Visions of the Smart Grid City

Discourses, Experimentation and the
Making of Urban Energy Futures
in Berlin, Germany

vorgelegt von

Dipl.-Ing.

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an der Fakultät I – Geistes- und Bildungswissenschaften

der Technischen Universität Berlin

zur Erlangung des akademischen Grades

Doktorin der Philosophie

- Dr. phil. –

genehmigte Dissertation

Promotionsausschuss:

Vorsitzender: Prof. Dr. Axel Gelfert
Gutachter: Prof. Dr. Liudger Dienel
Gutachter: Prof. Dr. Andreas Knie

Tag der wissenschaftlichen Aussprache: 02. Juni 2022

Berlin 2022

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Berlin, October 2022

Abstract

This dissertation examines the visions associated with urban smart grid technologies and how they are being mediated through processes of urban experimentation in the city of Berlin, Germany. Smart grids - vaguely defined as the combination of electricity infrastructures with information and communication technologies for sensing, monitoring, controlling and managing electricity flows - combine the promise of low-carbon transitions with that of high-tech development and economic growth, and are currently being tested and implemented in various so-called "urban laboratories" in the city. Through an in-depth case study of smart grid experimentation at three of these urban labs, this dissertation unveils what Berlin's energy futures could look like, and how their meanings are being discursively created by actor coalitions across the policy, research and business domains. In doing so, this dissertation critically interrogates the role of imagined futures and of experimental governance in processes of urban socio-technical change.

Conceptually, it is situated at the interface of urban studies, infrastructure studies, and science and technology studies. I conceive of smart grids as socio-technical infrastructures and political processes that are deeply entangled with the social, political, and cultural shaping of cities, and whose development is driven by visions and imaginaries that nurture certain assumptions about desirable and attainable urban futures. Using discourse analysis, I show how visions of urban smart grid futures are being promoted by relevant actors, discourses, and experimental arrangements in the city, discussing underlying rationalities and techniques and highlighting certain critical omissions.

My findings suggest that visions of Berlin's smart grid futures are being co-produced by urban policy narratives and corporate marketing strategies on the one hand and reinforced by research and implementation practices on the other. Although these visions have successfully activated an actor coalition that is pioneering urban change, they are also driven by techno-optimism, built on few peoples' perspectives, lack critical negotiation, and are strongly embedded in the economic opportunities associated with the logics of the smart – not the sustainable - city. I draw five main conclusions from these findings. Smart grid policy and implementation practices should a) understand smart technologies as a means not an end, b) more sincerely embrace the social, c) invite more pluralistic perspectives, d) dare more radical utopias, and finally, e) be backed by stronger political leadership.

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1 Introduction and background

This dissertation investigates how urban smart grid infrastructures are being envisioned and enacted in the city of Berlin, Germany. The development of these novel technological infrastructures is accompanied by numerous hopes and aspirations for the future, especially regarding the transformation of current unsustainable energy systems. Although these visions circle around the future, they have the power to shape processes of urban socio-technical change in the present. Visions of infrastructural futures have a long history of influencing urban development, from the introduction of water and waste water systems in the sanitary city of the late 19th century to the construction of expansive road networks in the Modern functionalist city of the early 20th century. Urban infrastructures embody notions of a better tomorrow that are often closely related to ideas of what it means to be modern, progressive or free today. They embody a society's hopes and values on the one hand, and can carry public messages about these hopes and values on the other. Oftentimes, which hopes and values are engineered into urban infrastructures is defined by certain infrastructural elites, such as government agencies, entrepreneurs, scientists, technology companies or NGOs that have the knowledge and the capabilities to influence infrastructural development in the city. The development of urban infrastructures is therefore closely attached to the power of these elites to translate their hopes, desires and fantasies in discursive and material terms.

In the case of smart grids in Berlin, these hopes for better infrastructural futures are currently being mediated through sites of urban experimentation, or so-called "urban laboratories" where actors from the business, policy, and research domains interact to create infrastructural prototypes for broader replication and scaling. At these sites, visions of infrastructural futures simultaneously serve as means and ends of city making. As actor coalitions gather to develop, test and implement smart grids at these sites, their visions thus become important vehicles of urban governance. To unpack the dominant rationalities underlying their visions and shed light on possible absences and alternatives, I critically analyze how smart grid infrastructures are being discursively constructed within and through Berlin's urban laboratories. I use smart grid infrastructures as lens through which to analyze the political processes of Berlin's urban socio-technical "becoming".

Firstly, I analyze how visions of smart grid futures are intertwined with visions of the smart city on the one hand and of the sustainable city on the other. My research reveals the ambiguity of imagining smart grid futures as low-carbon futures in the face of the more economically oriented politics of digitization. My research thus highlights the tension between "smart" and "eco" city imaginaries and how visions of the "smart grid city" produce and are at the same time being produced by this tension.

Secondly, my research engages with the ability of these visions to enact broader urban socio-technical change. It thus relates academic debates on visions of the future to debates on urban sustainability transitions. It shows that even a strong, politically backed vision might only translate into a relatively marginal phenomenon instead of developing into a widely shared and practically embraced urban reality. On a more conceptual level, this dissertation thus engages with the ability of visions, imaginaries and discourses to create the material and social reality of the city.

1.1 What are smart grids?

Although only vaguely defined, smart grids stand for the integration of information and communication technologies (ICT) into electricity networks. Visions attached to smart grids circle around a variety of goals, including low-carbon energy production through the integration of more (fluctuating) renewable energy sources, higher energy efficiency through the real-time coordination of resource flows, higher supply security through automatic grid reconfiguration, and more active consumer participation in energy markets (Covrig et al., 2014). Moreover, city governments see the digital enhancement of electricity grids as an opportunity for increasing economic competitiveness through high-tech infrastructural modernization and for attracting high-skilled, well-paying jobs. The promise of pairing high-tech development and economic growth with environmental protection has led to increasing investments into smart grid technological development by businesses and urban policy makers, which are being tested and implemented in a multitude of cities across the country.

Smart grids are challenging the large socio-technical systems that comprise urban electricity grids as we know them. Currently, electricity networks distribute stable loads uni-directionally from a small number of centralized power plants to a large number of local consumers, are centrally managed and usually controlled by few large network operators. By contrast, smart grids are conceived to accommodate fluctuating voltage profiles from renewable energies, enable two-way generation and distribution to and from various decentralized sources, and respond to customer specific demand. These features are enabled by an 'energy information system' (Bichler, 2012) or an 'internet of energy' (Karnouskos and Holanda, 2009; Weiler) that coordinates a complex web of producers, consumers and – in the future also - storage units (including, for example, electric vehicles). Long-term visions of the smart grid even include the integration of service sectors other than electricity, such as water, gas, heating, cooling, waste management and mobility. The smart grid is therefore envisaged as a highly communicative network that provides information in real-time, allows multi-lateral resource flows, reacts flexibly to demand and is accessible for a multitude of new market players.

1.2 Smart grids and urban energy transitions

Most modern cities are fundamentally built on the exploitation of fossil fuels. With very few exceptions oil, coal, gas and nuclear power have been the pillars of urban development in the Western world. The constant supply of energy that sustains modern city life is secured by intricate infrastructure networks that have evolved over the course of many decades and are deeply rooted not only in urban space but also in urban practices, institutions, economies and governance arrangements. The transition to renewable energies is challenging the nature of these infrastructure systems and with it the nature of the organization of urban life. While fossil fuels are still the dominant sources of energy today, there is rising pressure to integrate increasing amounts of renewable energies into urban electricity, heating and mobility systems.

In Germany, urban smart grid activities have especially gained momentum since the country's energy policy turn-around in 2011. This policy package - commonly known as *Energiewende*[1] - aims at phasing out nuclear power and replacing fossil fuels with renewable energies by the mid-2000s. The rising awareness for the need to transform urban energy systems and lower carbon emissions has put urban administrations under pressure to rethink the ways in which energy and other resources are used, produced and circulated in cities. It has sparked a competition between German cities to modernize their century-old energy infrastructure systems and accommodate novel technologies such as solar panels on rooftops and façades, battery storage facilities in private living rooms, or combined heat and power plants in tenement basements. All over the country, cities are therefore competing for the best technological solutions to their emissions problem.

'Smart' electricity grids are seen as one of these solutions. They are hailed as indispensable means to achieve the mass integration of renewable energies into urban energy systems and as promising pathways towards reducing energy consumption and reaching carbon neutrality. For this reason, smart grid technologies are being practically implemented and tested in the local settings of cities, where their advancement is becoming entangled with other urban development policies and concerns. Apart from promising low-carbon development, these new digital possibilities are also being embraced as opportunity to modernize and invest in century old urban infrastructure systems. They are being promoted as tools that will enable environmental protection and at the same time foster technological innovation and economic growth.

At the same time, smart grid technologies challenge the logics of the large technical infrastructure networks that have carried the flows of electricity, heating, gas and other resources for nearly a century. In Germany, existing electricity systems have been largely built following the logics of centralized management and public oversight over service provision (*Daseinsvorsorge*). For decades, supply security and economic profitability have been their guiding standards, as is laid out in the federal Energy Industry Act (*Energiewirtschaftsgesetz*). These existing networked infrastructures are therefore strongly associated with principles of centralization, integration and solidarity. Historically, electricity infrastructures have been understood as integrative and equalizing forces, which surpass socio-economic, spatial and political boundaries by facilitating homogeneous service provision across social groups, aligning standards and practices across regions, and catalyzing governmental cooperation across service territories (Coutard and Rutherford, 2016). Until today, this "networked infrastructural ideal" (Monstadt and Coutard, 2019) is built on the idea of spatial and organizational expansion and geared towards maximizing supply (rather than, for example, interest in user practices or sensitivity to demand). In turn, the "networked city" is commonly envisioned as a uniform, integrated and equitable (McFarlane and Rutherford, 2008: 370) space of collective infrastructural standards and practices.

[1] The national policy framework known as *Energiewende* sets out Germany's medium to long-term targets for the reduction of energy use and green house gas emissions as well as the country's goals for increasing energy efficiency. At the time of writing, its main aims were a 50% reduction of primary energy use by 2050 (compared to 2008 levels) and an 80% reduction of green house gas emissions by the same year (compared to 1990 levels). To reach these goals, the German government aims at steadily increasing the share of renewables in overall final energy consumption to 60% by 2050. Special importance is placed on increasing the share of renewably generated electricity consumption to 80% by the year 2050. These goals are complemented by the decision to phase out nuclear energy production by 2022. See Quitzow et al. (2016).

Smart grid technologies are challenging this networked city ideal in a variety of ways. In the urban context, the emerging technological possibilities associated with smart grids imply a number of significant transformations at the socio-cultural, socio-political and socio-economic levels. They reach far into the existing configurations of the urban electricity sector, including its dominant technologies, actor constellations, market logics, regulatory mechanisms, institutional structures, financial instruments and – not least - into the practices (and the privacy) of users (Canzler and Knie, 2013). Among others, smart grids raise questions about the relationship between centralized and decentralized structures of electricity production, consumption and management in the city. The integration of small-scale decentralized production and consumption units (e.g. 'smart homes') points to the development of a cellular structure of different-sized micro-grids and a possible fragmentation of services (Bhave, 2015; Bichler, 2012). This might lead to distinct product markets and service territories, and possibly result in spatial disparities. It is not yet clear which level of network decentralization is feasible in the city, whether sub-networks will emerge, and if so, whether this will result in different levels of – for example - supply security. Much will depend on how the network is regulated and managed. In order to synchronize supply and demand and flexibly adapt prices, operations pertaining to the grid and operations pertaining to the market will have to be orchestrated together. How and by whom they be managed is utterly unclear. What role will public authorities play? What role might network operators play? While traditional distribution service operators (DSOs) are responsible only for grid operations, their future role might include energy data and energy market management (Bichler, 2012). Smart grid development also raises questions about the roles and responsibilities of all stakeholders involved in urban electricity systems. This includes utility companies, network operators, regulatory authorities, and also users. Through the emergence of smart grids, established players are being confronted with a set of new actors that are claiming stakes in the sector, most notably the ICT industry but also small-scale energy producers and (network) service providers. This shift requires new business models and new corporate partnerships between highly unlike and hitherto unfamiliar actors. These shifts are also relevant for private electricity users, who are being confronted with possibilities of 'prosumage', i.e. the production, consumption and storage of electricity in small-scale household units (Canzler and Knie, 2013). The transformation of the grid therefore not only entails major technological innovations, but also significant shifts in the "commercial and political power structures" (Schleicher-Tappeser, 2012: 5) in the city. Currently, actor constellations are being reshuffled, institutional arrangements reordered, power relations newly distributed and the legal and regulatory framework overhauled. Given the messiness of the process, it is unclear, however, who or what is driving the development of smart grids in cities and to what ends. Research on the underlying processes of transformation is therefore timely.

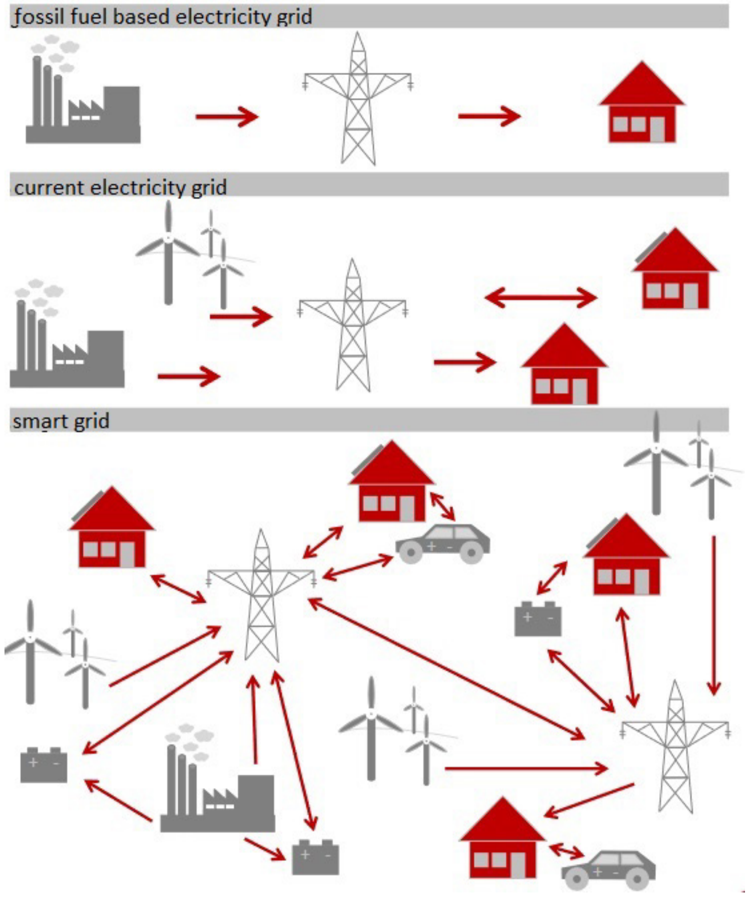

Figure 1: Differences between electric grid systems © adapted from www.energie-macht-schule.de

1.3 <u>Smart grids at urban labs</u>

The deployment of smart grid infrastructures is still in an early stage, and test versions have only been installed in micro-scale pilot projects. Their roll-out, though keenly expected, has not yet happened. All over the country, smart grids are being tested and implemented in so-called "urban laboratories", where actors such as IT companies, universities, and real estate developers collaborate to bring these infrastructural possibilities to matter. In effect, urban energy and infrastructural transitions are being implemented within and through such spatially delimited sites of urban experimentation (Bulkeley and Castán Broto, 2013; Castán Broto and Bulkeley, 2013; Evans and Karvonen, 2014; Hoffman, 2011; McLean et al., 2015; Schulte-Römer, 2015), where they are no longer the matter of politicians and urban administrations alone, but increasingly involve a diverse range of stakeholders (Blanchet, 2015). These "urban labs" provide a space for articulating and negotiating technological futures, as well as implementing and showcasing them to a broader public (Evans et al., 2016). By means of technology trials, they facilitate new policies, actor coalitions, institutional arrangements, and cultures around smart grids, and should therefore be understood as spaces not only for envisioning, but for governing and actively creating the city (Bulkeley et al., 2019; Evans et al., 2016). As smart electricity grids and urbanism come together, the city thus becomes a privileged site for energy experimentation while, at the same time, electricity becomes central to processes of urban governance (Bulkeley et al., 2016a; McLean et al., 2015). Bulkeley and Castán Broto argue that such "experiments are critical sites of urban climate politics" (Bulkeley and Castán Broto, 2013: 368), because they "are the means through which discourses and visions concerning the future of cities are rendered practical, and governable." (Bulkeley and Castán Broto, 2013: 367).

1.4 Problem statement

Although the broad dissemination of smart grid infrastructures suggests significant social and political transformations to the urban fabric and urban life, academic discussions about smart grids are still dominated by ICT and electrical engineering related concerns (see chapter 3 "Literature review"). Moreover, the political implications of how smart grid related visions of urban futures are being produced and translated into material reality in urban labs is hardly a matter of academic or of public debates. While there are broad debates about how the smart city and the low-carbon paradigms are bringing techno-politics back to the fore at the expense of "softer" urban problems, smart grids are largely exempt from these discussions.

To close this gap, this dissertation critically interrogates how smart grid infrastructures are being envisioned, translated and contested in the context of these urban laboratories in the city of Berlin, Germany. It sets out to uncover the visions underlying the development of smart grids in Berlin, and how they are being promoted by relevant actors, discourses and experimental arrangements in urban laboratories. It asks: who is envisioning smart grids in Berlin? What do different actors associate with smart grids? How do they relate smart grids to the urban context? And how are smart grids being realized in urban space?

By answering these questions, this dissertation provides a snapshot of visions of smart grid futures in Berlin. Instead of describing a process and a development over time, it paints a picture of how smart grids are being imagined in Berlin at the time of writing. In doing so, it draws on existing literatures on imagined futures, on the co-evolution of cities and socio-technical systems and on urban experimentation.

2 Research questions

This dissertation is interested in understanding how the future of urban energy production, consumption and distribution is being envisioned, negotiated and formed through urban experimentation with smart grids in the city of Berlin. I use smart grid infrastructures as lens through which to analyze the making of these energy-related socio-technical futures. Moreover, I understand urban experimentation as key interface between imagined futures and their material realization, and therefore as vital entry points for understanding the politics of urban socio-technical "becoming".

My overarching research question is:

> How are urban futures being imagined, negotiated and formed through urban experimentation with smart grid infrastructures in Berlin?

Subordinate research questions:

1. What kinds of smart grid futures are being imagined in Berlin?
   a. How are urban smart grid futures being constructed in discourse?
   b. What kinds of promises are being associated with smart grids in Berlin?
   c. How do they relate to broader urban development paradigms, such as urban energy transitions and smart cities?
2. What are the politics behind imagining urban smart grid futures in Berlin?
   a. How and by whom are these urban futures being imagined (i.e. communicated, performed, enacted)?
   b. What are different actors' roles?
3. How are imagined smart grid futures being mediated through processes of urban experimentation?
   a. How are the design and practices of urban experimentation shaping Berlin's imagined futures (and not others)?
   b. Which role do the pilot projects and the future sites play in this process?
   c. And lastly, how is urban experimentation therefore contributing to broader urban socio-technical change?

3 Literature review

Although smart grids are being largely implemented in cities, academic literature on smart grids is largely dominated by ICT and electrical engineering related concerns. In the following chapter, I present an overview of this literature, and then move on to discuss in more detail the smart grid related debates currently being conducted in the social and urban studies communities. Finally, I show how my research contributes to these debates, and the empirical gap it seeks to close.

3.1 Academic literature on smart grids

Academic debates on smart grids have developed within largely separate communities, where they have evolved more or less independently of each other and have centered on very diverse aspects of this broad, all-encompassing term. I identify three communities that are involved in the development of smart grids or smart energy systems in cities, and who are only just starting to take note of each other, be it in the practical domain of smart grid projects or in the abstract territory of academic literature. These are the “energy” community, the “ICT” community, and the “urban development” community. I define the “energy” community as consisting of people involved in energy systems engineering and management across different energy sectors and domains, such as electricity, gas, heating, cooling, generation, distribution, and storage; the “ICT” community consists of people involved with the technologies of everything “smart”, i.e. computational science and information technology, including both hard- and software engineering; and last but not least, the “urban development” community, which consists of all those concerned with the development of “the urban”. This includes city government and administrations, urban planning practitioners, community organizers etc.

Notably, the urban development community is least involved in both practical implementation and academic debate concerning smart grids. This is true even though smart grids are being implemented and tested in urban experimental “urban labs” across Europe, where the scene is being set for a fundamental reconfiguration of urban energy systems through the addition of a new, digital “layer”.

I traced these academic debates in a brief online search of academic data bases[2], which included SAGE, Web of Science, Taylor&Francis, dblp computer science bibliography, OLC-online contents, and The Collection of Computer Science Bibliographies. I used various search terms and categories to extract the relevant literatures from these platforms following an “energy”, an “ICT”, or an “urban planning” perspective. Community affiliation was inferred from the place of publication, so that relevant content in the journal “Supercomputing”, for example, was attributed to the ICT community, content in the journal “Energy & Environment” was attributed to the energy community, and content in the journal “Urban Studies” was attributed to the urban planning community.

This brief review suggests that the term “smart grid” first appeared in both energy and ICT related debates about twenty years ago and started gaining popularity and importance about ten years later. While energy and ICT

[2] The search was conducted in the year 2018.

related debates concerning smart grids were always interrelated, relevant urban studies debates developed independently and still remain largely separate. This seems in great part due to the work of the Institute of Electrical and Electronics Engineers (IEEE), which claims to be the largest technical professional organization in the world, and which has a long history of providing both energy and ICT professionals a common platform for continuous exchange and publications. Currently, IEEE's members include computer scientists, software developers, information technology professionals and many more apart from its electrical and electronics engineering core (https://www.ieee.org/about/ieee-history.html). Their smart grids related activities are bundled in a subdivision solely dedicated to this topic. As a result, by far the most publications concerning smart grids currently available on the web originate in one way or another from the IEEE. Urban development debates are largely absent from this platform.

From the very beginning, energy and ICT related debates concerning smart grids focused on the challenges of integrating distributed components, especially renewable energy generation plants, storage units, electric vehicles, and buildings, into a connected system. Primary concerns are with increasing system efficiency and lowering costs. While debates in the energy community also include questions of innovation management, institutional change, and policy (or market) design, the bulk of discussions in the ICT community circles around technical questions such as sensing, automation, and control mechanisms. Until very recently, neither of these communities showed much interest in the social aspects of smart grids or the specifics of smart grids in cities.

The urban studies community, on the other hand, is only just beginning to discuss smart grids at all. Moreover, this small amount of available literature is vastly diverse in its content. In general, however, this literature clearly favors the social and political dimensions of smart grids, addressing issues such as consumer practices, acceptance, social and environmental justice, citizenship, equity, self-sufficiency, and low-carbon governance. Although debates in the urban planning community are also generally in favor of smart grid development, it is here that most critical engagement with the "hows" and "whys" of smart grid development is found. Among others, this criticism questions current practices of urban experimentation, the market-driven roll-out of metering technology, the disengagement of urban publics, and the limited ability of city governments to access or deal with available (big) data. This critical, socio-political vantage point is currently missing in energy and ICT focused debates. Given the distinctly urban nature of smart grid transformations, there is a need to engage in research on smart grids in cities, and thus to inform those involved of the social and political caveats of smart grid implementation. My research project addresses this challenge by linking smart grids to urban change.

3.2 Smart grids in social and urban studies research (empirical gap)

Skjolsvold et al. (2015) identify three areas of relevant social scientific inquiry into smart grids: firstly, imaginaries and visions (Ballo, 2015; Köktürk and Tokuç, 2017; Skjølsvold and Lindkvist, 2015; Tricoire, 2015), secondly, expectations towards users, such as consumer engagement (Gangale et al., 2017), participation (Throndsen and Ryghaug, 2015), acceptance (Broman Toft et al., 2014; Geelen et al., 2013; Verbong et al., 2013) and empowerment (Shaukat et al., 2018), and thirdly, system building and transformation (Erlinghagen and Markard, 2012). Other researchers have also examined questions of trust and confidence (Büscher and Sumpf, 2015;

Reuver et al., 2016) or of ownership of electricity infrastructures (Hall et al., 2019). My research focuses on the study of visions and imaginaries associated with smart grids. This emerging body of research has approached visions and imagined futures from a variety of angels, inquiring about their function in the smart grid innovation process, their normative content, and the ways in which they relate to smart grid implementation processes.

Various scholars have criticized the dominance of positivist imaginaries that depict smart energy futures as more sustainable, reliable, efficient, transparent, democratic and secure (Ballo, 2015; Palensky and Kupzog, 2013; Skjølsvold et al., 2015; Wentland, 2016), while standing in the way of more comprehensive, critical public debates (Luque-Ayala, 2014; Vesnic-Alujevic et al., 2016). Others have shown that smart grid imaginaries can be much more nuanced and contested, especially in the policy domain (Hielscher and Sovacool, 2018). Researchers have also shown that the production of smart grid imaginaries is often confined to certain communities of experts, mostly within the context of bounded sites of experimentation (Ballo, 2015; Engels and Münch, 2015; McLean, 2013). These studies highlight that experts use visions to communicate largely positive views of energy system automation, consumer engagement and security of supply to the general public, while hiding their concerns about risks and uncertainties from view (Vesnic-Alujevic et al. 2016; Luque-Ayala 2014).

Moreover, research has shown that visions of smart grids can serve as medium of communication between experts and regular citizens or households. Among others, it highlights how normative ideals inherent in these visions are used to engage potential consumers and influence their practices in 'smart grid compatible' ways (Ferrari and Lösch, 2017). At the same time, scholars have also argued that smart grid imaginaries can function as common denominator between innovation actors, providing a point around which to gather and coordinate actions (Engels and Münch, 2015; Lösch and Schneider, 2017).

As smart grid projects gain popularity and scale, social scientists have also pointed to the contradictions between visions of smart grid technologies and the realities of their implementation. They have argued that the realities of smart grid implementation have failed to live up to, or even undermined the promises originally associated with them, for example regarding issues of social equity (Lovell, 2018). While experts tend to promote visions of end-users as engaged, flexible, price-sensitive and tech-savvy, actual implementation reveals much less active engagement (Bugden and Stedman, 2021; Schick and Gad, 2015). In a study of the US, Levenda et al. also show that beyond a unifying national vision, different local or regional smart grid imaginaries can lead to different local implementation politics and practices (Levenda et al., 2018). He also shows that, even though smart grid visions may be differently translated in different localities, they can still embody similarly restrictive ideas of citizen participation (Levenda, 2019).

Although the body of social studies research on smart grids has grown over the past years, most of these studies have focused on *national* level concerns, leaving question of urban development largely out of view (Bulkeley et al., 2016b; Levenda, 2016; McLean et al., 2015; Quitzow and Rohde, 2021). My research seeks to close this gap by explicitly focusing on the relationship between smart grids, experimentation and socio-technical change at the urban level.

3.3 The smart city in social and urban studies research

In doing so, my research also contributes to research on the "actually existing" smart city (Shelton et al., 2015) and how it relates to urban sustainability transitions. With the emergence of the smart city paradigm, technological infrastructures are once again at the center of contemporary urbanism. More and more urban planners, authorities, researchers and businesses are embracing 'smartness' as vision for overall urban development. Notions of smart homes, smart mobility, smart economy, smart government, and smart energy are being put forward as likely solution to a wide array of urban challenges, ranging from environmental protection to democratic participation and urban renewal (Berlin Senate, 2015b; Luque-Ayala and Marvin, 2015). The smart cities trend is increasingly being criticized by urban studies scholars for its narrow focus on technological development as the means (and ends) of urban change (Luque-Ayala and Marvin, 2015). Numerous scholars have criticized the rise of the global smart city imaginary as "empty rhetoric" masking neoliberal urban governance agendas (Greenfield, 2013; Hollands, 2008; Luque-Ayala and Marvin, 2015; White, 2016; Wiig and Wyly, 2016). These critics argue that urban governments and corporations are promoting positivist notions of the "intelligent", efficient, resilient and optimized city for purposes of marketing technological innovation rather than addressing existing urban problems (Karvonen et al., 2019). These imaginaries tend to rationalize cities into uniform and quantifiable systems, instead of engaging with the complexity and local specificity of urban issues (Greenfield, 2013). Alberto Vanolo warns that smart city strategies are depoliticizing concepts within urban policy-making by presenting supposedly 'correct' development pathways and thus avoiding discussions about possible alternatives (Vanolo, 2014). Urban studies scholarship also argues that smart cities strategies are largely built around the interests of private - mostly ICT - firms that reduce the role of citizens to passive and compliant urban subjects, and follow the logics of entrepreneurial urban governance (Datta, 2015; Hollands, 2008, 2008; Söderström et al., 2014; Vanolo, 2014). Among others, this view is based on the observation that international companies such as Cisco, IBM, Hitachi and others have created specialized departments for smart city 'solutions' that are increasingly involved in public private partnerships with urban authorities all over the world. In effect, there is increasing uneasiness in the critical urban studies community that "[ICT] companies are becoming the urbanists of the future, and their ways of thinking are likely to provide a template for future urban development" (Luque-Ayala, 2014: 168). In pursuit of primarily economic goals these "solutionist" imaginaries are often complimented and sustained by scenarios of future crises that appeal to looming threats such as climate change or fiscal austerity, and which serve to justify the need for technological interventions in the present (Caprotti, 2014b).

More recently, this literature has also critically interrogated the increasing convergence of the smart and low-carbon urban imaginaries (Caprotti, 2014a; Evans et al., 2019; Haarstad, 2017; Haarstad and Wathne, 2019; Martin et al., 2019). While some of these studies find that the so-called "smart-sustainability fix" is amplifying ecological modernization agendas and forms of entrepreneurial urban governance (Martin et al., 2019), others have found more nuanced, two-way relations. Haarstad and Wathne, for example, show that in their case studies from the UK, Norway and Sweden, the smart city imaginary is actually inspiring local actors to pursue low-carbon goals where they might otherwise not have, and that it is allowing them to do so through low-tech refurbishment initiatives rather than high-tech innovation (Haarstad and Wathne, 2019). Their research forms part of a broader effort to engage with the situated practices and material realities of the "actually existing smart city" in order to understand how the global smart city imaginary is being locally translated into specific socio-technical configurations, and how these are playing out in specific contexts, places and ways (Shelton et al., 2015). My research speaks to this literature by asking how specific real-life instances of smart grid development relate to smart city politics, urban energy politics, and experimental urbanism.

3.4 Concluding remarks

This section shows that academic literatures on smart grids are still dominated by contributions from the ICT and the electrical engineering communities, and that research from the social and urban studies communities is lacking. Moreover, it highlights that existing debates on the specific relationship between smart grids and visions of the future leave an empirical gap concerning research on cities, which this research project fills. Finally, this chapter has linked debates on smart grids with related debates on smart cities, urban experimentation, and urban sustainability transitions which this research project also addresses.

4 Conceptual foundations

I conceive of smart grids as socio-technical infrastructures and political processes that are deeply entangled with the social, political and cultural shaping of cities (Hommels, 2005; Hughes, 1983), and whose development is driven by visions and imaginaries that nurture certain assumptions about desirable and attainable urban futures.

This dissertation is situated at the interface of urban studies, infrastructure studies, and science and technology studies. It draws on these three strands of scholarly literatures to understand what the development of smart grids means for the future of urban electricity systems in Berlin.

In the following chapter, I review the literatures that have informed my conceptualization of smart grids, and lead over to my research design.

4.1 What are infrastructures?

In order to understand the relationship between smart grids and urban energy systems, one must understand the nature of networked technological infrastructures more generally. I draw my understanding of infrastructures largely from the social studies of technology that have provided a solid foundation for the more specific study of networked infrastructures in cities. First and foremost, this strand of research has shown that the development of technology is closely connected to the human idea of progress and modernity. Technological infrastructures introduce new possibilities and offer innovative ways of doing things. They satisfy our incessant desire for improving what is and enhancing what will be in the future. Moreover, technologies are proof of our human ability to overcome difficulties and to dominate our natural environment. At the same time, technologies can be overwhelming and inspire fears, especially if they get out of hand. Usually, however, technologies are taken for granted and live an invisible life that is – at best - forgotten. This is especially true for networked technological infrastructures, such as public transportation, waste management or electricity systems. As long as they run smoothly, we tend to forget that somewhere turbines are humming and engines are pumping to keep our routine lives going. Infrastructures are more than mere artefacts; they are objects that enable relations between other objects; they are technologies that enable other technologies to function, or "matter that enable the movement of other matter" (Larkin, 2013: 329). As opposed to technological artefacts, technological infrastructures work as systems and act as mediators. They are often buried underground or hidden behind walls. What we see and use, such as a water faucet or a light switch, is usually only the tip of the infrastructural iceberg that is in fact made up of pipes, treatment plants, dams, cables, substations, transformers and so on, the bulk of which remains beyond our immediate perception or influence. So where does a technology end and an infrastructure begin? Is the water faucet or the light switch part of the infrastructural system or not? And if so, is the wash basin that holds the faucet, or the television that we switch on, and perhaps even the TV room that we use to watch it, also part of this infrastructural system? And on the back end, is then the river that we obtain our water from part of this system or the uranium that we use to generate nuclear power for electricity? These are difficult conceptual questions that allow only fuzzy answers. Susan Leigh Star understands technological infrastructures as "fundamentally relational concept" (Star, 1999: 380) rather than a fixed set of technical elements. She reminds us that one person's infrastructure might actually be another person's obstacle, such as a staircase for the elderly or the disabled (Star, 1999). Technological infrastructures, in her view, depend on a person's perspective. Her colleague Brian Larkin agrees that infrastructures are conceptually too complex for any one overarching definition. Instead he suggests a pragmatic analytical approach: infrastructures, he proposes, are defined and delimited by the focus of our research. In fact, he states that "discussing an infrastructure is a categorical act. It is a moment of tearing into those heterogeneous networks to define which aspect of which network is to be discussed and which parts will be ignored" (Larkin, 2013: 330). He adds that "our study of infrastructure might thus center on built things, knowledge things, or people things" (Larkin, 2013: 329). I am interested in "the knowledge things" and the "people things" relating to smart grid infrastructures, and will now turn to the ways in which social scientists and urban studies scholars have understood technological infrastructures in the past, and how they have grappled with them conceptually and methodologically.

In the social sciences, technologies are often conceptualized as a conglomerate of material artefacts, social practices and knowledge (Degele, 2002). The physical things that we usually associate with technology, such as cars, computers or power lines are only the "hard" technological artefacts that we see, touch and use. But technologies also work in "softer", subtler and much broader ways. More than anything, technologies invite us to use them, and thus encourage practices. They enable us to move from one place to another, to do office work, or to plug in a radio and listen to music. The more quotidian and commonplace these practices become, the more deeply they affect our social and cultural lives. Technologies such as the computer, for example, have deeply influenced our perception of what it means to work, just like the invention of airplanes has affected the kinds of vacations we might plan. On an even more general level, the ubiquitous availability of electricity has changed the way we think about almost anything we do, from the way we eat our bread in the morning (toasted) to the way we travel to work (by subway) to where we indulge in a good story (at the cinema) and the way we initiate bedtime (by switching the lights off). The way we live and the way we think about our everyday routines have profoundly changed due to the invention and diffusion of electricity. Technologies are therefore not only material or functional, but deeply social and deeply cultural as well. Of course, the practices and meanings associated with specific technologies diverge between different groups, and can change as societies evolve. In Germany, for example, nuclear power plants were long understood as highly progressive engineering accomplishments, and efficient and safe ways to produce electricity for large groups of people. With the tragic accidents of Chernobyl and Fukushima and the looming threat of climate change, the perception of nuclear energy technologies has changed. What was once hailed as one of civilization's greatest technical achievements is now increasingly being criticized as near-sighted, expensive and potentially uncontrollable peril. This means that technologies the way we view technologies is not static, but in constant evolutionary flux. Lastly, technologies are deeply intertwined with the knowledge required to make them work. They need to be constructed, and they need to function, or else technologies are useless. Although we might use technologies and infrastructures on an everyday basis, we usually comprehend only the smallest fraction of how and why they actually do what they do. This profounder knowledge is mostly reserved for scientists, engineers or bureaucrats who are involved in the construction, operation or management of technological systems. For the majority of users, comprehension of technological infrastructures ends behind the plug or the light switch. Social scientists have especially contributed to critically unraveling the role of scientists and engineers in the development of infrastructures and what this can mean for a society (more on this in part 4.3 "The techno-politics of urban infrastructures"). Finally, technologies are closely bound up with our imagination of the future. They evoke hopes, fantasies and desires, and represent our aspirations for the future. Because technologies are usually developed to solve problems, they let us imagine a world without these problems. They inspire us to think of the world as a "better" place. Through technologies, people have imagined a world without diseases, without disaster, and even without death. Technologies, in this sense, represent our incessant pursuit of modernity and progress. Yet, technologies have always also inspired fears. These fears are so perpetual and so thrilling that they make up a whole literary genre – namely science fiction. Ever since people have invented technologies for a "better" world, they have also had this nagging fear of losing control over their own machines and becoming overpowered and subordinated. Thousands of science fiction thrillers tell stories of how machines have seized domination over the human race and the planet. But these are, of course, only the most extreme expressions of technological fears.

Overall, the social sciences have shown that the study of technological infrastructures can provide a fruitful avenue for understanding social worlds. They explicitly aim at unravelling and problematizing the – often obscured – relationship between the technological and the social. Research can take various different perspectives on this relationship. It can focus on the materiality and functions of technological infrastructures and how they relate to our cultural and political lives; it can also focus on the way technology is bound up with the production of (scientific) knowledge and how this knowledge is used for the sake of broader societal development; and finally, it can investigate the future-oriented hopes, desires and fantasies involved in the making of technologies. For the sake of this inquiry, I shall focus on the visions surrounding smart grid infrastructures, and how they relate to the future of energy in the city.

The following sections provide a more detailed overview of how the social studies of technology have conceptualized technological infrastructures and how these perspectives have influenced urban studies scholars to think about cities. It begins by reiterating the socially constructed nature of technological systems and their co-evolutionary relationship with cities. It then goes on to describe the political nature of this co-constitutive process, in order to conclude with various concepts that have been used to explain the emergence and change of socio-technical infrastructure systems.

In the next chapter, I lay out how the analytical concepts of socio-technical imaginaries and of technological "Leitbilder" relate to the co-evolution of cities and infrastructures, and introduces them as theoretical foundations of this dissertation.

4.2 The co-evolution of infrastructures and cities

Scholars from the social studies of technological systems have conceptualized large networked infrastructures in more than just technological terms. Rather than viewing infrastructures as mere physical artifacts, they have been conceived as socially configured and socially embedded systems that are "both socially constructed and society shaping" (Mayntz and Hughes, 1988: 51). These studies have shown that large infrastructure networks are shaped, reproduced and maintained by an intricate web of societal forces including politics and public policy, supply and demand, cultural and behavioral norms, expert knowledge and institutions (Hommels, 2005; Mayntz and Hughes, 1988; Star, 1999; Summerton, 1994a). These studies have also shown that the large networked infrastructure systems that sustain modern city life, such as water, electricity, communication and gas networks, are exceptionally stable, long-lived, and resistant socio-technical systems (Hughes, 1987). In his seminal study on electricity generation systems, Thomas Hughes explains how the interplay of social and material forces accompanies the evolution of large infrastructure networks, creating strong path dependencies that render these systems obdurate (Hughes, 1983). Over time, large capital investments are made, physical infrastructures are built, institutions are created, laws and regulations are passed, and people's behavior adapts, creating a functioning whole that is increasingly resistant to change. In this conception, the development of networked infrastructure systems depends not only on technological innovation and physical artefacts, but to an equal extent on the development of expert knowledge, rules and regulatory frameworks, political support and cultural norms that reinforce and maintain the system over time.

Building on this understanding, urban studies scholars have shown how the development of technological systems closely relates to the development of cities (Coutard and Guy, 2007; Graham, 2000a; Melosi, 2000; Tarr and Dupuy, 1988). They have shown how the construction of pipelines, wires and road networks is deeply intertwined with the complex spatial, social, economic and political shaping of cities. In particular, historians have shown that networked infrastructures are associated with the speed and complexity of modern urban life. The expansion of electric power systems, for example, was among the major drivers of late 19th and early 20th century urban development in Europe and the US. It brought permanent lighting into private homes and warehouses, powered public tram systems and enabled telephone communication, thus radically altering the scope and dynamics of urban everyday life (Bakke, 2017). In US cities, the introduction of networked gas and electricity systems during this time period went hand in hand with a new understanding of urban domestic comfort and changing family practices, enabled by central heating systems and modern household appliances (Rose, 1988). Among others, access to washing machines and vacuum cleaners increased general standards of cleanliness. These early days of urbanization were also closely intertwined with the introduction of water and waste water networks, which gave birth to modern notions of environmental and public health (Melosi, 2000; Tarr and Dupuy, 1988)). In his seminal study on urban water and sewerage infrastructures, Martin Melosi describes how the deployment of sanitary infrastructures in late 19th century America led to new hygienic standards and norms not only in urban homes but also in urban public spaces, giving rise to what he calls the modern "sanitary city" (Melosi, 2000). In Europe, the city of Berlin epitomized the modern "electric city", becoming widely known as "Elektropolis" (Dame, 2011) for its highly advanced electrification program. Here, the establishment of electric power systems paved the way for an inner-city public transportation network as well as for a flourishing nightlife with cinemas, theaters and bars. Electrification was therefore closely related to the city's growing importance as the continent's intellectual and cultural hub. It also consolidated the increasing political influence and economic strength of growing companies such as Siemens and AEG that brought modern methods of mass production and management to the city (Dame, 2011). These historical accounts show how intricately the development of networked infrastructures was interwoven with the development of modern cities as we know them today, deeply shaping their spatial patterns, systems of production and management, and social standards of – inter alia - comfort and hygiene.

More than anything, the networked city and the physical infrastructures it relies on can be understood as materialized expressions of modernity and progress. They have enabled the constant movement of goods, people, energy, water, data and information across time and space. These constant flows and complex circulations within and through cities have fundamentally influenced the speed, rhythms and scope of modern city life. Pedestrian rhythms have been replaced by the velocity of trains and automobiles, and the rhythms of personal conversation have been replaced by the pace and range of instant messaging to unknown worldwide audiences. Moreover, networked infrastructures have also increased the exchange of goods, people and services between cities, creating intricate connections between (formerly) distant geographies. Due to telecommunications networks, road systems and international pipelines, cities are now as closely connected to their immediate hinterlands as they are linked to the global economy. Because of networked infrastructures, cities no longer function independently, but are involved in complex relations of constant communication and exchange. In this sense, networked infrastructures are at once the "connective tissue and circulatory systems" of cities (Edwards, 2003). They form an "urban metabolism" that enables continuous cycles of intake and output, for example of energy, water and goods on the one hand, and waste on the other (Heynen et al., 2006). In this metabolism, networked infrastructures can be viewed as "mediators between 'nature' and the production of the 'city'" (Graham, 2000b: 114). They enable incessant circulations across time and space, powering what we know as modern city life.

The rise of the network city also gave birth to what is known as the "modern infrastructural ideal" (Coutard and Rutherford, 2016). It introduced a whole new way of organizing urban service provision, which largely prevails to this day. With their growing proliferation, services such as electricity and heating were increasingly centralized and managed by state-owned firms or municipal agencies. This went hand in hand with the creation of novel urban institutions such as public utility companies and network operators. Networked infrastructures therefore gave birth to modern notions of infrastructure services as (quasi) public goods that need to be centrally managed and accessible for everyone. What had once been each individual's responsibility (such as access to lighting or drinking water) became a universal claim. What had begun as the privilege of only few exceptionally wealthy families became the common standard for all. Household connections to the public networks for electricity, gas, water, and sewerage evolved into standard household commodities. Slowly but surely, ubiquitous network coverage, centrally managed supply services and equal access for all became the modern urban "infrastructural ideals" (Monstadt and Coutard, 2019). The introduction of urban infrastructures thus ended the era of the pre-industrial, disconnected "pedestrian city" and gave rise to the modern "networked city" of our times (Coutard and Rutherford, 2016).

The mutually constitutive relationship between infrastructure systems and modern urban development has been the focus of myriad of scholarly investigations. Recently, this literature has focused on the complex relationships between (renewable) energy infrastructures and the transition to "sustainable" cities. With increasing awareness for the challenges of climate change, more and more scholars have systematically investigated how energy infrastructures are tied into the making and unmaking of urban energy practices, politics, economies and ecologies (Rutherford and Coutard, 2014). In particular these scholars have shown how energy transitions occur through urban processes and urban change, and how at the same time, the urban condition is constantly being reconfigured by energy (Rutherford and Coutard, 2014). The same is true for emerging digital infrastructures and the development of "smart" cities. As more and more urban functions and processes are digitized, cities are changing their modes of communication, transport, production and trade. Scholars have argued that novel information and communication technologies might be compromising the modern infrastructural ideal, suggesting that "the network ideology that supports this ideal may be waning" (Coutard and Rutherford, 2016: 1). Others, by contrast, see the dawning of a hyper-connected urban world of highly interdependent, hybrid urban infrastructures (Monstadt and Coutard, 2019). Yet others are concerned about the implications of ubiquitous sensors and control mechanisms for issues of privacy and equality (Luque et al., 2014; Luque-Ayala and Marvin, 2020).

This passage has underlined the mutually constitutive relationship between infrastructures and urbanization. It has explained that networked urban infrastructures are understood as socio-technical systems that shape and are themselves shaped by cities. This passage has also highlighted how the development of large infrastructure systems has co-evolved with the "networked city" and "networked infrastructural ideal", which have dominated urban development discourses for over a century and are now being challenged by smart grids. Moreover, it has explained how the complicated back and forth between technological development and specific spatial, political, economic and cultural environments enable cities and their infrastructural networks to evolve in a co-constitutive process of constant reconfiguration and change.

4.3 The techno-politics of urban infrastructures

Both social and urban studies researchers have emphasized the inherently political nature of the mutually constitutive process of infrastructure and urban development (Graham and Marvin, 2001; Mayntz and Hughes, 1988; McFarlane and Rutherford, 2008; Monstadt, 2007). This section discusses the ways in which researchers have explored the politics of infrastructure and relates their insights to the making of smart grids. Understanding the political nature of infrastructures is fundamental to understanding how smart grids - even in their current stage of early emergence - are not only the result of urban politics but can indeed be understood as processes of urban politics themselves.

Sociologists of technology have argued that technologies often serve as "politics by other means" (Winner, 1980), or as programs of social ordering that are pursued by powerful elites in the guise of technological progress or modernization. Technologies in this reading are the means through which governmental politics come to matter (Barry, 2007). A rich body of urban studies literature has likewise built on these insights to disclose the diverse social, material and discursive power mechanisms attached to the development of urban infrastructures (see for example McFarlane and Rutherford, 2008; Kaika and Swyngedouw, 2006). Apart from their technical functions, many studies have shown that urban infrastructures can serve outright political purposes and have power-related effects. In their seminal study of "networked infrastructures, technological mobility and the urban condition", Graham and Marvin show that instead of serving their "integrated infrastructural ideal", the privatization of networked infrastructures has resulted in social segregation and "urban splintering" in metropolitan areas across the world (Graham and Marvin, 2001). They describe how access to urban infrastructures is often reserved for the financial elites, while poorer parts of society are bypassed and thus socially and spatially marginalized. In particular, they argue that the liberalization and privatization of urban infrastructures has led to the development of "premium networked spaces" (Graham, 2000a) for a privileged few that enjoy customized, high performance services, while the majority of urban citizens rely on dilapidated, century-old pipes and road systems. Instead of viewing infrastructures as material expressions of the welfare state and its ideals of social equity and cohesion, they have contributed to a more critical understanding of material infrastructures as potential sources of inequality and urban fragmentation.

In this sense, infrastructures can indeed be viewed as tools of urban governance. They can be "a powerful means of controlling and disciplining" urban citizens to the terms and conditions of those in hegemonic social positions (McFarlane and Rutherford, 2008: 366). Academic studies reveal how dominant social groups use the design and underlying logics of management surrounding technological infrastructures as means of reinforcing political hierarchies and controlling the everyday lives of urban citizens (McFarlane and Rutherford, 2008; Schnitzler, 2008). Critical urban studies research has therefore contributed to an understanding of infrastructures as hegemonic practices of authority and control. These material politics are often hidden in the bureaucratic management of technological infrastructures, which lie largely outside the realm of public visibility or debate (Barry, 2007: 292–293). Instead, they are enforced through administrative techniques such as regulatory standards or norms of distribution, which often revolve around legal forms, payment procedures, activation codes or the like. Typically, these techniques are associated with (seemingly value-free) notions of pragmatism and efficiency rather than interest driven political steering. Sociologist Michel Foucault (2010) takes this notion a step further when he argues that these techno-administrative techniques can become so entangled with political rationalities and taken-for-granted user practices that they evolve into what he has coined an "apparatus of governmentality" (Foucault, 2010). Foucault argues that the normalization of infrastructural processes into everyday routines and cultural practices subtly steers the consciousness and actions of users (i.e. their "conduct") towards rationality, effectiveness and productivity, turning them simultaneously into objects and – subconscious - subjects of a machinery of (neoliberal economic and) political control.

Yet social and urban research has also argued that the politics of infrastructure don't rest in the hands of states or markets alone but are instead shared sites of negotiation and contestation that can involve a vast array of actors – from national governments to urban institutions, all the way to businesses, civil society organizations and users (Moss, 2014). In their book "Infrastructural Lives" Stephen Graham and Colin McFarlane specifically venture into the realms of the urban "infrastructural experience" in order to capture the manifold ways in which regular people understand, use, contest and thus shape the production and management of urban infrastructures and – in turn – of cities (Graham and McFarlane, 2015). They argue that infrastructures can actually be important catalysts of political agency and negotiation. Other researchers have highlighted just how complex these political negotiations can be. In his study of the international Baku-Tbilisi-Ceyhan oil pipeline, Andrew Barry reveals how infrastructures can in fact become the issue of intense political disputes and long-term controversies, revealing how dynamic these processes of material politics are (Barry, 2013). Barry argues that the politics of large infrastructural projects comprise such a vast and complex web of relations and processes that they are hardly predictable or controllable. Instead of viewing them as purely hegemonic political programs, he points to the large variety of interests and power relations at play in the making of large infrastructural systems, and at the uncertainty of their development outcome.

My approach to urban infrastructures is likewise grounded in a firmly social constructivist ontology, and I therefore share this understanding of infrastructures as messy and contingent political processes (Rutherford and Jaglin, 2015: 173) rather than as products of systemic neoliberal orders or straightforward unilateral steering.

4.4 The knowledge politics of urban infrastructures

In the preceding passages, I have mostly engaged with the political nature of existing infrastructures, i.e. infrastructures that have already been built. Yet an important line of STS scholarship has shown that the politics of infrastructure can begin in the creative processes that *precede* technological maturity, namely in the seemingly far removed realms of techno-scientific knowledge production. Especially in today's knowledge-based economies, technological infrastructures increasingly emerge from processes of scientific research and development. Understanding the politics of techno-scientific knowledge production is therefore fundamental to understanding the politics of urban infrastructures, especially while they are still "in the making" – such as smart grids.

The notion that infrastructures have politics is firmly grounded in the notion that processes of techno-scientific knowledge production, which often accompany the development of technological infrastructures, are socially constructed and therefore have politics, too. It assumes that scientific knowledge is itself relative and very much shaped by the specific social and political contexts of its making (Latour, 1993). In his famous study on Louis Pasteur, Bruno Latour shows that processes of scientific knowledge production are not objective truth-seeking endeavors that take place within value-free laboratory environments, but are in fact context specific and interest driven, deeply social processes (Latour, 1993). Building on this conceptualization of scientific knowledge as socially constructed, Latour and many others have shown that techno-scientific achievements are not the "neutral" outcome of seemingly objective research processes, but in fact the result of processes of negotiation that take place within social environments that are structured by value systems and influenced by power relations (Jasanoff, 2004; Knorr-Cetina, 1981; Latour, 1987). Technologies and technological infrastructures can therefore be understood as material translations of the social values, norms and orders advanced by those involved in their making. Among others, feminist STS scholarship has built on these insights to show how male dominance can be established and reinforced through technological systems at the cost of less powerful women (Wajcman, 2010). These scholars have argued that the norms and values of - mostly male – technicians and engineers are "inscribed" into technological infrastructures without regard for their effect on or usability for women. For example, Yolanda Strengers has argued that smart grid infrastructures are currently being designed for a narrowly envisaged "Resource Man" who is interested in his own energy data, able to understand it, keen on managing it, sensitive to energy costs, and rational in his decisions (Strengers, 2014). She criticizes that this might not reflect the diversity and heterogeneity of current or future energy users. Similarly, urban studies researchers have criticized the growing influence of private ICT companies on the development of urban services of all kinds. They argue that in effect, smart city technologies are imposing neoliberal logics of individual profit maximization instead of collective well-being onto urban societies (Whitehead, 2013; Wiig and Wyly, 2016). These materialized norms or “frozen” expressions of societal interests are often obscured by the seeming objectivity of research driven innovation, and shielded from public criticism by the seclusion of the scientific lab. Among others, it is the job of social scientists to uncover these “black boxes” and make them available for public debate (Degele, 2002).

4.5 Infrastructures and imagined urban futures

The politics of infrastructural development can also be hidden in much subtler layers of abstract imaginaries, meanings and ideas. Urban infrastructure systems are therefore not only technical or even *socio*-technical in Hughes’ sense of the term, but also connected to much more abstract ideas, dreams, fantasies or ideologies of a better life and a better future. They are “intimately caught up with the sense of shaping modern society and realizing the future” (Larkin, 2013: 332). In his essay on “The Politics and Poetics of Infrastructure”, Brian Larkin puts it this way: “roads and railways are not just technical objects then but also operate on the level of fantasy and desire. They encode the dreams of individuals and societies and are the vehicles whereby those fantasies are transmitted and made emotionally real (Larkin, 2013: 333). Infrastructures thus embody a society’s hopes and aspirations; they are investments into a visual and conceptual representation of what a society thinks of itself and what it wants others to think of it.

Technological infrastructures can also carry *urban* imaginaries, such as that of the sanitary city, the modern functionalist city, the sustainable or – more recently - the smart city. These urban imaginaries are often built around conceptions of technological and societal progress, and carry collective notions of what it means to be modern. For example, the introduction of water, waste water and refuse disposal systems in the sanitary city promoted the idea of a hygienic, clean and environmentally healthy society (Melosi, 2000). Likewise, the modern functionalist city of mid-20th century Europe stood for the freedom of car enabled mobility and of a new conception of leisure. Both were enabled by new technological possibilities, and by new ideas about what it meant to be free, progressive and modern at the time. Similarly, today’s smart and sustainable city ideals are built on visions of livable, environmentally friendly and yet competitive and economically thriving cities. Infrastructures thus embody a society’s hopes and values on the one hand, and can carry public messages about these hopes and values on the other. This can take on qualities of technological “fetishism” (Kaika and Swyngedouw, 2000; Larkin, 2013). Kaika and Swingedouw go as far as to say that the construction of networked urban infrastructures in 19th century Europe “turned the city into a theatre of accumulation and economic growth”, and call these infrastructures nothing less than “iconic embodiments of and shrines to a technologically scripted image and practice of progress” (Kaika and Swyngedouw, 2000: 121). These examples show that infrastructures can indeed serve highly representational purposes, pursuing emotional effects rather than technical functions.

Oftentimes, which hopes and values are engineered into urban infrastructures is defined by certain infrastructural elites, such as government agencies, entrepreneurs, scientists, technology companies or NGOs that have the knowledge and the capabilities to influence infrastructural development in a city. The development of urban infrastructures is therefore closely attached to the power of these elites to translate their hopes, desires and fantasies in material and discursive terms. As McFarlane and Rutherford put it: “what is often at stake here is not simply the provision of infrastructure, but the conceptualization of the city” (McFarlane and Rutherford, 2008: 366).

4.6 <u>How do infrastructures change?</u>

In the last passages, I have reviewed various traditions of social and urban studies research on technological infrastructures, which show that these large networked systems are at the same time social, material, and imaginary and that they are constantly evolving in highly political processes of permanent adaptation and change. I have shown that these processes are often triggered by scientific innovations, which offer new technical possibilities and inspire multiple actors to envision new possible futures. In exploring the co-evolutionary relationship between infrastructures and cities, I have mostly engaged with infrastructures as existing parts of the urban fabric.

Yet, smart grids are an infrastructure that is still “in the making”. In Berlin (and in Germany) smart grids are still being developed and have only materialized under the special conditions of few experimental sites. To understand smart grid infrastructures, it is therefore important to understand how infrastructures emerge in the first place; and – once emerged – how they develop and change, and finally, how this change can be governed.

In his original model, Hughes explains infrastructural change as a sequence of phases, each characterized by a certain degree of technical maturity, a distinct set of actors and a typical development dynamic, which is significantly influenced by the capabilities and interests of each phase’s most influential system builders (Hughes, 1983: 14). According to Hughes’ model, new systems emerge in an initial phase of “invention and development”, are then reproduced in other regions and societies in a phase of system “transfer”, and finally established in a phase of “system growth” (Hughes, 1983: 14–15). Another fundamental concept of Hughes’ model is that of system “momentum”. According to his analogy, large technological systems acquire “mass, velocity and direction” as they grow and are therefore increasingly marked by inertia (Hughes, 1983: 15). Mass is created through the accumulation of machines, devices and structures, in which large capital investments have been made, and through the involvement of professionals such as government agencies, professional societies and educational institutions. Once large technical systems have reached a critical mass, their growth accelerates and acquires velocity. At the same time, it is directed towards certain goals or guided by a vision. With time, this overall momentum becomes increasingly resistant to change and renders the system obdurate. From his historical perspective, Hughes’ theory thus explains the evolution of large technical systems as linear processes of growth, which create path dependencies and lead to system “lock-in”. It stops short of explaining how “mature” infrastructure systems undergo change, much less how this change might be actively initiated or steered.

Building on Hughes' conceptual foundations, different theories of socio-technical change have emerged and influenced the study of urban development. These theories explain how large socio-technical systems can be altered despite their seeming stability and permanence. Among others, they have explored how large technical systems are reconfigured, for example through geographical expansion, functional recombination, or political reorganization (Summerton, 1994b). They have also investigated how infrastructure systems go through phases of contestation, stagnation and finally decline (Hess and Sovacool, 2020), or how they are assembled, re-assembled and translated through actor-networks, especially at the micro-level (Callon, 1984).

Most prominently, though, scholars from the tradition of innovation studies have introduced the notion of dominant infrastructural "regimes" that are disrupted by innovative "niches". Using this multi-level perspective, they have investigated how path dependencies sustaining dominant regimes are overcome and how change occurs in large infrastructure systems through the development of technological "niches" (Geels and Schot, 2007). This body of work has provided insights into the potential of experimental niches to introduce technological innovations and make them fit for mainstream markets. It suggests that broader socio-technical change can be actively initiated and steered if innovative niches are strategically managed (Schot and Geels, 2008). The idea of strategic niche management is based on the premise that technological selection processes or the development of technological variations can be influenced in an environment that is sheltered from mainstream competition, i.e. in "technological niches" (Schot and Geels, 2008: 539). Schot and Geels define technological niches as "protected spaces that allow the experimentation with the co-evolution of technology, user practices, and regulatory structures" (Schot and Geels, 2008: 537). Yet this literature also acknowledges that "niche innovations are rarely able to bring about regime transformation without the help of broader forces and processes" (Schot and Geels, 2008: 545). These broader forces and processes have been conceptualized as the "landscapes" within which niches and regimes are embedded and operate (Geels and Schot, 2007).

Like strategic niche management, the transition management approach also builds on the multi-level perspective. It offers a framework for how to initiate and govern socio-technical transitions at the micro-level as means of transforming dominant regime structures. While strategic niche management is built at least in part on test-bed approaches from the business world, transition management is more strongly grounded in social theory and governance studies. Coming from a governance perspective, transition management aims to tackle the complex governance challenges posed by wicked societal problems such as sustainability and climate change. It embraces complexity and uncertainty as opportunities to engage in reflexive processes of searching, learning and experimenting that can only induce change if they are based on broad social participation (Rotmans and Loorbach, 2008). The transition management approach encourages the establishment of so-called "transition arenas" to develop visions of sustainable transition pathways, and to experiment with possible ways to get there, and then finally to reflect and adjust these processes (Rotmans and Loorbach, 2008).

Both strategic niche management and transition management emphasize that niche experiments or demonstration projects can successfully enable socio-technical innovations if they encourage the development of visions, the establishment of strong social networks, and effective learning processes within and beyond their borders (Schot and Geels, 2008) (Rotmans and Loorbach 2008, p. 20).

In spite of its wide acclaim, the multi-level perspective has also been criticized especially by urban studies scholars for neglecting the spatial and political aspects of socio-technical change. These scholars have pointed to the importance of recognizing that socio-technical change is always embedded in specific local contexts and relations, and that these relations are subject to the specific power dynamics exerted by individuals and institutions (Bulkeley et al., 2011; Coenen and Truffer, 2012; Hodson and Marvin, 2010; Smith and Stirling, 2008).

Nevertheless, the multi-level perspective has inspired a critical research agenda that engages with the idea of urban experimentation or "urban labs" as means of studying, understanding and trialing socio-technical innovations on the one hand, and as means of governing urban infrastructural change on the other (Evans, Joshua 2016). This ongoing scholarly debate points to the importance of experimental sites as contemporary arenas of urban politics and highlights the necessity to keep a critical eye on them for this reason. In an era of "demo-ing unto death" (Halpern and Günel, 2017), the investigation of these experimental sites is paramount to understanding the direction that urban infrastructural transitions are taking, the effects they might have on the roles and practices of different social groups in a future urban energy system, and what this might mean for the future of energy in the city more generally.

4.7 Concluding remarks

What this chapter has shown is that the development of infrastructures, from the very first budding of a vague idea to the mastery and realization of all technological intricacies, are guided by the goals and value systems of those involved in their making. It has established that social values and political orders are necessarily engineered into technological systems by those who develop, design and manage them (Knie and Hard, 1993), and has thus drawn attention to the (political) work of scientists, engineers or bureaucrats who are often at the forefront of techno-scientific development. Moreover, this section has discussed the varied ways in which urban infrastructures are political and how urban politics can be implemented through infrastructures (in physical, managerial, or knowledge-related ways). Moreover, it has shown that these politics are often not explicit but hidden in the decisions made long before an infrastructural technology actually comes to matter. They can also be obscured by the – mostly positive – images or visions that infrastructures convey. The politics of infrastructures can therefore be exerted not only through their material qualities, but also through much subtler discursive attributions that evoke abstract idea(l)s and imaginaries. Currently, these imaginaries are often being developed in urban laboratories.

Understanding who is involved in imagining and making infrastructures in these labs can be a key to understanding – and revealing – the power of certain groups over others, the value systems that these groups are seeking to introduce or perpetuate, and the way in which they are utilizing infrastructures as political vehicles. Uncovering and problematizing these political workings and critically assessing possible alternatives is among the goals of this dissertation.

5 Theoretical framework

I use smart grid infrastructures as lens through which to analyze the making of Berlin's urban energy futures. In particular, I analyze the visions associated with smart grids as part of this political process of urban socio-technical "becoming".

In the previous chapter, I laid out the conceptual foundations of my research questions and approach. I explained why infrastructures lend themselves as analytical lenses through which to trace broader urban socio-technical transitions. Moreover, I explained how processes of infrastructural development are political in material and knowledge related ways, and what role visions play in this development process. I thus illustrated why the analysis of visions surrounding smart grid infrastructures in Berlin provides a fruitful avenue for critically interrogating the current making of Berlin's energy futures.

The following section now discusses the theoretical framework that guided my research design. This chapter discusses how I used the concepts of socio-technical imaginaries and of technological *Leitbilder* to analyze how visions of smart grid infrastructures are influencing Berlin's energy transition process, and what is political about these visions.

I begin this section by reviewing literatures from STS and urban studies, which illustrate the performativity of visions and imaginaries, i.e. the ways in which visions of the future impact reality in the present. I then move on to discuss how visions have been discussed in the urban planning community, and how they are currently being discussed in certain research communities as potential tools for guiding (urban) sustainability transitions. Finally, I explain in more detail the two concepts of socio-technical imaginaries and *Leitbilder*, and explain how I merged the two to guide my own research design.

5.1 <u>The performative power of imagining the future</u>

Social science research has shown that technological expectations act as important drivers of techno-scientific change, exerting a strong influence on technological development in the present (Borup et al., 2006; Dierkes et al., 1992; Ferrari and Lösch, 2017; Jasanoff, 2015). Expectations inspire activity, mobilize resources and translate into obdurate material artefacts. Visions of technological possibilities are therefore not only future-oriented abstractions, but in fact highly "performative" in their concrete manifestations in the present (Borup et al., 2006). Visions of future technological infrastructures must therefore be viewed not only as fundamental in guiding innovation processes but also in producing material outcomes and 'making' the fabric of the city. Analyzing the content and production of visions is therefore a means of unravelling (political) processes of city making. I seek to understand how the future of energy is currently being "made" in Berlin by analyzing the visions surrounding emerging smart grid infrastructures in the city today.

Research from the sociology of expectations and STS has shown that visions and imagined futures have an immediate effect on the present. Among others, the performative quality of imagined futures lies in their capacity to attract the interest of stakeholders and to enable cooperation between them. As Dierkes et al. (1992) show in their work on technological *Leitbilder*, guiding visions of technological progress have the power to attract stakeholders from various expert domains and to bridge communication between them (Dierkes et al., 1992). In the uncertain environment of technological development, visions provide a point of reference around which various stakeholders can gather, providing collective orientation and enabling cooperation in the present (Ferrari and Lösch, 2017). Dierkes et al. (1992) emphasize that guiding visions serve to mediate between different cultures of knowledge production, and to open up pathways for novel ways of thinking and collectively creating. In the case of smart grids, these stakeholders come from such diverse domains as energy, mobility, heating, urban development and ICT. Social science research has shown that visions of smart grids indeed function as common denominator between these various fields of expertise, providing a point around which innovation actors can focus and coordinate actions (Lösch et al., 2019). In (mostly German) urban planning literature, the term *Leitbild* is also associated with guiding visions for socio-spatial development. Here, the concept has been appreciated for its potential as means to build consensus through democratic discussion and participatory planning processes on the one hand, but also criticized as tool for expert-driven, hierarchical and top-down city planning on the other (Kuder, 2001). In both cases, the *Leitbild* concept describes how visions help coordinate action between those involved in a technological or urban development process.

Future-oriented visions can also develop a normative force that draws circles far beyond those involved in the innovation process. If collectively shared and sufficiently stabilized over space and time, visions of techno-scientific futures can influence innovation processes far beyond the micro-scale of research groups or pioneer alliances (Borup et al., 2006). In their work on socio-technical imaginaries, Jasanoff and Kim (2015) argue that once certain claims about the future are sufficiently wide spread, they develop into "collectively held, institutionally stabilized, and publicly performed visions of desirable futures, animated by shared understandings of forms of social life and social order attainable through, and supportive of, advances in science and technology" (Jasanoff and Kim, 2015: 4). They show that these imaginaries can gain the power to steer national level policy decisions, guide research programs or direct global financial investments. Jasanoff and Kim are especially concerned with the political dimension of this techno-scientific imagining. In their view, imaginaries produce simplified and standardized understandings of the complex social-political orders inherent in technological development, and can mask the political interests and power constellations that drive the development of technological systems. They show that socio-technical imaginaries act as somewhat fuzzy, implicit, broadly accepted and culturally embedded understandings of the ‘good life’ or the ‘good future’ that promote mostly positivist, seemingly value-neutral, apolitical notions of modernity and progress (Jasanoff and Kim, 2015). Whose visions take root in the collective imagination and how this influences what people consider to be ‘modern’, ‘progressive’ and ‘up-to-date’ as opposed to ‘backwards’ or ‘forgotten’ then becomes a highly political issue.

As Jasanoff, Kim and others have shown, future imaginaries only develop this kind of normative force if they are communicated and reinforced through narratives, images, material representations or (public) performances that make them “stick” until they are shared collectively (Hajer and Pelzer, 2018; Jasanoff and Kim, 2015). Dierkes et al. (1992) underline this by showing that collective claims about the future only stabilize if they are somehow “felt” and experienced in the real world (Dierkes et al., 1992). Visions therefore depend on continuous repetition and real-life enactments as means of perpetuation and diffusion. At the same time, Van Lente (2012) argues that a cycle of continuous reinforcement can also result in a paradoxical dynamic, such that “a compelling constellation of promising claims […] enforces action in a way that perhaps none of the companies or researchers themselves would have chosen. Participants will reason in terms of 'not missing the boat, but the 'boat' only exists due to the collective decision not to miss it" (van Lente, 2012: 773). The irrationality and contingency of this process resonates with what the social studies of infrastructural development have called technological "fetishism" (Kaika and Swyngedouw, 2000; Larkin, 2013). As Brian Larkin (2013) argues, technological infrastructures are far from purely rational in an economic or even a technical sense, but "emerge out of and store within them forms of desire and fantasy and can take on fetish-like aspects that sometimes can be wholly autonomous from their technical function" (Larkin, 2013: 329). Current calls for creating hyper-connected cities through an 'internet of everything' have arguably taken on certain qualities of fetishism. Imagined technological futures therefore carry much more than the relatively mundane promise of solving an engineering problem, but are intermingled with emotions of awe and hope that can be highly seductive.

In sum, STS and urban studies scholarship has shown that imagined futures can strongly influence actual developments in the present. It has also shown that the performative power of imagined futures is based on their reinforcement through communication and material representation or enactment. Lastly, research has revealed that the performative power of imagined future infrastructures often enfolds in highly irrational, self-fulfilling dynamics. In relation to smart grids, this section thus provides the basis for understanding that visions and ideas of possible future energy systems that are currently associated with smart grids need to be understood as important precursors of the urban energy systems we might actually encounter in the cities of tomorrow.

5.2 ***Leitbilder* as analytical concept**

I base my own analysis on two concepts from the social studies of science and technology, which I introduce in detail in the following sections.

The *Leitbild* concept developed by Meinolf Dierkes and colleagues in the early 1990s provides a framework for analyzing how guiding visions develop and operate in processes of techno-scientific innovation. The concept understands Leitbilder as "frameworks that guide perception, thinking, decision-making and action" (Dierkes et al., 1992: 11)[3]. Similar to ideals (and unlike more concrete goals), Leitbilder provide long-term objectives and stand for aspirations that can only ever partially be reached (Dierkes et al., 1992: 16). The concept was borne out of a certain techno-skepticism, and originally aimed at finding ways of anticipating and avoiding dangerous technological developments and instead steering them for the common good (Dierkes et al., 1992: 10). It starts by assuming that Leitbilder have a strong influence on techno-scientific development trajectories, and that they can be strategically adapted.

Dierkes' Leitbild concept primarily offers a framework for understanding socio-technical innovation processes at the micro-level of research groups or other small innovation systems. It situates Leitbilder at the level of interpersonal discourse (i.e. communication via language and symbols), merging ideas from the sociology of science and technology with ideas from psychology and communication studies. According to Dierkes et al.

[3] All quotes of statements originally made in the German language have been translated by the author.

(1992), techno-scientific innovations emerge through the "interference" between different (scientific) knowledge cultures that are themselves in a constant process of development and change. New techno-scientific knowledge emerges, is selected, consolidates, and becomes commercially successful not because different knowledge cultures split or merge, but because they "interfere" with each other and create newness (Dierkes et al., 1992: 32–33). Leitbilder synchronize this process of interference, and thus enable techno-scientific innovations to flourish.

Dierkes et al. (1992) attribute the ability of Leitbilder to accomplish this synchronization process to two main features, namely their "guiding function" and their "image function" (Dierkes et al., 1992: 43–58). According to the authors, Leitbilder bundle and align innovation actors' hopes and dreams for the future, and thus provide collective and individual orientation (guiding function). They provide a common corridor of possibility that gives direction to innovation actors' thoughts and activities. Secondly, Leitbilder conjure images that activate the imagination beyond existing lines of thought, mobilize emotions of interest and appeal, and finally stabilize interpersonal relations (image function). Leitbilder therefore excite, animate and produce an attractive "buzz" around which people tend to gather. Building on Dierkes' ideas, Ferrari and Lösch (2017) provide a concise summary of how guiding visions operate:

- "Visions *serve as an interface* which allows translations between present constellations and the future and thus open up imaginative and practical possibilities.

- Visions *work as communication media* between different actors and discourses to which all the involved or addressed actors can refer, even if they have very different interests and perspectives.

- Visions can serve in different discursive and other practical constellations as means that *enable coordination*, because they are a reference point to guide different and heterogeneous activities.

- Visions motivate because they *develop a normative* force; the envisioned and proposed emerging innovations are presented as the best and most feasible solution to current and/or future problems or challenges" (Ferrari and Lösch, 2017: 78–79).

As analytical framework, these categories help guide research on how Leitbilder function and why they spread. They offer an entry point for understanding what happens when a new, potentially disruptive idea is born, and how it becomes more and more accepted. Importantly, Dierkes et al. show that – in order to unfold their synchronizing capacity - Leitbilder need to be concrete enough to provide a collective reference point, but fuzzy and flexible enough to allow various interpretations. As opposed to goals, Leitbilder are thus necessarily unspecific.

Dierkes et al. (1992) situate their Leitbild concept at the beginning of longer processes of socio-technical development. They understand socio-technical trajectories as "evolutionary" processes that develop in phases of generation, selection, consolidation and commercialization. Leitbilder unfold their synchronizing capacity during the initial *generation* phase of techno-scientific innovation. Interestingly, Dierkes et al. (1992) argue that Leitbilder develop based on ideas rather than based on existing problems. In fact, they argue that Leibilder (can) develop entirely independently of the existence of a problem. This is interesting, because it resonates with some of the critique that has been voiced against the smart technology paradigm.

Moreover, Dierkes et al. (1992) explain that techno-scientific Leitbilder develop in phases: First, an idea with the potential for a Leitbild is born. It must be understandable beyond a circle of experts. Second, the Leitbild gains popularity through consensus building. During this phase, the Leitbild must connect with its (technical) artefact and must become known beyond a certain circle of experts. Third, a Leitbild establishes when vague ideas are increasingly "fleshed out", when specific organizational forms, symbols and rituals are developed, and people start looking back at the history, myths and strongest drivers of the guiding vision. And lastly, after this phase of establishment, a Leitbild is either conserved, reoriented or it dies, because it stops facilitating innovative ideas. Instead of initiating new processes, the Leitbild increasingly legitimates existing processes and becomes "obdurate". These phases of Leitbild production mirror broader phases of socio-technical development. In fact, they describe how Leitbilder and socio-technical systems co-evolve in an iterative process of discursive and material development.

Finally, Dierkes et al. (1992) argue that different socio-technical systems develop in different, unique and complex ways. On the basis of three examples – the Diesel motor, the typewriter, and the telephone – they show that each system develops within different pathways and on the basis of different conditions. They conclude that there can be no such thing as an overarching theory of socio-technical development. Instead specific technologies need to be researched and understood in their specific trajectories.

In sum, Dierkes et al's (1992) concept helps understand how guiding visions influence processes of socio-technical development, especially in the early phases of techno-scientific innovation. It provides a framework for analyzing how Leitbilder evolve out of existing knowledge cultures, and how they assist at creating new ones. In doing so, the concept explicitly aims at highlighting potential entry points for *steering* techno-scientific development. By dissecting the ways in which Leitbilder function, Dierkes et al. seek to provide a foundation for actively influencing these guiding visions, and thus for directing socio-technical change.

The concept does not, however, offer a framework for investigating the politics of these guiding visions in a broader societal context. The motivations, interests and political power of different innovation actors remain outside of the analytical focus. The Leitbild concept can thus assist in answering questions such as "how are techno-scientific innovations born and how do they develop?", but it doesn't offer much guidance for answering questions such as "whose interests do certain innovations serve, and what do they say about societal norms and power relations?" The Leitbild concept is therefore a useful tool for analyzing the creative processes of forming and establishing an innovative idea, but less useful for analyzing the politics inherent in these processes. Even though Dierkes et al are interested in using Leitbilder as political steering instruments, they stop short of offering a framework for investigating how Leitbilder serve political or economic purposes. For this reason, I recur to a second analytical concept, which is more focused on uncovering the politics of techno-scientific imagining.

5.3 Socio-technical imaginaries as analytical concept

The concept of socio-technical imaginaries developed by Sheila Jasanoff and Sang-Hyun Kim offers a suitable addition to the Leitbild concept. It is likewise grounded on a sociology of science and technology tradition but influenced by ideas from political and cultural theory (rather than psychology and communication). The concept of socio-technical imaginaries explicitly aims at uncovering the politics of imagining techno-scientific futures. While the Leitbild concept is primarily interested in how guiding visions influence creative processes of collaboration and innovation, the concept of socio-technical imaginaries is primarily interested in what they tell us about the socio-politics of the present. It assumes that techno-scientific envisioning is a deeply political act, and provides a conceptual foundation for analyzing these “politics of the future”. In particular, the concept of socio-technical imaginaries opens pathways for investigating the often fuzzy and unarticulated notions of social life and social order inherent in visions of the future, and for relating them to the present.

According to Jasanoff and Kim, socio-technical imaginaries are "collectively held, institutionally stabilized, and publicly performed visions of desirable futures, animated by shared understandings of forms of social life and social order attainable through, and supportive of, advances in science and technology" (Jasanoff and Kim, 2015: 4). Like Dierkes, Jasanoff and Kim understand technology as material embodiments of (scientific) knowledge. Yet arguably unlike Dierkes, they view technology not as strictly path dependent, but rather as continually co-produced with the organization of social life. Jasanoff and Kim are explicitly interested in the politics of this co-constitutive process. Their concept thus offers an entry point for analyzing how societal orders are (re-)produced through political processes of envisioning the future. As the subtitle of their book concisely summarizes, their concept uncovers the linkages between “socio-technical imaginaries and the fabrication of power” (Jasanoff and Kim, 2015).

In their original definition, Jasanoff and Kim associate these political processes with the governmental power of nation states: “socio-technical imaginaries as we define them are associated with active exercises of state power, such as the selection of development priorities, the allocation of funds, the investment in material infrastructures, and the acceptance or suppression of political dissent” (Jasanoff and Kim, 2009: 123). In later adjustments to this definition, however, they concede that socio-technical imaginaries can be found at other spatial scales and institutional levels such as cities, regions, community organizations, or social groups. Their concept thus helps “to investigate how, through the imaginative work of varied social actors, science and technology become enmeshed in performing and producing diverse visions of the collective good, at expanding scales of governance, from communities to nation-states to the planet” (Jasanoff, 2015: 11). Nevertheless, much of the research presented in their edited volume(s) focuses on national level imaginaries and national level politics. Jasanoff and Kim’s work thus primarily asks "how national science and technology projects encode and reinforce particular conceptions of what a nation stands for" (McNeil et al., 2016: 448). Taking this as my basis and starting point, I ask how *urban* science and technology projects encode and reinforce what a *city* stands for.

Like Dierkes et al. (1992), Jasanoff and Kim (2009, 2015) underline the importance of public performances for the reiteration and reinforcement of socio-technical imaginaries. They explicitly dwell on the function of creating “authoritative representations” that reinforce imaginations of what a society deems good and bad, right and wrong, desirable or not. For example, they argue that the opening of the Olympic Games in London in 2012 “blended together memory, technology, the monarchy, and popular culture in a performance designed to play to every register of Britain’s happiest imaginations of itself” (Jasanoff, 2015: 10). According to Jasanoff and Kim, such spectacles serve to display and (re-)enact the collective imaginary of what a nation believes in, what it values, and what it strives for. In this sense, public demonstrations of physical technologies attain representational functions. Indeed, Jasanoff and Kim explicitly relate their idea of performance to practices of scientific experimentation. In fact, they understand scientific experimentation as a mixture of knowledge performance and political performance, granting those involved a role and function as political citizens, rather than mere experimental subjects (Jasanoff, 2015: 11). This is important, because it attributes them with political responsibility one the one hand, and with the potential for political shaping on the other. Jasanoff and Kim therefore concede that public performance and experimentation can have an emancipatory role, especially if it holds authorities publicly accountable. At the same time, they also acknowledge that performance and experimentation are likely to reinforce existing categories, especially if their political potential is obscured. They conclude that whether and how performance and experimentation reinforce or challenge societal standards can only be answered empirically. Their concept thus serves as entry point for this kind of empirical analysis, especially because theorizing on imaginaries has largely neglected the importance of practices of performing to date (Jasanoff, 2015: 10).

The concept of socio-technical imaginaries is also very explicit about the relationship between imaginations of progress and potential fears. Jasanoff states that while socio-technical imaginaries tend to be "grounded in positive visions of social progress", these are necessarily correlated with fears, for example of the "failure to innovate" (Jasanoff, 2015: 4–5). Socio-technical imaginaries can therefore be tales of modernization and progress, but they can also be based on tales of fear and (of waging off) catastrophe. According to Jasanoff and Kim, these fears are likewise perpetuated through performances, which serve as performances of the dystopias that imaginaries entail.

Ontologically, Jasanoff and Kim explicitly position themselves in the social constructivist tradition. Their idea of socio-technical imaginaries is thus based on the notion that humans are the ones who imagine and also the ones who produce power relations. This stands in explicit contrast to other important lines of thought that have been borne out of STS, which understand the social world as constructed through the agency of people *and things*, for example technologies. These lines of thought, perhaps most prominently represented by actor-network-theory (Callon, 1984) and cyborg feminism (Haraway, 2013) have been widely acclaimed for ending the binary thinking in terms of human/non-human, science/society, nature/culture, subject/object. Yet Jasanoff and Kim criticize that the engagement with actor networks neglects issues of power imbalances. Instead, they return to co-production as theoretical framework for understanding modern societal orders. In their view “work in the co-productionist vein sensitizes us to the ways in which elements of human subjectivity and agency get bound up with technoscientific advances through adjustments in identities, institutions and discourses that accompany representations of things" (Jasanoff, 2015: 14). Put differently, the idea of socio-technical imaginaries is founded on the assumption that science, technology and society are co-produced in a constant iterative process of imagining, representing and changing. Importantly, technical infrastructures and cities are part of this constant process of mutual configuration.

In conclusion, socio-technical imaginaries are socially constructed, politically charged and collectively shared ideas of "the good life" and "the good future", which are perpetuated inter alia through (public) performances and experimentation, and which are often accompanied by fears. In turn, this delineates the many things that imaginaries are *not* (Jasanoff, 2015: 20–21). According to Jasanoff and Kim, these include:

> *Vanguard visions* (Hilgartner, 2015), which are ascribed to individuals, whereas socio-technical imaginaries are communally adopted or collectively shared (Jasanoff, 2015: 4);
>
> *Ideas* or *fashions,* which are less durable than socio-technical imaginaries;
>
> *Master narratives* and *ideologies*, which are more stationary, and less inviting to change than are socio-technical imaginaries. They are "not as welcoming of invention or prescriptive of new goals to be achieved" (Jasanoff, 2015: 20). I would add that master narratives and ideologies are not necessarily enmeshed with techno-scientific development, either;
>
> *Goals and policies*, which are much more concrete and specific than are socio-technical imaginaries;
>
> And finally, *discourses,* which are collective and systemic (Hajer, 2006), but mostly focused on language rather than action, performance or materialization in technical artefacts.

In addition, I would say that *utopias*, which have often been inspired especially in relation to cities, describe futures that are less feasible, less attainable, and much farther removed from present reality than are socio-technical imaginaries (Levitas, 2010: 2).

5.4 Merging the two

I dwell on these distinctions, because they are the only straightforward guidance that Jasanoff and Kim offer to produce conceptual clarity. Unlike Dierkes' Leitbilder, the concept of socio-technical imaginaries provides less of an analytical framework than broad conceptual orientation. Among others, socio-technical imaginaries can be understood as fixed notions or processes; as advancing change or sustaining established orders; as universally accepted or as culturally particular; as long-lived and durable or temporally situated; as ubiquitous or diverse and competing (Jasanoff, 2015: 19). This fuzziness presents an obstacle and an opportunity at the same time: it leaves the researcher without a clear manual for structuring her analysis; yet it offers an overarching umbrella for many different research questions and approaches. In the end, it leaves the researcher with less guidance, but more variety, more freedom, and more responsibility. Dealing with this ambiguity requires me to explicitly point out how I understand the concept and how it serves my purpose.

Firstly, I understand the concept as framework for analyzing the stable and long-lived, collectively embodied truths that a society lives by. Although Jasanoff and Kim repeatedly relate socio-technical imaginaries to socio-technical *change*, or even *innovation*, my understanding is that socio-technical imaginaries primarily preserve established values, norms and orders rather than changing them. Jasanoff and Kim offer more than one possible interpretation or analytical vantage point when they state that:

> "imaginaries operate as both glue and solvent, able [...] to preserve continuity across the sharpest ruptures of innovation or, in reverse, to upend firm worlds and make them anew". (Jasanoff, 2015: 29)

Yet in a different passage they concede that:

> "An imaginary is […] a continually articulated awareness of order in social life and a resulting commitment to that order's coherence and continuity" (Jasanoff, 2015: 26).

For my research, I stick to the latter definition. In my understanding of the concept, socio-technical imaginaries prescribe change only within the limited boundaries of the well-known. They point to newness only as means to perpetuate the existing, accepted, customary order of things. It is precisely due to this strong underlying tendency to preserve the familiar, that socio-technical imaginaries aren't found at the fringes of society but trickle down into the common and the everyday. It is also the reason why they are not the product of pioneers, but "the product of […] a shared cultural property" (Jasanoff, 2015: 21). Hence, I don't associate socio-technical imaginaries with innovation, but instead with the long-lasting, seemingly apolitical notions, which are so deeply engrained in the socio-cultural context of a community that they go mostly unquestioned.

This understanding differs from the way Leitbilder have been conceptualized. In contrast to socio-technical imaginaries, Leitbilder have a connotation of embracing the new, of pushing boundaries, and of explicitly challenging engrained knowledge cultures. While socio-technical imaginaries are strengthened and perpetuated by authoritative institutions, Leitbilder can develop at the fringes of society and be shared by only a few. I therefore understand guiding visions or Leitbilder as ideas that can be unique and challenging to existing norms and commonly shared expectations of desirable futures. Socio-technical imaginaries, by contrast, represent those much more broadly shared, broadly accepted, and commonly evoked notions of desirable, sensible and attainable futures. In short, Leitbilder can be unique and revolutionary, whereas sociotechnical imaginaries by definition are relatively commonsense and conservative. Over time, of course, Leitbilder can develop into socio-technical imaginaries (see Figure 2 on next page).

To conclude, I understand socio-technical imaginaries as somewhat fuzzy, implicit, broadly accepted and culturally embedded understandings of certain sociopolitical, socio-technical orders. These collectively internalized and uncritically perpetuated visions of the good life can be reproduced, or they can be challenged by techno-scientific innovations.

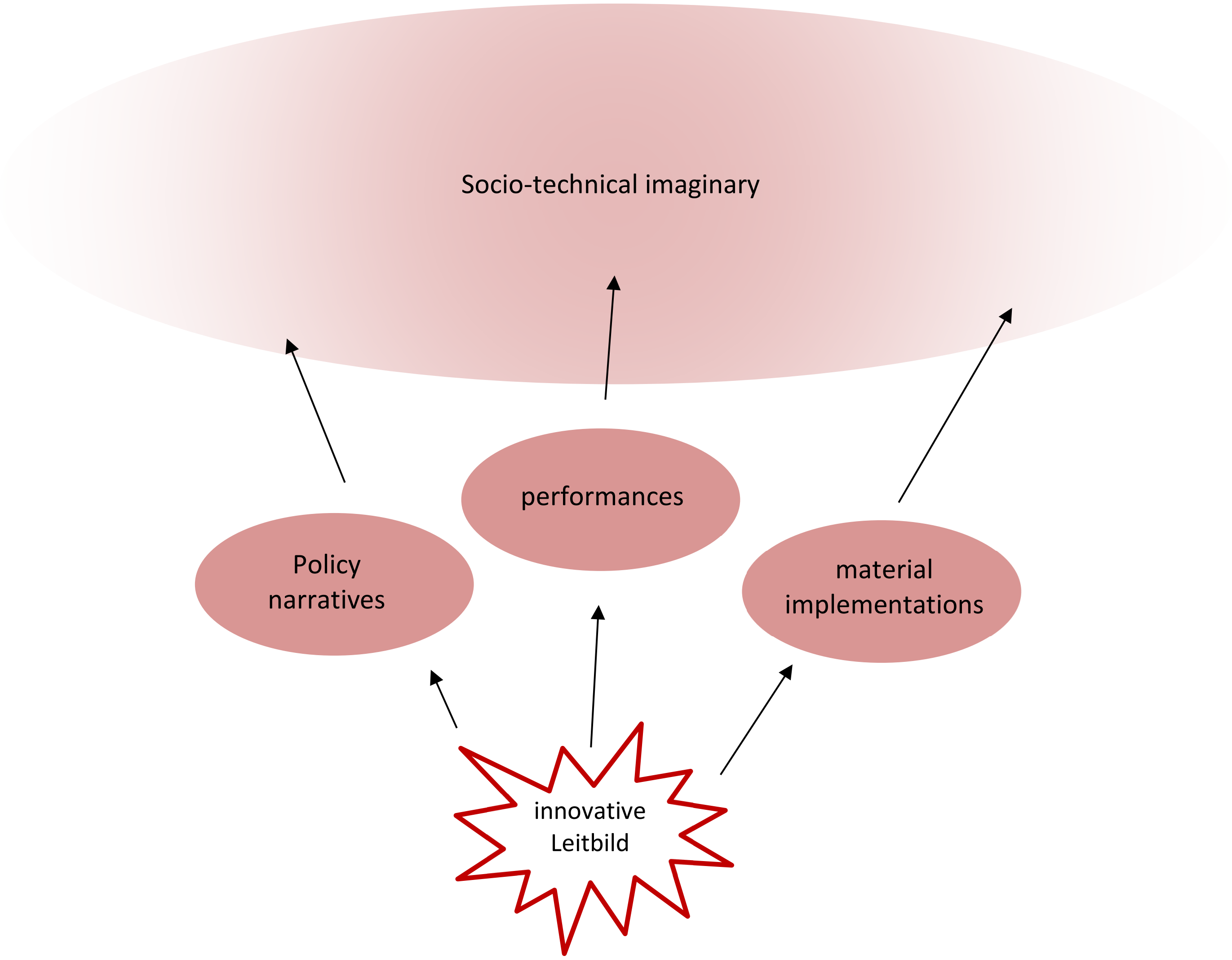

Figure 2: Innovative Leitbilder develop into socio-technical imaginaries (own figure)

5.5 Envisioning and steering the future of the city

Recently, the assessment of visions and imaginaries has gained increasing attention in social science research on urban energy and sustainability transitions. This rising interest is driven by a perceived necessity to actively create and steer visions as means to accelerate change. Social scientists are therefore increasingly understanding visions as useful instruments of active political world-making. Similar understandings have a long tradition in the urban planning profession, where the steering qualities of visions have not only been strategically used but also theoretically questioned. Because my research is especially interested in the impact of visions and imaginaries on *the city*, I use the following section to discuss the relevance of these debates for my research.

Envisioning the future resonates strongly with some of the guiding principles of urban planning theory. The practice of planning as deliberative process emphasizes the necessity of "motivating visions", "diagrams of possibility", or "*Leitbilder*" (Fainstein and DeFilippis, 2016). Here, the act of visioning has always served the purpose of steering. Unlike visions in techno-scientific processes, visions in urban planning have a long history of being consciously created as means to direct and to govern change. They have therefore been understood as processes, rather than only as future states to be strived for. The debate about guiding visions or *Leitbilder* in urban planning provides a valuable backdrop for reflections about how visions of smart grids are currently being developed in Berlin, and what this means for the future of energy in the city. In the following section, I therefore briefly summarize this debate and the influence it has had on the research and practice of urban planning. I then relate this debate to the scholarly discussion that is currently blossoming in the social sciences around the use of visions for steering sustainability transitions. Together, these discussions inform my own stance toward the use of visions as tools for future-making.

Since the mid-20th century, the planning profession and the role of visions in the planning process have gone through various phases of criticism and change. In Germany, the debate about guiding visions or *Leitbilder* of urban planning first emerged with the Modernist ideal of a functionalist city. In the early years after WWII, the term was associated with a hierarchically structured, expert-driven planning process in which planners were the ones to develop guiding visions for urban development. In the 1960s and 70s, this understanding was increasingly criticized, and guiding visions were associated with the enforcement of the political interests of individual charismatic leaders rather than the democratically legitimated process of collective city-making (Kuder, 2001). Urban planning visions were increasingly viewed as “subjective and superficial ideas that serve as uncritical steering mechanisms guided by notions of power and hegemony, which seek to adapt spatial structures to societal developments in the sense of dominant power relations” (Kuder, 2001: 17). They were increasingly criticized for simplifying complex urban development issues, and for masking the political interests behind these complex processes by operating in the name of a universal common good, and thus foreclosing any open discussion about values.

Starting in the 1970s and 80s, the urban planning profession has increasingly doubted the function and performance of visions as tools for normative guidance. Instead, visions are increasingly understood as processes of negotiating and learning, as communicative instruments, and as parts of participative and democratic planning processes. They are understood as the aggregated visions of desirable spatial and societal futures, which emerge out of complex negotiation and coordination processes, and are derived from the myriad subjective, individual paradigms of those involved. In this view, visions are not only guides for the future, but also tools to negotiate and articulate different interests (Shipley, 2000). Since this time, urban planning visions are therefore increasingly regarded as discursive development processes and participatory tools, i.e. as processes of visioning (Shipley and Newkirk, 1999).

The debate about visions and visioning in urban planning has been accompanied by a debate about the planning profession. Planning professionals started focusing on methods, instruments and processes of urban development, putting more emphasis on collective interests, and specific justifiable planning goals. With time, the planning profession has evolved into a management profession, and the process of finding guiding visions is increasingly understood as a cooperative and participatory process. Today, urban planning professionals are no longer regarded as the sole proprietors or interpreters of expert knowledge about cities, but instead as facilitators, managers and negotiators of multiple knowledges between diverse stakeholders in a collaborative city-making process. Visions, in this process, are more than distant ideals or fixed goals to strive for, but processes of collaborative imagining.

More recently, the development of guiding visions in urban planning has also been viewed as a contingent process that can emerge out of the complex, wholly unstrategic and unplanned contexts of broader societal change. In more recent urban planning history, guiding visions are therefore understood as closely related to the societal contexts in which they emerge, and thus themselves regarded as subjects to constant evolution and change (Shipley and Michela, 2006). In consequence, visions and visioning can have different functions depending on whether they are embedded in an authoritarian, hierarchical planning and governance system or in a more cooperative, democratic governance system.

Contemporary forms of cooperative planning involve top-down steering as well as cooperation and consensus building. These are attained through problem-oriented participatory processes that mediate long-term objectives and short-term interests. The formulation of objectives is neither incremental nor comprehensive – neither fully “top-down” nor fully “bottom-up”. Instead, it relies on open communication processes that aim at discursively and democratically agreeing on common guiding visions on the one hand, and small-scale, short-term problem-solving activities on the other (Kuder, 2001). Visions in urban planning can thus be defined as

> “concrete representations of complex and idealized goals, motivations, forms of communication and forms of cooperation, that are collectively developed in a discursive process and are based on common values. They serve as tools for defining more specific goals and for facilitating the making of decisions needed to pursue the desirable futures they describe” (Kuder, 2001: 57).

In short, Leitbilder are deeply enmeshed with the planning theories and practices of their times, and the planning professional plays the role of “visionary intermediary within a dynamic urban network” (Kuder, 2001: 90). At the same time, this increasing process-orientation has been lamented by certain planning theorists, who see the creativity of far-reaching utopian thought as one of the profession’s strengths (Myers and Kitsuse, 2000). Planning, in these theorists’ view, is best when it engages in “persuasive storytelling” (Throgmorton, 1992). In other words, there exists an unresolved tension between understanding guiding visions as top-down steering instruments or as bottom-up processes of participatory planning.

Similar discussions have started to take hold in the energy and sustainability research community. Scholars in the field of sustainability studies are increasingly engaging with the potential of visions and visioneering as strategic tools of future-making, and as means to facilitate change. The rising interest in strategic visioneering is driven by a perceived urgency to enact fundamental societal transformations in the face of the looming threats of climate change. It is aimed at understanding how to actively initiate, steer and govern broad sustainability transitions. These discussions circle around various terms, including ‘envisioning’, ‘imagining’, ‘storytelling’, ‘narrating’, ‘framing’ and ‘staging’. Moreover, they circle around two diverging standpoints: those who understand visions as potential means to accelerate broad societal change, and those who understand them as potential tools for collectively and democratically working towards shared societal futures.

A growing number of social science scholars argue that visions of the future should be used as tools to attract attention, communicate ideas, coordinate different stakeholders, and strategically influence people. These scholars argue that strategic narratives are necessary to close the gap between climate knowledge and climate action (Bushell et al., 2017). In this view, politics needs to shift its focus from informing about sustainability transitions to shaping them. For this purpose, the role of scientific knowledge needs to change from predicting probable futures to designing the pathway towards them in processes of "strategic futuring" (Hajer and Pelzer, 2018). In Hajer's view, a successful energy politics needs to be measured against its capacity to gather people behind a compelling imaginary (Hajer and Pelzer, 2018: 222). Energy and climate politics, in Hajer's view, need to be understood as a "set of staged performances" that strategically utilize and spread narratives of desirable renewable energy futures. Among others, Hajer argues that narratives can and should be strengthened by staging, enacting or performing them. In his view, politics should be analyzed as a "'sequence of staged performances' through which particular imaginaries loose or gain in influence (Hajer and Pelzer, 2018: 224). Similarly, Bushell et al. (2017) argue for constructing a "coherent strategic narrative" in relation to climate change, which will persuade people and enable coordinated action (Bushell et al., 2017: 39). They understand strategic narratives as political tools to communicate policy goals and convince audiences (Bushell et al., 2017).

While scholars such as Hajer and Bushell argue on the basis of urgency and leadership, others argue on the basis of plurality, democracy and ownership. These scholars contend that the futures evoked through practices of collective and participatory imagining should follow no singular goal or pathway, but must reconcile various interests, desires, hopes, experiences and perspectives. This strand of literature is also interested in narratives and the visions they portray, but more focused on the collective process of producing these narratives than on their content. For example, Paul Graham Raven states that "[storytelling] has the potential to open up discussion around energy futures, turning the discourse away from its current technocratic paradigm and towards a more inclusive, participatory process in which citizens can recognize their own experiences and perspectives" (Raven, 2017a: 165). Like Raven, various scholars find value in collective storytelling and its potential to gather the "everyday wisdom of ordinary people" (Moezzi et al., 2017: 3). They argue that collective storytelling can open up avenues for creative action that would otherwise remain unexplored. These authors explicitly seek to mobilize non-scientific formats of imagining future worlds, such as science fiction or folklore as means to engage non-scientific audiences and generate collective interest, meaning and action (Moezzi et al., 2017; Raven, 2017b). Others explicitly criticize the way energy interventions are frequently imagined and framed over the top of local communities' heads, leaving little room for expressing their own energy needs and aspirations (Cloke et al., 2017; Tidwell and Tidwell, 2018). In sum, this line of scholarship sees the need to engage more ordinary people in processes of collectively imagining energy and climate futures, and thus enabling collective ownership and creative problem solving. They argue that opening processes of future-making beyond the realm of policy makers and experts can facilitate broadly accepted change.

This discussion shows us that – like in urban planning - theorizing on imagined futures in the sustainability sciences also circles around a tension between getting people on board by strategically influencing or by involving them. It also shows us that visions and imaginaries and the stories or narratives that promote them can indeed be attractive political instruments.

Yet most researchers agree that these narratives can be "constructed, planned and promoted", but they cannot be fully controlled. Instead, they are "appropriated, interpreted, retold or rejected" by their multiple audiences (Bushell et al., 2017: 42). This means that any vision and any narrative, no matter how strategically invoked, is open to negotiation. Dierkes makes a similar assessment when he speaks of the possibility of creating Leitbilder to steer technological development. In his view, the possibility of gathering everyone around a common Leitbild rapidly decreases as technological systems gain complexity and the number of involved actors and individual interests rises. Even Bushell et al therefore concede that strategic narratives "should be developed dynamically, with influencers and audiences, in a strategic dialog" (Bushell et al., 2017: 47).

5.6 Concluding remarks

In conclusion, I understand acts of futuring as political tools and processes for discursively and cooperatively steering urban (socio-technical) development. It is important to note that, in turn, processes of futuring deserve as much empirical attention as the futures they evoke. The kinds of futures we envision is politically as interesting as how these futures are produced.

In this section, I reviewed the concepts of techno-scientific Leitbilder and of socio-technical imaginaries, and related them to discussions on their usefulness as political instruments for steering urban socio-technical transitions. First, I established that visions and imaginaries have a performative power to shape reality in the present, and that they are therefore highly political. I then argued that Leitbilder develop at the fringes of society and promote techno-scientific innovation while socio-technical imaginaries represent those broadly accepted cultural norms that are perpetuated at scale. Finally, I related the two concepts to discussions about strategically utilizing visions and imaginaries of the future as political instruments to steer processes of urban socio-technical change. Here, I argued that acts of futuring are political both in their contents and their production processes, and that uncovering these politics requires empirical inquiry.

In relation to smart grid infrastructures, I therefore ask:

a) What kinds of futures are smart grids conveying and what might this mean for the shaping of Berlin's future electricity system?
b) How and by whom are these visions being produced?
c) What role are visions of smart grids currently playing in Berlin's energy system transition?

In the following chapter, I explain how I translated these thoughts and questions into a plausible research design and research methodology.

6 Research design and methods

Knowledge of smart grids in Berlin is confined to a relatively small community of experts, institutions and organizations. This became relatively clear as I started collecting data in an inductive, explorative way, searching the web for documents and conducting first interviews with key stakeholders, whom I found by attending conferences and city sponsored dialog events on the topic. Each document and each interview led to further documents and further interview contacts. Once I had a relatively good overview over the field, I stepped back and reviewed what kinds of sources I was missing and expanded my research design accordingly. I also interpreted my data as I went along, continuously elaborating assumptions about the content, processes and effects surrounding the smart grid futures I was encountering and adjusting my research questions in the process. There is an element of Grounded Theory to my investigation in that I conducted interviews and collected documents until the storylines I encountered started repeating themselves and thus reaching the "point of saturation" (Strauss, 1987). In sum, I proceeded in a continuous loop from exploring my research field, interpreting my findings, adjusting my research questions and research design, and returning to the field.

My research was informed by existing literature on the topic(s), including policy documents, research papers and news articles. In many of these documents, smart grids are still primarily portrayed as technical or economic issues, and also as primarily national level concerns. Understanding what they mean for the *social* dimensions of energy futures at the *urban* level therefore drove my research interest. Concerns that accompanied me as I entered the research field circled around questions such as: what are visions of smart grid futures problematizing? Are these problems regarded as technical or social? What are these imagined futures possibly ignoring? How is this reflected in negotiation processes? Who is involved in the formulation of these visions of the future and who isn't? Who has influence and who doesn't? And lastly, how is this reflected in smart grid implementation?

6.1 <u>Leitbilder, socio-technical imaginaries and discourse</u>

Leitbilder of socio-technical innovation and imaginaries of socio-technical futures come alive in discourse. They are articulated in oral conversations, described in written texts, represented in images or films, performed in theatrical acts, or concretized in material artefacts. These expressions can involve formal communications such as academic literature, corporate advertisements or political speeches, but also more popular, informal genres such as science fiction or blogs. Yet discourse is more than just the sum of these forms of expression; it is a way of collective reasoning and acting. As Sovacool and Hess (2017) summarize, "the term 'discourse' means a 'historically emergent collection of objects, concepts, and practices' that 'mutually constitute' each other to cohere into stable meaning-systems" (Sovacool and Hess, 2017: 714). Much like Leitbilder or socio-technical imaginaries, discourse is therefore performative; it constitutes abstract social meaning-systems and, in doing so, creates concrete social realities. According to Jasanoff (2021), the analysis of discourse is therefore a valuable qualitative research method for understanding socio-technical imaginaries[4]. The following section explains

[4] http://sts.hks.harvard.edu/research/platforms/imaginaries/ii.methods/methodological-pointers/

different understandings of discourse, why its analysis can help disentangle both the content and development of socio-technical imaginaries, and how I operationalize it to serve the purpose of my specific research interest.

6.2 What is discourse?

I understand discourse as an action-oriented social practice (Wetherell and Potter, 1988). This means that it is not a neutral transmitter of information *about* the social world, but an *integral part of* the social world, and intimately bound up in its making. In this understanding, discourse is a collective means of making sense of the world, of understanding histories, of making judgements, and of acting upon these judgements. It thus serves not merely to formulate worldviews or express cultural mindsets, but actively creates them[5]. Because discourse theory has its origins in linguistics and semiotics, it is important to distinguish between pure understandings of discourse as "actual language", i.e. "talks and text" and broader socio-cultural understandings of discourse as "a form of social action taking place in context" (Tenorio, 2011: 185). This distinction is important, because it influences both the focus of analysis and the choice of methods. In my research, I work with the latter.

Discourse theory has evolved in the context of various academic disciplines including linguistics, philosophy, history, psychology, political science and sociology. Even within social scientific research, definitions of discourse - and hence modes of examining it - vary. What they have in common, though, is an understanding of discourse as constituent of meaning and performative of human activities and institutions. Discourse "reflects, shapes and enables social reality" (Tenorio, 2011: 187). This rests on the slightly paradoxical understanding that we shape discourse as much as discourse shapes us. In philosophical terms "discourse is thus a representation of what we want the world to be like, rather than a representation of how the world is" (Carver, 2002: 51). Ultimately, the world can therefore only be what it is represented to be in discourse. It follows that there is no such thing as a world outside discourse. Only what is expressed *is* (Carver, 2002). In this radically social constructivist understanding discourse is therefore more than a story, a narrative, a controversial discussion or a deliberation; it comprises all forms of human expression, including language, objects and action.

For critical social theorists discourse is therefore a highly political practice. Michel Foucault defines discourse as "set of practices that systematically form the objects of which they speak" (Foucault, 2013: 54). In his view, discourse is especially intertwined with the social systems of knowledge production and thus involved in shaping what a society collectively accepts as the "truth". It is a means of categorizing into "true" and "false", "right" and "wrong", "moral" and "immoral", or "reasonable" and "mad". By (re)producing such "truths" discourse can, for example, influence societal conventions for identifying and treating "madness". The way we understand and qualify (or disqualify) certain societal issues through discourse forms the basis for the laws we pass, the institutions we create (e.g., insane asylums), and the social orders we adhere to. Foucault's understanding of discourse as political action thus links it to the very physical world of institutions, people and power.

As a political practice, discourse is also a craft. Wetherell and Potter (1988) stress that discourse is intentionally created to convince audiences and thus follows certain underlying orders. Foucault underlines this by asserting

[5] http://www.tesl-ej.org/wordpress/issues/volume12/ej45/ej45r3/?wscr=

that discourse is structured by conventions, or what he calls "discursive practices" (Hook, 2001: 522). Maarten Hajer (2005) calls this the "situational logics of language-in-use" (Hajer and Versteg, 2005: 175). These discursive conventions constitute the rules, systems and procedures that govern discursive events. According to Foucault, these rules, systems and procedures are "constituted by and ensure the reproduction of the social system, through forms of selection, exclusion and domination" (Hook, 2001: 522). In other words, Foucault asserts that discourse operates to maintain the social orders that it is rooted in. As Hook summarizes, Foucault emphasizes that discourse can limit thinking rather than inspire it, constraining and restricting it to the constant reproduction of status quo rather than providing a space for exploring new horizons. For him, discourse is deeply saturated with "relations of force, strategic developments, and tactics" (Hook, 2001: 529). According to Foucault, these forces are embedded in "highly specific and idiosyncratic matrix of historical and socio-political circumstances, which give rise to, and are part of, the order of discourse" (Hook, 2001: 525). They are thus confined to the boundaries of existing societal standards and institutional arrangements. At the same time, Hook states that "discourse is both that which constrains and enables writing, speaking, thinking. What [Foucault] terms 'discursive practices' work in both inhibiting and productive ways, implying a play of prescriptions that designate both exclusions and choices" (Hook, 2001: 523). This dialectic is perhaps best highlighted by the existence of parallel and in part incompatible discursive universes within one and the same society, such as feminist discourse, black empowerment discourse, white supremacist discourse, natural scientific discourse, social scientific discourse or – in my case – smart grid discourse.

This dialectic of discourse as inhibiting *and* productive, as inherently restrictive *and* visionary has made it valuable for research in policy and planning. It builds on the notion that "discourses can be appropriated or colonized, and put into practice by enacting, inculcating or materializing them" (Tenorio, 2011: 186). This can be done by interest groups that form so-called "discourse coalitions" (Hajer, 1993) to promote certain worldviews and influence policy-making in their favor. Especially in times of uncertainty, these coalitions will compete for the prevalence of their worldviews and political convictions by means of discourse. Hajer (1993) calls this the "mobilization of bias" (Hajer, 1993: 45). The arguments that these coalitions bring forward in favor of or in opposition to certain issues will draw on different discourses at a time. In the case of smart grids, for example, they might combine elements of engineering discourse (how do smart grids work?), economic discourse (what are the costs and benefits to society?), climate discourse (what are smart grids good for?), as well as political considerations (do we want to commit ourselves to this specific solution?) (Hajer, 1993). Different discursive elements are then combined to present a coherent storyline. Politics, in this view, is a "process in which different actors from various backgrounds form specific coalitions around specific story lines" (Hajer, 1993: 47). The discourses they produce often work to conceal the complexity of a problem and mask or obscure underlying meanings, interests or intentions.

6.3 Analyzing discourse

Discourse analysis aims at revealing these hidden meanings and intentions, i.e. the (hidden) politics of discourse. In Hajer's words, discourse analysis aims at "identifying new sites of politics and analyzing the political dynamics therein" (Hajer and Versteg, 2005: 175). More broadly stated, discourse analysis aims at "deconstructing thoughts and language" (Sovacool and Hess, 2017: 715) or at unraveling the tacit and uncodified "rules, structures and relations" inherent in thoughts and language (Keller, 2013: 2). It does this to understand how discourse is constructed to "make things happen" (Potter and Wetherell, 1987: 3). In doing so, discourse analysis can lay its focus either on diagnosing or on critiquing certain societal orders. While Foucault is interested in unraveling "relations of power, not relations of meaning" (Hook, 2001: 529) others put more emphasis on meaning. Analysis focusing on issues of power typically "raises awareness concerning the strategies used in establishing, maintaining and reproducing (a)symmetrical relations of power as enacted by means of discourse" (Tenorio, 2011: 184). In the words of Carver "discourse analysis does not look for truth but rather at who claims to have truth, and at how these claims are justified in terms of expressed and implicit narratives of authority" (Carver, 2002: 52), or in how discourses legitimize action. In the words of Carver "discourse analysis does not look for truth but rather at who claims to have truth, and at how these claims are justified in terms of expressed and implicit narratives of authority" (Carver, 2002: 52).

6.3.1 Merging two approaches to discourse analysis

To work with discourse, I merged Reiner Keller's "sociology of knowledge approach" to discourse analysis (SKAD) with the "discourse coalition" approach of political scientist Maarten Hajer. I used the sociology of knowledge approach primarily to examine the meanings inherent in smart grid imaginaries in Berlin (i.e. for 'diagnosis'), and the discourse coalition approach to examine the politics of their becoming (i.e. for 'critique').

Both approaches fit my research questions and theoretical vantage point because they understand discourses as political practices that create social reality. They understand social realities as socially constructed in a constant, dialectical process of objective and subjective, individual and collective sense making through discourse (Keller and Truschkat, 2013). The sociology of knowledge approach to discourse emphasizes the importance of practices, materialities and infrastructures as integral parts of these sense-making processes, and thus as objects of analysis. It therefore conceives discourse not only as embedded in consciousness, but as thoroughly intertwined with the physical realm of 'world-making' and thus inextricably linked to the realization of material infrastructures.

The infrastructures addressed by the sociology of knowledge approach to discourse include statements or utterances, for example in texts, brochures, web animations, or interviews. They also include the technical "infrastructures of implementation" that emerge out of discursive problematizations, and which mediate between discourse and practice (Keller, 2011: 56). For this reason, the sociology of knowledge approach to discourse involves not just textual analysis, but also an observation of real-world infrastructural manifestations, which link "statements, practices, actors, organizational arrangements, and objects" with each other in broader socio-spatial processes (Keller, 2011: 56). Most importantly, however, the sociology of knowledge approach to discourse assumes that discourse is the place where "creativity, interpretation, fantasy, imagination and desire come to the fore" (Keller and Truschkat, 2013: 35). This approach thus facilitates insights into the connections between narrative and material forms of future-making and how these are related to experimental pilot projects on the one hand and broader urban development plans on the other.

6.3.2 The importance of storylines

Both Hajer and Keller identify storylines as central to the analysis of discourse. While Keller's approach focuses on the meanings conveyed by these storylines, Hajer's approach focuses on the (political) practices that create them. By combining their two approaches, my analysis focuses on both. In Keller's view, storylines emerge by relating the definitions, frames, and classifications of a discourse (Keller, 2011: 63). Keller defines *frames* as collective products of a societal knowledge repertoire. Frames are the typical qualities associated with a certain phenomenon in discourse, for example the "flexibility" of smart grid systems. *Classifications* qualify the content of a discourse, for example by classifying smart grids as desirable versus threatening. According to Keller, material realizations are especially important in the process of institutionalizing certain qualifications. Moreover, discourses can *structure phenomena* by emphasizing certain elements or dimensions of them, while leaving out others. The sociology of knowledge approach to discourse aims to unravel these phenomenological structurings. And lastly, discourses contain *narrative structures* that come to the fore when frames, classifications and phenomenological structures are related to each other and form a storyline. To understand these connections, I asked questions such as: what is this source's message? What are this message's core elements? Which words are being repeated? How do these words differ compared to other messages in the same discourse? Which arguments, categories, or classifications does this message contain? Which institutions/organizations are being introduced as relevant? Which subject positions are being introduced?

Hajer's discourse coalition approach likewise puts great emphasis on storylines. According to Hajer (2006), storylines help structure communication between people from various backgrounds and with different understandings of a certain problem. Especially in the case of complex problems that require various forms of expertise, Hajer contends that "even experts draw on storylines to convey meaning", and then adds that "storylines are the medium through which actors try to impose their view of reality on others, suggest certain social positions and practices, and criticize alternative social arrangements" (Hajer, 2006: 71). Storylines, in Hajer's view, must therefore be a central focus of discourse analytical work.

Moreover, Hajer links the use of storylines to acts of political coalition building. He assumes that discourses cannot be understood "outside the practices in which they are uttered"; instead, he states that discourse is inseparably linked to the "practices in which it is produced, reproduced and transformed". To Hajer, discourse coalitions emerge as the result of "practices in the context of which actors employ storylines" (Hajer, 2006: 70). He explains that even though many terms commonly used in communication mean different things to different people, this can actually work in favor of political coalition building. He goes as far as to say that "people, that can be proven not to fully understand one another, nevertheless together produce meaningful political interventions" (Hajer, 2006: 69). This resonates with the way Dierkes understands the functioning of Leitbilder, which trigger different associations with different people, and are yet the focal point for mutual coordination and collaboration. While Dierkes emphasizes the power of the 'image', Hajer emphasizes the power of 'storylines'

(Hajer, 2006: 69). He further points out that the forming of discourse coalitions is not necessarily a conscious act, but that these coalitions can emerge between actors or groups that are otherwise distant and unrelated. “A discourse coalition can then be defined as the ensemble of a set of storylines, the actors that utter these storylines, and the practices through which these storylines get expressed" (Hajer, 2006: 71). Nevertheless, Hajer’s discourse coalition approach helps analyze the strategic actions that people take to position a discourse, and to illuminate how different actors and organizational practices reproduce this discourse without necessarily orchestrating or coordinating their actions or without necessarily sharing deep values (Hajer, 1993: 48).

For this purpose, Hajer (1993) defines the two concepts of *discourse structuration* and *discourse institutionalization*. He states that “discourse structuration occurs when a discourse starts to dominate the way a society conceptualizes the world” (Hajer, 1993: 46). When a discourse is structurated, this means that it is widely shared, widely accepted, and largely uncontested. It means that a certain storyline has gained popularity to the point where alternative storylines are muted. After structuration, discourses can deepen in terms of their material translation and institutional manifestation. As Hajer (2006) puts it: “If a discourse is successful—that is to say, if many people use it to conceptualize the world—it will solidify into an institution, sometimes as organizational practices, sometimes as traditional ways of reasoning. This process is called discourse institutionalization” (Hajer, 1993: 46). Tying this back to the development of infrastructures, discourse institutionalization means that an innovative idea has traveled from the heads and the conversations of few experts and evolved into the dominant form of organizing a socio-technical system. Both discourse structuration and institutionalization occur due to the strategic actions of people and their discursive alliances. To understand these strategic actions, and how they influenced Berlin’s smart grid discourse, I asked questions such as: Which actors and institutions are imagining what kinds of urban smart grid futures in Berlin? How are they influencing the emergence of dominant storylines? Which contested storylines exist? Where and how are these storylines being voiced?

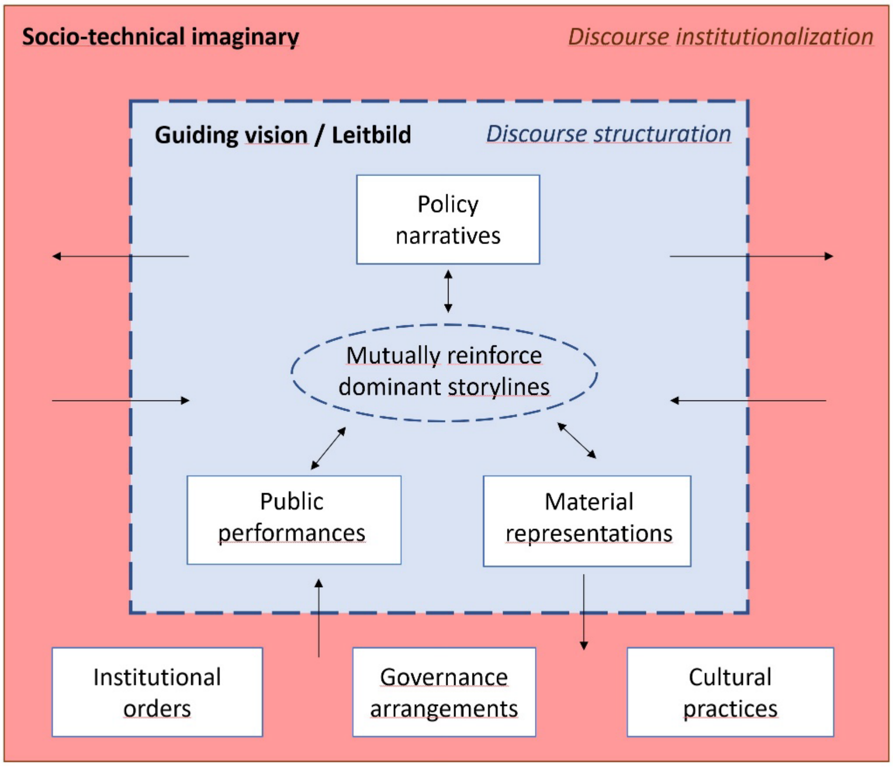

Figure 3: Relating discourse to visions and socio-technical imaginaries (own figure)

Both the sociology of knowledge and the discourse coalitions approach work with the concept of storylines as fundamental for understanding the meanings and politics of discourse. I used the sociology of knowledge approach to analyze the storylines that became apparent in the smart grid discourse that I encountered, and I used the discourse coalition approach to analyze the actors that uttered these storylines, and the practices that conformed to them (Hajer, 1993: 47). To me, these storylines are Berlin's imagined smart grid futures.

Both approaches are also sensible to the socio-institutional context of discourse. In other words, they examine who, how, where and for whom discursive events take place. Sensitivity to the situatedness of discursive events means awareness of the social relations, institutional settings, and important events that characterize the discursive setting or situation (Keller and Truschkat, 2013: 52). In my case, this socio-institutional context consists of the pilot projects at Berlin's future sites and the political-administrative rationale that backs them.

6.3.3 Technical procedure

To conduct my analysis, I transcribed all interviews and uploaded all documents to MAXQDA for systematic coding. I identified dominant frames associated with smart grid futures (such as "flexibility" or "demand-side management"), how they were being classified (for example as "modern", "green" or "intelligent"), and the way they were defining smart grids as a phenomenon (for example as "economic opportunity" rather than "critical privacy issue"). These findings led me to identify dominant storylines, which I call Berlin's imagined smart grid futures.

Moreover, I analyzed how places, times and actors were involved in the formation of these storylines. I identified the role of urban places (most notably Berlin's future sites) for the formation of certain storylines, when and how these storylines were disseminated (for example at events or through advertisements), and which actor networks were involved in their promotion (for example research institutions).

6.4 Case study design

I conducted a single case study of imagined smart grid futures in the city of Berlin, Germany. The case study aimed at revealing how the city's energy future is being imagined and reconfigured through the development of smart grids in policy and implementation circles. I unraveled these imagined energy futures by analyzing discourses and practices of smart grid development in the city of Berlin over the course of two years (2016 - 2018).

My research involved three major units of analysis: the city level, three urban development sites, and three smart grid pilot projects, which are being implemented at these sites.

I selected these three pilot projects, because they are typical for the way smart grids are currently being developed and implemented in many cities across Germany: they follow a logic of on-site "learning by doing", which means that smart grid infrastructures are being developed, tested and publicly demonstrated in openly accessible urban environments instead of secluded laboratories. This resonates with a recent trend in urban development, which builds on experimentation with infrastructures in the real-life context of "urban laboratories" (Bulkeley et al., 2019). My three pilot projects therefore relate not only to questions of techno-scientific innovation, but also to questions of urban change. In addition, all three pilot projects are being implemented within the context of larger urban development sites with exceptional meaning for the city of Berlin. In this regard, they can all be considered "projects within projects", which are closely related to Berlin's broader urban development plans. The selected pilots are therefore especially relevant for understanding the interlinkages between experimental "futuring" with smart grids and broader questions of urban change.

Despite their similarities, the pilot projects also present numerous differences, for example regarding project size, set-up, funding, and management. Because I am interested in understanding how experimentation with smart grids - regardless of its various guises and modes - is tied into the making of urban futures, these differences do not impede the research design. On the contrary, they show that in spite of these differences, my project-level analyses render similar results. In spite of very different project characteristics, they reveal similar dynamics regarding the role of imagined futures for techno-scientific innovation, for urban energy in Berlin, and for the politics of urban experimentation.

I chose a qualitative case study approach, because I am interested in understanding how my case relates to existing (theoretical) work on the shaping of cities through imagined futures, especially in the context of infrastructural experimentation. I was less interested in the representativeness of my findings. Instead, I was interested in reconstructing and interpreting the mechanisms at work in my specific case. My case study thus lends itself to generalizations about the role of imagined futures in processes of urban socio-technical change. It does not, however, lend itself to statistically representative generalizations, as case studies never do (Yin, 2009: 38). More precisely, my case study provides evidence of how experimental futuring with smart grids is shaping the city of Berlin. It does not, however, allow conclusions about how experimental futuring with smart grids is shaping other German cities. Relating my findings to other cities, in which experimental infrastructuring with smart grids is also taking place, must be done in another research project. Nevertheless, my research provides potentially important lessons for other cities, other experimental sites and other smart grid projects. For example, my research provides knowledge about what to be aware of, and possibly even how to proceed in similar cases to attain better urban futures for all.

I complemented my project-level analysis with an analysis of imagined futures at the city-level. This analysis connects my individual pilots with their broader urban environment, linking imagined futures of smart grids with imagined futures of Berlin as a smart and a low-carbon city, and linking the politics of imagining the future to the politics of urban experimentation.

To structure my case study, I investigated three spatial levels:

a) Each smart grid project as a whole, including selected institutions, companies or individuals involved;
b) The three so-called future sites (*Zukunftsorte*), which host these smart grid projects;
c) Berlin's political administration as well as relevant institutions and companies working in the field of smart grids in Berlin, but not necessarily linked to the future sites, such as the newly founded public utility (BerlinEnergie).

In each of my pilot sites, I investigated the imagined futures associated with smart grid infrastructures in the city. In my study of the broader urban context, I investigated the relation between these imagined futures and other imagined futures, such as the smart city and the low-carbon city. I also investigated how these futures were being promoted as part of the future sites' broader urban development narratives.

Robert K. Yin defines a case study as "an empirical enquiry that investigates a contemporary phenomenon in depth and within its real-life context, especially when the boundaries between context and phenomenon are not clearly evident (Yin, 2009: 18). I chose to work with a single case study, because the way urban futures are being imagined in the context of urban smart grid experimentation is certainly contemporary, and how these experimental sites are intertwined with their broader urban context is less clear. Other research designs, such as a survey or an experiment, would not have been able to capture my research phenomenon with the same depth.

6.5 <u>Data collection</u>

I collected data over the course of two years (2016 - 2018) using a mixed methods approach, which was based on expert interviews on the one hand and a review of relevant documents on the other. I collected data at the city level on the one hand, and at three sites of urban experimentation on the other. This way, I was able to trace how important stakeholders such as the administration and the electric grid operator are currently imagining urban smart grid futures, and at the same time understand how smart grids futures are being imagined by those actually implementing pilot versions of them on the ground.

My interviews therefore spanned experts from the three experimental project sites as well as key stakeholders from Berlin's energy sector, including representatives of city administration, the electric grid operator, the newly founded public utility, civil society organizations, the local energy agency, and mulit-national electronics and technology companies.

6.5.1 Semi-structured expert interviews

I conducted a total of 16 interviews with experts from 13 institutions. All interviews followed a semi-structured approach: the questions were based on pre-conceived guidelines (see appendix 12.1 "Interview guideline"), and the interviews were conducted as conversations. Each interview lasted approximately one hour. All interviews were audio-recorded and then transcribed into print. They covered six broad areas of interest, including – but not limited to – the specific questions listed below:

a) Definition of smart grids
   How do you define smart grids? What do smart grids do? What are they good for?

b) Urban smart grid ideal
   How would an ideal smart grid work in the city of Berlin and at [EUREF/Adlershof/TXL]?

c) Urban effects
   Who would use smart grids? What would change for households, SMEs, neighborhoods or communities if we had an ideal smart grid in Berlin? What kinds of spatial and/or environmental effects do you associate with smart grids?

d) Material implementation
   How is your institution involved in implementing smart grids in Berlin? How is implementation advancing in Berlin? What obstacles are you encountering? How do these relate to the city of Berlin? How and by whom could smart grid implementation be supported in Berlin?

e) Risks
   What kinds of risks do you associate with smart grids?

f) Alternatives
   What alternatives to smart grids can you think of?

I define experts as people who have special knowledge of the social context that I am researching (Gläser und Laudel, p. 12). In my case, this means that they are either experts for the smart grid pilot projects, for Berlin's future sites or for the city as a whole. Moreover, the development of urban smart grids relates to three different communities, including ICT, energy and urban development. To capture viewpoints and experiences from all three domains, I made sure that my selection of interviewees included members of each of these communities.

I conducted a total of eight interviews relating to the smart grid pilot projects, and eight relating to the city of Berlin. Out of the eight interviews conducted with experts from the pilot projects, one related to TXL, two related to Adlershof and five to EUREF. The number of interviews I was able to conduct in relation to my three pilot projects varied due different project sizes and varying degrees of implementation. TXL, for example, has not yet been put into practice, and is therefore better understood via documents. The pilot project at Adlershof involves fewer people than the one at EUREF, which means that I had fewer contacts. Moreover, my situation as researcher gave me better access to EUREF than to the other two pilot projects (see section 6.7 "My role as researcher").

For an overview of my interviews, including the year they were conducted, the names and types of institutions covered, and their relation to my case study, see Table 1. For overviews of the number of interviews I conducted with relation to each pilot project, type of institutions and level of analysis, see Tables 3-6.

Table 1: Overview of all interviews

Year of interview	**Name of institution**	**Type of institution**	**Type of community**	**Spatial scale**	**Relation to case study**
2017	Tegel Projekt GmbH	publicly commissioned urban development company	urban development	future site & smart grid pilot project	TXL
2018	SenWEB	city government / administration	urban development	city	Berlin
2018	BerlinEnergie	Public utility company	energy	city	Berlin
2018	BUND	civil society organization	energy	city	Berlin
2016	BürgerEnergieBerlin	civil society organization	energy	city	Berlin
2018	StromnetzBerlin	private grid operator	energy	city	Berlin
2018	StromnetzBerlin	private grid operator	energy	city	Berlin
2018	Siemens	private electronics company	ICT	future site & smart grid pilot project	Adlershof
2018	Cisco	private ICT company	ICT	city	Berlin
2017	Energy Eurasia GmbH	private energy consultancy	energy	future site	Berlin
2016	EUREF AG	private project development company	urban development	future site	EUREF
2016	Inno2grid	private energy consultancy	ICT	future site & smart grid pilot project	EUREF
2016	Inno2grid	private energy consultancy	ICT	smart grid pilot project	EUREF

2018	SenseLab	research	ICT	future site & smart grid pilot project	Adlershof
2017	WZB	research	urban development	future site & smart grid pilot project	EUREF
2017	SenseLab	research	ICT	smart grid pilot project	EUREF

6.5.2 Review of relevant documents

I complemented the data from my interviews with data from relevant documents, such as laws and policies, project reports, conference presentations, company websites, information brochures, press releases, advertisements, master plans, strategy papers, and conceptual guidelines. I reviewed a total of 54 documents relating to the different levels of my case study design, namely the smart grid pilot projects, the future sites and the city. All documents were published between 2012 and 2018. I analyzed only the written content of these documents (not images).

I reviewed a total of 17 documents relating to the three smart grid pilot projects, 16 documents relating to Berlin's future sites, and 21 documents relating to the broader city. Out of the 13 documents relating to the pilot projects, five related to EUREF, four to TXL, and four to Adlershof. For an overview of all documents that I reviewed, see Table 2 (next page).

Table 2: List of relevant documents

Year of publication	Document name	Type of document	Publishing institution	Type of institution	Type of community	Spatial scale	Relation to case study
2012	Studie Zukunftsorte Berlin	report	Technologiestiftung Berlin	public urban development agency	urban development	future site	Berlin
2012	Mobility2Grid project proposal	project proposal	Project consortium (TU Berlin)	research consortium	urban development	smart grid project	EUREF
2013	Berlin Adlershof - Stadt für Wissenschaft, Wirtschaft und Medien	information brochure	SenStadtUm	city government / administration	urban development	future site	Adlershof
2013	Masterplan Berlin TXL	project masterplan	SenStadtUm	city government / administration	urban development	future site	TXL
2013	Volksbegehren über die Rekommunalisierung der Berliner Energieversorgung	draft law	Berliner Energietisch	civil society organization	energy	city	Berlin
2014	Smart City Berlin - Urbane Technologien für Metropolen	report	Technologiestiftung Berlin	public urban development agency	ICT	city	Berlin
2014	Machbarkeitsstudie Klimaneutrales Berlin 2050	policy report	Project consortium (PIK)	research consortium	energy	city	Berlin
2015	Smart City Berlin	policy document	SenStadtUm	city government / administration	urban development	city	Berlin
2015	Stadtentwicklungskonzept 2030	policy document	SenStadtUm	city government / administration	urban development	city	Berlin
2015	Abschlussbericht der Enquete-Kommission "Neue Energie für Berlin"	policy report	Enquete Kommission	public urban development agency	energy	city	Berlin
2015	TXL Brochure	brochure	Tegel Projekt GmbH	publicly commissioned urban development company	urban development	future site	TXL
2015	Energienetz Berlin Adlershof	presentation	Project consortium (TU Berlin)	research consortium	energy	smart grid project	Adlershof
Year of publication	**Document name**	**Type of document**	**Publishing institution**	**Type of institution**	**Type of community**	**Spatial scale**	**Relation to case study**
2016	Berliner Koalitionsvertrag 2016 - 2021	policy document	City government	city government / administration	urban development	city	Berlin
2016	Energiewendegesetz Berlin	law	SenJustVA	city government / administration	urban development	city	Berlin

2016	Berlin Strategie 2.0	policy document	SenStadtUm	city government / administration	urban development	city	Berlin
2016	Poster "Digitale Räume"	poster	Project consortium (sub-group)	research consortium	ICT	smart grid project	EUREF
2016	Poster "Akzeptanz und Partizipation"	poster	Project consortium (TU Berlin)	research consortium	urban development	smart grid project	EUREF
2017	Änderung Energiewendegesetz Berlin	law	SenJustVA	city government / administration	urban development	city	Berlin
2017	TXL Eine Republik in Berlin	interview	AusserGewöhlich Berlin	news agency	Independent	future site	TXL
2017	Masterplan Energietechnik Berlin-Brandenburg	urban masterplan	Clustermanagement Energietechnik B-B	public urban development agency	energy	city	Berlin
2017	Vernetzte Energie im Quartier	report	Technologiestiftung Berlin	public urban development agency	energy	city	Berlin
2017	Poster "Beitrag eines Eisspeichers in einem Smart grid"	poster	TU Berlin	research consortium	energy	smart grid project	Adlershof
2017	Poster "Smart Grid Infrastrukturen"	poster	Project consortium (sub-group)	research consortium	ICT	smart grid project	EUREF
2017	"Forschungscampus Mobility2grid"	brochure	Project consortium (TU Berlin)	research consortium	urban development	smart grid project	EUREF
2018	Umsetzungkonzept Bek 2030	policy document	SenUVK	city government / administration	urban development	city	Berlin
2018	Masterplan Industriestadt Berlin 2018 - 2021	urban masterplan	SenWEB	city government / administration	urban development	city	Berlin
2018	Digitale Technologien		SenWEB	city government / administration	urban development	city	Berlin
Year of publication	**Document name**	**Type of document**	**Publishing institution**	**Type of institution**	**Type of community**	**Spatial scale**	**Relation to case study**
2018	Digitale Agenda	Website	SenWEB	city government / administration	urban development	city	Berlin
2018	CityLab	document	H2rund	civil society organization	urban development	city	Berlin
2018	Science at Work	advertisement	Tagesspiegel	news agency	Independent	future site	Adlershof
2018	Website	company website	EUREF AG	private project development company	urban development	future site	EUREF

2018	TXL Urban Technologies: Energy	project website	Tegel Projekt GmbH	publicly commissioned urban development comp.	urban development	smart grid project	TXL
2018	TXL Facts and Figures	project website	Tegel Projekt GmbH	publicly commissioned urban development company	urban development	future site	TXL
2018	TXL Event locations	project website	Tegel Projekt GmbH	publicly commissioned urban development company	urban development	future site	TXL
2018	TXL Real estate overview	project website	Tegel Projekt GmbH	publicly commissioned urban development company	urban development	future site	TXL
2018	Berlin TXL - The Urban Tech Republic	brochure	Tegel Projekt GmbH	publicly commissioned urban development company	urban development	future site	TXL
2018	It's all about the smart city, stupid	press release	Tegel Projekt GmbH	publicly commissioned urban development company	urban development	future site	TXL
2018	Philipp Boutellier als smart city leader ausgezeichnet	press release	Tegel Projekt GmbH	publicly commissioned urban development company	urban development	future site	TXL
2018	Energiekonzept 2018	project website	Tegel Projekt GmbH	publicly commissioned urban development company	urban development	smart grid project	TXL
2018	Low-Ex-Net News	press release	Tegel Projekt GmbH	publicly commissioned urban development company	urban development	smart grid project	TXL
2018	TXL Urban Technologies	project website	Tegel Projekt GmbH	publicly commissioned urban development company	urban development	smart grid project	TXL
2018	Smart Grid Allianz Adlershof	project website	Project consortium (TU Berlin)	research consortium	energy	smart grid project	Adlershof
Year of publication	**Document name**	**Type of document**	**Publishing institution**	**Type of institution**	**Type of community**	**Spatial scale**	**Relation to case study**
2018	Energienetze	project website	Project consortium (TU Berlin)	research consortium	energy	smart grid project	Adlershof
2019	Lagebericht 2019	report	Tegel Projekt GmbH	publicly commissioned urban development company	urban development	future site	TXL
2019	Energienetz Berlin Adlershof		Project consortium (TU Berlin/Siemens)	research consortium	energy	smart grid project	Adlershof
2020	Masterplan Solarcity Berlin: Monitoringbericht 2020	report	SenWEB	city government / administration	energy	city	Berlin
2020	Berlin Adlershof – Transformations-raum für die Energie der Zukunft	document	WISTA Management GmbH	public urban development agency	urban development	future site	Adlershof
2020	Website	project website	Berlin Energie	public utility company	energy	city	Berlin

2020	Brochure "Zukunftsorte"	brochure	Tegel Projekt GmbH	publicly commissioned urban development company	urban development	future site	TXL
2020	Standardisierte Leistungserfassung - Monitoringreport 2020 und Monitoring-Gesamtbericht	report	Project consortium (TU Berlin)	research consortium	urban development	smart grid project	EUREF
2020	Mobility2Grid - Sektkorenübergreifende Energie- und Verkehrswende	monograph	Project consortium (TU Berlin)	research consortium	urban development	smart grid project	EUREF
2020	Beratungskonzept: Energie- und Verkehrswende zusammendenken - Akzeptanz und Partizipation in Reallaboren gesellschaftlicher Transformation	report	Project consurtium (sub-group)	research consortium	urban development	smart grid project	EUREF
2021	Website "Zukunftsorte"	Website	SenWEB	city government / administration	urban development	city	Berlin
-	Smart City Berlin: The Future Starts Here	presentation	Berlin Partner for Business and Technology	public urban development agency	urban development	city	Berlin

The following tables give an overview of the complete data I collected - including documents and interviews - and relates them to the different spatial levels, pilot projects, types of institutions and type of communities that were covered.

Table 3: Overview of data collected in relation to each spatial scale

Spatial scale	Number of documents per spatial scale	Number of interviews per spatial scale	Sum of documents and interviews
City	21	7	28
Future sites	16	2	18
Future sites & pilot projects	0	5	5
Smart grid pilot projects	17	2	19
Total	**54**	**16**	**70**

Table 4: Overview of data collected in relation to each pilot project (sub-set out of total)

Site hosting pilot project	Number of documents	Number of interviews	Sum of documents and interviews
Adlershof	8	2	10
EUREF	9	5	14
TXL	15	1	16
Total	**32**	**8**	**40**

Table 5: Overview of data collected in relation to types of institutions

Type of institution	Number of documents	Number of interviews	Sum of documents and interviews
City government / administration	14	2	16
Civil society organization	2	2	4
Grid operating company	0	2	2
Publicly owned or commissioned project development company	21	1	22
Privately owned project development company	1	1	2
Research institution	14	3	17
Energy start-up	0	3	3
ICT/electronics company	0	2	2
Newspaper	2	0	2
Total	**54**	**16**	**70**

Table 6: Data collected in relation to each type of community

Type of community	Number of documents per community	Number of interviews per community	Sum of documents and interviews
Energy	12	6	18
ICT	3	6	9
Urban development	37	4	41
None of the above	2	0	2
Total	**54**	**16**	**70**

6.6 Limitations and disclaimer

Because knowledge of smart grids in Berlin is currently still confined to a relatively small community of mostly engineers and researchers, the discourses that I chose to examine in this project are limited to those produced in expert circles. I chose to focus on expert discourses, because I am interested in the discourse – and the future imaginaries - that *dominates* the current processes of production, consolidation and institutionalization of urban smart grids. Although it would certainly be worthwhile to explore the ways in which ordinary citizens make sense of smart grids in the(ir) city, this would serve a different research interest.

Moreover, my study is limited to the discourse produced by relevant social actors and institutions located in Berlin. This doesn’t mean that everything they do or think about in relation to smart grids is necessarily limited to or even focused on Berlin. But it does mean that they are based in the city, know the city, potentially view or even use the city as testbed, and – as experts – are involved in the city’s smart grid discourse.

It is also worth mentioning that discourse analysis as methodological tool has been criticized for focusing excessively on meaning - or what I have called “diagnosis” - rather than constructive critique (Hook, 2001: 529). I address this by engaging with the discourse coalition approach, i.e. identifying the actors and alliances involved in creating and perpetuating smart grid discourses, and thus opening the view for questions of power. This way, I seek to open the view for possibilities of politically engaging with this power.

Throughout the duration of my data collection, I was employed as researcher within the Science Policy Research Unit at WZB Berlin Social Science Center. During this time, my office was located on the premises of the EUREF Campus, one of the three future sites I researched as part of my case study. Moreover, my employing institution and numerous of my colleagues were (and still are) active members of the “Mobility2Grid” research consortium, which is responsible for the micro-smart grid pilot project located at EUREF. In fact, the current head of my research group - and long-time dissertation mentor - was among the initiators of this pilot project and is a member of the consortium’s board of directors.

7 Introduction to my case study of Berlin

In the preceding chapters, I reviewed relevant social and urban studies literature on smart grids, related them to my theoretical framework and presented my research design and methodology. I now proceed to introduce my case study. I start by providing an overview of Berlin's current political landscape, especially the city's energy and (smart) urban development policies. I then zoom into the latest developments in the contested politics of Berlin's electricity grid. Finally, I describe the three so-called "future sites" - EUREF Campus, Technology Park Adlershof and TXL Urban Tech Republic - which host the three smart grid pilot projects that I investigated and formed the entry points for my analysis. This chapter thus provides a backdrop for the presentation and discussion of my results, which follow in the next chapter.

7.1 Berlin's smart and low-carbon agendas

With the rising proliferation of smart, low-carbon urban agendas, the development of technological infrastructures is once again at the center of contemporary urbanism. City governments, researchers and businesses across Germany are putting a strong focus on technological innovations to confront the looming challenges of climate change and to tackle urban energy transitions.

In line with this, Germany's capital city of Berlin has set ambitious goals for becoming a leading "smart" and leading "green" European metropolis. In doing so, the city is attempting to position itself as frontrunner in the advancement of Germany's *Energiewende* and global competitor in the field of digital industries. These aspirations are based, among others, on the city's growing self-confidence as Germany's start-up capital, spurred not least by its success at attracting increasing numbers of young, creative tech entrepreneurs each year. At the same time, the city's economy is fragile compared to other states in the country: even though Berlin's urban economy has continuously grown since 2005, the city's unemployment rate remains high, and its average income is lower than in the rest of Germany (Berlin Senate, 2016a: 50). After a long phase of economic stagnation following the city's reunification, the prospect of developing leadership in a growing industrial field is being embraced by the city government as an opportunity to secure competitive, well-paying jobs.

'Digitizing' and 'greening' the local economy are therefore among the top priorities of Berlin's government. Numerous strategies and pieces of legislation back these priorities. In 2013, the government passed a Smart City Strategy (Berlin Senate, 2015b) that details how it aims to support the equipment of numerous areas of urban life with digitized technologies in the course of the coming years. This strategy has since been complemented by a less formalized digital agenda, which outlines the city's approach to confronting the so-called digitization challenge[6]. In 2014 and 2015, the city administration also commissioned two studies called Climate-Neutral Berlin 2050 (Reusswig et al., 2014) and New Energy for Berlin (Enquête-Kommission, 2015), which were translated between 2016 and 2018 into a binding local Energy Transitions Law (Berlin Senate, 2016b) and related Energy and Climate Protection Program 2030 (Berlin Senate, 2016c). These programs and strategies all emphasize the necessity of digitizing the city's electric grid infrastructure.

[6] available at: https://www.berlin.de/sen/energie/digitalisierung/

Digitization and sustainability are viewed as key means for providing an innovative and 'ecologically responsible' economic future for the city (Berlin Senate, 2016a: 53). Both digital technologies and new energy technologies are regarded as motors for innovation and economic growth. The local government aims at turning Berlin into a thriving and competitive industrial hub for new digital and new energy (and energy-efficiency) technologies that will create well-paying jobs and generate added value in the city (Berlin Senate, 2016a: 52).

Experimentation with knowledge intensive technologies and services is one of the government's primary tools for reaching these goals. The city aims to become a "testbed" for "intelligent" and "sustainable" technologies, which it seeks to promote in pilot projects (Berlin Senate, 2016a: 52). For this reason, the Berlin Senate has designated a total of eleven so-called "future sites", which are aimed at trialing and exhibiting the city's urban development ambitions. The government seeks to support pilot projects for developing, testing and publicly demonstrating novel (energy) technologies at these sites. It envisions coalitions between university born start-ups, scientific laboratories and business incubators to collaborate at these future sites (Berlin Senate, 2016a: 53), and seeks to support the future sites by elaborating a strategic concept for their development, fostering mutual exchange, and helping them build their individual profiles (Berlin Senate, 2016a: 56). Smart grids are being tested and developed at these future sites.

7.2 Berlin's local *Energiewende*

In Berlin, as in many other cities across Germany, political interest and engagement in local energy issues has gained momentum since the country's decision to transform its energy system under the *Energiewende* framework. By passing the Energy Transition Law (*Energiewendegesetz*) and related Energy and Climate Protection Program (*Berliner Energie- und Klimaschutzprogramm 2030*), Berlin was among the first federal states to pass binding climate protection legislation. The current Senate government calls both the Energy Transition Law and the study *New Energy for Berlin*, which it is based on, the "guiding threads" (*Leitschnur*) of its energy politics (Berlin Senate, 2016a: 61). Until today, only eight out of Germany's sixteen states have passed similar laws, and a national law is still being negotiated. Moreover, Berlin was the first federal state to set a legal deadline for ending coal-fired power generation. In 2019, the urgency of the government's ambitions was further underlined by its decision to officially proclaim a state of climate emergency (*Klimanotstand*). These measures have all been passed by Senate governments headed by the Social Democratic Party. Since 2014, the city is governed by a coalition between the Social Democrats, the Left Party and the Green Party. The current Senate's overarching goal is to reach climate-neutrality by the year 2045. For this purpose, it has set ambitious CO_2 reduction targets for various sectors, including households, transport, industry, businesses, energy, and buildings (Berlin Senate, 2016c). Moreover, it has passed programs to incentivize action towards these goals, such as the "Masterplan Solar City" (2020) aimed at covering Berlin's rooftops with solar panels.

Although the city's overall CO_2 emissions have slowly but steadily decreased compared to the baseline year 1990, major efforts are still needed in all sectors. Among others, the city lags behind its energy related goals, i.e. the transition from fossil-fuel based energy production and consumption to renewable based production and consumption. Currently, the city is still mainly powered by nine fossil-fuel based energy generation plants, three of which are coal-fired, three are natural gas-fired, two are based on oil, and one is based on the incineration of municipal waste (Bundesnetzagentur, 2020a). In 2017, Berlin's coal-exit was initiated when the city's last lignite-fired power plant (*Braunkohlekraftwerk*) was shut down and converted into a gas-fired power plant. By 2030 the same is expected for the three remaining hard-coal fired power plants (*Steinkohlekraftwerke*). Yet, while the city's coal-exit plans seem to be underway, its ambitions to expand renewable energy generation have largely failed: to this day, only about 2% of the city's energy are produced from wind, solar or biomass plants (Statistisches Bundesamt, Stand 2019). Similarly, its Masterplan Solar City, a program that aims to cover 25% of Berlin's energy consumption via solar energy by the year 2050 has rendered only meager results. By 2019, only 0,109 MWp out of the necessary 4.400 MWp had actually been installed (Berlin Senate, 2020). The same is true for the city's goal to install 1000 electric vehicle loading stations by 2018. By 2020, only 612 loading stations has been installed (Bundesnetzagentur, 2020b). In sum, the city of Berlin has set ambitious political targets for transforming its energy economy and is now struggling to reach them.

Especially in the German context, notions of decentralization and prosumage have gained widespread attention since the country's *Energiewende* policies have made small-scale renewable energy generation hugely popular throughout the country. Since the government's policy turn-around in 2011, distributed renewable electricity generation has experienced a steep increase from approx. 0.9 million in 2010 to 1.9 million units in 2020 (BDEW, 2020). Homeowners and small energy cooperatives throughout the country have invested huge amounts of private capital into solar panels and wind energy generation plants, and thus demonstrated their willingness and potential to contribute to Germany's clean energy transition. The distribution of (renewable) energy generation between many private households instead of few large electricity companies is viewed as one of the *Energiewende* policies' major achievements and reason for its continuous popular backing. In the German context, decentralization and prosumage are therefore commonly viewed as backbones of the country's future energy system (Agora Energiewende, 2017).

In this same vein, the Berlin government has committed to transforming the city's energy supply system into a "completely decentralized" and renewable energy system (Berlin Senate, 2016a: 63). This endeavor is backed by an independent energy commission that recommends the continuous integration of "decentralized supply" into Berlin's grid structure (Enquête-Kommission, 2015: 16), and the city's Energy and Climate Protection Program, which promotes the use of "decentralized facilities of energy production" in a "smart, decentralized energy market" (Berlin Senate, 2016c: 14, 28). Among other things, these urban policy documents promote decentralized energy production and trading on the basis of what they call "micro-prosumage" (*Kleinstprosumer*). To this end, Berlin's municipal government has launched a "Masterplan solar city" that aims to make rooftops and façades available for the generation of renewable electricity, and which has been complemented by instruments to facilitate so-called "landlord-to-tenant" electricity supply (*Mieterstrom*).

Yet distributed energy generation and prosumage are still marginal phenomena in the city. In Berlin - as in other German cities - this is in large part due to the high proportion of tenants (as opposed to home owners) without access to rooftops for installing solar panels. In 2018, only approx. 17 % of Berlin's inhabitants owned their homes, while the majority were tenants (Amt für Statistik Berlin-Brandenburg, 2019). Berlin's Masterplan Solar

City therefore targets rooftops on public buildings as a first step towards more urban renewable energy generation. Moreover, the regulation guiding Germany's liberalized and "unbundled" electricity market prohibits combined electricity production and trading and has thus kept private building owners from potentially selling rooftop solar electricity to their tenants. This obstacle was removed with the federal "Landlord-to-Tenant Electricity Supply Act" (*Mieterstromgesetz*), which was passed in 2017 with the specific goal of turning urban rooftop owners into actors on the electricity market and agents of Germany's urban *Energiewende*. Yet in Berlin, this Act has not had the sweeping effect initially expected. Instead of reaching small-scale private building owners, it has mostly spurred the initiative of few large housing companies. Despite the Solar City Masterplan and the Landlord-to-Tenant Electricity Supply Act, in 2020 only 12 % of newly built rooftop area in Berlin were being used for solar electricity generation (Wolf, 2021). All in all, the amount of renewable electricity being generated within the city of Berlin in 2018 amounted to approximately 5 % of the city's total electricity generation (Agentur für Erneuerbare Energien, 2021). In terms of distributed storage, the city faces a similar picture. The Berlin government has set out to integrate the extensive existing electricity, gas and district heating networks, and connect them to prosumage households (Berlin Senate, 2016c: 14). It envisages electricity storage as decentralized component of a smart energy management system that increases grid stability and fosters small-scale prosumage (Berlin Senate, 2016c: 14). Among others, it seeks to develop the use of power-to-heat and power-to-gas technologies for converting locally produced (excess) electricity into heating and gas, and thus increasing energy-efficiency and fostering local consumption (*Eigenverbrauch*). In addition, the government has set out to expand the small-scale use of combined heat and power plants (CHP) in private homes and rental complexes. Taken together, these measures all represent a strong effort towards realizing ideas of decentralization and prosumage in the city. The Berlin government is seeking to involve its citizens in the creation of a participatory, inclusive, and distributed future energy system. Nevertheless, in terms of implemented capacities, the small-scale decentralized production, consumption and storage of renewable electricity is not yet a relevant building block of Berlin's urban *Energiewende*.

Not surprisingly, the Berlin Senate is constantly reminded of its shortcomings by a vibrant local NGO community. This community includes alliances such as "Kohleausstieg Berlin" and "Berliner Energietisch", the cooperative "BürgerEnergieBerlin", the Berlin chapter of "Friends of the Earth Germany" and many more. A number of these NGOs have established themselves as respected experts and political players who are regularly consulted by the government on energy and climate issues. For example, two out of ten seats in the independent "Climate Protection Council" (*Klimaschutzrat*), which the Senate established in 2016, are reserved for representatives of civil society organizations and currently held by "BürgerEnergieBerlin" and "Friends of the Earth Berlin". Together with representatives of the city's most important utility companies, research institutions, housing corporations, the local Energy Agency and the local Chamber of Commerce, they regularly advise the Berlin Senate on energy and climate policies.

In the past few years, civil society organizations have also gained significant influence on the politics of Berlin's electricity grid. Since 2014, "Berliner Energietisch" and "BürgerEnergieBerlin" have effectively led campaigns to end private ownership of the grid and to reinstate a public grid operating company. In doing so, these two citizen-led initiatives have effectively put Berlin's electric grid back on the political agenda, and all but uprooted the city's decade-old infrastructure-related liberal market paradigm.

7.3 The contested politics of Berlin's electricity grid

Berlin's electricity grid is one of the largest distribution grids in the country. It covers an area of almost 900 km² with approximately 35.000 km of electric lines serving about 2.3 million households (Stromnetz Berlin GmbH, 2020). The grid is owned by the Swedish multi-national power company Vattenfall GmbH, which also holds the public concession to operate it. Vattenfall's subsidiary company, Stromnetz Berlin, is responsible for grid operation.

Until the late 1990s, Berlin's energy infrastructure belonged to the city-owned utility company Bewag. During the 1990s, however, the liberalization of Germany's energy market led to a wave of privatizations. The city's power plants and energy networks, including its electricity grid, district heating grid and gas network were sold to private companies. In 2001, Berlin's electricity and district heating grids were taken over by Vattenfall[7]. In addition to this, the company also owns and operates the city's nine major energy generation plants.

While the privatization of Berlin's public energy infrastructure and utilities went largely unnoticed in the 1990s, the same issue is highly disputed today. Most notably, two widely supported citizen-led initiatives – "Berliner Energietisch" and "BürgerEnergieBerlin" - have challenged the status quo by campaigning to buy back the electricity grid from its current owner Vattenfall. These initiatives have put not only Vattenfall, but also the Berlin Senate under considerable pressure, and have sparked public awareness for an otherwise 'invisible' issue.

Two events stand out: Shortly before Vattenfall's concession to operate the grid expired in 2014, "Berliner Energietisch" initiated a popular referendum aimed at forcing the Berlin Senate to reinstate public ownership of the city's energy infrastructure, including its distribution grids. The referendum was inspired by a similar initiative in Hamburg, which had successfully driven the city's authorities to establish a public grid operating company and buy back the electricity grid in 2009. While the referendum in Berlin failed (due insufficient voter turn-out), it put energy infrastructure back on the city's political agenda. The referendum provoked a heated debate within Berlin's political landscape, mobilizing wide civil society support and broad media coverage. This level of public attention helped another major citizen-led initiative - "BürgerEnergieBerlin" - to gain momentum. By 2016, this community-based energy cooperative had attracted enough members and mobilized enough financial capital to put forward an official bid in the city's call for tenders for the grid concession. Meanwhile, it had also convinced the Berlin Senate to support its initiative and create a public utility company (*Stadtwerk*) that partnered with BürgerEnergieBerlin in their official bid. After four years of legal quarrels with Vattenfall, BürgerEnergieBerlin finally reached its goal in March 2019: together with the city-owned utility, BürgerEnergieBerlin was finally awarded the concession to operate the city's electricity grid. However, Vattenfall again took legal action against this decision. Only in late 2020, Vattenfall finally conceded to sell the grid to the public authorities, and the deal was finally sealed in mid-2021.

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[7] https://www.berlinenergie.de/ konzessionsverfahren/gas-und-stromgeschichte

Berlin's electricity grid is therefore currently at the forefront of political debates, not only over infrastructure, but – as Beveridge and Naumann argue – over "promoting new urban futures" (Beveridge and Naumann, 2016). Berlin's electricity grid has become a highly politicized, highly disputed issue, "with discourses of both radical and reformist change apparent, and the current and future roles of the state, civil society and private sector heavily contested" (Beveridge and Naumann, 2016).

Although *smart* grids are not among the top priorities of these citizen-led initiatives, they are being developed within a highly politicized context, which exposes some of the most radical visions and controversial positions regarding the ways in which energy could and should be governed, traded, used and managed in the city.

7.4 Berlin's future sites

Since 2012, Berlin's urban administration has designated a total of eleven so-called "future sites" (*Zukunftsorte*) for pioneering and showcasing different kinds of novel digital technologies (Berlin Senate, 2016a: 55). These are: Technology Park Adlershof, Biotech-Campus Berlin-Buch, Campus Charlottenburg/City West, Clean Tech Business Park Berlin-Marzahn, Berlin Eastside, EUREF-Campus Schöneberg, Humboldthain, Schöneweide, IGZ Fabeckstraße, the site of Tegel airport for Urban Tech and the site of Tempelhof airport for the creative industry. At least three of these sites are dedicated – among other things - to the development of smart grids. These are the the Technology Park Adlershof, the EUREF Campus and the TXL Urban Tech Republic.

Berlin's future sites form part of the city's technology and innovation politics and are explicitly aimed at attracting high-tech businesses and a qualified international workforce to the city[8]. Their main goal is to strengthen the knowledge economy by attracting science-based industries and technologies, and "turning knowledge into jobs" (TSB Technologiestiftung Berlin, 2012). Among others, the future sites are supposed to provide spaces for creating personal networks between tech-oriented businesses and tech-oriented research institutions through physical proximity. The future sites are therefore a strategic instrument devised to forge connections between Berlin's well-established scientific institutions and the corporate-industrial world to incentivize regional economic growth.

For this reason, Berlin's future sites fall under the responsibility of the Senate Department for the Economy, Energy and Businesses (SenWEB), where they are part of the Economic Division, together with programs concerning electric mobility and the smart city. In 2017, SenWEB launched the future sites' joint managing office, which is funded by a program for the "improvement of the regional economic structure (GRW)"[9] and run by city-owned project development company WISTA Management GmbH. It is the office's explicit mandate to solidify the future sites as a brand, and thus to increase Berlin's visibility and competitiveness as a knowledge based economic hub in regional, national and international markets[10]. WISTA acts as mediator between the interested

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8 https://www.berlin.de/sen/wirtschaft/wirtschaft/technologiezentren-zukunftsorte-smart-city/zukunftsorte/artikel.109346.php

9 https://www.berlin.de/sen/wirtschaft/wirtschaft/technologiezentren-zukunftsorte-smart-city/zukunftsorte/artikel.109346.php

10 https://www.berlin.de/sen/wirtschaft/wirtschaft/technologiezentren-zukunftsorte-smart-city/zukunftsorte/artikel.109346.php

public and the future sites. Among others, it promotes the future sites via a website that bundles information, provides news, and advertises location specific events. Their common branding creates a joint platform and entry point mostly for external parties.

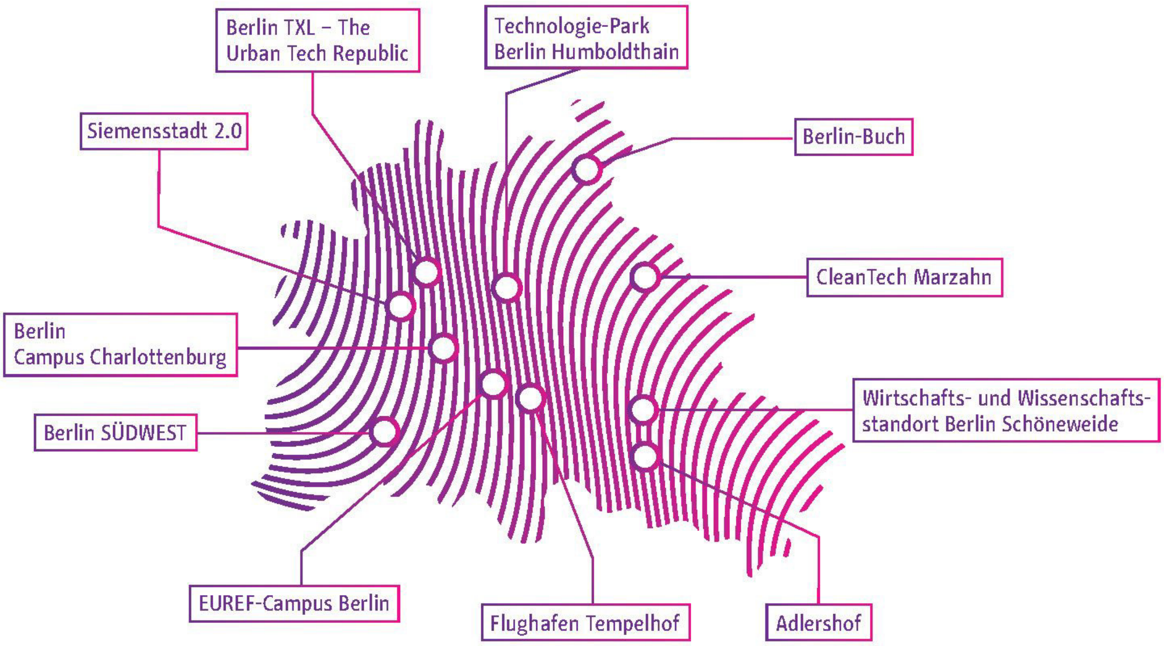

Figure 4: Location of Berlin's future sites in the city © Zukunftsorte Berlin / WISTA Management GmbH

On the ground, however, the future sites are marked by many differences, including their size, historical backgrounds, goals, sets of actors and institutional set-ups. Although the Senate has provided an institutional umbrella, the future sites each work independently, with hardly any institutionalized ties or overlaps.

The most fundamental difference between the three future sites in this analysis is their state of actualization: while the development of Technology Park Adlershof and EUREF Campus is well underway, activities at TXL Urban Tech Republic have been stalled due to problems with the project site – the city's former airport. Instead of being replaced in 2012 as originally planned, the airport remained in use until the fall of 2020 and TXL Urban Tech Republic continued in a state of seemingly never-ending expectation: always at the brink of realization, but never implemented. The material gathered in relation to this site is therefore informed by plans and aspirations rather than the details of actualization.

7.4.1 Technology Park Adlershof

Technology Park Adlershof is the oldest and most developed of Berlin's future sites, and therefore viewed by the government as role model for the development of all other future sites (Berlin Senate, 2016a: 90). Unlike EUREF and TXL, the site has a long history of hosting research, military, technology, and media related institutions. Currently, Technology Park Adlershof hosts a high-profile mix of research institutions and businesses, including more than 1.000 companies, more than 20.000 employees, and up to 7.000 students (Tagesspiegel, 2018). It covers an area of 420 ha and is likewise managed by WISTA Management GmbH.

Figure 5: Bird's eye view of Technology Campus Adlershof 2019 © WISTA.Plan GmbH / picture: D. Laubner

Its tradition as a site for pioneering research and technical innovation began with the rise of the aircraft industry in the early 20th century. Its proximity to a small airport attracted aircraft production companies and laid the foundation for what is today known as the German Aerospace Center (*Deutsches Zentrum für Luft- und Raumfahrt, DLR*), a research and development institution, which was founded in 1912. During the first and second World Wars, Adlershof developed into an important site for researching and producing military aircrafts. At the height of the Nazi regime, more than 2.000 people, including forced laborers, worked in this field at Adlershof[11]. After WWII, the site belonged to East-Berlin and was redeveloped into a space for the German Democratic Republic's (GDR) leading scientific research and media institutions. Numerous institutions belonging to the country's National Academy of Sciences settled in Adlershof, creating a hub for research in the natural sciences and engineering technologies. Apart from this, the site also hosted the country's national television agency and a regiment of guards belonging to the Ministry of National Security (Stasi). In short, Adlershof became a center for official, state-owned institutions of high public importance and rank.

[11] https://www.adlershof.de/kiez/geschichte

Figure 6: Iconic wind channel tower from the 1930s fotographed at Adlershof in the late 1980s © WISTA Management GmbH

With the fall of the Berlin Wall and Germany's reunification, most of these institutions were shut down and the site came to a standstill. Although the newly united city government quickly decided to redevelop Adlershof into a scientific and technology focused business area, it wasn't until 2003 that these developments actually materialized. The establishment of the Technology Park formed part of the government's strategy to support the area's overall development.

Over the past almost 20 years, Adlershof has enjoyed the status of a formally designated urban development zone under the city's overarching goal of becoming a "city for research and businesses" (*Stadt für Wissenschaft und Wirtschaft*). During this time, Adlershof has steadily and successfully attracted numerous businesses and research institutions. Today, it is the largest and most renowned of Berlin's future sites. According to its management, Technology Park Adlershof is also the "largest science and technology park in Germany", boasting more than 550 businesses and research institutions mostly from the natural and engineering sciences as well as various faculties of Berlin's Humboldt University and over 1.000 residential housing units, which connect it to the adjacent neighborhoods[12].

Unlike TXL Urban Tech Republic and EUREF Campus, Technology Park Adlershof is a large and well-established urban development site with a long history in science and technology-based research.

[12] https://www.adlershof.de/adlershof-in-zahlen/

7.4.2 EUREF Campus

Figure 7: 3D rendering of building development plans at EUREF Campus within its urban surroundings 2018 © EUREF AG

EUREF Campus is much smaller and much younger than Technology Park Adlershof. Launched in 2008, the campus covers an area of about 5.5 ha and currently hosts the offices of approximately 150 companies that employ a total of 1.500 people.

EUREF stands for "European Energy Forum", which links the site to its energy related history. The campus is located on the premises of the city's former gas utility and is dominated architecturally by the skeleton of a huge industrial gas tank, which served as one of the city's most modern gas production and storage plants in the late 19^{th} century. To this day, the site is well-known throughout the city for this landmark gas tank monument (*Gasometer*), which forms part of the neighborhood identity. During the Cold War, the tank was used as gas reservoir for West Berlin, but then shut down after reunification in 1995.

In 2008, after an almost ten-year period of vacancy, the site was purchased by a private developer under the city's strict condition to redevelop it into a "lighthouse" for sustainability related research, teaching and businesses. Since then, the site has evolved from a vacant lot into a bustling research and business center fully equipped with high-rise buildings, restaurants, event locations, visitor's service and beach volleyball court. The project development company, EUREF AG, has gradually refurbished three turn-of-the-century industrial buildings and constructed an additional eight new office towers. Among others, the site now provides office space for businesses especially from the energy, the mobility and the electronics sectors. These include various mobility start-ups working e.g. on electric vehicle loading schemes as well as tech giants such as Cisco and Schneider Electric. Moreover, the site hosts a number of sustainability-oriented research institutions, such as the

Mercator Research Institute on Global Commons and Climate Change and sections of TU Berlin. These research institutions offer post-graduate programs on sustainability related topics and regularly host scientific conferences on site. One of the founding ideas has been to foster collaboration and exchange between green-tech businesses and related research institutions.

In this same spirit, the site also hosts an "Infralab", a self-proclaimed co-working and co-creation project initiated by five of Berlin's large infrastructure companies. Together they are responsible for waste management (*Berliner Stadtreinigung, BSR*), public transportation (*Berliner Verkehrsbetriebe, BVG*), energy provision (*Vattenfall*), water and sewerage management (*Berliner Wasserbetriebe*), electric grid operation (*Stromnetz Berlin*) and gas provision and distribution (*GASAG*). In face of increasing transformative pressures on these large infrastructure companies, they created the Infralab to engage in mutual exchange and experimentation with new ideas for cooperation and collaboration towards what they vaguely call a "sustainable city"[13].

From the start, the project developer has built on these kinds of initiatives to promote EUREF Campus as "real-life laboratory" for the "energy revolution"[14], and encouraged the installation of technical artefacts for the interested public to see and visit. These artefacts include a roof-top solar PV plant, a biogas based combined heat and power plant, and various small wind energy generation plants. They also include different types of electric vehicle charging stations that can be accessed by the public to park and load vehicles which are part of a city-wide car sharing scheme. Other physical technologies being tested on campus include an inductive electric vehicle loading station and a top-loading station for electric busses. Most prominently, though, a self-driving passenger mini-bus was publicly tested and exhibited for a period of approximately two years, which attracted media attention well beyond the the campus' borders.

This kind of attention is welcomed and accommodated by the project management firm, EUREF AG, which regularly organizes guided tours to explain the campus history, present the LEED-certified architecture and demonstrate the various energy and other technologies scattered across campus. These tours are frequently booked by delegations of interested students, researchers, politicians and business people from across the world. They also involve a showroom, the so-called "zeeMobase", or "zero-emission energy and mobility base", which is run by the smart grid research consortium on campus, and equipped with screens, explanation videos and an interactive table-top to help explain all questions surrounding the micro-smart-grid system on campus. Apart from offering these tours, campus management has also attracted high profile events to EUREF Campus, such as international political summits and political party congresses. These events regularly attract political celebrities of national import, such as federal ministers or even the chancellor, as well as internationally renowned scientists and business people. Overall, the campus nurtures a feel-good atmosphere by mixing a combination of scientific intelligence, entrepreneurial inspiration, tasteful design and unapologetic wealth.

Although EUREF Campus is promoted as an inviting, hospitable place including hotel rooms and publicly accessible restaurants, its gated entrance and expensive high-rise architecture give it an aura of exclusivity. This

[13] https://infralab.berlin/about
[14] https://euref.de/en/welcome/

is in part due to its industrial heritage and surrounding train tracks, which have traditionally separated EUREF Campus from is nearby residential neighborhoods. It is arguably also because the site is fenced in and the entry is vigilated by a concierge. This has led to resentment from neighboring citizens who formed various civil initiatives against the owner's construction plans, but remained unsuccessful.

Figure 8: Gasometer on EUREF Campus 2018 © Christian Kruppa / EUREF AG

7.4.3 TXL Urban Tech Republic

Figure 9: Bird's eye view of Tegel airport © Geoportal Berlin / Digitale farbige Ortophotos 2011 (DOP20RGB)

Berlin TXL is a designated redevelopment area that was occupied by Berlin's Tegel airport until the fall of 2020. Although Berlin TXL was originally supposed to kick-off in 2012, the site was only handed over to its managing company, Tegel Projekt GmbH, in mid-2021. Construction and refurbishment are now set to begin in 2022. Due to this delay, it is the only one of the three future sites that hasn't entered the implementation phase. All envisaged technologies, including the site's ambitious plans for a smart grid, currently exist only in claims and on plans.

Berlin TXL occupies the premises of former West-Berlin's international airport, which operated from 1975 to 2020. First ideas for closing the airport and redeveloping its premises were voiced shortly after Berlin became the capital city of a reunified Germany in 1990. They were founded on the Senate's plan to replace its two existing, small international airports with the construction of one big new one, the now infamous BER. Although originally designated to open its gates in 2011, mismanagement heavily delayed the construction of this new airport, and the first airplane only took off from BER almost a full decade later, namely in November 2020.

Meanwhile, between 2009 and 2012, the city launched a series of workshops with six international planning teams to develop a masterplan for Tegel airport's reuse. The masterplan passed the Senate in 2013. It included plans for an industrial park called *Urban Tech Republic* and an adjacent landscape park. In 2016, due to rising pressure on Berlin's housing market, plans for a residential neighborhood called *Schumacher Quartier* were added. In 2011, shortly before BER was supposed to be inaugurated, the Senate commissioned Tegel Projekt GmbH to manage all three areas, including TXL Urban Tech Republic, the landscape park and the residential area.

Today, the entire redevelopment area of Berlin TXL comprises approximately 220 hectares for the industrial park called *Urban Tech Republic,* approximately 50 hectares for the residential *Schumacher Quartier,* and another 200 hectares of green space for the landscape park. Overall, it is therefore the largest of the three future sites. Within Berlin TXL, the masterplan envisages *TXL Urban Tech Republic* as a high-tech industrial park for research institutions and industrial firms in the field of so-called "future technologies". TXL Urban Tech Republic is supposed to provide space for approximately 1.000 private businesses, more than 17.000 employees and 5.000 students[15]. Many of the technologies potentially developed at TXL Urban Tech Republic are supposed to be implemented and used in the neighboring Schumacher Quartier.

During the twelve-year run-up to project implementation, plans for redeveloping Tegel airport were broadly debated in public, and once even seriously challenged. In 2017, a civil society initiative backed by the Liberal Democratic Party launched a city-wide referendum demanding Tegel's preservation as an airport. Although the majority of Berliners indeed voted to maintain Tegel airport in this referendum, the Senate decided to go forward with its redevelopment plans in 2018. Since then, opposition to these plans has dwindled and the airport was closed without further incidents. Today, it is arguably Berlin's most prestigious urban development project, and is seen as a city-wide development opportunity to generate jobs and positively affect the entire region (Coalition agreement, p. 90).

[15] https://stadtentwicklung.berlin.de/staedtebau/projekte/tegel/de/anlass.shtml

Figure 10: 3D rendering of building plans at TXL © Tegel Projekt GmbH / Macina

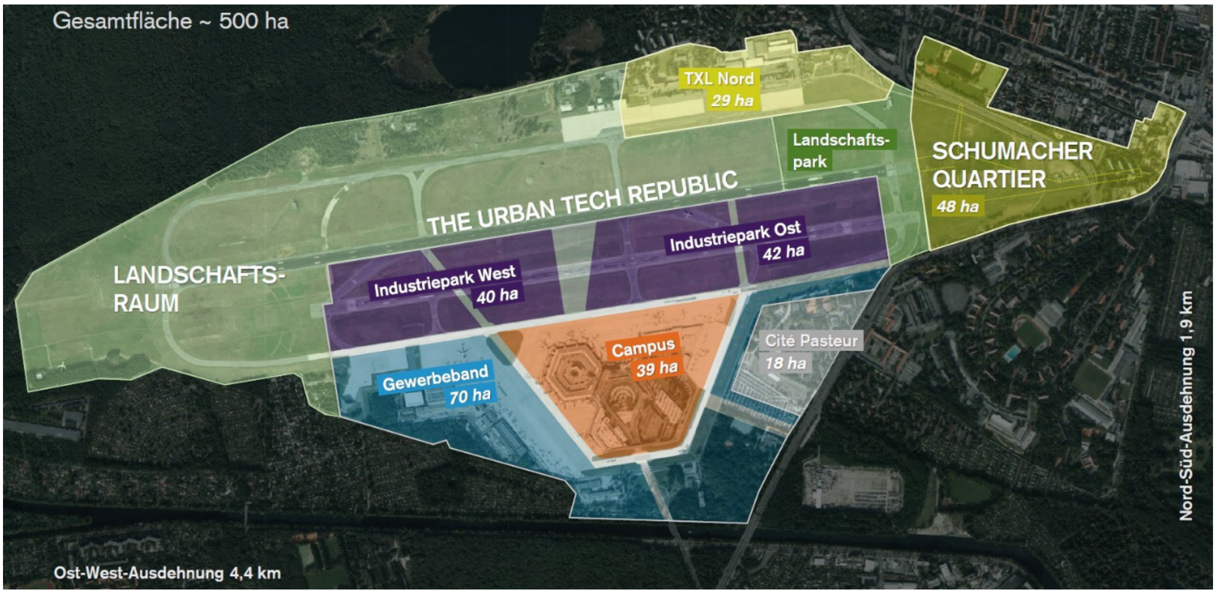

Figure 11: Schematic plan with different areas within Berlin TXL © Tegel Projekt GmbH

7.4.4 Closing remarks

Despite their differences, all three of these future sites are being marketed as “living urban laboratory” (TXL), “experimental hub” (TXL)[16], “real-world laboratory” (EUREF)[17] or innovation spaces (Masterplan Industriestadt, p.35). To this end, they all involve actors from the scientific community, private technology companies and government related actors. The smart grid pilot projects, in turn, provide the actual experimental activity.

[16] https://www.arup.com/projects/the-urban-tech-republic
[17] https://zukunftsorte.berlin/en/zukunftsorte/euref-campus-berlin/

7.5 Smart grid experimentation at Berlin's future sites

All three of these future sites involve projects to develop, test and practically implement pilot versions of smart grid technologies under 'real-life' conditions. While at TXL Urban Tech Republic, these projects are still in the planning stage, at EUREF Campus and Technology Park Adlershof, different stakeholders have been collaborating to implement smart grid pilots since 2011 and 2014 respectively. These pilot projects have thus become important spaces for negotiation and exchange, providing those involved with an opportunity not only for envisioning but also for making the urban smart grid in Berlin.

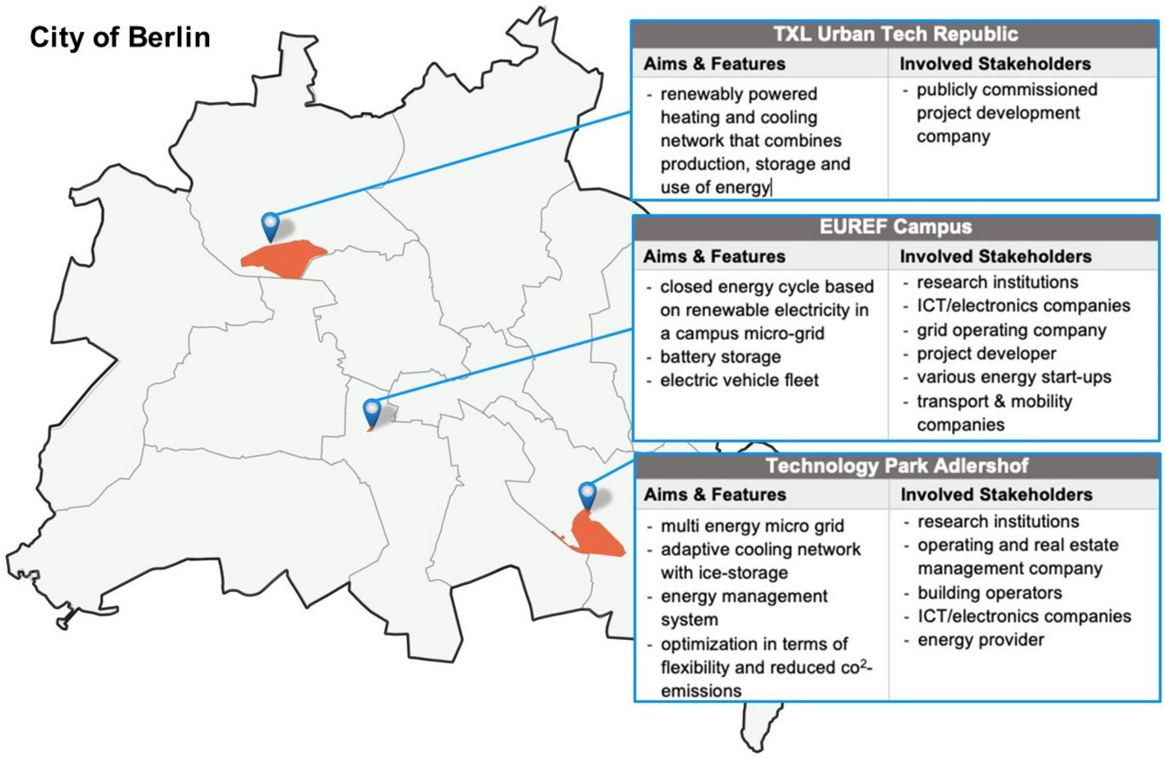

Figure 12: Location of the three future sites in the city of Berlin (own figure)

Two of the smart grid projects being pursued in these sites are headed by research consortia (at EUREF and Adlershof) and a third is headed by a publicly funded company commissioned by the city (TXL Urban Tech Republic). All three pilot projects are pursuing the connection between renewable electricity production, flexible electricity consumption and small-scale decentralized electricity storage. They circle around questions of micro-scale energy management and control and aim at finding smart grid solutions for replication in the broader context of the city of Berlin.

7.5.1 Energienetz Adlershof at Technology Park Adlershof

The smallest of the three smart grid projects is being implemented at Technology Park Adlershof and is called *Energienetz Adlershof*. It involves four partners, including two research institutions, an electronics firm, and the Technology Park's operating company, WISTA Management GmbH. Here, smart grid technologies are being used to automate an existing cooling network and connect it with a solar PV plant, and aquifer and a low-temperature storage facility (*Eisspeicher*). The smart grid project primarily aims at decreasing the energy related emissions and increasing the energy efficiency of an existing cooling process at the building level, and then expanding this knowledge to the neighborhood level. It focuses on integrating electricity, heating and cooling, because Technology Park Adlershof hosts numerous laboratory buildings with extraordinary cooling energy demand and extraordinary waste heat related energy losses.

Energienetz Adlershof was funded by the Federal Ministry of Economics and Technology (BMWi) for an initial phase of four years from 2014 to 2018 and was extended for a second three-year project phase from 2018 to 2021. In its first phase, the project's goal was to create a renewably powered, energy-efficient cooling network for a research laboratory complex. It aimed at reducing the enormous amounts of cooling energy needed to operate the laboratory processes and maintain the laboratory buildings. Its primary objective was to reduce the lab's energy related emissions and energy related costs. To this end, the project introduced an energy management system that coordinates renewable electricity generation from a solar PV plant with an aquifer for geothermal cooling, a brine-based cooling network, an ice repository as low-temperature storage facility (*Eisspeicher*), and the highly heat sensitive laboratory complex. The second project phase is dedicated to monitoring and optimizing this system.

Figure 13: Zentrum für Photonik und Optik © TU Berlin / Energienetz Adlershof

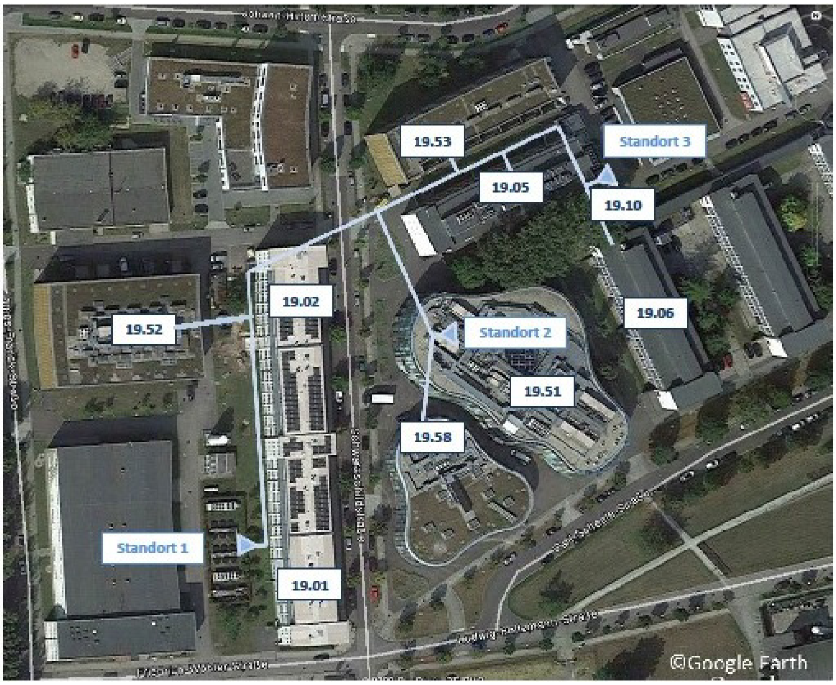

Figure 14: Site plan with laboratory buildings and cooling network © Energienetz Adlershof

In doing so, the project addresses an issue that is relevant for many other labs and businesses in the area, whose cooling energy demand accounts for a substantial portion of total energy demand across campus (Bschorer et al., 2019). The *Energienetz* project therefore forms part of a greater effort to introduce an instrument for energy related urban development planning (*Energieleitplanung*) across the broader Technology Park Adlershof. With the help of small-scale model projects like this one, the campus facility management company seeks to reduce the overall campus's primary energy demand by 30% (www.energienetz-berlin-adlerhof-de). Unlike EUREF, the Adlershof campus therefore hosts various smart grid projects that deal with diverse issues such as electric mobility (*FlexNET4E-mobility*), power-to-x technologies (*P2X@BerlinAdlershof*), and low-temperature heating networks (*Wohnen am Campus in Adlershof*). To bring them together, the *Energienetz Adlershof* project consortium heads a so-called *Smart Grid Alliance* aimed at integrating more and more campus facilities and businesses into a smart grid system. As head of this alliance, the project seeks to replicate and scale its results throughout campus and across the city. Despite its efforts to generate publicity via the Smart Grid Alliance, the project has little visibility across the wider Technology Park, because it represents only a fraction of the many other research projects and tech innovations currently being developed and tested in businesses or research institutions on site. *Energienetz Adlershof* therefore has little impact on the campus' overall development or its outside image.

The relatively small project consortium is headed by Berlin Technical University and involves two teams of researchers from the engineering and the social sciences that collaborate with an IT company, an engineering firm, and the campus facility management company, WISTA Management GmbH.

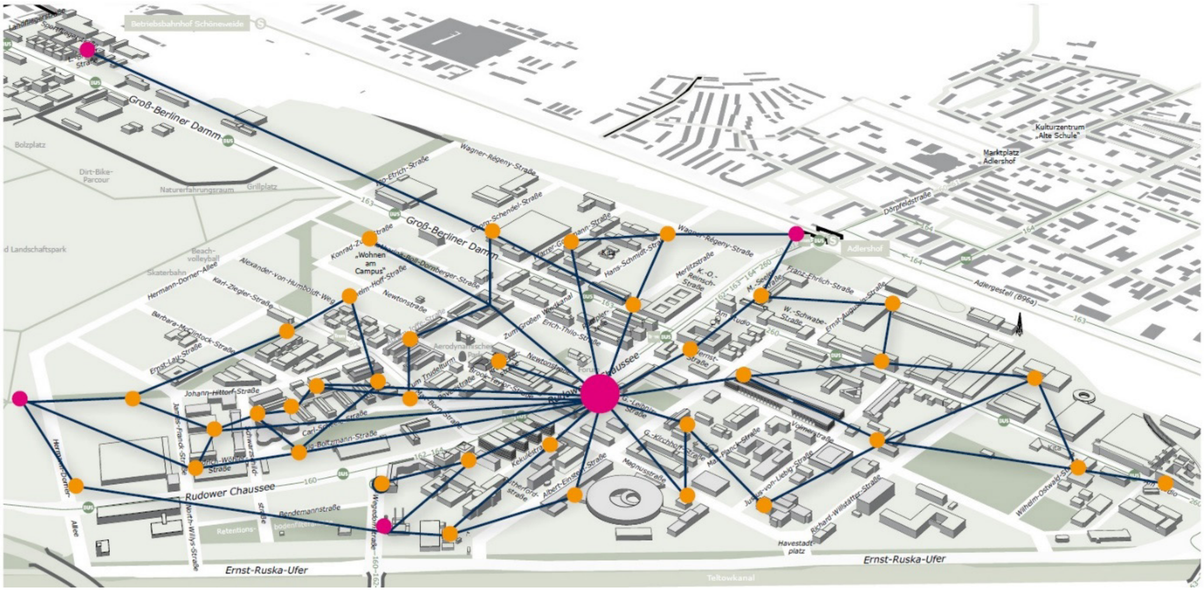

Figure 15: Schematic drawing of the smart grid project at Adlershof 2020 © WISTA Management GmbH

7.5.2 Research Campus Mobility2Grid at EUREF Campus

The largest of the three smart grid initiatives is the research driven smart grid project at EUREF Campus, which involves more than thirty partners from private firms including the local network operator, utilities, large electronics companies, and small energy related start-ups. It focuses on connecting solar PV panels, battery storage facilities and electric vehicles, and aims at linking renewable urban energy production and electrically powered traffic.

The Mobility2Grid project was launched in 2011. One of its central aims is to integrate an electric vehicle fleet into a (renewable) energy cycle and thus to test the capacity of electric vehicles as flexible energy storage. The establishment of a campus "micro-smart-grid" lies at the heart of the project. The micro-smart grid aims to connect a renewable energy generation plant with a fleet of electric vehicles, which relieve the overarching grid of excess energy by storing it in its batteries and stabilize the overarching grid by feeding electricity back into it when needed.

The Mobility2Grid project consortium comprises a total of 36 institutions and is headed by Berlin Technical University. Its six project teams involve researchers from the engineering and the social sciences, large international IT, energy and automobile companies, small energy and e-mobility start-ups, the grid operator, the national railway company, and the project development firm that owns the project site, EUREF AG. The project is funded by the Ministry of Education and Research (BMBF), and was recently awarded a third – and last - five-year project phase. This last project phase is due to begin in January 2022.

The project consortium has set out to contribute to a combined "energy and mobility transition" that will "radically transform" the structure of the electric grid into an "increasingly decentralized" system (Mobility2grid Antrag, p. 4) by developing, testing and implementing a micro-smart grid at EUREF Campus. To this end, the Mobility2Grid project involves a solar PV plant, which is connected to approximately 15 vehicle charging stations, a battery storage facility and a small refurbished garage that has been turned into office spaces. An automated energy management system equipped with sensors and control mechanisms senses how much electricity is being produced in the PV plant, how much is being used by the office space, how many vehicles are connected to the charging stations, and how full the batteries in the storage facility are at any moment in time. It then directs electric loads according to a predefined algorithm, i.e. according to demand. All loads and flows being directed through this micro-smart grid system are constantly visualized in a showroom, so that visitors can view and relate to the project. The loading stations are also associated with an electric-car-sharing fleet, which operates throughout the city and is accessible to the broader public. This way, the idea to integrate electric vehicles into a smart grid and use them as renewable energy storage is supposed to gain public visibility and acceptance beyond the campus (Technische Universität Berlin, 2012). The project explicitly targets urban areas and seeks to multiply and up-scale its results throughout Berlin and other cities.

7.5.3 Low-Exergy-Network

Plans for the smart grid at TXL Urban Tech Republic circle around combining a variety of technologies, including a heating and cooling network, a geothermal plant, vehicle-to-grid technologies, and automated building management systems. They are aimed at increasing the share of renewable energies used for powering on-site processes, and at ensuring their maximum energy efficiency.

Both the Urban Tech Republic and the Schumacher neighborhood are supposed to be serviced by a smart grid system that primarily circles around heating and cooling provision, and is combined with renewable energy production and storage in a so-called “Low-Exergy-Network” (Tegel Projekt GmbH, 2018b). The network is supposed to connect various on-campus renewable energy sources, including surplus heat from industrial processes, geothermal energy, solar thermal energy, solar electricity, a biogas powered CHP plant and electric vehicles. At its core, a so-called “Smart Grid Platform”, an openly accessible digital information hub, is supposed to serve as local market place for heating and cooling energy (Tegel Projekt GmbH, 2018b). Prosumage at TXL therefore also encompasses small-scale energy trading and direct peer-to-peer interaction.

Unlike the pilot projects at Adlershof and EUREF, the ideas for TXL’s smart grid systems are being developed by a city-owned project development company, Tegel Projekt GmbH, rather than research consortia. The company was created by the Berlin Senate in 2011 as a subsidiary of the campus facility management company that operates at Adlershof. At TXL, smart grid implementation is therefore not a matter of research but has been commissioned to private firms on the basis of public calls for tenders. Even though the TXL project site is still not accessible, concessions for configuring the smart grid platform and operating the Low-Exergy Network were awarded to private firms in 2016 and 2018 respectively.

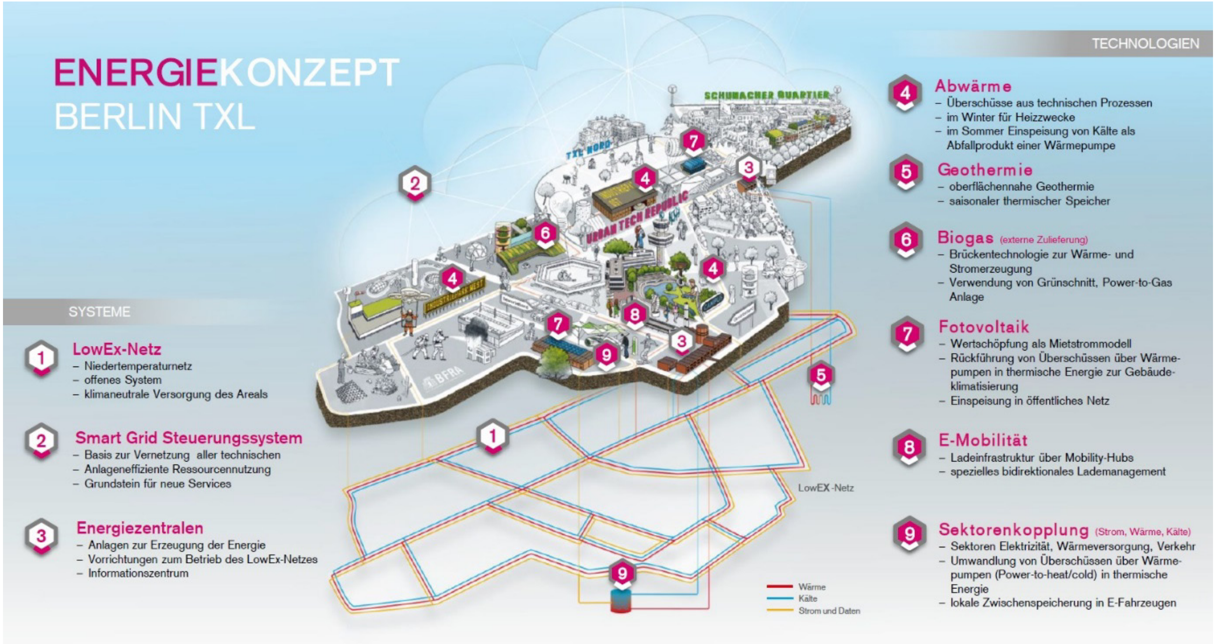

Figure 16: Energy concept including smart grid system for TXL Urban Tech Republic © Tegel Projekt GmbH

7.6 Concluding remarks

In this chapter I provided a detailed illustration of my case study, including descriptions of all three levels of my analysis: the city of Berlin, the 'future sites' and the smart grid pilot projects. Starting with an introduction to the city level, I highlighted relevant energy and urban development policies that frame the development of smart grids in Berlin, and discussed the political contestations surrounding the ownership of Berlin's electric grid. I then presented the three 'future sites' that formed part of my investigation, and thus illustrated the kinds of urban spaces and development plans that Berlin's smart grid projects are embedded in. Lastly, I described how smart grids are being (differently) developed, tested and showcased in the context of three specific pilot projects. In doing so, I also gave an overview of similarities and differences between the future sites and between the three smart grid pilot projects. In summary, this chapter provides an illustration of the case study that formed the basis for my examination. In the following chapter, I move on to show the findings resulting from my in-depth case study analysis.

8 Analyzing Berlin's smart grid discourse

In this chapter, I discuss the discourse of Berlin's smart grid futures as I encountered it at the three levels of my analysis. In doing so, I show which visions are being associated with smart grids and which meanings are attributed to these visions (for a reflection on how discourse relates to visions see chapter 6 "Research design and method"). As I laid out in my research design, I base my analysis on the sociology of knowledge approach to discourse (Keller, 2011). Based on Keller (2013), I structure my account by first revealing how different actors define smart grids as a *phenomenon* (i.e. what are smart grids portrayed to be); I then show the dominant *frames* that different actors associate with smart grids in Berlin (i.e. what do smart grids do); and finally, I present how they *classify* these phenomena and their associated qualities (i.e. are smart grids good, bad, interesting etc.). Together, the definitions, frames and classifications create dominant *storylines* that produce Berlin's imagined smart grid futures. These storylines reveal the different underlying worldviews that different groups of actors associate with urban smart grid futures, exposing the different value systems and convictions that these actors embrace. In short, these storylines convey the *meanings* behind Berlin's imagined smart grid futures.

I cluster my findings according to actors on the one hand and levels of analysis on the other. This way, I show how certain actor coalitions have formed around dominant storylines, and how they are (re-)inforcing these storylines across spatial levels despite their diverse interests and agendas.

It is important to note that the dominant storylines outlining Berlin's imagined smart grid futures are nourished not only by the discourse on smart grids, but also by adjacent discourses for example on the smart city, urban energy transitions and urban experimentation. These adjacent discourses are relevant to my topic, but I do not claim to have analyzed them in full. Instead, these adjacent discourses contribute to the dominant storylines that are being promoted in relation to smart grids in Berlin, for example through overlaps or contradictions, consistencies or inconsistencies, additions or omissions.

8.1 Defining urban smart grids: between umbrella term and empty label

The way actors in the Berlin smart grid community define smart grids sheds light on what they mean when they use the term. Especially in a transdisciplinary context, understanding different actors' definitions of smart grids can help understand their arguments or positions. Are smart grids predominantly understood as energy technologies or as information and communication technologies? Are they chiefly characterized as technologies or as services? Are they portrayed as means for coordinating infrastructures or coordinating people? Answering these questions can give insights into what actors mean when they refer to smart grids and thus reveal their values, convictions and priorities when it comes to imagining the future smart grid city.

The term 'smart grids' is essentially vague, and therefore interpreted differently by different actors. In Berlin, the technologies associated with smart grids vary considerably. Although all actors in my analysis associate smart grids with ICT, they also associate them with myriad other technologies, services and qualities. The most dominant associations are with renewable electricity, sector-coupling, electric mobility, heating, cooling, data management, steering technologies and technologies for coordinating infrastructures and coordinating people.

Moreover, notable differences exist between actors who say that smart grids have been successfully implemented in Berlin and those who say they have not. The ambiguity of the term and the controversy over the physical existence of smart grids in Berlin raises questions about smart grids as subjects and objects of communication: If nobody can agree on a definition, what is the value of their communication? And if nobody can say if a smart grid exists, how does their communication relate to the real world?

8.1.1 Smart grids as wishlist of technical artefacts

In Berlin, smart grids are associated with a variety of different technologies and artefacts. Not surprisingly, most actors identify their own area of technical expertise as central to the definition of smart grids. As a result, the network operator defines smart grids primarily as grid technology, energy companies define them as energy technology, mobility researchers define them as electric mobility technology and electronics companies define them as data and electronics technology. Although these definitions all overlap, they emphasize different qualities and thus point to different interests and future imaginaries that are being associated with smart grids in the city.

The network operator primarily describes smart grids in terms of their basic hardware, i.e. wires, cables and data protocols. In an interview, a representative defines smart grids as "primary technologies or the so-called hardware, such as cables and grid stations […] and the secondary technologies or steering and control technologies, that use data and information and impulses to steer the electric grid" (Interview, grid operator I 2018). This very practical understanding of smart grids is stripped of any higher-level concerns, such as energy transitions or the like. Instead, the network operator has a functional interest in smart grids as instruments to ease network operation and ensure stable electricity flows. It views smart grids as possibility to attain more energy information, especially in the low-voltage network, and thus enable more efficient control, but not primarily as means to integrate renewables (personal interview, grid operator II, 2018). In another interview, a different representative of the network operator associates smart grids mostly with the absence of grid-related problems: "If you aren't hearing or seeing or thinking about the grid, then it's smart" (personal interview, grid operator II, 2018). Put differently, if operations are smooth and electricity flows are stable then the grid is smart. For the private network operating company, Stromnetz Berlin, smart grids are therefore mostly about improving its own job of grid operation, which it narrowly understands as enabling smooth and steady electricity flows. The public utility company, Berlin Energie, conveys a similarly pragmatic understanding of smart grids as technical infrastructures. On its website and in interviews, Berlin Energie associates smart grids primarily with the possibility of physically combining cables and pipelines and integrating their management into one overarching maintenance system. In the company's communications, these visions pertain to the gas, electricity and heating networks, and are explicitly about the infrastructural hardware. Its main interest, like Stromnetz Berlin's, seems to be in perfectioning smooth and efficient operations rather than in developing a new energy system.

For energy start-ups and researchers involved in implementing smart grids at Berlin's future sites, by contrast, smart grids are primarily about new kinds of energy generation and energy storage technologies. For them, smart grids are mostly about the addition and integration of novel energy-related technologies and services into the existing grid system. The research consortia at Adlershof and EUREF Campus primarily understand smart grids as bridging technology between renewable electricity production and cooling or mobility technologies respectively. Perhaps not surprisingly, for those researchers interested in questions of electric vehicles, smart grids are very much about mobility technologies, whereas for those interested in heating and cooling, they are very much about heating and cooling technologies. For a leading employee of an energy start-up at EUREF, smart grids consist of "wind power plants, solar power plants, cables, cars, loading stations, transformers, low voltage system, medium voltage system, steering elements, software, supercap" (personal interview, energy start-up, EUREF, 2016). This definition clearly extends beyond the definition offered by the network operator and the public utility company; it extends beyond technologies needed to steer the grid and includes new energy and mobility related technologies that are connected to it. As a researcher at EUREF states: "A smart, decentralized grid tries to bring key sectors such as energy, heating and mobility supply to 100% renewables" (personal interview, researcher, EUREF, 2017). For energy start-ups and researchers at EUREF, smart grids are thus mostly about integrating mobility with energy (personal interview, researcher, EUREF, 2016), and their underlying interest isn't primarily to guarantee smooth flows, but to integrate renewables, and to do so by integrating end users (M2G Antrag, p. 47). Similarly, for those researchers working on questions of heating and cooling, smart grids are strongly about integrating heating and cooling technologies. A researcher at Adlershof defines smart grids as "more than an intelligent electricity network; they are an extended intelligent electricity network, combined with other media, energy media, such as heating and cooling" (personal interview, reseacher Adlershof, 2018). The understanding of smart grids as portrayed by energy start-ups and researchers goes way beyond smoothly operating the grid. Unlike the network operator or the public utility company, researchers currently involved in smart grid implementation focus on extending and overhauling what is currently understood as "the grid". For them, smart grids are not about making operations smoother, but arguably about radically changing the networked electricity system as we know it today.

Not surprisingly, for software engineers and electronics companies, smart grids are mostly about data and electronics. For them, smart grids are primarily an automation solution (interview, electronics company, Adlershof, 2018) and a data project (personal interview, electronics company, EUREF, 2018). Unlike any other actors, software engineers and electronics companies also define smart grids in terms of their very specific technological intricacies. As one software engineer specifies:

> "the grid is only smart if it involves anticipatory logics in the energy system. It is not yet smart when algorithms make the system automatically react to certain triggers, such as a certain threshold of solar energy that is currently being produced. It becomes smart when it starts anticipating these thresholds" (personal interview, researcher II, EUREF, 2017).

According to this definition, smart grids are essentially a combination of sensors and automatic control mechanisms that are equipped with artificial intelligence, and that react not only to real-time information but learn to anticipate this information and react to it in advance. For this software engineer, smart grids therefore go along with entirely new energy-related logics and new IT-related questions. Of course, ICT companies view these new logics as opportunity to develop new markets to sell their products. They are interested in developing "off-the-shelf software" (personal interview, electronics company, Adlershof), at bringing their "solutions, components, products to the table" (personal interview, electronics company, EUREF, 2016), at "introducing digital added-value processes" (personal interview, electronics company, 2018) and selling "standardized products" (personal interview, electronics company, 2018). One representative openly admits:

> "Our main interest is what do energy producers, network operators, metering stations need? Those are the companies to which we then sell our products" (personal interview, electronics company, 2018).

In sum, software engineers and electronics companies define smart grids very much in light of the products they want to sell. Consequently, they view smart grids as an engineering feat and a marketing tool rather than an energy system revolution.

Project managers at EUREF and TXL might ultimately mean the same things but have a completely different focus when they speak of smart grids. They define smart grids primarily as integrated facility management technologies, i.e. as technologies for automatically controlling lighting, heating and cooling energy demand within buildings. Although this might inherently entail the forecasting technologies mentioned by the ICT companies and the software engineers, project managers clearly focus on the building services rather than the IT. Their concern is with blinds, valves, heaters and air conditioners rather than algorithms.

To conclude, smart grids signify different technologies for different actors. Some view them mostly as hardware, others as software, still others emphasize services such as lighting, heating, cooling, or mobility. This bandwidth of understandings shows that the term "smart grids", even in purely technical terms, is essentially vague. It also shows that, even though definitions overlap, the emphasis and the priorities that different actors attach to smart grids vary considerably.

8.1.2 Smart grids as tools for coordinating people

Even though most actors in this analysis predominantly define smart grids in technical terms, some also explicitly depict smart grids as social and political phenomena. They view smart grids as various complex combinations of services and people. This view does not stand in opposition to their dominant technical understanding of smart grids but accompanies it as a side thought or subordinate concern. It is voiced mostly by actors involved in smart grid implementation at the pilot projects.

Although the technical understanding clearly dominates in the city administration's documents and programs, they also speak of networks that will "connect energy consumers and producers" (Smart City Strategy, p. 31), and a representative of the city administration defines smart grids as "coordination of actors within the grid" (personal interview, SenWEB, 2018). The same representative is certain that a smart grid will require "many actors" (personal interview, SenWEB, 2018). This definition emphasizes the importance of actors – not technologies - in the grid system. It thus acknowledges the necessity of coordinating people as much as of coordinating resource flows.

Various actors, especially those involved in smart grid implementation at the future sites, display a sensitivity toward the social and the political dimensions of smart grids. In the pilot project at EUREF Campus, smart grids are called a "complex coordination feat" (M2G-Antrag, p. 16). A researcher at EUREF even calls smart grids a "discourse community" (personal interview, researcher, EUREF, 2017), and a project manager calls them tools for "social and technical communication" (personal interview, project management, EUREF, 2016). This shows that in the context of project implementation, some actors understand smart grids not merely as technical artefacts but also as tools for inter-personal communication and as networks for coordinating people. These actors acknowledge the potential of the term "smart grids" to bring people and projects together, even calling it a "programmatic umbrella" (personal interview, researcher, EUREF, 2017). Yet, some actors involved in the pilot projects also show a heightened awareness for the politics that work as barriers or obstacles to smart grid implementation. This becomes clear in a statement by another researcher at EUREF Campus who calls smart grids a "multi-faceted set not only of technological but also of political integration problems that need to be solved" (personal interview, researcher II, EUREF, 2017). This points to an awareness for questions of interests and power inherent in smart grids. It is mirrored by a project manager at TXL who calls smart grids "a legal headache" (personal interview, project manager TXL, 2017).

Still others involved in smart grid implementation emphasize the need for trained personnel to make smart grids work. Especially software engineers and electronics companies point to the importance of knowing how to handle and maintain smart grids as a social prerequisite for their implementation. They are acutely aware of the necessity to train industrial mechanics and janitors, for example (personal interview, electronics company II, 2018, and energy start-up EUREF, 2016), and of the amount of time this can take.

The network operator sees this the same way. As a representative of Stromnetz Berlin states:

> "the smart grid [….] doesn't only work because of the technology, but also because of the people that assemble and operate the technology; and because of the people that invent it, […] and that plan it" (personal interview, network operator II, 2018).

As these quotes show, actors involved in the day-to-day handling of grids, valves or algorithms are keenly aware of the need to train and capacitate people to make these technologies work. They are thus highly conscious of the social nature of smart grids. Actors that are involved in the pilot projects for other reasons and in other roles, for example as researchers motivated by an energy ideal, are more aware of the political and regulatory landscape that smart grids are embedded in. Their understanding of smart grids is thus more political and more systemic.

To conclude, several actors in Berlin communicate a (vague) notion of smart grids as social and/or political phenomena and thus convey a certain awareness for the social and political dynamics inherent in these technological infrastructures. However, this awareness does not dominate the discourse but is instead enmeshed in a dominant definition of smart grids as technical artefacts.

8.1.3 Smart grids as empty signifier

At the same time, some of these same actors portray smart grids as little more than a marketing slogan or even a hoax. One civil society organization calls smart grids a "hype" and a "battle cry" (Interview, BUND 2018), and an energy start-up states that "everybody likes them, but nobody knows what they are" (interview energy start-up, EUREF, 2016). Even the network operator notes that "'smart' is such an amorphous term" (personal interview, network operator II, 2018). Still others mockingly ask "is it something to eat? What does it look like? Is it a monitor? What is it?" (Interview project manager, EUREF, 2016). Even those involved in the pilot projects are cautious about defining smart grids. One interviewee states that "there is no such thing as a smart grid […], only different degrees of an ever more decentralized and intelligent network" (Interview, energy start-up, EUREF, 2016). This understanding shows that smart grids as a phenomenon are also associated with uncertainty and even defiance.

While most actors involved in the pilot projects display engaged enthusiasm when asked to define smart grids, EUREF Campus management stands out as exceptionally doubtful: "I'm afraid that smart grids, or intelligent facility management or sustainable buildings, or all of these anglicisms, that everyone understands them differently" (personal interview, project manager, EUREF, 2016). The same project manager doubts that the real-time visualization of electricity flows to and from the solar paneled rooftop, the battery park, the EV-loading stations and the electric vehicles at EUREF is even real: "Currently nothing is being measured […] that's a film playing […] those aren't real-time data, come on!" (personal interview, project manager, EUREF, 2016), and adds: "You know, lots of people here are full of hot air" (personal interview, project management, EUREF, 2016). Even though this is a unique perspective, it is worth mentioning, because it confirms the NGO representative's notion of smart grids as a hype or a battle cry. Although this project manager seems utterly unimpressed by how smart grid implementation is advancing, he embraces the show: "I really couldn't care less if that's a film playing down there or if that's really electricity" (personal interview, project management, EUREF, 2016). This manager's position shows that smart grids can be understood as hollow but useful marketing tool.

There is also considerable disagreement about whether smart grids physically exist in Berlin or not, i.e. whether the pilot projects have successfully built a material infrastructure or only a virtual simulation. Actors involved in smart grid implementation at the future sites are skeptical. Neither researchers nor project managers see implementation at an advanced stage. A project manager at EUREF is quite clear about this: "I don't think we have a smart grid yet, and there is no smart grid anywhere in Berlin", adding that "those technical components take place on power point presentations" (Interview project manager EUREF, 2016). A leading researcher in the Mobility2Grid project confirms that the research consortium has "experimentally plugged some things together, and then plugged them back apart, but there is no closed, truly decentralized smart grid" and then adds: "what we have here is more of a demonstration facility, […] but we don't have a productive smart grid" (personal interview, researcher, EUREF, 2017). The same researcher, however, is certain that a veritable micro-smart-grid was operating on campus in the years from 2012-2013 (personal interview, researcher, EUREF, 2017).

Public administration, by contrast, is cautiously optimistic about the degree of smart grid implementation in Berlin:

> "at the ten future sites, let's pick Adlershof as an example, [the project management company] has already implemented a lot of intelligent things. They might not fit our target image of smart grids, but they contain many components of what that will need" (personal interview, SenWEB, 2018).

Public administration is therefore optimistic that smart grid implementation is underway, if not at its final stage. At the same time, its representative doubts if the integration of smart grids into existing – not newly planned - neighborhoods will ever succeed, stating that "the question is whether smart grids will ever be implemented into existing buildings and neighborhoods. I'm still skeptical" (personal interview, SenWEB, 2018).

8.1.4 Concluding remarks

In the end, most actors in this analysis understand smart grids primarily as technical artefacts that circle around their own primary research, business or marketing interests. Their engagement with smart grids is driven by different positions and priorities, which make them attach different meanings to the term. These differences don't, however, result in open conflict. None of the actors insist on their specific definition or their specific focus. The only real controversy that exists over smart grids in Berlin seems to boil down to personal animosities between a project manager and a research consortium at EUREF. Instead, communication via project documents, urban programs, advertisements, and personal interviews conveys a vagueness and general openness regarding the meaning of the term. Having a vague notion of what smart grids are or could be is clearly enough for all actors to engage. In this sense, smart grids can be viewed as abstract aspirations or reference points rather than as concrete goals. They seem to have a guiding function that mobilizes people's interests and ambitions yet is flexible enough to allow various interpretations. In this sense, smart grids can be understood as a *Leitbild* (Dierkes et al., 1992).

At the same time, my analysis shows that the vagueness of the term also evokes a certain skepticism towards the existence of smart grids on the ground. While the vague notion of smart grids is able to move people in a common direction, it also leaves room for interpreting what has been achieved in terms of material infrastructures and what hasn't. In effect, the vagueness of the term creates a broad range of expectations that complicates the definition of success.

8.2 Framing urban smart grids: between technical solutions and social change-makers

The discursive frames used to describe smart grids reveal what kinds of things smart grids are supposed to do and what kinds of problems smart grids are supposed to solve. In Berlin, smart grids are being framed first and foremost as *technical solutions*. A broad coalition of actors across all three levels of my analysis is framing smart grids primarily as technical devices for a) implementing the Energiewende, b) improving energy management, c) introducing smart and high-tech innovations, d) boosting the local economy, and e) fostering decentralization and prosumage. These dominant frames have implications for the storylines that emerge out of the overall discourse, because firstly, they emphasize the technical - not the social - components of smart grids, and because secondly, they relate smart grids to certain technical problems and not others (for example energy management but not cyber security). Although the frames being promoted by the dominant actor coalition are relatively coherent across all levels of my analysis, scrutiny also reveals subtle underlying differences. Among others, the technical framing of smart grids is accompanied by a discursive ambiguity towards questions of power and influence, decentralization and prosumage. Even though power and influence arguably play an important role in the deployment of smart grids in cities, their technical framing is – surprisingly - drowning out these issues.

8.2.1 Implement the *Energiewende*

Smart grids are being framed first and foremost as technological innovations that will help to implement Berlin's energy transition and lead the way into a post-fossil, low-carbon urban future. Most actors therefore promote smart grids as sustainable and resource efficient, i.e. as 'green' technologies, and as tools for integrating (more) renewable energies into the electricity system. This is especially true for public administration and researchers involved in project implementation.

The Berlin Senate and related government agencies view smart grids as prerequisite for balancing the volatile electricity flows from renewable energy sources, and thus as a necessary condition for increasing the amount of renewable energies in the system (Clustermanagement Energietechnik Berlin-Brandenburg, 2017: 23). In its Energy Transition Law, the Senate has clearly committed to expanding the amount of renewable energies produced within the city boundaries (Berlin Senate, 2016b). Although the term "smart grids" does not feature prominently in any of its programs or documents, these documents nevertheless relate smart grids directly with the Senate's goals of reducing CO2-emissions, reducing energy consumption, and increasing the amount of renewable energies in the city (Berlin Senate, 2015b; Clustermanagement Energietechnik Berlin-Brandenburg, 2017). The joint Masterplan for Energy Technologies in Berlin and Brandenburg therefore calls smart grids a "systemic solution to key questions of the *Energiewende*" (Clustermanagement Energietechnik Berlin-Brandenburg, 2017: 22).

A similar framing is also deeply rooted among actors involved in the pilot projects. Researchers, engineers and business people working at Berlin's pilot projects tend to be highly motivated to "make the Energiewende work" (personal interviews with researchers at Adlershof, EUREF and TXL). Members of the research consortium at EUREF classify smart grids as "sustainable concepts" (Technische Universität Berlin, 2012: 48), as "ecologically effective" (Technische Universität Berlin, 2012: 64), and as "energetically sustainable solutions" (personal interview, researcher II, EUREF, 2017). Similar to the city authorities, they directly link these goals to the implementation of smart grids. As one researcher states "the reason we need a smart grid is because we want to transition to more and more renewables" (personal interview, researcher Adlershof, 2018). They are motivated by a strong belief in the necessity of integrating more renewables into the city's energy system, and by the prospect of contributing to global climate protection. The Mobility2Grid research consortium promotes smart grids as nothing less than a "future project" that will help attain the "CO2-neutral, energy-efficient and climate adapted city" (Technische Universität Berlin, 2012: 7). Similarly, a project manager at TXL emphasizes that smart grids are "very, very important building blocks on the way to the *Energiewende*" and introduces a note of competition when adding that smart grids "could of course [….] propel us to the very top very quickly in terms of climate protection" (personal interview, project manager, TXL, 2017). An advertisement for TXL Urban Tech Republic uses heroic language to affirm that "the success of the energy revolution" will depend on intelligent infrastructures (Tegel Projekt GmbH, 2016). For the consortia involved in smart grid implementation, smart grids therefore carry meaning far beyond the mere technology, but also in terms of idealism, climate responsibility, future-orientation and change-making.

The network operator, Stromnetz Berlin, frames smart grids in much less idealistic, more prosaic terms. Both representatives interviewed for this analysis understand smart grids merely as means to make more efficient use of (renewable) energy sources (personal interviews, Stromnetz Berlin I & II, 2018). They therefore understand smart grids primarily as an efficiency technology, rather than an *Energiewende* technology. The grid operator portrays smart grids as 'business as usual' rather than an innovation, when it states that "the grid is already smart" (personal interview I, Stromnetz Berlin).

To conclude, the city authorities frame smart grids as fundamental prerequisites for the implementation of Berlin's *Energiewende*. They understand smart grids primarily as infrastructural enabler of renewables integration, and thus as basis for the achievement of the city's climate goals. This framing resonates with the deeply idealistic sentiment conveyed by the actors involved in smart grid implementation at the pilot projects. Together, this framing drowns out the conventional, routine type framing of smart grids as promoted by the network operator.

8.2.2 Improve energy management

More concretely, smart grids are being framed as technical tools for improving energy management. A broad coalition of actors portrays smart grids as technical tools to increase the availability of energy-related data and enable more flexible load management through the introduction of automatic control mechanisms. Except for the incumbent network operator, actors at all levels of my analysis agree that urban energy loads will need to be managed more flexibly in the future, i.e. that loads will have to be shifted at shorter intervals and coordinated more accurately with demand. They also agree that more accurate load management will require timelier and more accurate data on available energy resources, existing energy demand, possibilities of storage, and capacities for distribution. A broad coalition of actors is thus framing smart grids as technical tools for enabling increased system flexibility, gathering increased energy data and facilitating increased energy control. To most actors, the dominant problem being addressed by this framing is the fluctuating nature of renewable energy supply. Yet, certain actors also use this framing to address other problems. Most prominently, the Berlin Senate uses this framing to address the wasteful energy related behavior of households, and ICT corporations address a lack of overall "digitization". In sum, framing smart grids as enablers of system flexibility foregrounds notions of clean and efficient energy use, but also invites more economically grounded interests and rationalities to flourish.

8.2.2.1 Increase system flexibility

The Berlin Senate primarily portrays system flexibility as a technical tool for introducing more renewable energies into the system. It strongly supports "options for flexibilizing energy supply" (Berlin Senate, 2016b: 8) as part of its goal to "establish a climate-sensitive energy generation and supply system" (Berlin Senate, 2016b: 8). Similarly, the Enquete Report that it commissioned advises a "flexibly steerable, networked supply system with low consumption rates and alternative energy sources" (Enquête-Kommission, 2015: 18). The government thus clearly connects system flexibility with renewable energies. It makes clear that smart grids are needed to "better steer energy demand according to the fluctuating supply of renewable wind and solar electricity" (Berlin Senate, 2016c: 28). In their energy related policies and programs, Berlin's urban authorities are thus framing smart grids as "an important energy political contribution" (Enquête-Kommission, 2015: 37). The Berlin Senate views part of this energy political contribution as the private responsibility of households. The government's policies and programs strongly associate flexible energy management with people's energy behavior: "It is necessary that end users and producers be willing and able to make appropriate, intelligent appliances […] accessible for centralized load management" (Berlin Senate, 2016c: 28). The Senate's policies and programs promote better energy data as a prerequisite for increasing the energy-efficient behavior of private energy users. To a certain extent, the government thus frames smart grids as an instrument for capacitating users and incentivizing behavioral change (see also section 8.2.5. "Foster decentralization and prosumage"). To the city government, smart grids are thus also directly related to the notion of smart homes.

For corporate and corporate related urban actors, such as Siemens, Schneider Electric and the Technology Foundation, flexible energy management is part of an economic agenda. While the Senate portrays system flexibility as a technical tool for achieving Berlin's urban energy transition, the public Technology Foundation, for example, views system flexibility as a goal in itself: "intelligent grids and optimized management of supply and demand [….] will yield enormous innovations, and investments will open up future markets" (Erbstößer and Müller, 2017: 15). For this publicly funded foundation, increasing system flexibility is thus not a means for integrating more renewable energies, but a means for fostering technological innovation and economic growth. This mirrors the logics that large electronics companies are also adopting regarding flexible load management. For these companies, smart grids are a "means of implementing better automation and control mechanisms" (Interview electronics company, Adlershof, 2018), i.e. a means of selling their products. For these companies, system flexibility is primarily a way to address the "smart city idea" (Interview, electronics company, EUREF, 2016) not the *Energiewende*. Corporate and corporate related actors are thus framing smart grids as flexible energy management tools to promote their own sensing and automation products.

For the network operator, flexible energy management is primarily viewed as way to improve the quality of its supply services. Smart grids are about "intelligently reacting to user demand" (Interview I, network operator, 2018), making services smoother and more efficient. For the operating company, these users are not necessarily households, but commercial customers with higher levels of energy demand: "We should start with the large loads [….] Once we control those, we've won a lot [….] but individual washing machines, that's still far far in the future" (Interview I, network operator, 2018). For the grid operating company, better access to information about energy usage at the household level is primarily a question of improving supply services, not of saving energy (Interview II, network operator, 2018). For Stromnetz Berlin, more energy related data is mostly an issue of precisely locating potential disturbances and reacting more quickly to power outages. Currently, the company relies on customers' phone calls to locate the sources of power cuts. It therefore associates the possibility of automatically receiving energy data at the household level with the possibility of reducing its current "blindness" (Interview network operator, 2018). Unlike the Berlin Senate, it views households not primarily as active energy managers, but rather as providers of energy data.

Likewise, the smart grid pilot projects currently being pursued at Berlin's future sites are not focused on households at all. Households are not involved in any of the investigated projects and therefore not the focus of any scientist's active research interest. Instead, all three pilot projects focus on the connections between technologies typically found outside of households, such as renewable energy generation plants, electric vehicle fleets (at EUREF), an ice storage facility (at Adlershof) or multi-functional streetlamps (at EUREF and TXL). The projects focus on understanding the technicalities of sensing and automatically controlling energy flows, on programming algorithms according to different optimization parameters, and on monitoring their effectiveness. Although these algorithms are related to certain patterns of social activity (for example patterns of mobility), they are not related to patterns of household life. Even though the Berlin Senate stresses the integral role of urban households in the future smart grid system, the research consortia are framing smart grids as high-tech tools far removed from the everyday homes of people.

Questions of energy data, management and control are also questions of power and influence. Whoever has access to energy data and whoever programs energy distribution mechanisms controls critical societal functions, such as industrial production or traffic. Yet interestingly, questions of who should gather energy data or who should manage the steering mechanisms do not feature prominently in Berlin's smart grid discourse; they are at most secondary. Most actors express only vague notions of who could or should potentially control energy data and manage energy flows. Should private energy users administer their own energy data and flexibly adjust their activities based on financial incentives? Or should the network operator administer private energy data and remotely control users' appliances according to system needs? Or should intermediate aggregators oversee the combined energy data of clusters of end users and flexibly trade incoming and outgoing loads according to system demand? Questions like these could have far reaching implications for the architecture of the urban electric grid system, yet they hardly feature in the smart grid discourse in Berlin. Instead, different urban actors portray different views of who should control energy data and flows in the future smart grid city.

Public administration is torn between framing the issue of control as an open question: „Does every household get to decide if they want to steer their energy flexibly […], or do we permit the network operator or the operator of a district heating system to do this for every single apartment?" (Interview public admin, 2018). The city authorities also ask: "to what extent should [customer installations] benefit the public grid? I think no one wants to give up too much of their authority, or acquire more authority […] That's a challenge and a discussion that we need to have: who will have what kinds of access rights and how far do they go?" (Interview public administration, 2018). Yet, in other documents and contexts, Berlin's public administration also frames the issue of energy control as household responsibility (Berlin Senate, 2016c), or as the network operator's responsibility (Berlin Senate, 2016c; Enquête-Kommission, 2015), or even as the grid's very own responsibility: "an intelligent grid will […] connect, […] assess, […] and react" (Berlin Senate, 2015b: 31). In short, Berlin's public authorities promote a blurred picture of who should control energy data and manage flows in the future smart grid city.

Software engineers at the pilot projects, by contrast, have a much clearer understanding of their influential role in the smart grid system: "We set the parameters", says a researcher at EUREF (Interview researcher II EUREF, 2017). "The software decides", says another (Interview, researcher Adlershof, 2018). Researchers in the field of electronics and software engineering are aware that the decisions they make and the priorities they set are at the core of the grid's "smartness". Yet understanding, not steering, is their primary motivation and concern.

Only the network operator leaves no doubt about its ambitions as load manager: „Of course […] we need the possibility to intervene when large loads are being shifted back and forth" (Interview II, network operator, 2018). "We have a control center that controls the entire grid. It has been doing so for many decades" (Interview I, network operator, 2018). For the grid operating company, load management belongs to the core responsibilities that it doesn't want to give up.

Overall, a dominant actor coalition is framing smart grids as technical enablers of flexible energy management and automatic control. While government documents and strategies emphasize the role of households, neither the network operator nor researchers at the pilot projects share this emphasis. Moreover, key social questions surrounding the technical abilities of smart grids remain obscure: who will oversee energy data, who will manage energy loads, and who will exercise control over whom or what? The omission of these key social questions in Berlin's smart grid discourse, and the lack of open controversy about them points to an overall (regulatory) uncertainty over the costs and benefits of these issues.

8.2.2.2 Enable sector-coupling

Another important framing describes smart grids as technical tools for coordinating different infrastructural sectors. This concept called "sector-coupling" is promoted across all levels of my analysis, and spans various infrastructures including electricity, gas, heating, cooling, and (electric) mobility. The term sector-coupling describes the idea of using (renewable) electricity to power different infrastructural sectors, and in turn using these various sectors to store excess electricity when needed. In this sense, sector coupling can be viewed as a technical prerequisite to system flexibility: whenever excess electricity is available, it is flexibly converted into gas, chemicals, heating, cooling or battery loads according to demand, and then flexibly converted back into electricity when needed. The dominant problem being addressed by this framing is one of energy and cost-efficiency. For most actors in my analysis, sector-coupling is a way of maximizing the use of (renewable) energy resources and minimizing energy waste. However, actors at the city level, most notably the Senate and the newly founded public utility company, as well as electronics companies also view sector-coupling as tool for saving money and time. This framing also portrays smart grids as infrastructural mediators. They are depicted as connecting devices, as add-ons or as secondary layers between utility sectors. Due to this cross-sectoral framing, the ideas associated with smart grids are so broad that they are compatible with many different actors and agendas.

Berlin's city authorities primarily depict sector-coupling as a tool to implement the *Energiewende*. Especially in its energy policies, the government depicts sector-coupling as way to save energy and integrate renewable energies into the system, mainly by bridging the electricity and the heating sectors (Berlin Senate, 2016b, 2016c; Enquête-Kommission, 2015). Among others, the Senate aims to integrate power-to-heat facilities, combined heat-and-power generation facilities, and heating storage facilities into the grid (Berlin Senate, 2016c: 23)and is undertaking concrete measures to reach these goals. In other government documents, such as the coalition agreement and the Smart City Strategy, the Senate also associates sector-coupling with the mobility sector (Berlin Senate, 2015b, 2016a). In this case, however, it portrays sector-coupling as a desirable yet vague possibility. In both instances, Berlin's city government primarily presents sector-coupling as way of dealing with (fluctuating) renewable electricity supply, and of increasing electricity and heating-related energy-efficiency. But the Senate is also interested in sector-coupling for more mundane issues of saving money. Considering the city's large and well-developed gas and district heating networks, the Senate also views sector-coupling as means of increasing the time and cost-effectiveness of managing these networks (Enquête-Kommission, 2015: 40). It views integrated network management as potential tool for synergizing operational processes, for example customer care, service provision, and construction management and thus saving costs. In other words, the Senate sees sector-coupling not only as facilitator of urban energy transitions, but as a possibility to save money and time.

The new public utility company, Berlin Energie, largely echoes this position. In its mission statement, the company emphasizes the benefits of sector-coupling primarily in terms of convenience, cost-effectiveness and security of supply. For Berlin Energie, sector-coupling is first and foremost about offering a "combined network connection" or a "one-stop networked infrastructure"[18] that integrates electricity, gas and heating networks into one combined system. It propagates this mainly for reasons of convenience, invoking personal convenience on the one hand: "Berliners will have one contact person, one appointment, one hole drilled into their wall for the connection, and one bill"[19], and urban convenience on the other: "these measures will […] not only save costs but reduce traffic impairments: if the road is opened only once and not repeatedly"[20]. Although the company also associates smart grids and sector-coupling with the city's climate and *Energiewende* related goals, it foregrounds questions of convenience and cost-effectiveness, calling cost-effectiveness a "fundamental building block for the success of the *Energiewende*"[21]. The company's commitment to sector-coupling is thus based primarily on values related to money, time and efficient management rather than the *Energiewende*. An interviewee highlights this position: "one asset management, one service management and one thinking and doing, one failure management all the way to one combined service technician" (Interview, BerlinEnergie, 2018). In line with this, the company describes itself as "combined network operator" that will operate the city's infrastructure "efficiently and reliably" (www.berlinenergie.de/ueber-uns/kombinationsnetzanschluss/). Moreover, it argues for combining infrastructural sectors for reasons of supply security. The same interviewee underlines the necessity of creating a "cross-sectoral security landscape" (Interview, Berlin Energie, 2018). In sum, the city-owned company Berlin Energie understands smart grids and sector-coupling not primarily as instruments to achieve a sustainable urban energy transition, but rather as means to achieve an economically viable, secure and efficient energy supply.

Similarly, large electronics companies don't promote sector-coupling primarily as means to foster sustainability, but rather as means to foster "smartness" in technological and economic terms. Not surprisingly, these companies consider sector-coupling as new opportunity to place their "smart" sensing and automation

[18] www.berlinenergie.de/ueber-uns/kombinationsnetzanschluss/
[19] www.berlinenergie.de/ueber-uns/kombinationsnetzanschluss/
[20] www.berlinenergie.de/ueber-uns/kombinationsnetzanschluss/
[21] www.berlinenergie.de/ueber-uns/leitbild/

technologies and to create added value. They therefore perceive sector-coupling as an important issue but associate it with the smart city and smart technologies rather than the sustainable city. An interviewee confirms this emphasis: “what belongs into this smart city issue? That’s energy, that’s mobility, that’s water, i.e. waste water [...], possibly surveillance by cameras or traffic management systems. Then, as fifth sector, that’s buildings [….] and underneath these five sectors there’s always the issue of integration, communication, that needs to be embedded” (Interview, electronics company, 2016). As this quote illustrates, this employee highlights the technological aspects of sector-coupling, not their underlying purposes. In its blog, the same company describes how it advises clients on “sector-coupling and digital services”[22], thus emphasizing the digital aspect of sector-coupling over sustainability. Likewise, in its brochure, this electronics company subsumes smart grids and sector-coupling under the heading “comprehensive digitization” (Schneider Electric brochure, p. 5). In an infomercial on its website, another large electronics company emphasizes the economic benefits of sector-coupling: “sector-coupling enables the integration of renewables in decentralized energy systems; sector-coupling takes care of profitability, and opens new business segments not only for energy providers; sector-coupling facilitates surprising synergies and new opportunities for added value, and for attracting and retaining customers”[23]. In sum, large electronics companies see a business opportunity in the integration of infrastructural sectors, and thus foster sector-coupling primarily for economic reasons.

This is different at the pilot projects, where intrinsically motivated researchers are mostly interested in smart grids and sector-coupling for the sake of making urban energy (and mobility) transitions work. At EUREF Campus, a leading researcher affirms that “a smart grid […] aims at moving the essential sectors such as energy, heating and mobility supply towards 100% renewables” (Interview, researcher, EUREF 2017). Here, the primary motivation is to integrate renewables and foster a clean energy system. At TXL, smart grids and sector-coupling are about creating an “all electric” future. As one of the TXL project’s leading actors states “if our project was 10, 15 or 20 years further down the road, then we would do everything electrically. Because electricity would be renewable, and we would be able to store it, we would use electricity for heating, cooling, producing, driving, everything” (Interview, TXL 2017).

In sum, actors at the city level, such as the city government and the newly established public utility company (Berlin Energie), are promoting smart grids and sector coupling for very different reasons. While the government primarily focuses on achieving the *Energiewende*, Berlin Energie is mostly interested in an economically viable, secure and efficient energy supply. Similary, the incumbent network operator, Stromnetz Berlin, has little to say about sector-coupling at all. At the pilot level, similar differences prevail. While researchers are driven by an interest in urban energy transitions and 100% renewables, private electronics companies seek to sell their products.

8.2.2.3 Maintain stability, security and comfort

Thirdly, smart grids are being framed as important guarantors of stable electricity loads and secure electricity supply, and thus as guarantors of the city’s energy related status quo. Like system flexibility, this framing is

[22] https://blog.se.com/de/smart-cities-vernetzte-staedte/2019/01/29/inno2grid/

[23] https://new.siemens.com/global/de/branchen/stadtwerke-und-verteilnetzbetreiber/geschaeftsmodelle.html

related to the introduction of renewable electricity into the system. It paints smart grids as technical solutions to the volatility of renewable electricity flows, i.e. to the uncertainty of the time and amount of their generation. The underlying problems being addressed by this framing are potential supply interruptions that could result from insufficient generation (for example on a dark and calm day) and potential power outages that could result from inadequate voltage levels (above or below 50Hertz). Because neither load stability nor security of supply are problems in Berlin's current electricity system, this framing is also built on the fear of losing a cherished certainty. The city's current standards are indeed high: based on the network operator's data, Berliners only experience a network related power outage once every five years, and in these rare instances, they remain without power for an average duration of only 48 minutes[24]. Although this is higher than the German average of approximately 15 minutes of power outages per year[25], it is still significantly lower than the average length of power outages in other countries, for example the U.S. In California, for example, the length of power outages has averaged 133 minutes per year over the past 12 years[26]. The relative steadiness and reliability of current electricity flows in Berlin have arguably rendered the city's energy supply infrastructure "invisible", creating a sense of comfort, confidence and safety that neither the city authorities nor any other of the city's smart grid related actors are willing to challenge. All actors in this analysis therefore promote the maintenance of steady and reliable electricity flows as indispensable to the city's future electricity system.

In various policies and programs, Berlin's city authorities draw a direct line between integrating more renewable energies into the system, needing to maintain system stability, reliability, and supply security and needing smart grids. They consistently argue that the "networks of the future (electricity, heating, gas) must [...] facilitate a stable, secure and reliable energy supply that is based in large parts on renewable energies" (Clustermanagement Energietechnik Berlin-Brandenburg, 2017: 23). In light of the unreliable renewable energy supply, the city authorities argue for smart grids as guarantors of network stability and security of supply (Berlin Senate, 2015b: 32). They even state that "because electricity supply is every modern society's Achilles heal, [network stability] must be given exceptional attention" (Berlin Senate, 2015b: 33). These formulations leave no room for doubt about the need to maintain the system's current high supply standards. Without discussing or explaining this assumption, Berlin's authorities make its high standards of supply security appear as an undisputed necessity and smart grids as only way to get there.

Private actors fill this gap by directly connecting notions of system stability with notions of personal comfort. The network operator states this in simple terms: "you shouldn't see it, you shouldn't hear it, that would be best; you should simply not be aware of it [….] When you press the button, the light should go on, that should be the feeling" (interview, network operator II, 2018). As this quote shows, the network operator argues from a service-oriented position, in which supply interruptions need to be avoided, because they pose an inconvenience to the customer. For the network operator, not the integration of renewables, but customer satisfaction are presented as top priority. A similar argument prevails at TXL Urban Tech Republic, where maintaining network stability while also maintaining peoples' comfort levels are presented as the main goals to be achieved with smart grids

[24] https://www.stromnetz.berlin/uber-uns/zahlen-daten-fakten
[25] Owen calculation based on https://www.cleanenergywire.org/news/average-power-outage-time-germany-decline-renewables-share-grows
[26] https://www.statista.com/statistics/1078447/average-blackouts-duration-by-state/

(Interview, TXL 2017). The argument that is being tapped into here is like frequent arguments about energy-efficiency: smart grids are painted as technical tools that will correct expected deficiencies while maintaining current comfort levels.

Various actors also associate system stability with the idea of creating different levels of (interlinked) micro-grids in the city. The city administration, for example, argues that micro-grids increase system "resilience" (Enquête-Kommission, 2015: 155). Project managers and ICT companies similarly argue that micro-grids could establish "redundancies" or "fallback options" within an urban electricity system to offset possible interruptions (Interview, ICT company 2016). A researcher at EUREF views this as an interesting challenge: "because we implement more capacities and each component has a probability of failure, and we must include redundancies. I don't see that as a danger, but definitely as a challenge" (interview, researcher II, EUREF, 2017). Yet, not all actors view micro-grids as a stabilizing mechanism. For Berlin Energie, for example, micro-grids pose a security risk, not a security asset (Interview, Berlin Energie, year 2018).

In sum, Berlin's city and pilot level actors argue for smart grids as means of maintaining high levels of supply security and high levels of comfort. While some actors at both the city level and the pilot sites also build on this argument to promote micro-grids, others view micro-grids as problem for system stability. None of Berlin's smart grid related actors question the need for these high levels of stability, supply security or comfort. Arguments for smart grids are therefore based on the implicit assumption that the comfort and constant availability and dependability of electricity flows, i.e. the smooth 'invisibility' of electricity infrastructures are non-negotiable. This gives smart grids a touch of a necessity.

8.2.3 Make the city "smart" and "green"

Beyond these strictly energy related framings, smart grids are also being framed as broader smart-eco city "solutions". Though Berlin's urban and energy policies primarily depict smart grid technologies as a prerequisite for achieving Berlin's local *Energiewende*, this expectation goes hand in hand with an increasing overall reliance on technological development to solve urban environmental problems. In Berlin, visions of low-carbon urban futures are becoming increasingly interwoven with 'smart' technological progress, merging notions of environmental consciousness with notions of high-tech development and digital sophistication.

Among others, the current city government's energy policies aim to help advance the city's Smart City Strategy and turn Berlin into a "Smart Energy City" (Berlin Senate, 2016a: 64). The Smart City Strategy, in turn, describes the development of "intelligent" supply infrastructures as its "backbone" (Berlin Senate, 2015b). It is therefore unclear whether smart grids are being pursued as means to achieve a smart city, or the smart city is being pursued as means to achieve smart grids.

Similarly, a report commissioned by the urban administration in 2015 entitled "New Energy for Berlin" states that Berlin should introduce smart grids "so it can become a Smart City that contributes to the Energiewende" (Enquête-Kommission, 2015: 80). The "smartification" of electricity grids is therefore not only being justified with energy-related goals, but with the vague and overarching aim of digitizing urban life in general. The Masterplan Energy Technology Berlin-Brandenburg (2015) further underlines this by stating that "energy is part of an interconnected smart city and region” (Clustermanagement Energietechnik Berlin-Brandenburg, 2017). This shows how closely imaginaries of resource-efficiency and sustainability are being linked with notions of digitization and vice versa. The interface between energy and ICTs is regarded as a natural and inevitable process that goes hand in hand with the increasing digitization of everyday life. By linking the smart city to local energy transitions, smart technological solutions are being depicted not only as healthy and clean, but also as part of a response to the pressing global challenge of climate change and thus as a seeming moral imperative. Concomitantly, urban development discourses are systematically linking imaginaries of the smart city to notions of climate-friendliness and sustainability, describing the smart city of Berlin as “resource-efficient” (Erbstößer and Müller, 2017), “post-fossil” (Berlin Senate, 2015a), ‘”ecologically modernized”, and “green” (Berlin Senate, 2016a). In Berlin’s local policies, low-carbon transitions are therefore imagined to be inherently “smart”, and smart cities are imagined to be “low-carbon”.

The seemingly inevitable connection between technology and environmental protection is being strengthened by the way smart grids are depicted at the city’s future sites. TXL Urban Tech Republic, for example, advertises that “we need new solutions for mobility, for energy, and for resources. And we need new materials and intelligent systems to make these solutions possible. We need Urban Technologies. Technologies for the cities of tomorrow” (Tegel Projekt GmbH, 2015: 5). According to this advertisement, there seem to be no alternative ‘solutions’ to technological advancement. Moreover, these technologies are claimed to be “what will keep alive the growing metropolitan centers of the 21st century” (Tegel Projekt GmbH, 2018a), and thus depicted as fundamental prerequisite for the sake of pure survival. The same is true for the EUREF Campus, which claims to bridge solutions not only for the “intelligent transformation of the energy sector” (Technische Universität Berlin, 2012), but also for the intelligent city:

> „We are discussing the global context, how to design the future intelligent city? […] and [for me] a smart grid is part of that (Interview, EUREF Campus_2017).

Here, too, smart grids are depicted as “intelligent” and necessary means of urban environmental protection.

8.2.4 Boost the local economy

Berlin’s city administration also depicts smart grids as an attractive opportunity for boosting the low-carbon economy, evoking visions of a thriving and industrialized, yet post-fossil urban future (Berlin Senate, 2015a). The current government underlines this by stating that "a smart city, an intelligent city, is able to increase growth while decreasing resource-use" (Berlin Senate, 2016a: 51). Among others, smart grids are envisaged to "increase industrial value generation, expand technological expertise, create new jobs and increase urban quality of life" (Berlin Senate, 2015b: 28). These promises are built to a large degree on Berlin’s existing strengths in the fields of research and digital industries. Apart from hosting numerous renowned research institutions, Berlin has become Germany’s leading hub for the (digital) start-up scene (Kollman et al., 2019). The urban administration therefore views smart grid technologies as way to combine the city’s socio-economic capital with its energy transformation goals, and for leading it into a ‘green’ economy:

> "The Energiewende offers Berlin's businesses unique opportunities on the future markets of a resource-efficient economy based on renewable energies. The extension and advancement of an intelligent electricity grid, smart grid, are important technological challenges that Berlin is especially suited for due to its combination of scientific research and industry" (Berlin Senate, 2015b: 26).

The city's future sites advertise the same combination. At EUREF, the project development company states that "we all benefit from this topic; we benefit, the companies benefit, and the idea behind it does too" (Personal interview, project development company, 2016). And then adds:

> "I want to prove that what we are doing here is not more expensive than what we have now. The Energiewende will only succeed if customers don't end up paying more. Maybe even pay less [….]. I think that this is a commercial project that we are doing here" (Personal interview, project development company, 2016).

Smart grids are therefore depicted as economic opportunity that will help the Energiewende, not the other way around. Similarly, large ICT and electronics companies involved in Berlin's future sites are primarily driven by the opportunity for expanding into an emerging market:

> "Suddenly the grid becomes a huge data project, and that makes it interesting for us. […] Wherever data packages are transmitted based on internet protocols, independent of whether it's video live streams or stock market data or private emails, we don't really care what it is, as long as it's a lot. That pretty much sums up our interests" (Personal interview, ICT/electronics company, 2017).

Not surprisingly, large ICT companies are participating in Berlin's future sites primarily because they see a chance to increase their specialized knowledge and turn it into standardized products that can be transferred to multiple systems and situations. They are especially interested in devising 'cookie-cutter' solutions and developing them into mass-products (Personal interviews, ICT/electronics companies, 2016 & 2017).

The way smart grids are being portrayed in the city's documents and programs and also at the future sties shows how deeply interwoven notions of energy transitions and low-carbon futures are with economic interests. This raises questions about the interests and priorities at work in promoting smart grids for the city. In particular, it raises questions about the environmental claims around smart grids and about the fine line between exploiting existing synergies and creating a 'green' image for the city.

8.2.5 Foster decentralization and prosumage

Lastly, a dominant framing portrays smart grids as enablers of a decentralized energy system based on wide-spread prosumage. This framing presents smart grids as the technical solutions to a problem of reorganizing energy across urban space and of redistributing energy-related roles and responsibilities within this space. Yet, this framing is ambiguous. While policy documents, research proposals, company websites, and public communications associate decentralization and prosumage with notions of autonomy and empowerment, most experts involved in urban smart grid implementation paint a different picture. My analysis reveals a certain disconnect between how smart grids are being promoted in official communications and how they are being experienced in implementation circles. It shows that what decentralization and prosumage actually mean for different actors and within different contexts in the city of Berlin varies substantially.

While in public communications and appearances, the local government promotes an imaginary of close-to-home, citizen-empowering, smart low-carbon urban futures, other important actors in Berlin's smart grid community portray a more nuanced and differentiated picture. These actors include incumbents and start-ups, researchers and businesspeople, municipal administration and NGOs. Instead of framing households as intrinsically motivated, powerful backbones of Berlin's urban *Energiewende*, they see them as unnecessary, disinterested and disempowered energy users.

8.2.5.1 Households between empowered prosumers and disinterested users

The local government's framing of smart grid enabled prosumage is connected to the widespread idea of decentralized or distributed energy responsibility either within individual households or neighborhood size micro-grid communities. Berlin's city government frames the urban *Energiewende* and local smart grid systems as highly participatory, with an active role for citizens in energy markets that work to their benefit in a variety of ways. By and large, the local government portrays decentralized prosumage as opportunity to save money and energy, actively manage energy, to be more informed about and aware of energy, and to become increasingly free to choose between various energy sources. Berlin's Energy and Climate Protection Program (*BEK 2030*), for example, builds on prosumers as "active agents of the *Energiewende*" (Berlin Senate, 2016c: 64). Among other things, it aims at "strengthening the role of micro-prosumers in the electric grid" (Berlin Senate, 2016c: 28). The same is true for the independent commission's "New Energy for Berlin" report. As active members of the energy system, this report refers to prosumage households as "grid participants" (Enquête-Kommission, 2015: 37). These active grid participants are envisioned as highly flexible market actors that take on alternating roles as electricity producers, consumers and suppliers. To strengthen their role as electricity suppliers and system stabilizers, the Berlin Energy and Climate Protection Program (BEK) encourages local grid participants to make their "intelligent" household appliances accessible for centralized load management (Berlin Senate, 2016c: 28). Prosumage households are therefore not only envisioned to benefit themselves, but also to take over responsibility for stabilizing the grid and benefitting the system. The local government seeks to increase their "ability and willingness" to perform grid stabilizing duties (Berlin Senate, 2016c: 28), and to adapt their electricity consumption to the volatility of renewable energies (Enquête-Kommission, 2015: 17). Among other things, it points to the possible integration of private refrigerators, washing machines or other relevant electric appliances into an ICT enabled energy information system:

> "The digitization of networks and appliances offers substantial potential for increasing the energy-efficiency of private households. Combining smart home solutions with informative energy billing can provide pathways for substantially increasing energy-efficient behavior" (Berlin Senate, 2016c: 136).

According to this document, smart grids and related energy information systems will empower private households to act responsibly and control their energy consumption. Even regular households that don't (or can't) act as prosumers or grid participants are portrayed as potentially interested, flexible and actively engaged in managing their electricity consumption. In its Smart City Strategy the city government underlines that the information made available through smart grids (and meters) will motivate and enable these households to adapt their electricity consumption according to system needs (Berlin Senate, 2015b: 31). By providing information about peaks in the overall energy system and about individual consumption patterns, the government assumes that households will increase their system awareness and adapt their consumption behavior:

> "In the next two decades, Berlin needs to install smart energy infrastructures in all areas of urban consumption (housing, transportation, economy, administration, leisure etc.), which will enable consumers to increase their energy-efficiency on the basis of transparency and controllability" (Enquête-Kommission, 2015: 16).

The government expects that households have an inherent interest in flexibly adapting their routines to reduce electricity consumption either for reasons of climate protection or for financial benefits. In fact, the city's climate protection program presumes that the main obstacle to this kind of flexible energy management is currently a lack of financial incentives, not a lack of inherent motivation (Berlin Senate, 2016c: 28). The local government's idea of intrinsically motivated, flexible, and environmentally conscious prosumage households is reinforced through the public communications surrounding Berlin's future sites. This is especially true for TXL, which hardly exists outside the realm of communications. As the director of TXL's project management company states in a public interview:

> "In the end it's all about people. It only becomes interesting with people! […] The users should have a say in what happens here" (AusserGewöhnlich Berlin, 2017).

This notion of a participatory urban energy future is underlined by the term Urban Tech *Republic,* which was chosen as a provocative, fun and slightly tongue-in-cheek way of emphasizing the importance of citizen engagement at TXL (AusserGewöhnlich Berlin, 2017). The term *republic* also stands for autonomy and democracy, i.e. for the notion of an independent and self-organized future energy system, in which free and informed energy citizens contribute their share to a functioning overall energy community. It rings of well-behaved debate, of compromise, and of individual service to the higher common good. This framing gives the impression that becoming a prosumage household is not a matter of individual preferences but of moral obligation. It obviously speaks to a certain class of energy households. As a leading employee of Tegel Projekt GmbH confirms when asked about the kinds of people that might become part of the TXL campus: "I believe in self-selection" (personal interview TXL, 2017). At the same time, this leading employee reveals an underlying concern about attracting these potential prosumers:

> „And of course, we will try to work towards attracting […] the right people, that fit into the Urban Tech idea, […] that are intrinsically motivated and maybe interested in connecting and taking part in such a higher-level energy production; and maybe even becoming a driver in the whole thing" (personal interview TXL, 2017).

Here, the possibility of actively engaged prosumage households seems less certain. Instead, it sounds like work needs to be done to attract a rare species of specialized energy clients rather than relying on the intrinsic motivation of regular urban households. It shows that participation and inclusion in energy issues might not be as simple and attractive as promoted in the smart grid discourse, and that urban households willing and able to engage in prosumage activities might actually be hard to find.

In fact, the notion of flexible, intrinsically motivated and active prosumage households is not mirrored by many other actors in Berlin, especially not by those involved in smart grid development and testing. Their notion of decentralization and prosumage is not one of inclusion, participation or empowerment, but rather one of disillusionment and convenience. There is a gap between the visions being promoted by policy documents, research proposals, company websites, and public communications and the visions actually fostered by the experts involved in the urban smart grid community themselves. While participation and empowerment feature prominently in the vision of decentralization and urban prosumage that is being advanced in public, these notions are much more brittle and doubtful on the individual expert level. Many even doubt the system relevance of household prosumage altogether. Two participants in the research project at Adlershof call into question the benefits of household prosumage for the energy system:

> "In the beginning that might be exciting, but in the end […] that's just fooling around a little, and the practical advantage is really marginal. And that's why […] in private households, I'm not convinced" (personal interview, businessperson at Adlershof, 2018).
>
> A colleague shares this skepticism: "Smart grids in households, of course that's imaginable; the only question is how high their potential really is" (personal interview, researcher at Adlershof, 2018). The same person continues:
>
> "After I open the refrigerator, it has to keep on cooling, otherwise my sausage could get warm, and I wouldn't want that to happen [….] the washing machine, I'm also skeptical about that. I mean, to have the laundry lying half wet in the machine for eight hours, nobody wants that" (personal interview researcher at Adlershof, 2018).

These actors don't view private households as actively engaged citizens that are driven by an inherent climate-consciousness or an interest in saving energy, but simply as driven by their everyday routines and by convenience. They view future energy households as relatively disinterested in energy issues, and more concerned about their comfort than their efficiency. Prosumage households, in their view, are not eager to take part in Berlin's urban *Energiewende*, but rather concerned with maintaining their everyday routines. This assessment is shared by a representative of the local network operator who is also involved in the EUREF project. This person is highly skeptical of peoples' willingness to change their energy related behavior:

> "The German mentality simply isn't like that. You know, in Italy, they use so-called *breakers*, like an extra fuse; they tell them they can't use the washing machine and the water boiler and the stove and

the dishwasher at the same time; they cut the power off, the fuse breaks and that's it. To give up your comfort like that would never be possible in Germany" (personal interview, Stromnetz Berlin, 2018).

In this expert's view, future energy households are even highly inflexible: "society's inertia is extremely high […] that's why I wouldn't say that once we have a smart grid, everyday life will change" (personal interview Stromnetz Berlin, 2018). Contrary to the overarching imaginary of smart grids as technological basis for "openness, participation and connectivity"[27], which is being promoted on the company's website, this representative of the network operator nourishes a vision of Berlin's future energy households as passive and disinterested rather than open, passionate and engaged. There is an obvious discrepancy between what is being publicly promoted and what Berlin's experts actually portray. An employee of an energy start-up at EUREF speaks of a similar experience:

> "[Smart grids] need to be turned into products. And that's the hardest part, you see? How do you sell a smart grid? There is no such thing as a micro-smart grid, and there aren't any customers either. Nobody says 'hey, I'd like to buy a smart grid'" (personal interview, energy start-up EUREF, 2016).

Instead of encountering ready customers, this person has obviously encountered frustration. For a representative of the Senate Department of Economics, Energy and Public Enterprises (SenWEB), the role of households seems at most uncertain. When interviewed, a Senate Department representative states that „some people will [install smart grid systems], because they are either a) technologically interested or b) environmentally conscious or both [….] But a large portion of society certainly won't do it" (personal interview SenWEB, 2018). A representative of the Berlin section of Friends of the Earth Germany shares this opinion:

> „If you break it down to the household level there's always this thing with the controllable refrigerator, and I don't buy it" (personal interview BUND, 2018).

In sum, my analysis shows that despite an overall agreement about the necessity of advancing smart grid systems in Berlin, the visions portraying the role of urban households in these systems remains varied and in part contested. The framing of participation and empowerment on the one hand and that of disinterest and incapability on the other reveal a disconnect not only between political and other actors, but also between abstract political programs and the reality of implementation.

8.2.5.2 Neighborhoods between self-sufficiency and collaboration

Although decentralization and prosumage feature prominently in visions of smart grids, there is vagueness and unclarity about the degree of decentralization and hence the scale of prosumage. Like the term "smart grids", the term "decentralization" has become a buzzword in the German *Energiewende* discourse. Apart from prosumage households, another dominant vision in this discussion sees a new role for prosumage *neighborhoods*. This narrative circles around smart grids as tools for creating self-sufficient neighborhoods that are largely autonomous of energy utilities and large-scale networked infrastructures. These prosumage

[27] https://www.stromnetz.berlin/fur-berlin/smart-city

neighborhoods are often portrayed as locally delimited, small-scale energy cells that defy the "old" system order, and stand for a new distribution of responsibilities and power in the energy system. This narrative evokes notions of ownership and self-determination, in which urban neighborhoods stand for themselves and form largely autonomous energy "islands". At the same time, smart grids are being portrayed as highly complex and integrative systems that create and require extreme interdependencies, not only within neighborhoods, but within a city-wide "network of networks" (personal interview energy start-up EUREF, 2016). In the neighborhood context this narrative rings not of autonomy and empowerment but of control and (inter-)dependence. These two arguably contradictory narratives are both being promoted to foster the development of smart grids and make them attractive for cities.

In Germany, the narrative of small-scale energy cells is being promoted by institutions from the federal to the local level. In 2015, the German national association of electronics (VDE) published a report called "The Cellular Approach", which describes a future energy system based on self-sufficient energy "cells" – or micro-smart grid systems (Benz et al., 2015). These are envisioned at various scales and can consist of individual households, streets, neighborhoods, towns, or entire cities (Benz et al., 2015: 29). Small-scale energy neighborhoods are also envisioned by the think tank Agora Energiewende, which concludes that decentralization fosters identification with local or regional electricity "products", and local prosumage is based on a wide-spread "do-it-yourself" mentality (Agora Energiewende, 2017: 142).

In the city, the idea of energy cells is built on a narrative that describes neighborhood-sized units that function as zones for producing, using, trading and storing electricity independently. Within these zones, smart grids make sure that renewable energy production and demand are synchronized, while local storage units ensure that surplus energy is kept in the neighborhood system, and peer-to-peer transactions ensure that energy is traded within a local market. These narratives build on dedicated prosumage households, and on small-scale energy infrastructures such as solar panels, CHP plants, battery storage facilities etc. at the neighborhood level. All in all, the neighborhood scale as inherently urban unit is evoked as independent energy management zone. These energy neighborhoods are viewed as key for reaching Berlin's energy and climate goals, and micro-smart grid systems are viewed as catalyst for private investments into infrastructures and private commitment to prosumage (Erbstößer and Müller, 2017: 9–11). To underline the importance of neighborhoods for the urban *Energiewende*, the local technology foundation has hosted a workshop series called "networked energy within neighborhoods" since 2016 (*Vernetzte Energie im Quartier*). Among others, it views micro-smart grid neighborhoods as important future market places for peer-to-peer energy trading (Erbstößer and Müller, 2017: 11). The city administration envisions future smart grid neighborhoods as networked islands, especially in newly built areas of the city (personal interview SenWEB, 2018). The Enquête-Commission seeks to build on existing neighborhood structures and envisions the parallel refurbishment of buildings and the establishment of micro-smart grids therein. It envisions energetically refurbished micro-smart grid neighborhoods, in which various neighboring buildings are combined to form virtual power plants (Enquête-Kommission, 2015: 79). Local smart grids are viewed as indispensable for the use of surplus electricity and the combination of sectors (Enquête-Kommission, 2015: 153).

The idea of independence, empowerment and self-sufficiency is influenced by the country's surge of (mostly non-urban) energy cooperatives that have brought new voices into the energy discourse and distributed responsibility away from large energy companies. These narratives of independence and self-determination are being conjured in clear contrast to the one-size-fits-all national monopolies that prevailed in the "old" energy system.

EUREF, TXL and Adlershof all emphasize the idea of increasing neighborhood-scale energy independence. The smart grid project at EUREF, for example, is based on visions of a "polycentric" future energy system enabled by a smart and highly complex electricity grid (Technische Universität Berlin, 2012: 4). This idea of "polycentricity" is strongly connected to the idea of independence of the overarching grid. As a leading researcher at EUREF states in an interview:

> "We imagine a densely built industrial neighborhood that organizes 100% of its own energy on-site on the basis of renewables - wind, solar – and even in the areas of electricity, heating and transport" (personal interview, researcher EUREF, 2017).

> „of course [EUREF] also stands as a symbol for urban development, that can pick up this decentralization idea, and maybe the city as a whole can reinvent decentralized facilities" [personal interview, researcher EUREF 2017).

Berlin's future sites are promoting an imaginary of largely independent energy neighborhoods that is supposed to be reproduced throughout other neighborhoods in the city. Here, micro-smart grid systems are being developed with the explicit goal of managing energy outside the overarching network, and of creating largely independent micro-smart grid solutions for replicating and scaling.

> "If I operate a photovoltaic plant, for example, I imagine that a smart grid could help me increase my own consumption and make me a little more self-sufficient" (Personal interview researcher Adlershof, 2018).

On the other hand, a contrasting narrative evokes notions of smart grids as vehicles for collaboration and sharing. According to this narrative, smart grids are instead technologies for building collaborative communities.

> "The users are supposed to participate. They are supposed to contribute, and we hope to create a form of community that helps us move forward" (AusserGewöhnlich Berlin, 2017).

Among others, this narrative portrays smart grids as potential pillars for the creation of virtual power plants, i.e. interconnected energy generation, storage and distribution systems that rely on flexible trading within a (neighborhood) network. Instead of fostering independence of the grid, virtual power plants are designed to balance the grid. The Berlin Senate therefore also speaks of neighborhoods as "services to the grid" (Enquête-Kommission, 2015: 69). According to this narrative, smart grid neighborhoods play an important role in levelling peak loads and stabilizing the overarching grid not least by allowing external steering mechanisms to manage flows into and out of their networks, and thus reducing independence instead of increasing it. The Berlin Senate speaks of creating “synergy effects” (Berlin Senate, 2016c: 35). This narrative of integration and aggregation stands in direct contrast to the idea of energy independence or even autarky. A leading representative of the TXL project even sketches his vision of a neighborhood “sharing economy”, in which neighbors not only sell, but donate or give away their excess electricity (personal interview, TXL 2017). Smart grid neighborhoods, in this view, stand for a new and attractive form of community building (personal interview, TXL, 2017).

In sum, Berlin’s smart grid discourse is comprised of two at best complementary narratives that highlight the independence and self-sufficiency of future energy neighborhoods on the one hand, and their integration and subservience to the surrounding city on the other. Decentralization and prosumage feature in both narratives, yet their qualities and social implications greatly vary.

8.2.6 Concluding remarks

In conclusion, smart grids are being dominantly framed as technical tools to a) implement the Energiewende, b) improve energy management, c) introduce high-tech innovations, d) boost the local economy, and e) foster decentralization and prosumage. These framings show that smart grids are universally being framed as solutions, but to different underlying problems.

It also shows that the social challenges relating to decentralization and prosumage play a subordinate role within the dominant techno-ecological framings of smart grids. Moreover, my analysis reveals that the visions of social orders underlying a seemingly uniform, uncontested smart grid imaginary are actually diverse and in part contradictory. Underneath the surface, diverging notions of decentralization and prosumage are circulating and arguably competing for prevalence in the implementation of Berlin’s energy future. These different storylines promote smart grids as vehicles for participative and community-centered energy transitions on the one hand, and independence and self-sufficiency-oriented energy futures on the other. While the first storyline focuses on empowering households and neighborhood communities to become conscious market actors in the city’s energy system, the second storyline understands households as liabilities and neighborhoods as self-contained islands or disconnected hubs. There is little overlap between the two. Interestingly, these contradictory storylines don’t follow the lines of actor coalitions, but run right through institutions, projects and even documents. This reveals an inconsistency and uncertainty about the roles and responsibilities of households and urban neighborhoods in future electricity systems.

I conclude that the term “smart grid” is still primarily associated with technical possibilities rather than social change. While the term “smart grid” unequivocally conjures positive, hopeful yet vague visions of a low-carbon electricity regime, there is little agreement about how to design this socio-technical system. While the technical possibilities inherent in smart grids are clear to all actors involved, their social implications are much more ambiguous. Smart grids are primarily viewed as technical innovations that are associated with widely shared technical goals (such as the integration of renewable energies into the electricity system), while the necessary social changes remain secondary and are thus left to follow.

8.3 Classifying urban smart grids: between intelligent and unintelligible

The way different actors classify smart grids uncovers the kinds of qualities and emotions they associate with smart grids in the city. Are they predominantly communicating excitement and hope? Or are they mostly communicating fear and insecurity? Are certain actors leaning strongly in one of these directions or are they carefully weighing advantages and disadvantages? Answering these questions can point to the value systems and possible interests that underlie different actors and positions. It can further reveal possible voids and highlight the absence of certain voices or positions in a discourse.

At all levels of my analysis, smart grids are predominantly being classified in positive, forward-looking terms. First and foremost, smart grids are being classified as sustainable, intelligent, enabling, modern, and exciting. Next to this dominant position, few voices also classify smart grids as highly complex, challenging and problematic.

8.3.1 Intelligent optimizers

Whether at the level of the city authorities or among researchers and electronics companies at Berlin's future sites, all actors in this analysis consistently associate smart grids with intelligence, using the term interchangeably with the term 'smart'. In its laws, masterplans, strategies and reports, the city authorities speak of "intelligent networks" (Berlin Senate, 2015b, 2016b; Enquête-Kommission, 2015; Erbstößer and Müller, 2017), "intelligent meters" (Enquête-Kommission, 2015: 37), "intelligent measuring systems“ (Enquête-Kommission, 2015: 38), "intelligent coupling“ (Enquête-Kommission, 2015: 155), "intelligent design“ (Clustermanagement Energietechnik Berlin-Brandenburg, 2017: 23), "intelligent steering“ (Erbstößer and Müller, 2017: 11) or "intelligent load management“ (TSB Technologiestiftung Berlin, 2012: 14). Researchers at Adlershof speak of "intelligent storage technologies" (personal interview, researcher Adlershof I, 2018) and of making the grid "reasonable" by "adding intelligence" (personal interview, electronics company Adlershof, 2018). Researchers at EUREF describe their objective as finding "intelligent solutions" (Forschungscampus Mobility2Grid, 2017). At TXL, the notion of intelligence is broadened to encompass not only the grid but the entire city. An advertisement for TXL Urban Tech Republic asks, "how can a city using smart technology and networking become an intelligent energy sponge?" Here, the intelligence attributed to the grid is linked to the intelligence of the entire city. In these diverse statements and analogies, smart grids are thus likened to humans in their ability to understand, interpret and react to external impulses.

Yet 'intelligence' as a metaphor focuses on how smart grids are supposed to perform rather than what they do or how they do it. Highlighting 'intelligence' or 'smartness' emphasizes the characteristics of the technology in terms of speed or accuracy instead of bringing attention to its function or purpose (Boucher, 2021). In the case of smart grids, this is in part mirrored by the multiplicity and resulting vagueness of the existing definitions. While most actors agree that the grid needs to become more 'intelligent', there is little agreement about how grid intelligence works (i.e. how programming is done) and what grid intelligence is for (e.g. to save money, to save CO2, to showcase electric mobility, to sell products etc.). The use of the term 'intelligence' therefore sustains an ambiguity about what smart grids are doing and why, and instead perpetuates a non-specific, hazy image.

Moreover, the attribution of human qualities such as 'intelligence' or 'smartness' to a technology insinuates competition between humans and technologies instead of emphasizing their necessary cooperation (Boucher, 2021). It creates a sense that technical 'knowledge' and technical 'ability' are comparable to human knowledge and human ability. This, in turn, fosters the impression that technical 'intelligence' exists outside of and independently of humans. To an extent, this fuels the notion that 'smart' technologies could one day 'out-smart' people. More importantly, however, this notion tends to sideline the fact that human beings are still responsible for programming and operating smart technologies. It eludes the fact that even an allegedly 'intelligent' technology will always be run by people. The notions of 'intelligence' or 'smartness' are thus fundamentally misleading. They suppress a precise conception of human involvement in the grid's 'smartness', and how heterogeneous this 'smartness' can therefore be. Instead, the notion of 'smartness' suggests universality, and brushes over the multifaceted ways that 'smartness' can be implemented, and the multitude of purposes that 'smartness' can serve. In sum, it black boxes the human act of programming, including the skills and intentions that programming involves. In doings to, it thus masks the idea that humans are responsible for how a 'smart' technology works and should be held accountable for its potential failings.

This black boxing is underscored by an equally vague, complementary notion of system 'optimization'. While most actors agree that system 'intelligence' serves system 'optimization', there is no clear-cut definition of what an optimized system entails. What optimization means remains open to interpretation and therefore obscure. While for most actors, system optimization is about maximizing energy-efficiency, i.e. about balancing out energy supply with demand, for others, it is about maximizing the utilization of renewable energy supply, i.e. prioritizing renewable energies over others. For still others, system optimization is about minimizing energy costs or maximizing system stability (Enquête-Kommission, 2015). All these cases assume different logics of optimization and can revolve around different types of energy (e.g. electricity, gas), different supply technologies (e.g. wind, solar), different storage technologies (ice storage facility, lithium ion batteries), and finally different use cases (e.g. for heating, cooling, vehicle charging). In spite of this diversity of meanings and interpretations, the term insinuates the existence of one single, non-disputable 'optimum'. This rings of one scientifically rational target that can be measured in numbers and compared. Instead of inviting a differentiated conversation, this also reads as if 'optimization' were a goal that can either be attained or missed. It reads as if there was one 'optimal' state and as if everything else were a failure. This all-or-nothing, one-or-zero type association leaves little room for nuance and complementarity. Although both 'intelligence' and 'optimization' are essentially blurry and ambiguous terms, they promote a sense of straight-forward rationality that forecloses any detailed exchange.

8.3.2 Modern, exciting, innovative

At the same time, smart grids are not only regarded in rational and scientific terms, but also as exciting and desirable, modern infrastructural 'must-haves' for the city of the future. They are painted as little less than the dawning of a new world (interview, Berlin Energie, 2018) and a "compelling challenge" (interview, project manager EUREF, 2016) for "modern energy integration" (Technische Universität Berlin, 2012: 48), which are rated to be "extremely important" (interview, project manager TXL, 2017) for the "energy supply of the future" (Erbstößer and Müller, 2017: 15).

Researchers and engineers mostly classify smart grids as exciting collaborative challenge and interesting opportunity for techno-scientific experimentation. Most engineers involved in smart grid development at the city's future sites are driven by a sense of being at the cutting edge of research and development and by an interest in advancing and exploiting the full potential of existing technological possibilities (personal interviews with researchers at Adlershof, EUREF and TXL). Moreover, they view their work as exciting possibility to build an attractive, interesting, modern, and highly functional technology, thinking only marginally about risks or social consequences (personal interviews, researchers at Adlershof and EUREF). Among other things, they view smart grid technologies as "stylish" (personal interview, public service provider, 2018), "sexy" (personal interview, project development company at TXL, 2017), "progressive" (personal interview, researcher at EUREF, 2017) and "cool" (personal interview, researcher at Adlershof, 2017). These attributes stand in stark contrast for example to questions of costs, which they perceive as mundane and reactionary ("ewig gestrig") (personal interview, ICT entrepreneur at EUREF, 2016).

While the city government is well aware of costs, it too regards smart grids as a "sexy" technology that small and medium sized enterprises need to be convinced of (personal interview, Berlin Senate Department for Economics, Energy and Public Enterprises, 2018). Most engineers and researchers involved in Berlin's future sites view smart grids as a personal opportunity for creating something new, and the *Energiewende* thus takes on a quality of being 'the next big thing' in technological advancement.

8.3.3 Inevitable and without alternative

These optimistic, forward-looking notions are also built around a number of fears. They convey a strong sense of urgency and inevitability that depict smart grids as progressive technologies that are not only necessary for the sake of the *Energiewende*, but to win a global race for economic competitiveness. This undertone of urgency and inevitability also promotes the notion that smart grids are without alternative.

Berlin's Digital Agenda, for example, describes digital technologies as Berlin's "only chance" at securing its economic competitiveness. There is a sense that Berlin needs to 'catch up' both in environmental and in technological terms (personal interviews, project development company at TXL and public energy agency). This is echoed by experts from Berlin's future sites:

> „New York is ahead; Amsterdam, Copenhagen are also ahead of Berlin in many points. They have a more flexible administration, that isn't so stuck in the 80's and 90's as it is here. [Their administration] isn't as ideological, more pragmatic" (Interview, TXL Urban Tech Republic, 2017).

Urban policy makers, researchers and businesses alike are conveying a sense that digitization is coming, and that Berlin can either keep up with the pace of technological development or lose in the run for global competitiveness. Asked about possible alternatives, an expert from the city's network operator responds:

> "Adobe huts. Then we won't need electricity, we won't need hot water; it'll be one cold shower a week [….] Of course, then we'll use much less energy per person, but I don't know if that's really the path Germany wants to take" (personal interview, network operator, 2018).

Smart grids, in this expert's view, are needed to avoid regression, underdevelopment, and cold. The city of Berlin, in this reading, has to make a choice between being a pioneer or a loser, a world class competitor or a poor house. There seems to be no middle ground and no time for considering possible risks or alternatives.

Only one interview partner in Berlin, notably from an environmental NGO, actually imagined possible alternatives, asking:

> "What is the goal of smart grids? If the goal of smart grids is, let's say, climate protection, which is actually our overarching goal; and climate protection in terms of energy use means avoidance, efficiency, and the rest renewable; then I think there are a lot of good alternatives. You don't need the intelligent house; it's a question of habits and how to address habits" (Personal interview, 2018).

Although smart grid technologies are (to some extent) necessary for integrating renewables at scale, contrary to dominant smart and low-carbon imaginaries, the growing reliance on digitized technologies is significantly increasing overall electricity consumption and resource use, and therefore counteracting long-term environmental objectives (Lange and Santarius, 2018: 146). The resource intensity of smart grids (first and foremost for servers, but possibly also for attached batteries or the like) has yet to be researched. To date, there is no data measuring the trade-off between resource savings and resource use directly related to smart grids. Moreover, it is well known that energy efficiency technologies tend to generate a "rebound-effect" that threatens to cancel out any resource savings due to increased usage (Lange and Santarius, 2018). Data on the rebound effect of smart grids is also lacking.

8.3.4 Complex, challenging and expensive

Finally, a small minority of actors in Berlin also conveys a sense that smart grids are not just a thrilling prospect, but rather a difficult and demanding endeavor that faces numerous obstacles. They classify smart grids as complex, challenging and - most of all - expensive.

The complexity of smart grid infrastructures and resulting difficulties are especially palpable among actors involved in the pilot projects. Even in its proposal, the research consortium at EUREF states that "the future electricity grid will be more complex than ever before (Technische Universität Berlin, 2012: 4), and that developing it will be a "scientific, technical and social challenge" (Technische Universität Berlin, 2012: 4). A representative at TXL seems to be utterly overwhelmed by this same prospect:

> "If we want to build a smart grid steering system that does everything we want it to do, then the degree of complexity will quickly reach a point that is virtually uncontrollable" (interview, project manager TXL, 2017).

The same project manager humbly calls solving this complex problem an "art" (interview, project manager TXL, 2017). Both researchers and project managers seem to confront the complexity of smart grid systems as welcome challenge and interesting opportunity to put their research and development skills to the test. But even though most actors are well aware of the challenges involved in developing, implementing and testing smart grids, these challenges play only a minor role in the city-wide smart grid discourse.

The same is true for costs, which also play a subordinate role in the discourse, but are especially relevant for a specific group of actors, namely those involved not only in developing smart grids as researchers, but in marketing and doing business with smart grids as entrepreneurs. Not surprisingly, those interested in selling smart grids and those faced with potentially investing in smart grids have opposing views on this issue. A representative of an energy start-up aimed at selling its expertise in micro-smart-grid systems is especially worried about costs as barriers to rolling out smart grids in the city: "people want to have them, but they don't want to pay for them" (interview, energy start-up EUREF, 2016). This concern is mirrored by the network operator, Stromnetz Berlin, that simply dismisses the idea of smart grids as "quite expensive" and warns that "we need to watch out that it doesn't become too expensive" (interview, Stromnetz Berlin II, 2018). Although these two actors share a concern about costs, this concern arises out of very different motivations. While the start-up is eager to launch its new product and establish its new business model, the network operator is mostly concerned with holding on to its existing product and sustaining its current business model. A leading representative of Stromnetz Berlin therefore dismisses various of its own company's efforts in relation to 'smartness' as "not necessary [....] to operate the grid" and then adds, "but we do it anyway, because we believe that we can't completely shut our eyes to this new development" (interview, grid operator I, 2018). This shows that while costs might pose a critical concern in relation to smart grid implementation for incumbents and newcomers alike, the concern comes from different directions. While the start-up complains that incentives to invest are lacking, the network operator complains that the pressure to invest is increasing.

More fundamental concerns about the resource-intensity and thus the environmental impact of smart grids are similarly marginal in Berlin's discourse. These concerns are being voiced only by environmental non-profit organizations, and only in interviews (not in any published documents). As mentioned above, they question the trade-off between the energy use required to store and manage increased data quantities and the energy savings gained through more efficient energy load management.

8.4 Thoughts on risks and critical absences

In conclusion, most actors in Berlin frame smart grids in positive, attractive, even urgent terms. Due to the challenges of implementation, some actors also classify smart grids as difficult or complex, but still as clearly desirable. The uniformity and dominance of this discourse leaves three important question marks: What about risks? What about opposition? And what about alternatives?

While Berlin's smart grid discourse is firmly grounded on certain fears, other risks are strikingly absent. The dangers that are communicated, such as insufficient grid stability or lack of supply security or even the inherent possibility of unsustainable futures, only serve to stabilize the dominant discourse. They imply that the risk lies not in implementing smart grids, but in failing to do so. Yet other risks play a subordinate, almost negligible role. Berlin's smart grid discourse therefore exhibits several critical absences. It currently doesn't address the risks or potential problems that smart grids might entail, leaves little room for controversial discussion, and hence involves no real opposition. In the end, this leaves visions of Berlin's smart grid future seemingly without alternative.

A range of questions comes to mind in relation to digitization, from questions of data privacy and data sovereignty to cyber crime. None of these play a notable role in Berlin's smart grid discourse. Nor do the more specifically smart grid related questions of resource-use or such delicate regulatory issues as steering permission. None of these questions are prominent in the Senate's documents or strategies, they play an insignificant role in the pilot projects' research design and they are only mentioned by interviewees upon explicit request. Of the few risks that do play a minor role in the discourse, data security is most prominently, albeit ambiguously discussed. The Berlin Senate is quite clear on this issue, especially in its New Energy for Berlin report, where it states:

> „Due to the collection of personalized data involved, the responsible handling of network data must be ensured, and the protection of personal privacy must be guaranteed" (Enquête-Kommission, 2015: 135).

In this document, the Senate shows an awareness for the need to protect the data of the city's energy users. In its Smart City Strategy, the Senate adds that "without an integrated security and data privacy concept across all levels, smart grids will be subject to significant operational hazards and acceptance related risks" (Berlin Senate, 2015b: 33). Here, data security is no longer framed as a privacy problem, but as problem for system operation and acceptance. Indeed, of all smart grid related Senate documents, the Smart City Strategy is most outspoken and concrete about the existence of data security issues. It urges that

> "equipping IT-security in the best possible way both staff-wise and material-wise must be a matter of course and the starting point of every smart city project. Pursuing the horizontal conjunction of different sub-systems (for example mobility and energy in vehicle-to-grid contexts) can only be of added value economically and for individuals under this fundamental principle" (Berlin Senate, 2015b: 34).

This strong position is part of the smart city discourse, but is only marginal in direct relation to smart grids. In a third document, the Senate also attributes data security a "key role in securing a sustainable and economically viable energy supply" (Clustermanagement Energietechnik Berlin-Brandenburg, 2017: 33). However, these kinds of strong statements are not echoed by similar publications or projects directly relating to smart grids. In the Senate's view, data security is therefore also necessary to keep energy supply cheap and running. Its standpoint on data security is therefore slightly ambiguous. The same is true for that of researchers at the city's future sites. Various researchers at Adlershof and a project manager at TXL express a certain concern about data security when directly asked about risks related to smart grids in interviews (interviews, researcher Adlershof, 2018; project manager, TXL 2017). At the same time, none of the three pilot projects explicitly tackle questions of data security. Positions on data security are therefore mostly individual and intuitive rather than research based. They range from seeing data security as an important prerequisite for the social acceptance of smart grids (interview, researcher Adlershof, 2018) to seeing it as the users' responsibility (interview, project manager TXL, 2017).

A representative of an environmental NGO doubts the truthfulness of these concerns. She believes that data gathering at the household level is, in fact, "mainly driven by the wish to scan people" (interview, environmental NGO, 2018). This representative of an environmental NGO is obviously skeptical that data security at the household level is even considered an objective of smart grids; or if their objective might really be data collection instead of protection.

Even this small overview of in part contrary perspectives shows that data security is indeed an issue that most actors are thinking about in relation to smart grids in Berlin. Yet, their standpoints largely remain at the level of secondary, often uncommunicated and ambiguous thoughts. They are only mentioned in passing in the Senate's documents, they are not highlighted at the pilot projects, and therefore they are not openly - let alone controversially - discussed within or beyond Berlin's smart grid community.

Other data related issues, such as data integrity, data authenticity or cybercrime have even less representation in the discourse. They are marginally mentioned in the city's documents but are not being investigated, developed or tested as part of any of the pilot projects. The city's Smart City Strategy dedicates two of its thirty-six pages to general security issues. In relation to smart grids, it states that "data integrity, data authenticity and the availability of data in times of crisis are essential security aspects" (Berlin Senate, 2015b: 33). It does not, however, follow up on what these terms mean or what kinds of security issues they pose. Consequently, it does not elaborate on how these issues are supposed to be confronted. According to the glossary of the Computer Security Resource Center of the U.S. National Institute of Standards and Technology, data integrity is defined as "the property that data has not been altered in an unauthorized manner. Data integrity covers data in storage, during processing, and while in transit"[28]. Data integrity can therefore be understood as the opposite of data corruption. In the case of smart grids, this would refer to the integrity of data on available energy production, related energy prices and energy usage at any given time. Without data integrity, i.e. with false or inaccurate information, smart grids might lose much of their functionality, and thus their efficiency and environmentally related appeal. If this were the case, then ensuring data integrity in a smart grid system would seem like a fundamental matter. The same is true for data authenticity, which is defined as a sub-category of data integrity and means that the data in question originates from its purported source[29]. Without accurate and truthful information on the origin of data, i.e. where energy is being produced and where it is being consumed, smart grids would lose their ability to synchronize flows and thus lose one of their primary functions. Given the importance of data related risks to the smooth and effective functioning of smart grids, the superficiality of Berlin's discourse on these issues is striking. Cyber crime is similarly absent from this discourse. Although it is likewise mentioned in the Senate's documents, it is hardly mentioned in interviews and clearly not a priority for researchers. In its Smart City Strategy, the governmental authorities at least mention that

> "in Berlin and elsewhere, modern urban society is increasingly dependent on its infrastructures. Electricity shortages of only a few hours could fundamentally call the operability of existing systems into question. Cyber attacks are on the rise all over the world" (Berlin Senate, 2015b: 33).

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[28] https://csrc.nist.gov/glossary/term/data_integrity
[29] https://csrc.nist.gov/glossary/term/authenticity

The Senate is therefore aware of the rising risk of cyber crime. Yet, judging by the attention this issue receives in its overall communication about smart grids, the Senate doesn't treat this risk as equally important as the benefits of smart grids. Moreover, protection against cyber crime is not part of any of the pilot projects. Overall, this results in a one-sided picture of the future that smart grids might bring.

The marginal presence of ICT-related risks in Berlin's smart grid discourse does not mean that these risks do not exist. As my analysis has shown, it doesn't even mean that the actors involved in Berlin's smart grid community aren't aware of the risks that exist. In fact, risks play a much larger role in the smart grid discourse at the federal level. Among others, the German Energy Agency (dena) and the Federal Agency for Information Security (BSI) have issued detailed publications on ICT-related risks and security issues pertaining to the digitization of the *Energiewende*, which focus specifically on smart grids (Bundesamt für Sicherheit in der Informationstechnik, 2021; Limbacher and Richard, 2018). Berlin's public energy agency (BENA), by contrast, has not. This means that most participants in Berlin's smart grid discourse are choosing to prioritize benefits, potentials and hopes over risks, insecurities and possible dangers. They are thus painting an unbalanced picture of Berlin's smart grid future, coloring it in positive, attractive terms while leaving out the less appealing, perhaps more controversial or even frightening nuances. In effect, this has led to a one-sided and undisputed idea of Berlin as a future smart grid city. It has generated no opposition and seems to leave no alternatives.

8.5 Concluding remarks: dominant storylines of Berlin as a future smart grid city

The way smart grids are being collectively defined, framed and classified by the actors promoting Berlin's smart grid discourse gives rise to a set of dominant, overarching storylines that are promoting techno-optimistic visions of urban smart grid futures while ignoring certain risks and also ignoring alternatives. These storylines depict smart grid technologies as environmental necessity and collaborative challenge that will advance urban energy communication, transparency, flexibility, stability, and intelligence. Moreover, Berlin's smart grid storylines are depicting the city as a clean, convenient, collaborative, socially agreeable, innovative and economically thriving future metropolis.

More precisely, these dominant storylines are promoting smart grids as a) environmental necessity for advancing Berlin's local *Energiewende*, b) high-tech innovation for improving energy management while maintaining current comfort-levels, c) economic imperative to secure Berlin's future as a thriving metropolis, d) facilitators of energy empowerment and public participation, and finally as e) exciting experimental challenge to modernize the city's infrastructure. According to these dominant storylines, smart grids are not only cutting edge and attractive, but also in the public's environmental and economic interest. Moreover, they are urgently needed to secure Berlin's competitive advantage in the global race for high-skilled, high-tech jobs. These techno-positivist storylines elevate smart grids to nothing less than a moral imperative. They are deeply rooted in a belief that technological innovation can and will bring about desired social and environmental change (Sand and Schneider, 2017).

Yet, these positivist storylines come at the cost of a more nuanced, differentiated debate about the specific use cases for smart grids, possible side effects and conceivable alternatives. Among others, the discourse hardly distinguishes between infrastructural worlds for example of heating and mobility, and their very different cultural practices, institutional structures or governance arrangements. It doesn't distinguish between the steps needed to change either one or the other. Neither does it dwell on the logics inherent in the design of smart grid related algorithms. The vagueness of the discourse keeps data and steering related issues largely black boxed. The same is true for risks and possible alternatives. Berlin's smart grid storylines don't capture the potential risks built into the digitization of this critical urban infrastructure, for example in relation to data privacy or cyber crime. In consequence, the overarching smart grid storylines are confronted with little critique and are not competing with any alternative storylines.

Overall, smart grid technologies evoke a fuzzy but enticing vision of urban futures that merges technological optimism with fantasies of economic achievement and environmental health. Among others, this fuzzy vision of a future smart grid city promotes a modern, eco-progressive "Zeitgeist" that blurs the lines between the means and ends of "smart": does Berlin need to advance the smart city to advance its smart grid? Or does it need a smart grid to become a smart city?

In this chapter, I scrutinized the discourse surrounding smart grids in Berlin using Reiner Keller's sociology of knowledge framework of discourse analysis. This approach enabled me to unravel the various definitions, frames and classifications that Berlin's smart grid discourse is bringing to the fore and to distill the dominant storylines that this discourse is promoting. In doing so, I showed the *content* and the *meanings* being attributed to smart grids in Berlin.

In the chapter that follows, I proceed to analyze the *politics* inherent in Berlin's smart grid discourse. As elaborated in chapter 6, I do so using Hajer's concepts of discourse coalitions (see chapter 6 "Research design and methods"). This second analytical approach enables me to focus on the processes of discourse production, the formation of actor coalitions and the questions of power that underlie them.

9 The politics of experimental futuring with smart grid infrastructures in Berlin

In the previous chapter I outlined the meanings and dominant storylines that are being promoted by Berlin's smart grid discourse. In this chapter, I reflect on the alliances that have formed around these storylines in the city and the social (power) relations at play in the process. I show which different actors have gathered around smart grids in the city, and how they have promoted Berlin's dominant smart grid storylines, for example through collaboration within the pilot projects or by advertising the city's future sites. In short, this chapter analyzes the politics inherent in Berlin's smart grid discourse.

As outlined in my research design, I base this analysis on Hajer's concept of discourse coalitions (Hajer, 1993), which allows me to unravel the politics inherent in the production of Berlin's dominant smart grid storylines (for a detailed overview, see chapter 6.3 "Analyzing discourse"). Hajer defines discourse coalitions as "the ensemble of a set of storylines, the actors that utter these storylines, and the practices through which these storylines get expressed" (Hajer, 2006: 71). The concept of discourse coalitions enables the analysis of the relations between the actors that are producing Berlin's smart grid storylines and the ways they interact (or not) at the pilot projects, the future sites or at other sites of discursive production in the city. I begin by introducing the main actors involved in creating and maintaining the discourse and then show how they do this through research and implementation activities at the pilot projects, through strategies for marketing the future sites and through urban development policies and programs supported by Berlin's city government and administration. To apply Hajer's concept, I asked questions such as: What are the sites of argumentative exchange, i.e. where are arguments being voiced and where are discussions taking place? What are key incidents in the debate? What is the sequence of events? (Hajer, 2006). By answering these questions, the concept of discourse coalitions helped me unveil the "tactics" or power politics behind discourse production, especially when opposing parties are struggling to dominate a discourse. Yet unlike the discourses analyzed in much of Hajer's work, Berlin's smart grid discourse is not openly controversial. My findings reveal that – at least on the surface – smart grids are being promoted by one strong discourse coalition that largely agrees on the same storylines.

Based on Hajer's conceptual categories (Hajer, 2006), I conclude that Berlin's urban smart grid discourse can be viewed as *structurated* (i.e. the same storylines are shared by many), but it is not yet *institutionalized* (i.e. the discourse has not entered the lived reality of institutions or homes). On the implementation level, this is mirrored by the fact that smart grid technologies have not surpassed the experimental stage, let alone reached the broader urban mainstream in Berlin.

In the chapter that follows, I discuss why Berlin's smart grid discourse hasn't moved beyond structuration by unraveling the qualities and limitations of smart grids as *Leitbilder* and imaginaries, and their potential as means of activating urban socio-technical change.

9.1 Who is involved in Berlin's smart grid experimentation and what are their roles?

This section introduces the actors involved in Berlin's smart grid experiments at all three levels of my analysis. It discusses how different actors are involved in producing, reproducing and transforming Berlin's imagined smart grid futures. This section thus primarily aims at laying out and illustrating the communications, activities and positionings of Berlin's smart grid community.

The following institutions are involved in smart grid experimentation in Berlin and thus actively involved in creating Berlin's smart grid discourse. They can be divided into seven categories: the acting grid operator, city government and administration, the new public utility company, the scientific community, project developers, ICT companies, and NGOs (see chapter 6.5 "Data collection"). National institutions, such as the German Association of Electrical Engineering, Electronics and Information Technology (*Verband der Elektrotechnik, Elektronik, Informationstechnik – VDE*), the Federal Network Agency (*Bundesnetzagentur - BNetzA*) or the Institute for Applied Ecology (*Öko-Institut*) play an important role in Germany's national smart grid discourse (similar to the IEEE internationally), but are not as closely linked to the smart grid discourse pertaining specifically to the city of Berlin. For this project, national level discourses are treated as context, rather than part of the investigation.

9.1.1 The acting grid operator

The city's long-term grid operating company, Stromnetz Berlin, is in a powerful position to negotiate or even instigate changes to the "smartness" of Berlin's electricity grid. As incumbent, however, Stromnetz Berlin is contributing to Berlin's *Energiewende* and its smart grid discourse in ambiguous ways. It is primarily committed to guaranteeing steady and reliable energy supply for its customers. It views itself as centralized controller that is dedicated to keeping the city "alive" by keeping energy supply secure and flowing (Interview, Stromnetz Berlin 2018). First and foremost, it is committed to an ethics of keeping the city functional and running. Instead of clearly positioning itself towards Berlin's *Energiewende*, the grid operator views its own role as neutral platform that is neither 'for' nor 'against' the integration of renewable energies. As a leading representative states: „we are a platform, a conductor, we are not per se environmentally friendly or unfriendly" (Interview, Stromnetz Berlin, 2018).

The grid operator takes the same ambiguous position towards smart grids. Even though Stromnetz Berlin advertises smart grids as "electricity grids of the future"[30], the company does not consider smart grids necessary for operating electricity flows, but rather as "add-ons" that are being pushed by outside market forces. For Stromnetz Berlin the term "smart grid" describes an electricity grid that is equipped with digital control mechanisms on all voltage levels, and which therefore has the capacity to react intelligently to user demands. In the grid operator's view, both is already the case (Interview, Stromnetz Berlin 2018). For Stromnetz Berlin, the electricity grid is already "smart", and initiatives to integrate more ICT present an unnecessary effort and an unwelcome disturbance to the company's operations. These micro-smart-grid initiatives start where the company's responsibility ends, namely behind the meter. On its website, it simply calls micro-smart-grids

[30] https://www.stromnetz.berlin/technik-und-innovationen/smart-grid

customer installations[31]. This shows that in spite of its powerful position, the Stromnetz Berlin currently displays little interest in changing how the grid is technically equipped or by whom it is managed.

At the same time, the company is cautiously and strategically on guard for anything happening through "outside market forces" (Interview, Stromnetz Berlin 2018). In the past years, the grid operator has come under increased pressure not only to back down from grid operation, but to innovate its technologies and its business model in favor of more "smartness". It has been confronted with a growing political commitment to integrating renewable energies and electric vehicles into Berlin's electricity system and thus to adapt to the idea of making the grid "smart". Among others, the grid operator has reacted to these pressures by becoming part of at least one of Berlin's pilot projects and publicly facing up to discussions about its role and responsibilities. As business partner of the Mobility2Grid project, the company is claiming an active role in Berlin's smart grid research and development process, and is regularly represented at project conferences and other public events on campus. Stromnetz Berlin is thus actively involved in crafting Berlin's smart grid discourse. At the same time, a representative of Stromnetz Berlin admits to its passive role in Berlin's smart grid process: "Innovation management in my unit is driven by external influences" (interview, Stromnetz Berlin 2018).

Most importantly, however, Stromnetz Berlin spent many years actively opposing the city's attempt to regain public ownership of the grid. Since 2014, the company continuously resisted every step of of the Senate's bidding process. Only in 2021, after seven years of stalling, the company stepped back from the tendering process, thus clearing the way for public grid ownership and operation. At the time of writing, the grid is still in the company's hands. Although Stromnetz's long resistance was only marginally related to the question of making the grid *smart*, it shows how strongly Stromnetz Berlin is clinging to its long-term position as incumbent grid operator and its reluctance to reinvent or renegotiate its role within Berlin's energy system.

9.1.2 The ambiguous public administration

Berlin's public authorities are historically divided into district and city governments. Questions of authority and responsibility are therefore often complicated. At the administrative level, the responsibility for supporting the development of Berlin's local smart grid infrastructures lies mostly with the Senate Department for the Economy, Energy and Businesses (SenWEB). SenWEB is not only responsible for all city-wide issues relating to renewable energies, the energy industry, and digital infrastructures, but also for the development of Berlin's future sites. While in theory all issues relating to climate protection and climate change adaption fall under another Senate Department's authority – the Department for the Environment, Transport and Climate Protection (*SenUVK*) – SenWEB effectively concentrates many relevant responsibilities. Even though the Senate Department for the Environment oversees the implementation of Berlin's Energy and Climate Protection Program (*BEK 2030*), the Senate Department for the Economy is responsible for its most important component, namely energy. Energy and climate issues have only been separated administratively since 2016, when the current city government took office. Since then, both SenUVK and SenWEB have been headed by Senators from the Green Party. Under their leadership, climate protection and Berlin's urban energy transition have become high priorities on the

[31] https://www.stromnetz.berlin/einspeisen/micro-grids

government's agenda. Yet, through the administrative separation of energy and climate issues, energy has arguably been viewed more through an economic than an environmental lens. While SenWEB is truly dedicated to transforming the city's energy infrastructures, it is likewise devoted to helping the city profit from its urban *Energiewende*.

As a cross-sectional topic, smart grids are not assigned to any specific division within the Senate Department, which means that there is no designated contact person for smart grid issues in the entire administration. Instead, smart grid related issues are broadly assigned to SenWEB's division for Energy, Digitization and Innovation. Actors involved in smart grid implementation criticize the absence of a clear responsibility, and – as a consequence – the borders of the administration's "responsibility silos" (interview, energy start-up, EUREF, 2016). A representative of an energy start-up at EUREF Campus explicitly complains that "you can't be in a dialog with the city […] that's the reality. You can't talk to the city. With this city absolutely not, it doesn't work, the city consists of 1000 different [….] Okay, of course, we're in a discourse […] we participate everywhere, we are invited everywhere, we lecture everywhere […] but you can't talk to the city […] No, that doesn't work. That's not a dialog partner in this development" (interview, energy start-up EUREF, 2016).

Instead of actively participating in smart grid implementation at the pilot projects, SenWEB views its role mostly in identifying and supporting meta-level "lighthouse" projects, for example as part of the future sites. Among others, it does this by hosting the managing office for all 11 of Berlin's future sites, where it concentrates all relevant publicity and marketing activities. The administration has also outsourced direct management of the future sites in this analysis to the project management companies WISTA Management and Tegel Projekt GmbH, and is therefore far removed from concrete smart grid developments in the city. Actors actively participating in existing "lighthouse" projects, such as the pilot project at EUREF Campus, thus tend to view the administration as a disinterested, uninformed obstacle to smart grid development in the city.

9.1.3 The new public utility company, Berlin Energie

The new public utility company, Berlin Energie, was founded in 2012 for the sole purpose of regaining the concession to operate the city's gas and electricity networks. In 2013, the state-owned company joined forces with the citizen-led cooperative, BürgerEnergieBerlin, and submitted a bid in the tendering process. In 2014, this public-private consortium won the bid for tenders. However, the current concession holder, Vattenfall, appealed against the decision in court, stalling the process for a period of over seven years. Only in 2021, Vattenfall unexpectedly withdrew its appeal and backed down from the tendering process. In effect, Berlin Energie has been waiting to take over grid management for almost a decade.

In the meantime, the small state-owned company has taken on a role as advocate for transforming Berlin's energy system, especially regarding combining the city's electricity, gas, and district heating grids. According to its website, Berlin Energie is dedicated to making these grids smart, and transparently managing all data collected in the process. The company's managing director campaigns for these goals at public events, such as the Berlin Energy Days (*Berliner Energietage*) or at open houses (*Tage der offenen Tür*).

The company is not actively involved in any of the three smart grid pilot projects in this investigation. Yet, as my interviewee confirms, the company envisages the large-scale implementation of power-to-gas and power-to-heat infrastructures in Berlin in the future. The same interviewee is convinced that the grid operator could and should be allowed to control both energy production and distribution, i.e. BerlinEnergie argues for rebundling the electric grid system. Overall, as long as grid operation remained firmly in Vattenfall's hands, BerlinEnergie's role was that of a small, rather toothless tiger.

9.1.4 The scientific community

Although smart grids are often claimed to be technically mature, in Berlin their development involves various scientific challenges, and is therefore driven by research interests and institutions. Since the term 'smart grids' is understood very broadly, existing research spans a wide range of topics from bi-directional loading to market design to the social acceptance of smart meters. Many smart grid applications are indeed not new; yet their combination still raises technical and/or political issues.

The two smart grid pilot projects in this investigation are research driven and aimed at tackling some of these issues; these are the pilot projects at Technology Park Adlershof and at EUREF Campus. Both projects were initiated and are headed by research consortia and are financed to a large part with public research funding. They involve some of the city's most prominent research institutions, including Berlin Technical University (TU Berlin), Berlin Social Science Center (WZB) and the University of Applied Sciences (HTW) as well as research institutions from outside the city, such as Freiburg-based Fraunhofer Institute for Solar Energy Systems (Fraunhofer ISE) and the Karlsruhe-based Research Center for Information Technology (FZI). Berlin Technical University (TU Berlin) and Berlin Social Science Center (WZB) play especially prominent roles in in these two research driven projects. They represent two areas of Berlin's spectrum of scientific expertise: the engineering sciences and the social sciences. It is worth mentioning that both projects, though predominantly focused on solving engineering challenges, are significantly informed by social science scholarship.

Researchers at the pilot projects view their role as inventors, as conceptualizers, and as problem solvers (interview researcher, EUREF, 2017). Researchers have indeed acted as intellectual pioneers of the smart grid pilot projects and thus of smart grid development in Berlin. Other consortium members understand their role as a kind of radical low-voltage guerilla: "Yes, we are the radicals in this system at the uncontrollable low-voltage level" (interview, energy start-up, 2016).

Yet, their influence on actual project implementation has been limited. Their impetus to implement micro-smart-grids systems in and outside of the future sites has been rather complicated and slow. As a result, it remains unclear whether a smart grid ever existed at EUREF Campus. Researchers depend on funding from federal institutions and on cooperation with private companies. Moreover, they also depend on the availability of physical space for implementing their project ideas. The research community therefore depends on the project management companies that manage the future sites. Inspite of its role as accelerator of Berlin's smart discourse, the scientific community largely depends on external funding and property to actualize its visions. The scientific community therefore plays an important role in activating and sustaining Berlin's smart grid discourse but is limited in its power to carry this discourse into the broader urban fabric.

9.1.5 Project development companies

Carrying stories into the broader urban fabric is the job of the project developers. Berlin's smart grid discourse is also being influenced by three project management companies that are responsible for managing and developing the three future sites. These are EUREF AG (at EUREF Campus), WISTA Management GmbH (at Technology Park Adlershof) and Tegel Projekt GmbH (at TXL Urban Tech Republic). While EUREF AG is a privately-owned company, WISTA Management GmbH is commissioned by the Senate, and Tegel Projekt GmbH is a direct subsidiary of WISTA. The latter two therefore work under governmental directives, and act as direct links between the smart grid pilot consortia and the city administration. WISTA Management GmbH and EUREF AG are also both members of the smart grid consortia at their respective campuses, although they hardly participate in the day-to-day research and development activities. Their main job is to manage and market the future sites, whether in their own or in the city's interest. This includes communicating with the public, attracting businesses and negotiating with research institutions. For advertising purposes, they each cultivate site-specific corporate identities, maintain websites, and regularly organize public events. The project developers incorporate smart grids and smart grid related artefacts into these advertising campaigns to varying degrees.

EUREF AG has used smart grids and smart grid related artefacts as core features of its marketing activities ever since the Mobility2Grid project kicked off in 2011. Since then, smart grids have formed an integral part of the developer's campus advertising. This is in part because the campus is relatively small, and the smart grid project therefore occupies a large portion of the campus' overall area and involves numerous campus related institutions. The marketing activities mostly circle around the physical smart grid infrastructures that are presented on campus in catchy, interesting ways. These infrastructures are provided by different partners of the research consortium, and EUREF AG uses them to present the campus via photos on its website, during campus tours, and through activities at public events. For example, the company demonstrates electric vehicles and different types of loading stations at public events or shows a small wind energy generation plant that is set up at street level during campus tours. Even though my research reveals that the project developer shows skepticism and even outright contempt for the pilot activities, the company publicly advertises the micro-smart-grid and related technologies as "groundbreaking" and among its so-called "EUREF stars"[32].

WISTA Management GmbH and Tegel Projekt GmbH use smart grids and smart grid related infrastructures to promote their future sites in less conspicuous, less specific ways. In the case of Adlershof, this is arguably because the smart grid pilot project is much smaller compared to the overall size of the Technology Park, involves fewer participants and is therefore much less significant compared to the many other institutions and projects being pursued on campus simultaneously. Here, smart grids are thus only one of many other technologies, institutions and topics that dominate the site's public image. In the case of TXL Urban Tech Republic, this is likely due to the project's ten-year period of uncertainty, and because none of the envisaged infrastructures have yet been built.

[32] https://euref.de/en/euref-campus_en/#zeemobasemicro-smart-grid

At both sites, smart grids are therefore used to feed into a broader narrative that brings “innovation and sustainability”, “economy and ecology” together[33].

Overall, the project development companies use smart grid research and implementation projects as interesting and potentially helpful tools for marketing their sites as future-oriented, business-friendly and sustainable spaces, but smart grids are not central or even necessary for this endeavor. Nevertheless, in their role as managers and advertisers of the future sites, the project developers play a crucial role in embedding visions of smart grid futures in a greater urban storyline, and for carrying this storyline into the broader public. In fact, EUREF AG recently launched a second EUREF Campus in Düsseldorf where it boasts to be implementing an “innovation campus” and “mobility research hub” to show that “the *Energiewende* can be done and financed”[34]. A representative of EUREF AG therefore sees his role as that of businessperson, visionary and pioneer: “I'm really a little bit like Elon Musk” (interview, project development company EUREF; 2016), he says. With or without smart grids, the project development companies are powerful voices in Berlin's landscape of urban techno-scientific experimentation.

9.1.6 ICT and electronics companies

ICT and electronics companies are involved in the pilot projects, because they are interested in opening new markets for their products. They view the potential to digitize electric grids like the potential to digitize all areas of city life as progress and as opportunity. Their focus as project partners is therefore to understand the technology and to push it. They are primarily interested in expanding their knowledge of specific ICT technologies, which are already part of their portfolio, and which they are interested in expanding. A representative of an international ICT company very clearly outlines their company's role as followers:

> “I would say that [the company] has no strategic orientation yet, for example, to systematically develop anything with a partner; from the company's perspective one would always say, if Vattenfall has a smart grid project, then we are ready and willing to contribute the infrastructure. If it's the public utility, we do the same” (interview, ICT company, 2018).

This statement clearly shows that ICT companies are lined up to contribute smart grid technologies but not interested in being their forerunners. If others take the lead, they will follow. The same representative states that “the colleagues from sales […] are always quickly interested in the fast revenue goals, not so much in long-term development partnerships” (interview, ICT company, 2018).

9.1.7 Civil society organizations (BUND, BürgerEnergieBerlin)

Civil society organizations are only marginally involved in smart grid experimentation in Berlin. Although they are not directly involved in the pilot projects, civil society organizations have strongly influenced Berlin's electric grid politics in the past years. Most importantly, BürgerEnergieBerlin, the cooperative that successfully campaigned

[33] https://www.adlershof.de/en/news/the-minus-sign-represents-something-positive/

and then bid against the incumbent grid operator has strongly influenced Berlin's electric grid politics, and thus the grid discourse. However, BürgerEnergieBerlin primarily advocates for public participation in managing the electric grid; not so much for the implementation of *smart* grids. The cooperative sees its role in ensuring transparency and public participation and holding the grid operator publicly accountable rather than overseeing the implementation of smartness into the grid. In sum, BürgerEnergieBerlin is only marginally involved in Berlin's smart grid discourse.

9.1.8 Concluding remarks: few powerless pioneers, many opportunists and an ambiguous administration

As this overview shows, the broad coalition of experts that has formed around the idea of smart grids in the city has emerged despite an array of different interests and agendas. It unites unlikely allies under one discursive umbrella that each display very different motivations and are equipped with varying degrees of power. As a result, all actors find themselves in a reactive, following role, whether by choice or by force.

The discourse coalition is headed by a scientific vanguard of "thought leaders" (Levenda, 2016) and followed by a reluctant majority of sustainability opportunists and ambiguous facilitators. The scientific community is willing to take the lead but lacks the mandate and the financial ability to move forward on its own. The research consortia are the driving forces behind the pilot projects and thus strongly involved in shaping visions of Berlin's smart grid futures. They have powerful voices in the discourse coalition but have little influence over the broader smart grid system, because they depend on federal research money and project developers for support. Meanwhile, the network operator has the position and the financial ability but lacks the willingness to go forward and take the lead. The network operator has a unique position of power in Berlin's smart grid discourse coalition but is not driving the discourse out of fear of losing power and revenue. The newly founded public utility company, by contrast, has no power over the grid and has instead been forced into a position of waiting. The project developers have supported the pilot projects and are responsible for marketing the future sites, which gives them a strong, but slightly ambiguous voice in the discourse. They use smart grids as entry points for marketing the smart city more generally and are driven mostly by economic concerns. Finally, incumbent ICT companies with the financial ability lack incentives. ICT and electronics companies are interested in selling their technology, but not in the driver's seat; they are going with the flow. While they might be pushing for smart grid technologies internationally, their influence on the discourse in Berlin is rather marginal. Civil society organizations have taken a strong leadership position in the city-wide discourse about re-instating public ownership of the grid but have little to say about smartness. In this situation, the public authorities see themselves as moderators rather than drivers of smart grids. The Berlin Senate is reserved when it comes to Berlin's smart grid futures.

Among other, this shows that smart grids work as common reference points for researchers and businesses, energy and ICT companies, project developers and public administrators despite their diverging institutional logics, cultures and objectives. Even beyond the day-to-day collaboration at the pilot projects, Berlin's smart grid storylines thus prove open and flexible enough to incorporate various vantage points and priorities, yet specific enough to drive different actors in a common (discursive) direction. However, this broadness is also a deficit. It disguises a lack of clarity about the ultimate goals and possible pathways towards these goals, i.e. a lack of political leadership, which has resulted in a general "wait-and-see" attitude. Everybody seems to have stakes in smart grids, but nobody is taking the lead. It therefore comes as no surprise that in spite of a seemingly strong and unified vision of the future smart grid city, material smart grid implementation has hardly travelled beyond the borders of the pilot projects. Berlin's discourse on smart grids remains marginal even though smart grids are being developed, tested, and showcased at various future sites, backed by policy documents and promoted by corporate advertisements. Yet the discourse about smart grids has not reached the general public. Unlike adjacent discourses, for example about Berlin as a smart city, Berlin's urban *Energiewende*, or even Berlin's electricity grid, the specific discourse about making Berlin's grid *smart* remains confined to a relatively small community of experts.

9.2 The politics of experimental "futuring" with smart grid infrastructures

In the previous chapter, I showed that the discursive dynamics of Berlin's smart grid futures are being created by a combination of research and implementation practices at the smart grid pilot projects, the city's science and technology centered future sites and by political policies and programs (see chapter 8 "Analyzing Berlin's smart grid discourse"). The sites, actors and types of discourse production are mutually reinforcing each other to create a dominant smart grid discourse coalition and dominant storylines of Berlin as a future smart grid city. As described in chapter 8, these dominant storylines promote smart grids as a) environmental necessity for advancing Berlin's local *Energiewende*, b) high-tech innovation for improving energy management while maintaining current comfort-levels, c) economic imperative to secure Berlin's future as a thriving metropolis, d) facilitators of energy empowerment and public participation, and finally as e) exciting experimental challenge to modernize the city's infrastructure. These largely coherent and uncontested storylines of Berlin's smart grid futures are being produced by an unlikely coalition of public and private, corporate and research actors, and are developing largely without controversy. Moreover, these dominant storylines fail to address risks and are muting the discussion about possible alternatives (for the detailed analysis, see chapter 8 "Analyzing Berlin's smart grid discourse").

This raises three main questions, which I explore in the following chapter: How are the design and practices of urban experimentation shaping Berlin's dominant smart grid storylines (and not others)? How are different actors using urban experimentation to advance these storylines? And lastly, how is urban experimentation therefore contributing to broader urban smart grid related change? The following chapter therefore addresses the politics of envisioning Berlin's smart grid futures, especially through urban experimentation.

To understand how Berlin's dominant smart grid storylines are emerging under the specific circumstances of the city's experimental landscape, and how different actors are using urban experimentation to advance these storylines, I now analyze the interplay between Berlin's smart grid pilot projects, the city's future sites and the broader urban development policies and programs that they are embedded in. I show how the interplay between different types and levels of smart grid discourse production (i.e. policy narratives, corporate marketing strategies, research and development initiatives) are mutually reinforcing each other, and which role the pilot projects, future sites and urban policy play in this process.

This section does not, however, analyze the processes of day-to-day collaboration at the pilot projects. It does not cover instances of discourse production that occurred in the context of internal project meetings. Because this analysis is not based on ethnographic research, I do not make any statements about how different definitions, positions, or arguments developed between project stakeholders internally.

9.2.1 What is urban experimentation?

In the introduction to this dissertation, I laid out that smart grid technologies are currently still in the making, and that pilot versions are being developed and implemented at experimental sites in cities (see chapter 1.3 "Smart grids at urban labs"). This experimental approach is embedded in the growing interest of city governments to initiate and govern energy and sustainability transitions, for example by supporting the development of "green" technological innovations in experimental "urban labs". Urban governments are increasingly exploring ways to actively steer infrastructural change and are increasingly building on urban experimental approaches to do so. These approaches build at least in part on experiences from the business world, where novel technologies are commonly trialed with potential users under "real-life" conditions to test and adapt them for better marketability. According to Bulkeley et al (2019), the readiness to experiment with urban futures can be attributed to the rising overall awareness for the need to protect the climate, an increasing uncertainty about how to do so, and an ever more flexible, adaptive and participatory understanding of urban planning and urban governance, that has developed over the past decades and is increasingly being translated into practice (Bulkeley et al., 2019: 318). Especially urban energy and infrastructural transitions are increasingly being implemented within and through such spatially delimited sites of urban experimentation (Bulkeley et al., 2013; Castán Broto and Bulkeley, 2013; Evans et al., 2016; Evans and Karvonen, 2014; Hoffman, 2011). These sites are seen as ways to create the necessary knowledge for promoting grander societal change, especially in contexts of uncertainty, or "indeterminate futures" (Edwards and Bulkeley, 2018: 352). They are often explicitly aimed at triggering broader societal change by "scaling-up" or "rolling out" new infrastructural solutions (Potjer, 2019). Often these processes of experimenting are not the matter of politicians and urban administrations alone, but increasingly involve a diverse range of stakeholders, from private businesses and universities to local grass roots organizations (Blanchet, 2015). Due to their proliferation, experimentation in urban labs has arguably become a new form of urban governance (Bulkeley et al., 2019; Caprotti and Cowley, 2017).

The idea of publicly experimenting in "urban labs" merges ideas from different research traditions that have evolved in parallel and are increasingly overlapping. These are science studies on the one hand, and innovation studies on the other. The idea of urban experimentation is based in part on the deconstruction of the scientific lab as closed, placeless, "objective" and value-free environment, and on the acknowledgement that scientific processes of knowledge production are deeply enmeshed with the interests and values of those involved. It is therefore based on the idea of co-producing knowledge with actors from outside the scientific community (Jasanoff, 2004). The German sustainability research community is strongly influenced by these insights from science studies, which focus on the role of researchers in promoting sustainability related change, and on an understanding of researchers as partners in collaborative processes of knowledge production rather than mere external observers. This idea of promoting experimental labs as spaces of collaborative knowledge production of course resonates with the idea of introducing experimental niches to challenge existing socio-technical regimes (see section 4.6 “How do infrastructures change?”). Although experimentation lies at the heart of the urban lab rhetoric, Bulkeley and Castán Broto find that most urban labs “do not use experiment in the formal scientific sense of the term but rather to signify purposive interventions in which there is a more or less explicit attempt to innovate” (Bulkeley and Castán Broto, 2013: 363). Experimental interventions are often loosely set up to enable “learning by doing” in spatially and temporally bounded ways and aimed at applying whatever lessons can be learned to a broader scale (Caprotti and Cowley, 2017: 1442).

Urban experimental constructs indeed go by multiple names and are built around different underlying concepts, from real-world laboratories, innovation spaces, transition labs, real-world experiments, living laboratories, test beds to urban labs. In the German context, the Federal Minstry of Economics and Technology (BMWi) defines “real-world laboratories” as “regulatory sandboxes” that are “temporally and geographically bounded sites for testing innovative technologies or business models under real-life conditions” (Bundesministerium für Wirtschaft und Energie, 2019: 7). BMWi thus emphasizes technological innovation, business and regulatory learning but remains vague regarding the design of these learning processes, the types of actors involved, and the types of technologies in question. By contrast, scholars from the German sustainability research field explicitly focus on sustainability related learning processes and sustainability related change. They conceptualize urban “living labs” as transformative and transdisciplinary research programs that are aimed at promoting sustainability, and designed to optimize processes of co-production, co-design and co-evaluation in geographically defined spaces (Rose et al., 2019). In this conceptualization, the scientific community plays a key role in collaborating with practitioners in an explicit effort to bring about sustainability related change. In an attempt to systematize different understandings and make them useful for the study of urban governance, Karvonen and van Heur (2014) conclude that “urban living labs” boil down to three common characteristics: local situatedness, contingency and change-orientation. Bulkeley et al (2019) add that urban living labs must contain participatory elements, display “alternative modes of leadership and ownership to those found in traditional private sector projects or urban planning processes” (Bulkeley et al., 2019: 319) and involve some sort of institutionalized monitoring and evaluation process.

Implicitly or explicitly, these conceptualizations all involve the idea of envisioning alternative futures, demonstrating them in public and expanding them across time and space. Karvonen and van Heur (2014) make an important point when they argue that experimentation in urban labs is as much about producing scientific or technical knowledge as it about publicly performing and pursuing certain narrative strategies to persuade an audience. Urban labs are therefore not necessarily about open-ended experimenting, but also about goal-oriented showing, telling and steering. For the same reason, Jasanoff (2015) understands experimental sites not only as sites of knowledge performance but also of political performance (Jasanoff, 2015: 10). They are public exhibits that are aimed at effectively sparking and spreading certain discourses in the public arena (Hajer and Versteeg, 2019). Hajer and Versteeg (2019) therefore also understand living labs as “technique of futuring”. In urban lab settings, these techniques can include technical standardization processes, corporate advertisements, artistic interventions or the creation of lived experiences (Pelzer and Versteeg, 2019).

Although these performances are often accompanied by a rhetoric of radical innovation and system change, they can also perpetuate dominant worldviews and reify existing (socio-technical) regimes. They can privilege certain discourses of the future over others, and thus solidify existing power relations. Research has shown that urban lab approaches are not necessarily as radical as their claims, and can very well disguise developmental "business as usual" (Marvin et al., 2018).

As Berlin's city government designates more and more spaces as experimental urban labs, these spaces, too, are becoming important sites of urban governance, where Berlin's urban futures are not only imagined but materialized (Bulkeley et al., 2013; Engels and Münch, 2015; Evans et al., 2016). Understanding how these urban labs are designed, which practices they encourage, and which types of visions they produce can then unravel what kinds of urban electricity futures are being stimulated or suppressed and how.

9.2.2 Berlin's pilot projects as demonstrators of entrepreneurial smart grid futures

The way smart grid technologies are being negotiated, technically trialed and publicly demonstrated within and through Berlin's pilot projects has helped create the dominant storylines of Berlin as a future smart grid city. The pilot projects have created a space for transdisciplinary expert exchange on the topic, forging (discursive) bonds between actors from different backgrounds and sensitizing them to each other's perspectives. Moreover, they have materialized the abstract smart grid idea into visible, tangible and usable artefacts and thus created a reference point for actors to gather around, and a concrete "thing" for the public to touch and see. By way of materialization, smart grids are thus being translated into an emotional experience and a thrilling, entertaining, sensual adventure.

As I elaborated in the introduction to my case study, the pilot projects and the future sites in this analysis are at very different stages of development (see chapter 7 "Introduction to my case study Berlin"). This is especially true for their different levels of material smart grid implementation. While various material representations have been developed at the "Research Campus Mobility2Grid" and the "Energienetz Adlershof" projects, nothing at all has materialized at the "Low-Exergy Network" project. For my analysis of the discursive production of smart grids at the level of the pilot projects, I therefore focus solely on the "Research Campus Mobility2Grid" and the "Energienetz Adlershof" projects. For my analysis at the level of the future sites, I analyze all three, namely EUREF Campus, Technology Park Adlershof and TXL Urban Tech Republic.

Both the "Mobility2Grid Research Campus" and the "Energienetz Adlershof" projects can be considered urban living labs in the sense that they are locally situated, change-oriented and at least in part contingent. They are "inclusive, practice-based and challenge-led initiative[s] designed to promote system innovation through social learning under conditions of uncertainty and ambiguity" (Sengers et al., 2019: 161). Both projects are also technological niches in the sense that both the M2G and the Energienetz projects are headed by research institutions and funded under research funding schemes, which shields them from the usual market pressures and enables them to focus on processes of collaboration, knowledge production and learning. Unlike purely commercial endeavors, the projects are governed by the logics of "co-creation and empowerment of multiple stakeholders in co-shaping of the experimental approach in a 'triple' or 'quadruple' helix mode of bringing science, policy, business and civil society together" (Bulkeley et al., 2016a: 14). This also involves continuous cycles of monitoring and evaluation aimed at identifying regulatory obstacles to smart grid integration, and at giving advice on the possibilities and obstacles for upscaling smart grid solutions to other spatial entities in and outside the city of Berlin. Like other urban living labs, both projects are conceived in part as testing grounds, and in part as blueprints for other facilities, neighborhoods, cities and regions. Under the protective realm of the spatially and temporally bounded "lab", they are supposed to render results that are scalable and can be broadly disseminated.

The projects are conceived both as experimental laboratories and as demonstration spaces, i.e. as spaces where visions of smart grids are not only developed but also exposed to the public. For this reason, the consortia refer to their projects as "field test" (Technische Universität Berlin, 2012: 6), "trial" (Forschungscampus Mobility2Grid: 2)and "real-life laboratory" (Bschorer et al., 2019; Gegner and Knie, 2020), and also as "reference neighborhood (Forschungscampus Mobility2Grid: 2), "model" (Bschorer et al., 2019), and "experiential and demonstration space" (Gegner and Knie, 2020). Both projects contain elements of testing smart grid infrastructures in open-ended, contingent search processes, and elements of demonstrating their results as models for replication. Both M2G and Energienetz are thus guided as much by experimental openness as by predetermination. They clearly aim not only at testing, but at *proving* the technological feasibility of infrastructural integration through smart grids, at convincing relevant actors and ultimately at multiplying their solutions throughout the city.

Figure 17: Ice storage facility at ZPO © TU Berlin (left) and cooling network being connected to ZPO © Energienetz Adlershof (right)

To increase the public visibility of their smart grid visions, both project consortia have created material manifestations of smart grid infrastructures and have partnered with private companies to demonstrate and showcase them to a broader public. They have both installed showrooms as interfaces between their research process, material smart grid infrastructures and the public. Because the smart grid visions developed within the Energienetz project concern heating and cooling, and those developed at M2G concern mobility, their material manifestations greatly vary. The smart energy management system of the Energienetz project integrates a photovoltaic plant with a cooling energy network, including a brine network as well as an aquifer and an ice storage facility as energy retainers. This smart grid system synchronizes the energy supply from the photovoltaic plant and three (conventionally powered) compression refrigeration machines with the cooling energy demand of a total of eight laboratory buildings. Large engineering infrastructures such as water tanks, re-cooling units, absorber chambers and pipelines for brine distribution therefore dominate the physical appearance of this smart grid system. Most of these technical artefacts are located inside or outside the various laboratory buildings, where they are not staged or performed in any engaging way, but designed for purely functional purposes.

Figure 18: Newly constructed cooling distribution system with information point © TU Berlin

To demonstrate and explain certain parts of this system to a broader public, the project consortium has instead built a special "demonstration pavilion". This small, greenhouse-like building serves specifically to test and showcase the extraction of brine as storage for excess heating energy, and is regularly used as demonstration object to explain the research and its results to the interested public. Apart from these physical smart grid installations, the Energienetz project consortium has also created an interactive mobile phone application that invites the public to explore smart grids by answering quiz questions, earning points and playfully advancing in five stages from "beginner" to "energy manager" (Bschorer et al., 2019). The app explains smart grids to individual consumers in fun, visually attractive and motivating ways. It breaks down the complexity of smart grid technologies and makes them accessible for (future) end users for the sake of actively engaging them. In sum, the Energienetz project has built the majority of its technical infrastructures in rather sober and functional ways, sidelining these artefacts with a few showcases that focus mainly on information rather than on emotion or entertainment.

Figure 19: Demonstration pavilion from the outside (left) and the inside (right) © Energienetz Adlershof

By contrast, the M2G consortium has put significantly more emphasis on outside representation and the creation of positive "smart grid experiences". In concert with large ICT companies such as Schneider Electric and the project development firm, EUREF AG, the consortium has installed physical smart grid infrastructures for presentation to the public in highly visible and attractive ways. Among others, it has installed small wind energy generation plants at the top of the *Gasometer* that generate little electricity but are visible from afar, and built numerous electric vehicle charging stations that are generously distributed across campus and regularly used by EUREF AG's CEO to park and exhibit his expensive Tesla limousines. The branded charging stations are covered by a roof made of transparent solar panels that offers a close-up underneath view of photovoltaic technology and provides welcome shade on hot summer days. These physical artefacts are aesthetically designed and carefully staged to create an atmosphere of comfort, high-tech modernity and even luxury. Moreover, the consortium has created a showroom that offers a glimpse of behind-the-scenes technologies, such as stacks of lithium-ion batteries, which are visible behind glass windows. In this showroom, energy flows are visualized on a screen that presents timely data on the amount of electricity being produced by the solar panels, the amount of storage space available in the stationary batteries and the loading capacity of the electric vehicles. The showroom's design resembles something in between an interactive museum and a control room where smart grids are presented as cutting-edge technical devices and abstract tools for automatic energy management. In effect, the presentations at the showroom have created a point of contact between the living lab setting and the interested public that is regularly invited to view and marvel at them during public events. Tours of the showroom and related artefacts can be booked by interested groups anytime and are also regularly displayed at festival-like open house happenings such as "E-Mobility Day" or "Future Mobility Summit", which cater to the broad public. At these events, smart grid infrastructures can be viewed and experienced as exciting high-tech attractions in an entertaining environment of food trucks, volleyball tournaments, family games and the like. Not least through these spectacles, the M2G project has regularly crafted positive "smart grid experiences". As urban living lab, it has therefore created a space of "experiential knowledge production" (Levenda, 2016: 132) where visions of smart grid futures are interactively staged and enacted. It produces lived experiences of future states for the sake of convincingly spreading its vision of the future smart grid city (Hajer and Versteeg, 2019: 125).

Figure 20: Wind energy generation plant (left) @ Reiner Lemoine Institute, and electric vehicle charging stations at EUREF Campus (right) © Esteve Franquesa

Figure 21: Photovoltaic roof and electric vehicle charging stations at EUREF Campus © InnoZ / Vipul Toprani

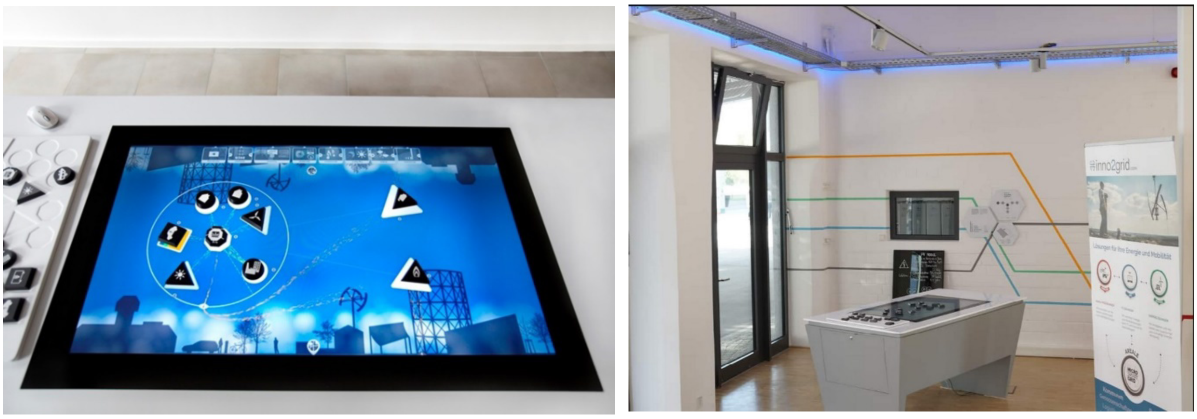

Figure 22: Interactive monitor (left) © Inno2Grid in M2G smart grid showroom (right) © InnoZ

These smart grid experiences are embedded in a broader "EUREF Campus experience", which is being staged by the project development company, EUREF AG. The boundaries between the way M2G is staging smart grid technologies and the way EUREF AG is staging the EUREF Campus are at best blurred. It is somewhat unclear where the research and demonstration project ends, and where the urban development site begins. The consortium members, the project developer and the public authorities often refer to the two interchangeably, promoting both as urban living labs, even though the two follow very different – and in part contradictory – logics. While the M2G consortium works under the funding and governance framework of a research project, EUREF AG follows the commercial logics of entrepreneurial real-estate development. The "smart grid experience", in this way, becomes enmeshed in the privately orchestrated branding and marketing scheme of the "EUREF Campus experience". This creates certain dissonances and contradictions. For example, EUREF AG provides ample space for conventional, gas-powered automobiles in underground parking lots, while simultaneously promoting renewable energies and e-mobility above ground. As an M2G consortium member comments:

> "[EUREF Campus] isn't completely accessible to us, you know? Because there is the investor, who has completely different plans, who says 'what do I care about the smart grid? Of course, I'll gladly put that into my marketing agenda, you know? But technologically, I'm not interested at all'" (personal interview energy start-up, 2016).

This interview excerpt illuminates the ambiguous relationship between the goals of the M2G research project and the goals of the EUREF Campus. While EUREF AG benefits from the M2G project and its science-based, innovative artefacts for advertising purposes, it is unclear to what degree the M2G project benefits from the activities of the EUREF AG. In a study of four of Berlin's future sites, Suwala et al find that "EUREF feels […] like a cleverly managed and extended show room with multiple convention centers, event locations, and top cuisine" that "evokes an exhibition and trade fair venue" (Suwala et al., 2021: 424). Effectively, the visions of smart grid futures being demonstrated by the experimental micro-smart-grid project are thus engulfed by demonstrations of business-friendliness and of a fun, artsy and luxurious work environment that are being staged for the primary purpose of profitable – not sustainable - Campus development.

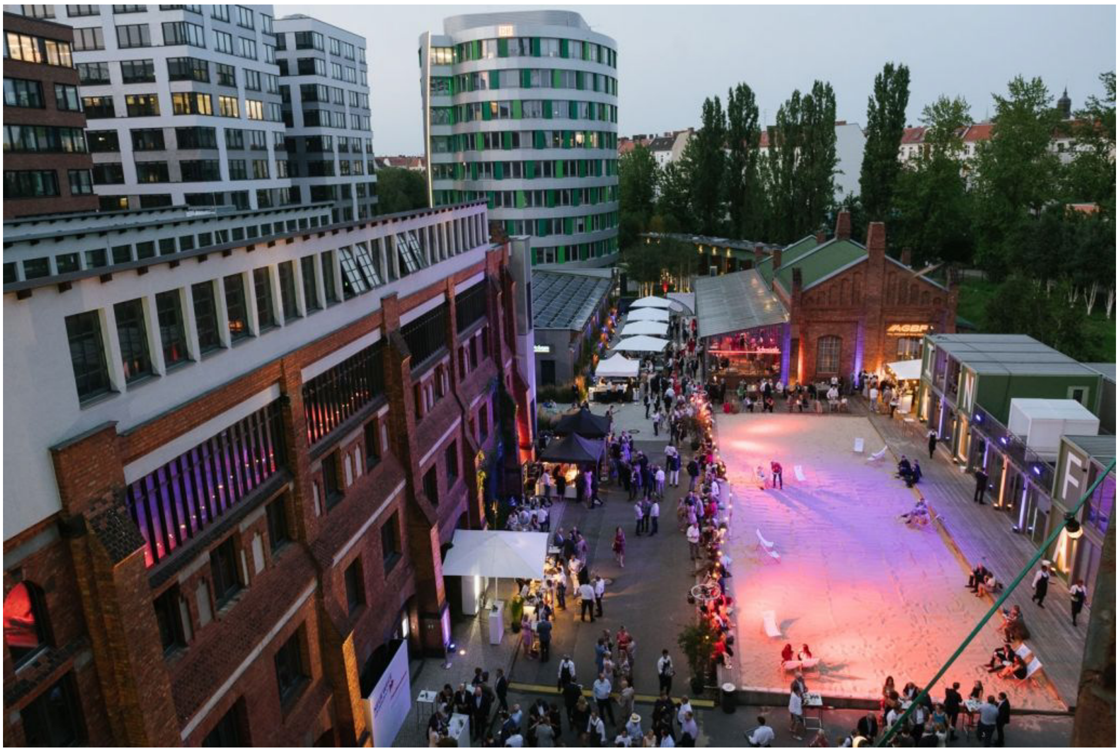

Figure 23: EUREF Campus as event location © EUREF AG

Figure 24: Office towers at EUREF Campus © EUREF AG

9.2.3 Berlin's pilot projects as generators of social acceptance for smart grid futures

Both the M2G and the Energienetz Adlershof projects also aim at generating research results for campus-wide, if not city-wide dissemination. For the purpose of replication and scaling, both M2G and Energienetz Adlershof put a strong focus on generating "social acceptance". They stress the need to generate social acceptance between their project partners, especially businesses, and within their immediate neighborhood communities. To foster this process, they emphasize participation, knowledge transfer and public outreach. Among others, the Energienetz research consortium built its demonstration pavilion "to increase acceptance for the new technology" (Bschorer et al., 2019), and ran campus wide information campaigns and campus internal workshops aimed at increasing smart grid related knowledge and overcoming barriers for participation across the Technology Park Adlershof. Moreover, the consortium partnered with the campus management firm, WISTA Management GmbH, to create the Smart Grid Alliance, to generate interest for smart grids and acquire new partners among other businesses and institutional facilities located on campus. Similarly, M2G regularly offers activities aimed at creating strong social networks within its project consortium, and at generating acceptance within its urban surroundings and vis-à-vis the general public. These activities include Master's degree courses, open house events, workshops, conferences, social media coverage and many more. Based on its experiences from these activities, the M2G project has elaborated an advisory concept for other actors interested in establishing similar urban living labs, especially with a focus on integrating energy and mobility technologies. The concept mostly focuses on how to create high levels of internal project identification and community acceptance by "gently dissipat[ing] potential reservations" (Gegner et al., 2020: 9) in and outside of the living lab. Internally, both projects have successfully stimulated communication and cooperation across disciplinary boundaries, and thus forged personal and professional connections between actors that would otherwise hardly collaborate, including research scientists, public utility companies, energy start-ups, research laboratories, the network operator and new and incumbent mobility companies. Both consortia have successfully maintained this day-to-day collaboration despite the broad range of diverging interests and agendas. In effect, both projects have been awarded funding extensions for second and third project phases: Energienetz Adlershof was granted a second three-year project phase (2018 – 2021) and M2G was granted a third five-year project phase (2022 – 2027) to continue its research and development work.

However, neither of the smart grid pilot projects have integrated households into their experimental project designs. Interaction with families, for example, is limited to showrooms that explain certain energy technologies and visualize flows, but regular citizens are not part of the projects. This stands in stark contrast to the city's policy language, which embeds smart grids in a discourse of user empowerment, user responsibility and social participation. The Senate's vision is not mirrored by the experimental design of the pilot projects. Instead, electricity users are only marginally involved, for example in their capacity as car drivers, laboratory tenants, or building owners. In effect, both projects have focused internally on participation and externally on knowledge transfer and outreach. The latter activities can arguably be understood as curated demonstrations of public involvement.

While both projects have succeeded at creating strong networks within their project consortia, they have been less successful at actually replicating their visions of future smart grid infrastructures at scale. The Smart Grid Alliance, for example, was able to gather a pool of interested actors, but missed its original goal of extending a smart energy management system to a broad range of facilities across the broader Technology Park Adlershof. And although M2G plans to replicate parts of its living lab concept at two new sites in Berlin starting 2022, the integration of energy and mobility technologies in a campus micro-smart-grid-system even at EUREF Campus still poses technical and regulatory challenges. "'[U]pscaling' [....] comprises all activities aimed at embedding of the experiment in regime-level structures (or transforming them), gaining structural support, involving key regime-players, overcoming barriers and making experiment part of a broader process of change" (Sengers et al., 2019: 155). Although both projects have successfully involved key regime players, such as the grid operator or ICT companies, they have gained little structural support and instigated only small-scale processes of change in Berlin.

Both projects have addressed the issue of replication and scaling mainly by focusing on knowledge transfer and social acceptance, not on learning. While M2G and Energienetz Adlershof both put a strong emphasis on transferring smart grid related knowledge and generating social acceptance through participatory activities, neither one of the projects has focused on organizational or institutional learning, for example within their partner institutions or – more importantly – within business organizations or the public administration. Evans et al (2021) find that "while learning is commonly identified as important to urban experimentation it rarely receives explicit treatment" (Evans et al., 2021: 173). Instead, "[f]unding schemes position commercial markets and technical performance as the motor of change in cities, but pay little attention to how cities develop new organizational processes" (Evans et al., 2021: 178). The same holds true for the M2G and Energienetz Adlershof projects. Both projects have effectively addressed questions of scalability as questions of communication. In other words, they have relied on creating strong visions and disseminating a powerful discourse rather than on systematically initiating processes of institutional change.

9.2.4 The future sites as tools for smart city marketing

At the future sites, smart grid pilot projects are embedded in a greater endeavor to showcase and market the city of Berlin as attractive places to work on science-based technological innovations. At the level of the future sites, smart grids therefore serve the purpose of city marketing rather than of infrastructural development or specific grid related change. Instead, smart grids are welcomed as useful assets and marketing tools to attract high-skilled professionals and high-tech businesses from the "smart" and in part also the "green" economic sectors. More than anything, the future sites are supposed to contribute to crafting Berlin's "image as a city" (Berlin Senate, 2016c: 42).

The image that Berlin's authorities are promoting through these sites link "the future" first and foremost with science, technology, businesses, innovation and jobs[35]. In line with this, different policy documents interchangeably call them "future sites"[36], "innovation spaces" (Berlin Senate, 2018: 12), "transformation spaces" (Berlin Senate, 2015a: 58) or "technology clusters" (Enquête-Kommission, 2015: 20). As the city's urban development concept suggests, Berlin's future sites are supposed to become "spaces for entrepreneurial activities geared toward innovation" (Berlin Senate, 2015a: 34). Even though the same concept also suggests that Berlin's future sites will put strong emphasis on other urban issues such as "population growth, […] social cohesion, climate change and energy transitions" (Berlin Senate, 2015a: 63), these issues are at most secondary. Moreover, all concerns regarding the future sites are officially administered by the Senate Department for Economics, Energy and Public Enterprises (SenWEB) and not – for example – by the Senate Department for Urban Development (SenStadtWohn) or the Senate Department for the Environment (SenUVK). In public communications at the city level, economic concerns thus clearly dominate the future sites' agenda.

For this reason, the city authorities describe EUREF Campus, Technology Park Adlershof and TXL Urban Tech Republic as hubs for techno-scientific innovation that support the city's economic priorities. For example, the city calls TXL Urban Tech Republic a "competence hub for urban technologies" (Berlin Senate, 2015a: 69) and "a smart city laboratory" (Berlin Senate, 2015a: 69) that is supposed to attract the "industry of the future" (Berlin Senate, 2018: 18). It calls Technology Park Adlershof the "economic motor of Berlin's South-East" (Berlin Senate, 2015a: 72) and a "successful model for the attraction of science, research and businesses", which it seeks to "extend to other future sites" (Berlin Senate, 2016a: 91). These attributes and associations suggest that the city authorities view economic development as main objective of the future sites and consider techno-scientific innovation an appropriate vehicle to achieve it. As communicated across various policies and programs, the city is thus putting the strongest emphasis on increasing its economic – not its sustainability related - potential through techno-scientific development at all three future sites.

[35] www.zukunfstorte.de
[36] www.zukunfstorte.de

The city's policies and programs are echoed by the way the future sites are being advertised by their respective managing companies. WISTA Management GmbH is advertising Technology Park Adlershof as Berlin's "grande dame" of techno-scientific development, marketing it as an established, successful, internationally competitive role model for Berlin and other cities. The marketing language establishes the Technology Park as experienced, senior development site with a long history and tradition in technological innovation. EUREF Campus is much younger and smaller and therefore still depends on building a positive public image. EUREF AG is advertising the campus as showcase for Berlin's *Energiewende* on the one hand and for smart-entrepreneurial development on the other. And lastly, Tegel Projekt GmbH is promoting TXL Urban Tech Republic as science-fiction fantasy of big money and big dreams. It is wholly in the future and therefore very dependent on creating a brand through catchy advertisement. Tegel Projekt GmbH is promoting TXL Urban Tech Republic as a fascinating, futuristic, even otherworldly place for the realization of world-leading technological dreams: "The dream of flight has been fulfilled. Time for a new dream" (Tegel Projekt GmbH, 2015: 3), and "Will we live in space stations on Mars? Maybe. But maybe we will soon be living in space stations on Earth" (Tegel Projekt GmbH, 2015: 4). The 1970's architecture and the envisaged technologies are staged to leave the public awestruck. More than the other two sites, TXL Urban Tech Republic is also being marketed with slogans that sound snazzy and young. It is marketed as a hub for collaboration between creative, intelligent, international, productive pioneers in an open, innovative and attractive space. Moreover, this image is connected directly to profitability: "Future technology is always a future market. And that is no pipe dream" (Tegel Projekt GmbH, 2015: 13). Overall, it is marketed as being at the cutting edge of urban technological innovation that is globally connected, and internationally leading. It is marketed as a site where technological fixes to the most pressing urban problems in energy, water, mobility and recycling will be developed, produced and exported globally. Here, smart grids are one of various technological ideas that play into broader storylines of developing a smart, progressive, ecologically pristine city of tomorrow. These technologies are described as the DNA of cities. They are intelligent, efficient, clean and perfectly flawless. They are urgently necessary and absolutely inevitable. They (especially ICT) will make the world a better place, make your life easier, and bring big money.

The visions of Berlin's urban future promoted through the future sites are heavily based on a rhetoric of technical innovation and economic growth. Smart grids, in this language, are only interesting in their capacity to attract businesses and jobs, not as basis for real energy system change. While smart grids play only a minor role, the smart city is much more present as an idea and link to the surrounding city, and cities around the world. Although these broader storylines also influence and perpetuate the specific storylines about smart grids, they are not tied specifically to smart grid technologies or specific on-site collaborations. Moreover, Berlin's future sites are designed for an exclusive urban business and research establishment, catering to the young, creative, intelligent, cosmopolitan elite. They invite "students, entrepreneurs, industrialists, and researchers", to "learn from one another and come up with new ideas together" in a joint "democratic ambition" for making "the cities of the future" (Tegel Projekt GmbH, 2015).

This stands in contrast to the high priority on public participation and civic engagement that Berlin's current city government has written into its energy and its smart city agendas. In its coalition agreement, it states that Berlin's *Energiewende* can only succeed with the participation of its inhabitants, and that the government therefore builds on “active energy citizens (*Bürgerenergieakteure*) (Berlin Senate, 2016a: 61) and "prosumer solutions" (Berlin Senate, 2016a: 64). Apart from this, the city aims at regaining public ownership of the city’s electricity grid, which it views as important tool for designing the city’s *Energiewende*, and whose communal ownership could “offer Berliners an opportunity to engage in the concrete implementation of the *Energiewende*” (Berlin Senate, 2016a: 65). Since 2016, the left-wing government coalition has also been very careful to embed its smart city agenda in a vision of socially inclusive, participatory urban development. Among other things, it has set out to publicly discuss and overhaul the previous government’s Smart City Strategy, in order to ensure that the city’s inhabitants have a say in the digital transformation of their urban environment (Berlin Senate, 2016a). Citizen engagement is being fostered at the newly founded CityLab, a space for collaborative exchange that explicitly aims at “involving the urban public in exploring the potentials of smart city technologies and finding practical solutions for Berlin and possibly other cities” (Abgeordnetenhaus Berlin, 2017), which was officially inaugurated in 2019. At the same time, experimentation at the future sites and the pilot projects is less committed to public participation than to innovation and economic growth.

Instead, the city explicitly envisions the future sites as places for advancing " urban Energiewende innovations (Berlin Senate, 2016c: 32). It is marketing them as spaces for pioneering technological advancement and offering cutting-edge research and development opportunities. They are supposed to “make Berlin future-proof, shape its economic profile, and increase its international visibility” (Berlin Senate, 2015a: 54). They are depicted as “hot spots”, and “innovation spaces” (Berlin Senate, 2018) for showcasing urban energy technologies to the world, and increasing Berlin’s global competitiveness (Berlin Senate, 2015a). Adlershof even boasts to be Berlin’s Silicon Valley (Tagesspiegel, 2018). Beyond their function as local testbeds, these sites are conceived as "lighthouses" and shining examples with an outreach and impact far beyond the region (TSB Technologiestiftung Berlin, 2012: 26). Berlin’s city authorities are promoting the future sites as showcases and shining examples of urban economic, environmental and scientific development. They are being advertised as places that will make the city “fit for the future, strengthen its economic profile and increase its international appeal” (Berlin Senate, 2015a: 58). In sum, Berlin’s future sites are being created as demonstrators that show, inform and excite the public and are being marketed as entrepreneurial spaces that promote spectacular visions of urban futures in thrilling and theme-park type ways.

9.2.5 Visualizing Berlin’s smart grid constellation

The production of Berlin’s smart grid futures is not only influenced by social actors. It is also enabled and/or constrained by rules and regulations, technical artefacts, and natural phenomena (such as the existence of sun and wind power for harvesting). To complete the picture, I therefore add an analysis of Berlin’s overall smart grid constellation, i.e. an analysis of all the different elements influencing Berlin’s smart grid discourse and thus the production of the city’s dominant smart grid storylines. Constellation analysis is a concept that enables interdisciplinary research on complex questions at the interface of society, technology and nature (Schön et al., 2004: 1). It acknowledges the power not only of social actors, but also of signs, ideas, natural phenomena and material artefacts in shaping current reality (Ohlhorst and Kröger, 2015: 97). In fact, it is a fundamental principle of constellation analysis to regard the heterogeneous elements of a constellation as equally important (Ohlhorst and Kröger, 2015: 99). It is thus very much in line with my comprehensive understanding of discourse. Constellation analysis identifies social actors (such as people or institutions), material artefacts (such as technologies), natural phenomena (such as the sun or the wind), signs (such as laws and regulations) and ideas (such as visions or Leitbilder) as equally powerful in producing current reality. By including all these elements and visualizing their influence on smart grid discourse, I can paint a comprehensive picture of what is currently driving or impeding its popularity, and thus driving or impeding smart grid development in the city (see next page for visualization).

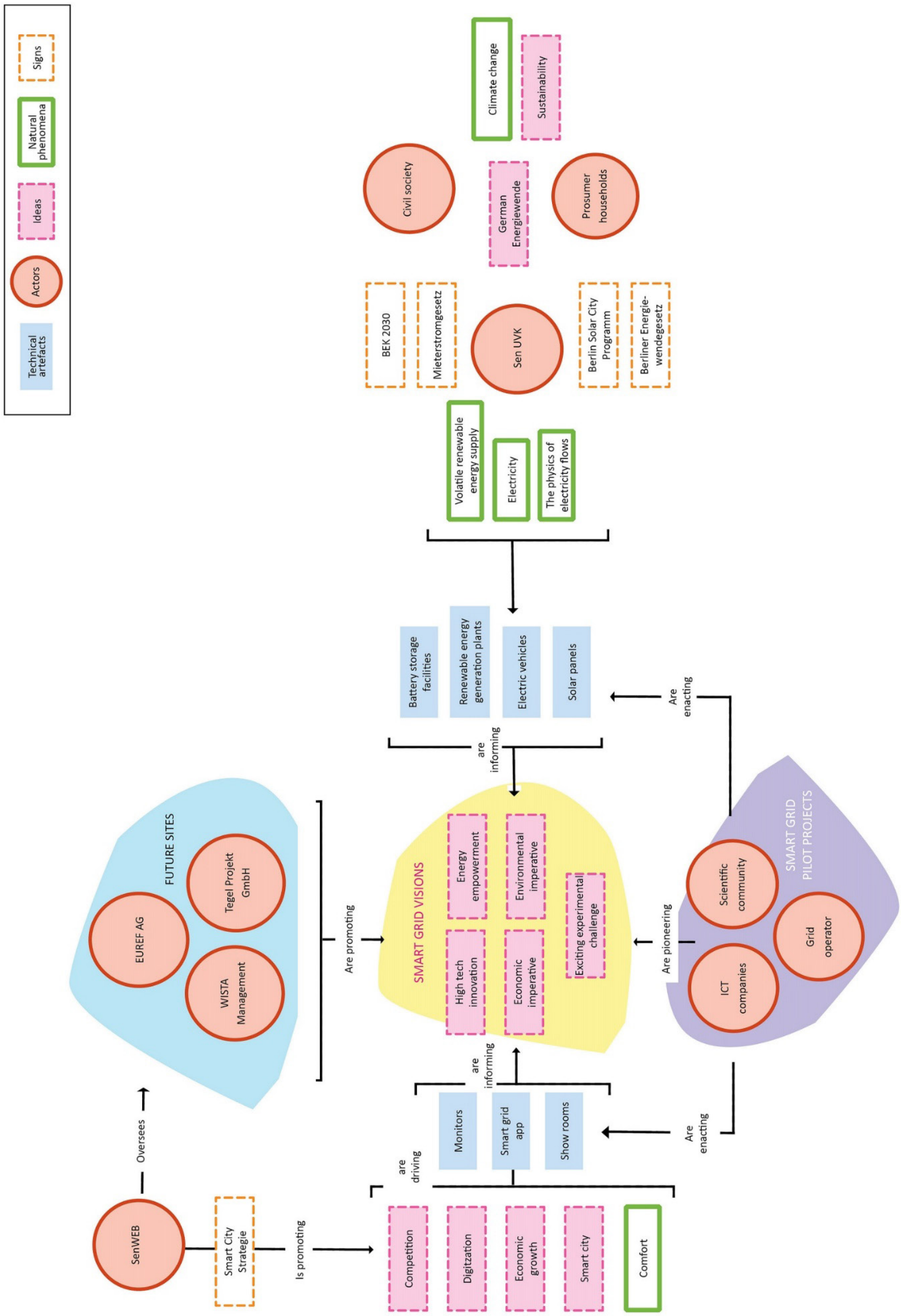

Figure 25: Who and what is influencing Berlin's smart grid discourse? (own figure)

9.3 Concluding remarks: everybody wants smart grids, but nobody nobody is taking the lead

The pilot projects have been fundamental in promoting visions of smart grids and shaping Berlin's expert discourse as generators of transdisciplinary collaboration and exchange. They have thus pioneered the idea of smart grids in Berlin. However, the pilot projects are also embedded in an institutional environment that is pursuing a primarily economic agenda, and thus promoting business-as-usual scenarios instead of radical system change.

9.3.1 Pilot projects as drivers

The research consortia driving the pilot projects at M2G and Energienetz Adlershof have pioneered Berlin's smart grid discourse and continue to exert a strong influence on it through the pilot activities. These consortia are spearheaded by the scientific community, which has been pivotal to generating the original project ideas, initiating the consortia, acquiring federal funding and leading the research and development activities. Due to the scientific community's initiative, a broad range of stakeholders from various backgrounds and fields has engaged in regular exchange on the topic, yielding countless discursive contributions, from written and spoken communications, to public performances and material artefacts.

At the micro-level (i.e. at the pilot projects), smart grids have arguably functioned as successful *Leitbilder* in Dierkes' sense of the term. The smart grid *Leitbild* has worked as "framework that guides perception, thinking, decision-making and action" (Dierkes et al., 1992: 11). It has developed enough force to enable communication and collaboration within a heterogeneous expert community, working as communicative bridge across different academic disciplines, business interests and political agendas. The pilot projects have forced reluctant actors such as the grid operator to attend public events and confront the rising pressure to change the current grid system. They have also pulled private ICT companies and project developers on board, giving them an incentive to invest in physical smart grid infrastructures. In doing so, the Leitbild has successfully motivated Berlin's expert community to overcome communicative differences over the course of many years and sustained this effort for years into the future. It has provided collective orientation on the one hand, and mobilized emotions of interest and appeal on the other, thereby stabilizing interpersonal relations. In this way, the pilot projects have played an important role in introducing smart grids to the city and developing a normative force within Berlin's expert community that has established smart grids as essential solutions to reaching the city's climate goals and implementing the urban *Energiewende.* Moreover, the pilot projects have given smart grids increasing public visibility. They have created a connection between the abstract smart grid idea and its artefactual presence, giving the conceptual idea a representation in built reality. This material representation has also given smart grids a visibility beyond the small circle of experts involved in the research consortia. The visibility of smart grid infrastructures at EUREF Campus has arguably been pivotal to attracting green tech businesses to the campus.

However, this showcasing has also blurred the boundaries between the research community's interest in advancing energy and mobility transitions, the companies' interest in selling their products, and the project developer's interest in attracting renters to the property. Moreover, it has neglected questions of institutional learning, and thus remained on the far end of systemic socio-technical change. In this sense, visions of sustainable and innovative smart grid futures as they are being developed within the pilot projects, are being buried under the more powerful smart city imaginary, which caters to a techno-entrepreneurial, business-as-usual urban development paradigm

9.3.2 Shared visions, questionable alliances

Yet in spite of these pioneering qualities, the pilot projects are also helping to reproduce the corporate language of the smart city. They are perpetuating a restrictive, techno-centrist imaginary of the future sustainable city instead of daring to promote radical alternatives (Hajer and Versteeg, 2019). These visions convey a future urban development trajectory that is confined to the well-known trajectories of the past. They are narrowly confined to the idea of linking technological innovation with economic growth and the "good" city. Hajer states that "experiencing the possibility of alternatives" is a fruitful avenue for convincingly spreading the sustainability paradigm (Hajer and Versteeg, 2019: 125). I argue that Berlin's pilot projects have been largely successful at creating an environment for "experiential futuring" (Pelzer and Versteeg, 2019). They have built up the idea of smart grids into a discourse, gathered a community behind it and created material infrastructures. The pilot projects in Berlin have successfully created "sites through which to explore and experience different futures" (Edwards and Bulkeley, 2018: 350). However, they are producing experiences that are chic, entertaining, even spectacular and awe-inspiring – but not necessarily challenging or new. The material realities they showcase can be visited and "experienced" much like the technologies in a science museum. Technical artefacts are presented as gadgets that can be tried out in fun ways. They are creating "experiential futures" (Pelzer and Versteeg, 2019) in form of fun weekend excursions for interested citizens, but not fundamentally challenging their status quo.

More importantly, these experiences do not invite contestation. On the contrary, they are focused on knowledge transfer and outreach for social acceptance. In this sense, M2G and Energienetz Adlershof are in many ways curating Berlin's smart grid future, not experimenting with it. As urban living labs, both projects are aimed at generating technological know-how on smart grids, creating strong social bonds within their transdisciplinary project consortia and transferring their technological findings to the broader market. In Berlin, the scientific community is playing a major role in co-producing these business-as-usual scenarios and for spreading them into the public. Among others, the project consortia are partnering with corporate actors to create these visions of the future, instead of engaging a broader societal basis.

Through the future sites, the city is equally succumbing to the corporate imaginary and language of the smart city. It is mainly promoting the future sites as futuristic, high-tech, competitive, young, exciting and comfortable urban ideals (much in line with the smart city imaginary). It uses the *Energiewende* to accompany these visions, treating it as welcome side-effect and dependent result. The project developers and other corporate actors are hijacking this low-carbon rhetoric to pursue their own economic agenda, i.e. to sell their products and market their property. Visions of smart grids are therefore being used to enhance the low-carbon rhetoric, but ultimately drowned out by a much more mundane, business-as-usual, economic agenda. In sum, the future sites are embedding Berlin's smart grid discourse into the broader marketing language of the "smart city". The pilot projects fit into these logics and perpetuate them.

9.3.3 The long path from visions to socio-technical change

Their embeddedness in the logics of the smart city might also explain why the smart grid *Leitbild* hasn't translated into broader urban socio-technical change. My research shows that the smart grid *Leitbild* is an attractive idea that has reached a certain degree of popularity through connection with a technical artefact. It has not, however, become generally established in organizational practices or institutional arrangements outside the pilot projects, or even become "obdurate" in the sense of dominating the infrastructural landscape (Dierkes et al., 1992). Visions of smart grids have activated a research community, but haven't activated a broader city-wide discussion, let alone radical city-wide change. In Jasanoff and Kim's (2015) terms, visions of smart grid futures have not evolved into a "collectively held, institutionally stabilized" socio-technical imaginary.

As I laid out in the conceptual underpinnings of my research design, Hajer (1993) distinguishes between the concepts of discourse *structuration* and discourse *institutionalization* (see chapter 6.3 "Analyzing discourse"). He understands a discourse as structurated when it is widely shared, widely accepted, and largely uncontested, and as institutionalized only when it consolidates into social institutions, such as organizational practices or traditional ways of reasoning (Hajer, 1993). In Hajer's (1993) terms, Berlin's smart grid discourse can therefore be viewed as structurated but not as institutionalized. Despite slight underlying differences, the dominant storylines that comprise Berlin's smart grid discourse are built on a solid foundation of general agreement that is shared by many actors. The visions of the future that are transported by this discourse, and the broad lines of argument that the discourse circles around remain largely undisputed. Yet despite the strength and consistency of visions of Berlin's smart grid futures, and the structurated nature of the discourse, there is no broad media coverage, party political debate or even general knowledge about smart grids in the city. In spite of its success, the *Leitbild* has not traveled far beyond the borders of the pilot projects, and the discourse is arguably stagnant. Unlike the debate about the smart city or the urban *Energiewende*, there is hardly a city-wide debate about smart grids. Going back to Hajer's terms, Berlin's smart grid discourse cannot therefore be viewed as *institutionalized* in the sense of developing enough force to transform city-wide institutions, governance arrangements or practices. Even though these dominant storylines are being produced and shared by policy makers, corporate marketing strategists and researchers, the discursive dynamic that has mutually reinforced their visions has not been powerful enough to reconfigure the city's electricity related institutions. Instead, Berlin's smart grid discourse remains confined to a relatively small expert community that interacts closely at the pilot projects – but remains invisible beyond. This is true even though both the pilot projects and the future sites were developed with the explicit goal of disseminating and "scaling up" ideas for the city's energy future.

This raises questions about the effectiveness of experimenting with infrastructural futures in Berlin. As the sustainability transitions literature suggests, for local experiments to unfold a sustainable impact, visions are important but not at all sufficient (Rotmans and Loorbach, 2008). The establishment of durable social networks and institutional learning are key (Potjer, 2019). According to Potjer (2019), the concept of scaling up is based on the assumption that experiments can "change the institutional world with little additional help". She then concludes that "in reality, it is the other way around: it is the institutions that promote or restrict experimenting" (Potjer, 2019: 15–16). While many urban labs use the rhetoric of "scaling-up" and "rolling out" their solutions, Potjer is sure that no single experiment can spread its unique local solution into the broader urban fabric. Local experiments need to connect, exchange learnings, inspire each other and develop a joint force or common cultural shift (Potjer, 2019: 36).

Although Berlin's smart grid pilot projects are all aimed, at least rhetorically, at "scaling up" and "rolling out" their best practice solutions into the broader city, they lack a clear structure for how to go about this task. In Berlin, the various smart grid experiments that are currently underway at the pilot projects and beyond have little to no horizontal or vertical connections. There is no such thing as a "Platform for Living Labs" in Berlin (Potjer, 2019), to foster exchange and learning between different smart grid pilot projects. The pilot projects in Berlin are not embedded in a structural approach to experimental governance. They are stand-alone projects with little to no institutional backing from the public authorities. Instead, they are embedded in the governance logics of the future sites, which are mostly targeted at "improving the regional business structure"[37]. From an urban governance perspective, smart grids are, in effect, part of a coordinated city-wide endeavor to create economic growth, but not to create sustainable electricity grids. Therefore, the pilot projects are successfully rendering innovative solutions to a variety of smart grid related problems at the local level – but have failed to make their ideas, the discourse or their technological innovations spill over into the urban fabric.

There is a disconnect between the potentially idealist, sustainability-oriented lab environment of the pilot projects, in which scientific consortia are experimenting, testing and demonstrating smart grids, and their broader setting within the future sites, which are focused on showcasing these technologies as means of attracting businesses, and thirdly, governmental policies, which link experimental sites more with technological innovation for economic goals than for sustainability. Although the Berlin Senate is committed to implementing more ICT technologies, it is not specifically committed to implementing smart grids. It is pushing a technology-oriented agenda, which is little concerned with the outcome of specific technology trials, because its primary objective is to secure jobs. The city is pushing this agenda with an indecisive rhetoric that paints Berlin as a smart *and* participatory *and* experimental *and* low-carbon. Yet their main goal is the attraction of high-tech companies and jobs. These goals and the institutional set-up of the future sites are therefore only supportive of the pilot projects at the rhetorical level, but not at the institutional level. It is not offering an institutional embedding for the lessons learned at the pilot projects to be translated into governmental logics. Energy and mobility regime change is thus being smothered by economic – business-as-usual - interests.

[37] https://zukunftsorte.berlin/en/

10 Conclusions and outlook

The purpose of this dissertation has been to disentangle and critically discuss dominant visions of the future smart grid city and how they are being (co-)produced in Berlin’s policy and implementation circles. My analysis was guided both by Dierkes’ (1992) concept of technological Leitbilder and Jasanoff and Kim’s (2009) concept of socio-technical imaginaries, which understand visions as synchronizers of techno-scientific innovation on the one hand (Dierkes et al., 1992) and political programs on the other (Jasanoff and Kim, 2009). By building on these concepts, I was able to merge the analysis of visions at the micro-level of techno-scientific experimentation and at the city-wide level of urban policies and programs. I used discourse analysis as operational framework for examining the meanings (Keller, 2011) and the politics (Hajer, 1993) inherent in the (co-production of these) visions. This discourse analytical approach enabled me to identify and critically scrutinize the (co-production of) dominant storylines depicting Berlin’s future as a smart grid city.

My empirical findings show that visions of Berlin’s smart grid futures are being mutually reinforced by urban policy narratives and corporate marketing strategies on the one hand and by research and implementation practices on the other. This co-constitutive process of envisioning and making the smart grid city is driven by a relatively small circle of experts. While urban policy experts and corporate professionals are primarily using smart grids as marketing tools to attract businesses and professionals, researchers at the implementation level are mostly committed to smart grids in a genuine effort to contribute technological solutions to Germany’s *Energiewende*. Together, they are envisioning and enacting an urban future that is driven by techno-optimism, built on few peoples’ perspectives, lacks critical negotiation and is strongly embedded in the economic opportunities associated with the smart city.

I identify five dominant storylines that depict the smart grid city as a) environmental necessity for advancing Berlin’s local *Energiewende*, b) high-tech innovation for improving energy management while maintaining current comfort-levels, c) economic imperative to secure Berlin’s future as a thriving metropolis, d) facilitators of energy empowerment and public participation, and finally as e) exciting experimental challenge to modernize the city’s infrastructure. I show that these dominant storylines merge notions of technological progress (most notably digitalization) with the achievement of Berlin’s urban energy transition, thus latching onto the techno-positivist gravitation of Berlin’s smart city paradigm. Put differently, these visions depict urban smart grid technologies as a necessary prerequisite for developing Berlin into a low-carbon city on the one hand, and a smart city on the other, making ICT-implementation seem like a natural and inevitable process (i.e. "the smart city will have smart grids" (Erbstößer and Müller, 2017: 11).

Moreover, I show that these visions of a progressive, eco-friendly, economically thriving, attractive and livable future smart grid city are in part driven by a sincere interest in making Berlin’s energy transition work, but also in part by economic concerns and the pure thrill of spearheading technological development. They thus emphasize promises of economic competitiveness and (global) leadership over risks and vulnerabilities. Moreover, I show that in Berlin, dominant visions of the smart grid city remain largely uncontested. Instead, the combined promises of the smart grid city are being pursued and marketed by Berlin’s urban policy-makers, researchers and businesses alike, be they from the energy, the ICT or the urban development sectors. I argue that the visions that are created, reproduced and publicly promoted through processes of experimentation at Berlin's urban labs are thus reinforcing what the city government is promoting in its policies and vice versa, and that a broader, more inclusive and possibly controversial debate is lacking.

At the same time, my findings also show that a vision or a *Leitbild,* even if it gains enough traction to render fifteen years of pilot activities, is not enough to effect broader urban socio-technical change. Visions can foster collaboration and render local innovations, but for these innovations to travel and effect broader socio-technical change, they need something more. In Berlin, visions of smart grid futures have "activated" and "motivated" discourse coalitions among different actors to promote socio-technical change. But visions of the smart grid are being obstructed by the stronger socio-technical imaginary of the smart city.

I draw the following main conclusions from my empirical findings. I complement these conclusions with suggestions for further avenues of inquiry.

10.1 <u>Treat smart technologies as a means not an end</u>

First, my analysis shows that Berlin's urban experiments are co-producing technology centered visions of the smart (grid) city. These visions are not only fueled by urban (energy) policy but also gain traction through material manifestations in urban laboratories. In Berlin, this co-productive process of mutual reinforcement has created a spiral of reciprocal encouragement and affirmation rather than controversial debate or critical scrutiny. Smart grids have arguably taken on the fetish-like qualities of a technological fix or a 'boat' that is not to be missed, rather than one out of various means to an end. The resulting discourse presents smart grid technologies as future energy solutions that need to be "reverse-engineered" (Cloke et al 2017) into the urban fabric to accommodate current ideas of growth, comfort and (energy intensive) lifestyles by perpetuating technology-based, and efficiency-enabled expectations of pleasure (Strengers 2013). The resulting visions are thus reproducing the corporate language of the smart city, which is deeply embedded in the well-known, unsustainable present. I criticize that these visions are foreclosing debate about other pathways towards low-carbon urban development such as digitally sufficient alternatives (Lange and Santarius, 2018) or smart grids as commons (Hall et al., 2019; Melville et al., 2017). Smart grid experimentation is currently producing a self-referential discourse that emphasizes (possible) technological benefits instead of weighing them against the environmental costs of technological expansion or the risks of digitally-born vulnerabilities.

Instead of critically interrogating the benefits of energy-efficiency and weighing them against the shortcomings of increased energy use, Berlin's urban laboratories are taking the benefits for granted and neglecting potential shortcomings. As Strengers argues: "With the lure of efficiency benefits and energy savings, we too easily forget that becoming smart also necessitates the consumption of smart stuff" (Strengers, 2014: 28). In the case of Berlin's smart grids, this extra "stuff" might include sensors, meters, electric vehicles, batteries, and server parks, all of which have energy and environment-related effects not only during use, but also during production and disposal. In addition, these effects might be exacerbated by ICT-induced economic growth. In the case of Berlin, the integration of electric vehicles into smart grid systems could lead to increased car-use, for example. If attention is not paid to these trade-offs, then energy-efficiency gains might well be cancelled out by this so-called "rebound effect" (Lange et al., 2020; Santarius and Soland, 2018). A burgeoning line of scholarship therefore calls for a mind-shift away from researching and developing efficiency-inducing technologies toward focusing on energy-efficient practices (Shove, 2018). It argues that for energy transitions to work, we need to encourage energy-sufficient lifestyles, not technologies (Thomas et al., 2015). Another line of scholarship has taken a similar approach by looking at smart grids as commons. Among others, this literature suggests that communities can benefit from neighborhood level energy governance not only environmentally, but socially, too (Melville et al., 2017). It suggests that novel forms of communal energy governance need to be considered in research and development projects. These literatures all question the ability of the technology-centered paradigm to foster energy and sustainability transitions and offer alternative, more socially sensitive entry points. Their critical voices are not part of Berlin's smart grid discourse.

10.2 Embrace the social

Secondly, my findings show that by focusing on techno-centric, techno-managerial urban futures, Berlin's smart grid discourse is glossing over some of the more complicated, unsexy and potentially conflicted issues relating to urban energy transitions. Urban scholarship has shown that urban laboratories are often designed as privileged sites of formalized knowledge production that favor certain actors and interests over others (Evans and Karvonen, 2014). More often than not "the social aspects of urban development […] are largely ignored" (Evans and Karvonen, 2014: 425). Similar to this observation, Berlin's future sites and urban pilot projects are putting a strong emphasis on technology and efficiency while neglecting the social.

At the same time, Berlin's energy and climate related policies and programs are making very far-reaching assumptions about the social life and social practices of future energy users living in future energy neighborhoods. By advancing notions e.g. of household prosumage, micro-grid residential neighborhoods, energy empowerment or energy capacity building, the Berlin Senate is proposing a complete overhaul of energy production and use as we know it. Yet, these visions are built on simplistic, rationalized notions of ordinary energy users. Notions of ordinary citizens as "active energy agents" or "grid participants" (Berlin Senate, 2016c) are built on a perception of the average energy user as information-hungry, data-driven, energy-interested, technology-savvy, efficiency-seeking *Resource Man* (Strengers, 2013). This perception assumes that households are inhabited by individuals with the time, ability and motivation to subordinate their activities to managing efficiency gains. It overlooks that homes are also inhabited by families or family-like systems that are kept together by people with complex schedules, different personalities and multiple preferences. By promoting visions of homes as resource management units and disregarding the complexity and messiness of the social life they contain, these simplistic visions risk standing in the way of more far-reaching, and more transformative change. As Pelzer and Versteeg (2019) criticize "cities are crucial for societies to move beyond carbon dependency, but the current debate is dominated by corporate imaginaries of self-driving cars and other smart technologies. This technological vision does little right to the complexities of the urban fabric" (Pelzer and Versteeg, 2019: 14).

This is especially problematic, because smart grids heavily depend on user integration and thus broad user acceptance for their effectiveness. Research indeed suggests that user engagement is crucial to the success of smart grids systems (Goulden et al., 2014; Kaufmann et al., 2013). At the same time, recent studies find that, even despite extensive user engagement, user acceptance and with it the willingness to engage in micro-smart-grid systems can dwindle substantially over time (Bugden and Stedman, 2021). Especially users who initially embrace smart grids on the idealist basis of environmental protection are shown to lose interest over time, resulting in less active involvement and a subsequent lowering of the overall environmental effectiveness of micro-smart-grid systems (Bugden and Stedman, 2021). As Budgen and Stedman (2021) remark:

> "That the public becomes less interested in smart grid technologies over time will be troubling for proponents, especially those that advocate for distributed generation microgrids as a crucial component of any future climate-friendly grid" (Bugden and Stedman, 2021: 7).

This points to the importance of developing a nuanced understanding of how users want to be involved in the first place. It points to the need of integrating users into the development and design of micro-smart-grid-systems not least for reasons of system effectiveness. Yet, in Berlin, where visions of smart grid futures strongly circle around the idea of household and neighborhood prosumage, household and neighborhood prosumers are in fact hardly involved in the smart grid pilot projects.

Moreover, Berlin's techno-centric, techno-managerial visions do not account for the different ways users or neighborhoods can be involved in smart grid systems. Indeed, smart grid systems can involve users with different degrees of personal engagement - from end-users whose consumption is externally monitored and controlled for example by utilities, all the way to prosumers who take active control over their own energy production, consumption, trading and use (Goulden et al., 2014). Smart grids can be designed for any one of these extremes or anywhere in between. Smart grid systems can therefore favor different degrees of centralized or decentralized management, which go along with different degrees of individual responsibility. Yet Berlin's visions of smart grid futures are not differentiated in this respect. They promote highly decentralized household and neighborhood prosumage as backbones of the city's *Energiewende* without asking what people might be willing and able to contribute. This is true even though my research reveals a certain underlying mismatch between the consistency of these visions and the (lack of) confidence put in the people they are for. As long as this dissonance is not resolved through active user engagement, smart grids are likely to fall short of their expected environmental effects.

In sum, my research shows that acts of envisioning and experimenting with smart grid futures in Berlin are too far removed from peoples' experiences and aspirations. They do not reflect the complex, interconnected, imperfect, and very human realities of urban existence (Greenfield, 2013), and are thus arguably stuck in the energy intensive, unsustainable lifestyles of the present. This is exacerbated by Berlin's urban experimental design. There is a disconnect between Berlin's corporate-inspired future sites, which cater to these technosolutionist storylines, and the much more socially inspired urban *Energiewende* policy rhetoric. Instead, future sites, urban labs and urban policies should engage more in discussions about the risks, environmental impacts and implications for inclusive urban development when it comes to smart grid implementation projects instead of advocating material intensive smart grid futures as the unalterable solution that will solve all urban energy challenges we are currently facing. In short, they need to move from their eco-technological vantage point and focus more on the eco-social.

10.3 Invite more pluralistic visions of urban sustainability

Stronger eco-social visions be achieved by engaging more people and perspectives into envisioning smart grid futures, and inviting a more pluralistic, controversial debate. Currently, Berlin's smart grid visions are being promoted by a relatively small community of experts, who convey a sense of urgency that hardly tolerates opposition, not least because urban experimentation is limiting – instead of encouraging - necessary public debate. My findings show that the resulting visions of Berlin's smart grid futures are therefore one-sided, simplistic and undemocratic.

Through processes of urban experimentation, the Berlin Senate is effectively giving scientists, engineers and corporations significant influence over imagining the city's urban smart grid futures. It is entrusting processes of experimental co-production to intrinsically motivated academics and engineers on the one hand, and economically driven, opportunistic smart city advocates on the other. These actors rarely mention risks, and if so, only in vague and unspecific ways. Only few critical voices or alternative futures are making themselves heard in the city of Berlin. Issues such as supply security, data security and cyber security are mentioned as necessary prerequisites for smart grid implementation, yet they don't feature as part of the pilot project design. Instead, costs are perceived as the most important "risk" or obstacle to smart grid implementation. Currently, Berlin's future sites are little more than showcases for new technological developments and experimental playgrounds for engineers and tech-enthusiasts to pursue their inspiring high-tech innovations. I criticize that the urban futures that are being mobilized through Berlin's smart grid experiments are therefore fundamentally technocratic and profit-oriented, as well as elite-driven and undemocratic. They exclude a broad spectrum of people and perspectives, and thus do not reflect "a plurality of visions of the good life" (Appadurai, 2013: 300).

Due to this exclusivity, Berlin's smart grid experiments are arguably depoliticizing the transition to smart grid infrastructures in the city (Bues and Gailing, 2016). They are standing in the way of an open, city-wide dialog and do not invite controversy or constructive deliberation. Instead, they are producing one-sided visions that promote smart grids as necessary and good, but are largely "devoid of debate" (Sadowski et al., 2020). Currently, Berlin's smart grid experiments are driven by a strong belief in the possibility of "rolling out" generic technological solutions to achieve energy sustainability. At least rhetorically, these experiments are prepared to "scale up" their results and disseminate them throughout the rest of the city. As research in the field of sustainability transitions has shown, this rhetoric neglects that the complexity of sustainability related problems requires complex answers instead of one-size-fits-all technological solutions. It neglects and that "sustainability itself is not a straightforward concept, but subject to ongoing ambiguities, uncertainties and contestations" (Raven et al., 2017: 580). It is an ambivalent concept that means different things to different people in different contexts (Raven et al., 2017). How to prioritize economic development, environmental protection and social justice within energy related urban change thus remains an open and very context-specific question that depends on the values and norms of those involved in answering it. Research has indeed shown that conceptions of sustainability and possible transition pathways vary according to different cultural contexts, values and norms (Matschoss et al., 2019), and recommended to engage citizens to include different values into urban decision-making processes (Elelman and Feldman, 2018). However, Berlin's experiments are leaving this assessment to entrepreneurs, academics and engineers. Within the context of urban experimentation, these actors are laying out possible transition pathways toward sustainable energy solutions on the basis of a very narrow, techno-economic perspective. This "anti-political" approach ignores or even suppresses "discussions of normativity and ethics in socio-technical change" (Sadowski et al., 2020: 2). Most importantly, it inhibits political discussions about the role of users in future smart grid systems. As a result, Berlin's smart grid experiments are also defying their own purpose of generating a city-wide smart grid discourse, realizing extensive smart grid implementation and achieving universal smart grid acceptance.

Instead, urban experimentation needs to be designed with more democratic, emancipatory ambition. Similar to practices in urban planning and design, it needs to be informed by collective processes of participatory visioneering in order to yield more controversially discussed, more democratically inclusive and more socially accepted results. If designed accordingly, smart grid experiments could benefit from the creativity, wisdom and experience of ordinary, non-scientific energy users (Moezzi et al., 2017; Raven, 2017b). They could open up a city-wide dialog about possible transition pathways towards sustainable energy futures that values different lived realities and considers creative ways of problem-solving. On this basis, smart grids could also enjoy much broader recognition, collective ownership and acceptance in the city. This is especially important if urban experiments are undertaken with the aim of scaling-up smart grid solutions into the broader urban fabric. Plans to comprehensively disseminate residential prosumage could benefit from embracing and reconciling the various ideas, hopes and experiences of ordinary urban households. This way, smart grid experiments could not only be finetuned to people's needs and aspirations, but also gain widespread acknowledgement and appreciation.

Overall, I argue that acts of urban experimental future-making need to engage a broader cross-section of urban actors, most importantly citizens, civil society organizations, artists and urban planners. This way, sites of urban experimentation could become hubs for actively developing visionary ideas and ideals, much in the way urban planning theory foresees, namely in a collaborative, democratic endeavor. Ideally, these participatory processes of collective visioneering would unlock the city's full potential to progress toward democratic, equitable, accessible, just, sustainable, and generally livable urban futures. These pluralistic visions could work as fundamental elements of a new, sustainability oriented experimental governance approach. In effect, urban experiments could become places for inclusive, controversial and democratic debate and thus potential catalysts for urban change.

10.4 Dare more radical utopias

Fourthly, citizen participation has the potential to yield much more radically transformative visions of the future. Berlin's urban experiments have been discursively constructed as radically innovative *Energiewende* projects but are in fact favoring pragmatic action over utopian ideas. They have successfully tested and demonstrated novel technologies but have not created radically new energy experiences, let alone fostered sweeping socio-technical change. Hajer argues that sustainability transitions are stalling in part because imaginations of post-fossil urban futures are lacking (Hajer and Versteeg, 2019). Indeed, truly different kinds of futures are difficult to imagine while wandering amid conventional office towers powered by conventional electricity surrounded by conventional automobiles, as is the case at Berlin's future sites. I criticize that the narrow techno-managerial paradigm guiding Berlin's smart grid experiments is constraining the development of more profoundly outside-the-box ideas. In doing so, it is also constraining their potential as forces for urban change.

To activate more daring ideas, the future sites and the pilot projects first need to depart from the logics of "the city as a market". They need to be normatively guided by intentions beyond economic growth. Their tech-related storylines need to be driven by a sustainability-oriented agenda and sustainability-oriented goals, not the other way around. In the case of Berlin's sites of urban experimentation, the sustainability related storylines are currently driven by a predominantly technology-oriented agenda. Put differently, the "smart growth" paradigm comes first, and the *Energiewende* paradigm comes second. If judged by this underlying orientation, the pilot projects and the future sites have already been immensely successful. They have attracted businesses, created jobs and increased the scientific knowledge on smart grid technologies in the city. They have thus fulfilled their primary objectives. From the administration's current perspective, there is no reason to change course, even though smart grid experimentation has not fostered systemic energy-related change. I argue that if urban experimentation was guided by a sustainability-oriented agenda, it could yield more sustainability related imaginaries and more radical, sustainability related change. What if, for example, experimentation with smart grids was guided by the overarching aim of empowering local energy communities? Or of capacitating residential prosumers?

That said, it is important to note that Berlin's current smart grid storylines have a radical core that is competing with a century-old infrastructural ideal of the grid as a "copper plate" (Agora Energiewende, 2017). This cooper plate imaginary has defined the relationship between energy and the city for the past one hundred years. The copper plate stands for an electricity system based on centralized management and centralized coordination, equal supply security, and equal pricing for all. Berlin's current smart grid storylines are indeed challenging these logics. Current visions of smart grid futures are radical in the sense that they stand in stark contrast to the institutional and regulatory structure of the current electricity regime and possibly even the current networked infrastructural ideal (Luque-Ayala and Marvin, 2020). However, they are much less radical when it comes to envisioning sustainable urban futures. Here, Berlin's urban experiments are (re)producing a techno-optimist paradigm that is narrowly confined to – or arguably overwhelmed by - a hegemonic, business-as-usual ideology. In doing so, they resemble "bounded studios within which to integrate finance, computation and digital media with discourses of sustainability" (Halpern and Günel, 2017: 7). I criticize that Berlin's visions of urban smart grid futures are thus daring to challenge incumbent electricity system logics on the one hand, but failing to challenge processes of smart, “entrepreneurial urbanism” (Datta, 2015) on the other.

For this to change, Berlin’s smart grid experiments need to embrace a much more clearly sustainability-oriented agenda that is guided by inclusive, open-ended processes of radical visioneering, or what Strengers calls processes of “reimagining *how we live*” (Strengers, 2014: 30). Currently, however, the visions of sustainable urban futures promoted through Berlin’s future sites are limited to the effectiveness of novel technologies to allow us to keep on doing as we already do, and living as we already live. Indeed, Pelzer and Versteeg assess that visions of sustainable urban futures generally pay

> “very little attention to the everyday intricacies of urban life after carbon. Terms like ‘decarbonization’ and ‘CO_2-neutral’ address the problems of our current world, but these descriptions are limited to what the situation beyond the fossil era *should not* be and seem unable to sketch a vision of what it *could be* like” (Pelzer and Versteeg, 2019: 13).

Too often, visions of the future dwell on assessments of the present while neglecting the difficult processes of imagining the unknown future. Especially in relation to smart technologies, Hajer and Versteeg criticize that these processes are left in large part to corporations, advertisers or norming institutions (Hajer and Versteeg, 2019). They also observe that “academics currently co-produce a highly restrictive imaginary of future cities”, and that urban policy-makers are quick to follow suit (Hajer and Versteeg, 2019: 129). Too frequently, visions of (smart) urban futures are not systematically developed but driven by the requirements of research funding institutions or the corporate logics of public-private partnerships.

Building on these insights, scholars are increasingly examining how radical new ideas can be inspired and with what effect. Pelzer and Versteeg (2019) find that urban experiments often simply lack an understanding of how processes of imagining work in relation to sustainability transformations (Pelzer and Versteeg, 2019: 24). They argue that an awareness for the strengths and weaknesses of different imaginative logics could positively influence their ability to generate truly outside-the-box ideas. Various scholars thus encourage urban experiments to systematically embrace the realms of art and emotion (Hajer and Pelzer, 2018; Pelzer et al., 2021; Stripple et al., 2021). Among others, they invite the creative input of designers, film-makers, writers or performance actors to challenge our relationship with the present through artistic interventions (Stripple et al., 2021). In effect, they all point to the need to engage more consciously and more intentionally in processes of imagining urban futures, and to make use of the abundant knowledge that exists in the creative disciplines. By contrast, visions of Berlin’s smart grid futures are not being developed in a systematic way. Instead, they are being promoted eclectically, be it through scientific conferences, corporate websites, brochures, showrooms, presentations, family events or the like.

I argue that visions, too, need to be understood as governance tools and fundamental prerequisites for enabling and shaping urban socio-technical transitions. Although the transitions literature finds that visions alone aren’t able to generate transformative change (van der Voorn and Quist, 2018), visions nevertheless play a fundamental role in instigating socio-technical change (Gustafsson and Mignon, 2020). As such, they need to be systematically integrated into processes of urban experimentation. In this sense, I argue that urban experimentation could (and should) also learn from processes of visioning as they have been practiced and theorized in urban planning. As I laid out in my theoretical framework (see chapter 5.5 "Envisioning the future of the city"), guiding visions in urban planning have a long history as fundamental parts of city-making processes. In planning history, the act of envisioning urban futures was long considered the creative work of individual planner masterminds, but this notion has been largely replaced by a conceptualization of visioning as processes of participatory community development (Shipley and Michela 2006, p. 224-225). Although an ongoing debate reflects the need for both inspiring individuals *and* community participation, acts of developing a guiding vision – or visioning – are fundamental to the planning process and require a structured approach. As Shipley and Michela (2006) synthesize:

> "The first lesson for practice, therefore, is that the bases of influence from visions and visioning should be conceptualized ahead of time, and actions to formulate, communicate and otherwise develop and promote a vision should be shaped as precisely as possible to conform to one's conceptual/theoretical assumptions" (Shipley and Michela, 2006: 240).

Some of this urban planning literature expands the notion of visioning into the slightly broader but arguably more accurate notion of *storytelling*, i.e. of giving meaning to certain pasts, presents and futures through imaginative stories (van Hulst 2012; Throgmorton 2007; Sandercock, 2011). While notions of visions or visioning imply the existence of an ultimate future state that can be achieved, the notion of a story or storytelling better captures the procedural nature of planning and essentially of urban change. As an urban planning tool, storytelling is understood as social (instead of individual) act of co-constructing a story that considers "the complex social networks, physical settings, and institutional processes in which those stories are told" (Thogmorton 2007, p. 250 – from van Hulst). It thus strongly resonates with the concepts of discourse and of storylines, which underlie this dissertation.

In urban planning literature, both storytelling and visioning are theorized as purposeful acts that depend on shared meaning-making and on inclusivity for success. If visions or storylines are to be broadly accepted and to incentivize change, they need to be created *with* not for audiences (van Hulst). If a vision is to lead to action, then "the processes of formulating, communicating and otherwise shepherding a vision should keep salient the connection between the ends sought in the vision and the values held by community members" (Shipley and Michela, 2006: 240). Guiding these processes then has the potential to lead to radical urban change. This kind of "dialectic utopianism" (Harvey, 1996) or "dialectical imagination" (Sandercock, 2012) refers to processes of envisioning city futures that are not fixed and coherent, but "accept struggle and flux as necessary and in need of acknowledgement, rather than something to be hidden in the creation of a supposedly conflict-free realm" (Pinder, 2002: 238). Put differently, the idea of visioning in planning is strongly underpinned by notions of deliberative, open-ended exploration and even conflict rather than the (rather authoritarian) idea of imposing a fixed (technological) ideal and working toward it. It is precisely this process-orientation that "allows utopianism to play a continuing role in radical thinking about cities" (Pinder, 2002: 239). Or as Stripple et al put it, "the best imaginary worlds have an open-ended, work-in-progress quality" (Stripple et al., 2021: 89). By contrast, urban experimentation in Berlin has brought expert communities closer together, but it has not rendered a broadly discussed or socially accepted “strong story” (Hajer 2010) of Berlin’s future relationship with energy. It has not offered a forum for deliberation or a platform for discussing what kinds of energy futures in what kind of city for what kind of society could be desirable.

To do so, Berlin’s urban experiments might need to re-evaluate their relationship with contingency and control (Bulkeley et al., 2019). They might need to re-evaluate in how far they are driven by a truly open-ended, experimental approach or by predetermined, uni-directional steering. More precisely, Berlin’s urban experiments might need to dare higher levels of contingency to allow more open and more radical processes of sustainable city-imagining. Just like urban planning, urban experimentation might need to embrace what they do as “always unfinished social project” (Sandercock, 2002). I close this section with the words of David Pinder, who warns that “at a time when the language of alternatives is declared outdated if not impermissible, it appears that the capacity to imagine and conceptualize social transformation and different urban futures – the very essence of utopian urbanism – is itself thrown into doubt” (Pinder, 2002: 232).

10.5 <u>Show stronger political leadership</u>

Finally, I argue that by promoting smart grid experimentation in this way, the city of Berlin is squandering a much-needed chance to fundamentally transform its current unsustainable energy system. Instead of understanding and designing its sites of urban experimentation as governance tools for implementing the *Energiewende*, these sites are designed as research and development projects for technology tinkering and demonstration. They are embedded in the logics of industrialization and innovation politics, not *Energiewende* politics. Under these circumstances, is not surprising that the *Energiewende* related visions and material infrastructures that have been developed at these sites have functioned more as superficial branding than as catalysts for urban change. I argue that if urban experimentation was more strictly understood and designed as tool for sustainability governance, then Berlin’s urban *Energiewende* could benefit much more strongly from its smart grid related results. Unfortunately, however, Berlin’s future sites are currently understood primarily as governance tools for achieving regional economic growth, and the pilot projects are understood as possibility for scientific collaboration and technological learning. This is reflected in their design, affects the technology centered storylines they promote and restricts their energy related impact.

Even though the biggest obstacles for smart grid implementation in Berlin arguably lie in the institutional and regulatory domains, Berlin’s smart grid pilot projects are neither designed to enable institutional learning nor embedded in a structural approach to experimental governance. If cities want to learn from experimentation, they need to build up structures to integrate the lessons learned from urban experimentation in a systematic way. As enablers of experimentation, they must use the knowledge acquired in urban living labs to enable transformative change, first within their own organizations. As Potjer et al summarize: “ Urban experimentation as a form of governance can be an important catalyst to change, but only when it is connected to the practices of governance that take place around it, whether that be on the urban level, the regional, national or supranational level” (Potjer et al., 2018: 4). As long as Berlin’s experimental pilot projects are embedded first and foremost in governmental programs to generate regional economic growth, they will hardly lead to energy related institutional learning or catalyze energy related change. Instead, they need to be embedded in governmental structures that enable and embrace energy related institutional learning. In other words, the Berlin Senate needs to create the ideal environment for its pilot projects to thrive (Potjer, 2019). Evans et al (2021) find that urban administrations are actually very often eager to learn from experiments, but that they mostly do so "implicitly and without a clear methodology or dedicated resources for capturing learning" (Evans et al., 2021: 176). For this purpose, Turnheim et al. (2020) argue that "policymakers may need new skills to deal with a variety of stakeholders (beyond large firms), manage and evaluate experiments (including acknowledging inevitable failures), and monitor progress on multiple dimensions (not just costs)" (Turnheim et al., 2020: 119).

Concomitantly, the idea of "scaling-up" needs to be more systematically addressed in the experimentation processes themselves. The pilot projects need to extend their focus from technological and social learning to systematically embrace questions of institutional learning. Currently, Berlin's smart grid projects have addressed learning mostly as internal processes of technological "learning-by-doing" between project partners, and as external processes of public outreach and "experiential learning" at events. However, forms of institutional or second-order learning have been largely neglected. Evans et al (2021) mention a smart grid project in the UK, which "spent four years out of a five-year project resolving contractual and trust, rather than technical, issues" (Evans et al., 2021: 177). According to Potjer et al. (2019), urban experiments need to involve policy-makers from the start, nurture meaningful exchange with other pilot projects at the local level, and connect with the institutional world "so that institutions can create the optimal conditions for experiments and use their lessons for change" (Potjer, 2019: 87).

In sum, Berlin's political leaders need to show stronger leadership when it comes to defining the goals of its urban experiments (energy transitions not economic growth) and open their governmental practices to embrace the changes advanced. Otherwise, experimentation will remain a hype. And hypes are typically followed by disappointment. If the Berlin Senate was truly interested in smart grids as prerequisite for the city's *Energiewende,* it should understand urban experimentation as possibility to develop pluralistic visions of a future smart grid system, to promote social (over technological) energy innovation, to tinker with different possible transition pathways and to provide the necessary framework conditions for institutional learning and urban change. In short, urban experimentation could use more sustainability oriented political leadership.

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Appendix

<u>Interview guideline (english)</u>

Block I - Introduction

1. My project
   - How will urban energy production, consumption, and trading potentially change through the introduction of smart grids?

2. What do you do at [your company]?

Block II – Ideas about and evluation of smart grid

3. In one sentence, what do you mean when you say „smart grid“?
4. How does [your company] relate to your definition of smart grid? And how do they differ?
5. What are smart grids good for?
   - Renewables integration?
   - Distributed generation?
   - Flexibility?
   - Co2 reduction?
   - Lowering energy costs?
   - Sector coupling?

6. What visions do you have for smart grid technologies in cities (at the distribution level)?
   - Who will prosume in the city? SMEs? Households?
   - Role model? (Brooklyn?)
   - Network of networks?

Block III – Expectations of smart grid technology for people

7. Who will use the technology?
8. What will change for energy users (households) through smart grid technology?
9. Describe a typical prosumer, for example in Berlin
   - What advantages or disadvantages might urban residents have?

10. What will change for neighborhoods or communities through smart grids?
    - You say that the smart grid of the future will be able to operate “in total isolation”. What does this mean for those neighborhoods?
    - The brochures also says “community sustainability”. What do you mean by this?

Block V – Implementation of smart grids in Berlin

1. Do you have pilots of smart grids underway in Berlin? Elsewhere?
2. Tell me more about the pilot!
    - Participants?
    - Role of resarch institutions?
    - Role of private companies?
3. What is the role of the Berlin Senate in this whole enterprise?
    - How are you working with them?
4. What are obstacles to the implementation of smart grids (in Berlin)?
    - Obstacles?
    - Technical difficulties?
    - Regulatory difficulties?
    - Opponents?
    - Is there critcism of smart grids? Why?
    - Any Berlin-specific obstacles? Senate? Neighborhood collectives?

11. What do smart grids mean for the local utility?
    - Wie sehen Sie die Rolle des Stadtwerks beim Thema Digitalisierung?

5. Alternatives to the smart grid?
    - What alternatives are there to smart grids?
    - Do you know people or groups that are against smart grids or proposing alternatives?

Block IV – Advantages and disadvantages of smart grids for Berlin

6. Where will renewable energies come from in the Berlin case?
    - Roof tops?

7. Spatial effects?
    - Different energy prices per region?
    - Different supply security per neighborhood?

8. What are the risks that smart grids entail?
    - Cyber attacks?
    - Data privacy?

Block V - Closure

9. Could you recommend further interview partners?