessity for integrated development concepts. Therefore, regional and urban planners must include energy issues in their decision making, and integrated master plans will contain energy plans as obvious as traffic plans on every scale. Especially the interaction with smart and electric mobility and their requirements [3]. In terms of a modular data and services platform, a first approach is exemplified in the context of Designetz and on the basis of the preliminary results, the authors of this study are confident they'll achieve a coherent concept for the blueprint of the energy network looking ahead to the year 2035.

SINTEG
SMART ENERGY SHOWCASES
Supported by:
Federal Ministry for Economic Affairs and Energy
on the basis of a decision by the German Bundestag

Acknowledgement. This work was supported by the SINTEG-project Designetz funded by the German Federal Ministry of Economic Affairs and Energy (BMWi) under the grants 03SIN235, 03SIN231 and 03SIN222. The authors would like to kindly thank the project partners in Designetz, namely Hager Electro GmbH & Co KG, htw saar, innogy SE, IS Predict, Westnetz, and Saarland University for their valuable contributions.

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